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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DEPARTMENT OF ENERGY

10 CFR Parts 429, 430, and 431

[Docket No. EERE–2014–BT–TP–0008]

RIN 1904–AD18

Energy Conservation Program for Certain Commercial and Industrial Equipment: Test Procedure for Commercial Water Heating Equipment

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

ACTION: Final rule.

SUMMARY: On May 9, 2016, the U.S. Department of Energy (DOE) published a notice of proposed rulemaking (NOPR) to amend its test procedures for commercial water heaters, unfired hot water storage tanks, and hot water supply boilers (henceforth, ''commercial water heating (CWH) equipment''). That proposed rulemaking serves as the basis for this final rule. Specifically, this final rule incorporates by reference the most recent versions of relevant industry standards; modifies the existing test methods for certain classes of CWH equipment; establishes new test procedures for determining the

efficiency of commercial heat pump water heaters and standby loss for instantaneous water heaters and hot water supply boilers; clarifies test set-up and settings for various classes of CWH equipment; revises the certification requirements for CWH equipment; and establishes associated definitions.

DATES: The effective date of this rule is December 12, 2016. The final rule changes will be mandatory for representations related to energy efficiency or energy use starting November 6, 2017. The incorporation by reference of certain publications listed in this rule is approved by the Director of the **Federal Register** on December 12, 2016.

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

A link to the docket Web page can be found at: *https://www.regulations.gov/docket?D=EERE-2014-BT-TP-0008.* This Web page contains a link to the docket for this rulemaking on the *www.regulations.gov* site. The docket Web page contains simple instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket, contact the Appliance and Equipment Standards Program staff at (202) 586–6636 or by email: *CommWaterHeatingEquip2014TP0008@;ee.doe.gov.*

FOR FURTHER INFORMATION CONTACT:

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Mr. Eric Stas or Ms. Jennifer Tiedeman, U.S. Department of Energy, Office of the General Counsel, GC–33, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 586–9507 or (202) 287–6111. Email: *Eric.Stas@hq.doe.gov* or *Jennifer.Tiedman@hq.doe.gov.*

SUPPLEMENTARY INFORMATION: This final rule incorporates by reference the following industry standards into part 431:

(1) American National Standards Institute, (ANSI) Standard Z21.10.3–2015/Canadian Standards Association (CSA) Standard 4.3–2015, ''Gas-fired water heaters, volume III, storage water heaters with input ratings above 75,000 Btu per hour, circulating and instantaneous,'' ANSI approved on October 5, 2015, Annex E (normative) Efficiency test procedures—E.1 ''Method of test for measuring thermal efficiency,'' Paragraph c, ''Vent requirements'' and Paragraph f, ''Installation of temperature sensing means'';

(2) American Society of Heating, Refrigeration and Air-Conditioning Engineers, ANSI/ASHRAE Standard 118.1–2012, ANSI approved on October 27, 2012, ''Method of Testing for Rating Commercial Gas, Electric, and Oil Service Water-Heating Equipment''; Section 3 ''Definition and Symbols,'' Section 4 ''Classifications by Mode of Operation,'' Section 6 ''Instruments,'' Section 7 ''Apparatus,'' Section 8 ''Methods of Testing,'' Section 9 ''Test Procedures,'' and Section 10 ''Calculation of Results'';

(3) ASTM International (ASTM) C177–13, ''Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus,'' approved September 15, 2013;

(4) ASTM C518–15, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus,'' approved September 1, 2015; and

(5) ASTM D2156–09 (Reapproved 2013), ''Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels,'' approved October 1, 2013.

Copies of ANSI Z21.10.3–2015/CSA 4.3–2015 and ANSI/ASHRAE 118.1–2012 can be obtained from the American National Standards Institute, 25 W. 43rd Street, 4th Floor, New York, NY 10036, (212) 642–4800, or by going to *http://webstore.ansi.org/.*

Copies of ASTM C177–13, ASTM C518–15, and ASTM D2156–09 can be obtained from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428–2959, (610) 832–9585, or by going to *http://www.astm.org/Standard/index.html.*

See section IV.N of this final rule for further discussion of these standards.

Table of Contents

I. Authority and Background

Title III, Part C [1] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6311–6317, as codified), added by Public Law 95–619, Title IV, section 441(a), sets forth a variety of provisions designed to improve energy efficiency.[2] It established the ''Energy Conservation Program for Certain Industrial Equipment,'' a program covering certain commercial and industrial equipment (hereafter referred to as ''covered equipment''), which includes the commercial water heating (CWH) equipment that is the subject of this rulemaking. (42 U.S.C. 6311(1)(K)) Title III, Part B [3] of EPCA (42 U.S.C. 6291–6309, as codified) sets forth a variety of provisions designed to improve energy efficiency and established the Energy Conservation Program for Consumer Products Other Than Automobiles. This includes consumer water heaters, which are also addressed in this rulemaking. (42 U.S.C. 6292(a)(4))

Under EPCA, the energy conservation programs for consumer products and industrial equipment generally consist of four parts: (1) Testing; (2) labeling; (3) establishing Federal energy conservation standards; and (4) certification and enforcement procedures. The testing requirements consist of test procedures that manufacturers of covered products and equipment must use as both the basis for certifying to DOE that their products and equipment comply with the applicable energy conservation standards adopted pursuant to EPCA, and for making representations about the efficiency of that equipment. (42 U.S.C. 6293(c); 42 U.S.C. 6295(s); 42 U.S.C. 6314; 42 U.S.C. 6316)

The initial test procedures for CWH equipment were added to EPCA by the Energy Policy Act of 1992 (EPACT 1992), Public Law 102–486, and correspond to those referenced in ASHRAE and Illuminating Engineering Society of North America (IESNA) Standard 90.1–1989 (*i.e.,* ASHRAE Standard 90.1–1989) which went into effect on October 24, 1992. (42 U.S.C. 6314(a)(4)(A)) EPCA requires that if an industry test procedure that is referenced in ASHRAE Standard 90.1 is amended, DOE must amend its test procedure to be consistent with the amended industry test procedure, unless DOE determines that the amended test procedure is not reasonably designed to produce test results that reflect the energy efficiency, energy use, or estimated operating costs of the equipment during a representative average use cycle. In addition, DOE must determine that the amended test procedure is not unduly burdensome to conduct. (42 U.S.C. 6314(a)(2), (3) and (4)(B))

If DOE determines that a test procedure amendment is warranted, it must publish a proposed test procedure in the **Federal Register** and offer the public an opportunity to present oral and written comments. (42 U.S.C. 6314(b)(1)–(2)) When amending a test procedure, DOE must determine to what extent, if any, the proposed test procedure would alter the equipment's energy efficiency as determined under the existing test procedure. (42 U.S.C. 6293(e); 42 U.S.C. 6314(a)(4)(C))

The Energy Independence and Security Act of 2007 (EISA 2007), Public Law 110–140, amended EPCA to require that at least once every 7 years, DOE must review test procedures for each type of covered equipment, including CWH equipment, and either: (1) Amend the test procedures if the Secretary of Energy (Secretary) determines that the amended test procedures would more accurately or fully comply with the requirements of 42 U.S.C. 6314(a)(2)–(3),[4] or (2) publish a notice of determination not to amend a test procedure. (42 U.S.C. 6314(a)(1)(A)) Under this requirement, DOE must review the test procedures for CWH equipment no later than May 16, 2019, which is 7 years after the most recent final rule amending the Federal test method for CWH equipment.[5] This final rule satisfies the requirement to review the test procedure for CWH equipment within 7 years, as well as the aforementioned requirement that DOE amend its test procedure if an industry test procedure is updated.

DOE's test procedure for CWH equipment is found at 10 CFR 431.106, *Uniform test method for the measurement of energy efficiency of commercial water heaters and hot water supply boilers (other than commercial heat pump water heaters).*[6] DOE's test procedure for CWH equipment provides a method for determining the thermal efficiency and standby loss of CWH equipment. In a direct final rule for test procedures for CWH equipment, DOE incorporated by reference certain sections of ANSI Standard Z21.10.3–1998 (ANSI Z21.10.3–1998), *Gas Water Heaters, Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous.* 69 FR 61974, 61983 (Oct. 21, 2004). On May 16, 2012, DOE published a final rule for certain commercial heating, air-conditioning, and water heating equipment in the **Federal Register** that, among other things, updated the test procedures for certain CWH equipment by incorporating by reference ANSI

[1] For editorial reasons, Part C was codified as Part A–1 in the U.S. Code.

[2] All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015 (EEIA 2015), Public Law 114–11 (April 30, 2015).

[3] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated as Part A.

[4] 42 U.S.C. 6314(a)(2) requires that test procedures be reasonably designed to produce test results which reflect energy efficiency, energy use, and estimated operating costs of a type of industrial equipment (or class thereof) during a representative average use cycle (as determined by the Secretary), and not be unduly burdensome to conduct.

42 U.S.C. 6314(a)(3) requires that if the test procedure is a procedure for determining estimated annual operating costs, such procedure must provide that such costs are calculated from measurements of energy use in a representative average-use cycle (as determined by the Secretary), and from representative average unit costs of the energy needed to operate such equipment during such cycle. The Secretary must provide information to manufacturers of covered equipment regarding representative average unit costs of energy.

[5] DOE published a final rule in the **Federal Register** on May 16, 2012, that, in relevant part, amended its test procedure for commercial water heating equipment. 77 FR 28928.

[6] DOE has reserved a place in its regulations for a test procedure for commercial heat pump water heaters at 10 CFR 431.107, *Uniform test method for the measurement of energy efficiency for commercial heat pump water heaters.* However, in this final rule, DOE is removing 431.107 and addressing the test method for commercial heat pump water heaters in Appendix E to Subpart G of 10 CFR 431.

Z21.10.3–2011. 77 FR 28928, 28996. These updates did not materially alter DOE's test procedure for CWH equipment.

The American Energy Manufacturing Technical Corrections Act (AEMTCA), Public Law 112–210, was signed into law on December 18, 2012, and amended EPCA to require that DOE publish a final rule establishing a uniform efficiency descriptor and accompanying test methods for consumer water heaters and certain CWH equipment. (42 U.S.C. 6295(e)(5)) AEMTCA required DOE to replace the current efficiency metric for consumer water heaters (energy factor) and the current efficiency metrics for commercial water heaters (thermal efficiency and standby loss) with a uniform efficiency descriptor. (42 U.S.C. 6295(e)(5)(C)) Further, AEMTCA required that the uniform efficiency descriptor and accompanying test method apply, to the maximum extent possible, to all water heating technologies currently in use and to future water heating technologies. (42 U.S.C. 6295(e)(5)(H)) However, AEMTCA allowed DOE to exclude from the uniform efficiency descriptor specific categories of covered water heaters that do not have residential uses, that can be clearly described, and that are effectively rated using the current thermal efficiency and standby loss descriptors. (42 U.S.C. 6295(e)(5)(F))

DOE published a final rule for test procedures for certain CWH equipment on July 11, 2014 (''July 2014 final rule''). 79 FR 40542. The July 2014 final rule modified the current consumer water heater metric (energy factor) to create uniform energy factor (UEF), the descriptor to be used as the uniform efficiency descriptor for all consumer water heaters and CWH equipment that have residential uses. *Id.* at 40544. The July 2014 final rule excluded CWH equipment from the uniform descriptor equipment that has no residential use, that can be clearly identified and described, and that is effectively rated using the current thermal efficiency and standby loss efficiency descriptors. In the July 2014 final rule, DOE defined and adopted a new test method for ''residential-duty commercial water heaters,'' which are commercial water heaters that have residential uses. *Id.*

For this final rule for CWH equipment test procedures, DOE is only amending test procedures for the CWH equipment classes that are not ''residential-duty commercial water heaters'' as adopted in the July 2014 final rule.[7] On February 27, 2014, DOE published in the **Federal Register** a request for information (February 2014 RFI) to seek public comments on several issues associated with the current test procedure for CWH equipment. 79 FR 10999. On May 9, 2016, DOE published a NOPR proposing amendments to its procedures for certain CWH equipment (May 2016 NOPR). 81 FR 28588. The May 2016 NOPR considered and responded to comments received in response to the February 2014 RFI.

In this final rule, DOE responds to all comments received from interested parties in response to the proposals presented in the May 2016 NOPR, either during the May 2016 NOPR public meeting or in subsequent written comments.

II. Synopsis of the Final Rule

As explained in detail in section III, in this final rule, DOE amends subpart G of 10 CFR part 431 to:

- Incorporate by reference certain provisions of the most current version of the following industry standards, older versions of which are currently incorporated into DOE's regulations: (1) ANSI Z21.10.3–2015/CSA 4.3–2015, *Gas-fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous*; (2) ASTM Standard Test Method D2156–09, *Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels*; (3) ASTM Standard Test Method C177–13, *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus*; and (4) ASTM Test Standard Method C518–15, *Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus*;
- Update the requirements for ambient condition requirements, measurement locations, and measurement intervals for the thermal efficiency and standby loss test procedures;
- Amend the test set-up requirements for storage water heaters, storage-type instantaneous water heaters, instantaneous water heaters, and hot water supply boilers;
- Update provisions for setting the tank thermostat for storage and storage-type instantaneous water heaters prior to the thermal efficiency and standby loss tests;
- Update requirements for establishing steady-state operation for CWH equipment;
- Update existing and adopt new definitions for certain consumer water heaters, certain CWH equipment, residential-duty commercial water heater and storage-type instantaneous water heaters;
- Update the test set-up for instantaneous water heaters and hot water supply boilers that are tested using a recirculating loop;
- Adopt a new standby loss test procedure for flow-activated and externally-activated instantaneous water heaters;
- Modify the standby loss test procedure for internally thermostatically-activated instantaneous water heaters;
- Update the test procedure for determination of storage volume for instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters);
- Adopt requirements for gas supply pressure and gas outlet pressure of gas-fired CWH equipment;
- Adopt a new test procedure for rating commercial heat pump water heaters (CHPWHs) based on certain sections incorporated by reference from ANSI/ASHRAE Standard 118.1–2012, *Method of Testing for Rating Commercial Gas, Electric, and Oil Service Water-Heating Equipment;*
- Adopt provisions for measurement and enforcement of fuel input rate; and
- Specify default values for certain parameters for testing oil-fired CWH equipment.

The final rule also amends 10 CFR part 429 to clarify certification requirements and enforcement procedures for certain CWH equipment, and amends certain definitions in 10 CFR part 430. Specifically, in 10 CFR part 430, this final rule removes the definitions of ''Electric heat pump water heater'' and ''Gas-fired heat pump water heater,'' and revises the definitions of ''Electric instantaneous water heater,'' ''Electric storage water heater,'' ''Gas-fired instantaneous water heater,'' ''Gas-fired storage water heater,'' ''Oil-fired instantaneous water heater,'' and ''Oil-fired storage water heater.''

III. Discussion

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

[7] Although DOE did not consider amended test procedures for residential-duty commercial water heaters, DOE is amending the definition for ''residential-duty commercial water heater,'' as discussed in section III.G.3.

TABLE III–1—INTERESTED PARTIES PROVIDING COMMENT IN RESPONSE TO THE MAY 2016 NOPR

Name	Abbreviation	Commenter type*
A.O. Smith Corporation and Lochinvar, LLC	A.O. Smith	M
Air-Conditioning, Heating, and Refrigeration Institute	AHRI	IR
American Gas Association and American Public Gas Association	Gas Associations	IR
Appliance Standards Awareness Project and American Council for an Energy-Efficient Economy.	Joint Advocates (ASAP and ACEEE)	EA
Bock Water Heaters, Inc	Bock	M
Bradford White Corporation	Bradford White	M
Bradley Corporation	Bradley	M
California Investor Owned Utilities	CA IOUs	IR
Earthlinked Technologies Inc	Earthlinked	M
Edison Electric Institute	EEI	IR
GE Appliances	GE	M
HTP, Inc	HTP	M
Lochinvar, LLC	Lochinvar	M
Northwest Energy Efficiency Alliance	NEEA	EA
Raypak, Inc	Raypak	M
Rheem Corporation	Rheem	M
Rinnai America Corporation	Rinnai	M

* ''IR'': Industry Representative; ''M'': Manufacturer; ''EA'': Efficiency/Environmental Advocate.

These interested parties commented on a range of issues, including those identified by DOE in the May 2016 NOPR, as well as other issues related to the proposed test procedure. The issues, the comments received, DOE's responses to those comments, and the resulting changes to the NOPR test procedure proposals for CWH equipment adopted in this final rule are discussed in the following subsections.

A. Updated Industry Test Methods

DOE's test procedure for measuring the energy efficiency for CWH equipment currently incorporates by reference the industry standard ANSI Z21.10.3–2011 at 10 CFR 431.105. Additionally, DOE lists ASTM Standard Test Methods D2156–80, C177–97, and C518–91 as sources of information and guidance in 10 CFR 431.104. DOE defines ''ASTM Standard Test Method D2156–80'' at 10 CFR 431.102, and points to this source in DOE's current test procedure at 10 CFR 431.106. DOE points to ASTM C177–97 and ASTM C518–91 in its definition of ''R-value'' at 10 CFR 431.102. In the May 2016 NOPR, DOE proposed to update the references to industry test methods to incorporate the most recent version available of each of these standards.

As described in section I, with respect to CWH equipment, EPCA initially directs DOE to use industry test methods 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)) If and when such an industry test method is amended, EPCA requires that DOE amend its test procedure as necessary to be consistent with the amended industry test method 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)(2), (3) and (4)(B))

AHRI and Rheem stated that DOE is obligated to adopt generally accepted industry testing procedures and may only adopt an alternate procedure upon proving by clear and convincing evidence that the industry test standard is not designed to reflect the energy efficiency of the equipment being tested or is unduly burdensome to conduct. (AHRI, No. 26 at pp. 3–4, Rheem No. 34 at p. 2) AHRI argued that the May 2016 NOPR does not address this statutory requirement and instead shifts the burden of data production to the regulated industry, and further argued that DOE must quantify the benefits of the proposed test procedure over the industry test standards. (AHRI, No. 26 at pp. 3–4) Rheem asserted that the appropriate reason to amend the current Federal test procedure is the statutory requirement to amend the Federal test procedure whenever the industry-accepted test standard for commercial water heating equipment is amended, and recommended that DOE adopt the industry-accepted test procedure rather than amendments to it. Rheem added that, in its view, the proposed test procedures lack justification, are burdensome, and are contradictory to the requirements of Executive Order 12988, ''Civil Justice Reform.'' (Rheem, No. 34 at pp. 1–4) A. O. Smith stated that the proposed test procedure is not justified by empirical and qualitative data. (A. O. Smith, No. 27 at p. 1)

DOE does not agree with commenters' interpretations of the relevant statutory provisions at issue here. Under 42 U.S.C. 6314(a)(4)(B), when DOE is triggered by the amendment of an industry test method applicable to ASHRAE equipment, the Secretary is directed to undertake an assessment of that industry test method to determine whether amendments to the Federal test procedure are ''necessary'' to be ''consistent'' with the amended industry test method. (There may be cases where the industry standard-setting organization reviews its method and puts out a new version with minimal or no changes, in which case it may not be necessary for DOE to amend its own test procedure.) The term ''consistent'' does not equate to ''identical,'' so Congress envisioned that some differentiation from the industry standard may be necessary. However, in the event DOE determines that a more significant deviation from the industry test method is needed (*i.e.,* a change that would not be ''consistent'' with the industry method), the Secretary must determine by rule published in the **Federal Register** and supported by clear and convincing evidence that a Federal test procedure consistent with the industry test method would not meet the requirements of 42 U.S.C. 6314(a)(2) and (3). It is only in the latter case that the clear and convincing evidence standard would apply.

In DOE's experience, industry standard-setting bodies typically undertake a thorough and professional approach to their test procedures. However, DOE must remain cognizant of its statutory duty to ensure that the Federal test method be consistent with the industry test method while meeting other statutory requirements at 42 U.S.C. 6314(a)(2)–(3) (including that the procedure produces test results that reflect the energy efficiency, energy use, and estimated operating costs of that equipment during a representative average use cycle and is not unduly burdensome to conduct). To the extent that DOE identifies provisions of the relevant industry test method that would produce inaccurate, inconsistent, or unrepeatable results, as demonstrated by DOE's testing or analysis, such results would be unlikely to reflect a product's representative average energy efficiency or use. Such findings would demonstrate that the industry test procedure would not meet the statutory requirements of 42 U.S.C. 6314(a)(2)–(3) without alteration, thereby justifying DOE's decision to modify the industry test procedure (or in certain instances, even to deviate from the industry test procedure entirely, in which case the clear and convincing evidence standard would apply). That is why DOE usually adopts certain sections of industry test methods rather than adopting industry methods wholesale and adjusts the industry test methods as needed to satisfy the aforementioned statutory requirements. Such is the case here, where DOE is adopting amended test procedures that are largely consistent with the industry test methods (parts of which are incorporated by reference), and any deviations from those industry test methods adopted in this final rule are intended to clarify the test method to ensure consistent application, improve repeatability, or make the test method more representative of the energy efficiency during a representative average use cycle, and ensure that the test procedure is not unduly burdensome to conduct.

DOE is tasked with providing clear, repeatable procedures through the rulemaking process. The differences between the Federal test methods that DOE is adopting in this final rule and the industry test methods, and the rationale for these differences, are explained in detail in the sections that follow. As one example, a major difference between the test method DOE is adopting in this final rule and the method contained in ANSI Z21.10.3–2015 is the method for setting the thermostat for gas-fired and oil-fired storage water heaters—DOE requires the thermostat be set based on the reading from the top-most thermostat, while ANSI Z21.10.3–2015 requires the thermostat be set based on the mean temperature of the water stored within the tank. As discussed in detail in section III.E.1 below, certain CWH designs having a large amount of stratification cannot achieve the mean tank temperature of 140 ± 5 °F required by ANSI Z21.10.3–2015. Thus, if DOE were to adopt the industry method wholesale, there would be certain models that could not be tested in accordance with the test procedure. Further, the thermostats of gas-fired and oil-fired storage water heaters are generally set in the field to deliver water at the temperature needed for the application, without regard to the mean temperature of the water stored within the tank, as it is typically not relevant to the user as long as the water at the outlet can meet the temperature requirement for the application. Therefore, for this particular example, the DOE test method adopted in this final rule differs from the industry standard only to the extent that it is appropriate for and can be used for all types of CWH equipment. This approach to amending test procedures both maintains consistency with the industry test method and ensures that the Federal test method meets the statutory requirements set forth above.

Nonetheless, assuming that DOE requires clear and convincing evidence for its amendments to industry standards here, DOE believes its findings fully satisfy that threshold. To explain that conclusion, DOE articulates how it understands the ''clear and convincing evidence'' concept to operate in the context of DOE's establishing of test procedures. A rulemaking procedure is unlike the context of litigation, where ''clear and convincing'' means that the evidence must ''place in the ultimate factfinder an abiding conviction that the truth'' of its conclusions is ''highly probable.''[8] Nonetheless, DOE fully recognizes that whenever it must have ''clear and convincing evidence'' pursuant to 42 U.S.C. 6314(a), it needs a higher degree of confidence in its conclusions than would be required under the ''preponderance'' standard that ordinarily applies in agency rulemaking. In such matters, the administrative record, taken as a whole, must justify DOE in a strong conviction that its conclusions are highly likely to be correct.[9]

For purposes of establishing test procedures under 42 U.S.C. 6314(a), ''clear and convincing evidence'' can include the same sorts of evidence that DOE would use in any other rulemaking. But DOE will conclude it has ''clear and convincing evidence'' only when it is strongly convinced that it is highly likely to have reached appropriate findings. With respect to the findings discussed in this rulemaking, DOE does have that strong conviction.

In addition, contrary to AHRI's assertion, DOE is under no statutory obligation to quantify the benefits of adopting improved test procedures other than to find that the test procedures are not unduly burdensome to conduct. In response to Rheem's suggestion that DOE simply adopt industry test methods without amendment, where the industry-based test procedure contains one or more provisions that would prevent it from generating results that meet the requirements of the statute, EPCA directs DOE to adopt a Federal test procedure that resolves the identified problem(s)—not to adopt the industry method unquestioned. See 42 U.S.C. 6314(a)(2), (3) and (4). For the example given above, the industry test method cannot be used without modification for certain CWH equipment, as those equipment are not designed to operate in the manner prescribed by the industry test method. Therefore, the energy efficiency resulting from the industry test method (if possible to test) would not reflect the energy efficiency of that equipment during a representative average use cycle, and in such instances EPCA requires DOE to modify the test procedure.

Consistent with this authority, DOE is adopting a test procedure that is generally consistent with the industry-based test procedure. The justification and evidence supporting each provision adopted is described in the sections that follow, including DOE's compliance with Executive Order 12988, which is addressed in section IV.F of this final rule.

The following subsections discuss revisions to DOE's test procedure for CWH equipment vis-à-vis these industry standards.

1. ANSI Z21.10.3 Testing Standard

As previously noted, DOE's test procedure for measuring the energy efficiency for CWH equipment currently incorporates by reference the industry

[8] *Colorado* v. *New Mexico,* 467 U.S. 310, 316 (1984).

[9] Because a test procedure rulemaking is not a litigation, the differences warrant some differences in how the ''clear and convincing evidence'' threshold operates. DOE both develops the record and reviews it to make findings. Also, as an agency tasked with setting policy, DOE is ordinarily expected to use its technical judgment.

standard ANSI Z21.10.3–2011 at 10 CFR 431.105. Specifically, the DOE test procedures at 10 CFR 431.106 directs one to follow Exhibits G.1 and G.2 of ANSI Z21.10.3–2011 for measuring thermal efficiency and standby loss, respectively. An updated edition of the industry test method, ANSI Z21.10.3–2015/CSA 4.3–2015, *Gas-fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous* (hereinafter referred to as ''ANSI Z21.10.3–2015''), was approved on October 5, 2015, and released in November 2015.

In the May 2016 NOPR, DOE proposed to incorporate by reference certain sections of ANSI Z21.10.3–2015 in its test procedures for CWH equipment. 81 FR 28588, 28595 (May 9, 2016). Specifically, DOE proposed to incorporate by reference only Annex E.1 of ANSI Z21.10.3–2015 (which corresponds to Exhibit G.1 of ANSI Z21.10.3–2011). As discussed in the May 2016 NOPR, DOE did not propose to incorporate by reference Annex E.2 of ANSI Z21.10.3–2015 (which corresponds to Exhibit G.2 of ANSI Z21.10.3–2011) because of an error in a standby loss equation; however, DOE included certain language from Annex E.2 in its standby loss test procedures proposed in the May 2016 NOPR. *Id.* DOE has concluded that the standby loss test procedure for storage-type CWH equipment adopted in this final rule is consistent with the approach taken by Annex E.2 of ANSI Z21.10.3–2015; nonetheless, any differences in the DOE test method (as discussed in the applicable subsections within section III of this notice) are also supported by clear and convincing evidence. CA IOUs responded to the May 2016 NOPR by expressing support for updating the reference to ANSI Z21.10.3–2015 with as-needed modifications. (CA IOUs, No. 23 at p. 1) In the May 2016 NOPR, DOE's proposed test procedures included specific references to sections c, f, and j of Annex E.1 of ANSI Z21.10.3–2015. 81 FR 28588, 28595 (May 9, 2016) However, as discussed in section III.F.1 of this final rule, DOE is adopting new requirements for establishing steady-state operation prior to the thermal efficiency test, as recommended by several stakeholders. Therefore, in this final rule, DOE is not referencing section j of Annex E.1 of ANSI Z21.10.3–2015, which includes conduct of the thermal efficiency test and establishment of steady-state operation. However, DOE is adopting language and equations for determination of thermal efficiency that are similar to those included in section j of Annex E.1 of ANSI Z21.10.3–2015. Consequently, in this final rule DOE is amending its test procedures for CWH equipment by incorporating by reference sections c and f (''Vent requirements'' and ''Installation of temperature-sensing means,'' respectively) of Annex E.1 of ANSI Z21.10.3–2015.

ANSI Z21.10.3–2015 also includes a new standby loss test procedure—Annex E.3, *Method of test for measuring standby loss for tube type instantaneous water heaters with 10 or greater gallons of storage.* This procedure provides a method to test standby loss of instantaneous water heaters and hot water supply boilers, including those that require continuous flow of water to activate the burner or heating element (*i.e.,* ''flow-activated instantaneous water heaters''). DOE reviewed this test procedure for the May 2016 NOPR and discussed the issues with incorporating Annex E.3 of ANSI Z21.10.3–2015 as a test procedure for conducting the standby loss test for flow-activated instantaneous water heaters. Specifically, DOE noted that Annex E.3 of ANSI Z21.10.3–2015 contained several apparent errors, such as equations that appeared to have typos and variables that were incorrectly defined. Further, the test method in Annex E.3 would have ended the test after 1 hour, and assumed that the entire amount of thermal energy contained in the stored water above room temperature is lost in exactly 1 hour, regardless of the rate at which the equipment actually loses heat. DOE tentatively concluded that such a procedure would unfairly assume the same rate of standby losses for models that may lose heat at different rates, and would not be representative of the energy efficiency of this equipment. DOE discussed these issues in detail in section III.G of the May 2016 NOPR. Ultimately, in the May 2016 NOPR, DOE proposed a test procedure similar to Annex E.3 of ANSI Z21.10.3–2015 with modifications to: (1) The equation to calculate the standby loss; (2) the conduct of the test; (3) the parameters that need to be measured; and (4) the stopping criteria for the test. 81 FR 28588, 28607–28613 (May 9, 2016). In the May 2016 NOPR, DOE also proposed to adopt a different method for determining the storage volume for use in the standby loss calculation for flow-activated instantaneous water heaters than that specified by Annex E.3 of ANSI Z21.10.3–2015. Specifically, DOE proposed to use a weight-based method similar to the method specified in section 5.27 of ANSI Z21.10.3–2015, rather than the method included in section 5.28 of ANSI Z21.10.3–2015, which leaves the actual method for determining storage volume to the discretion of the test entity.

In section III.H of this final rule, DOE discusses the comments received from interested parties on the proposed test procedure for flow-activated instantaneous water heaters, including comments on the methodology used to determine the storage volume. In addition, based on the comments received, DOE has expanded the applicability of the adopted test procedure to externally thermostatically-activated instantaneous water heaters and modified the methodology to determine the storage volume to allow the measurement using calculations of physical (or design drawing) based dimensions. For additional details, see section III.H of this final rule.

2. ASTM Standard Test Method D2156 and Smoke Spot Test

DOE's current test procedure for oil-fired CWH equipment at 10 CFR 431.106 points to ASTM Standard Test Method D2156–80. Specifically, DOE requires that smoke in the flue does not exceed No. 1 smoke [10] as measured by the procedure in ASTM D2156–80. A more recent version of ASTM D2156 was approved on December 1, 2009, and reapproved on October 1, 2013. After reviewing D2156–80 and D2156–09 for the May 2016 NOPR, DOE tentatively concluded that no substantive changes were made between these versions in the test method for determining the smoke spot number, and therefore DOE proposed to incorporate by reference ASTM D2156–09 in its test procedures for oil-fired CWH equipment. 81 FR 28588, 28595 (May 9, 2016). In response to the May 2016 NOPR, several parties expressed support in updating references to ASTM D1246–09. (Bock, No. 19 at p. 1; AHRI, No. 26 at p. 13; A.O. Smith, No. 27 at p. 2) DOE did not receive any other comments on this proposal, and, therefore, DOE is incorporating by reference ASTM D2156–09 in its test procedures for oil-fired CWH equipment in appendices A, C, and E to subpart G of 10 CFR part 431.

DOE's current requirement for the flue gas smoke spot number for oil-fired CWH equipment requires that the smoke in the flue does not exceed No. 1 smoke;

[10] The smoke scale, as described in ASTM D156, consists of ten spots numbered consecutively from 0 to 9, ranging in equal photometric steps from white through neutral shades of gray to black.

however, the regulations do not specify when during the test to determine the smoke spot number. To improve consistency and repeatability of testing CWH equipment, in the May 2016 NOPR, DOE proposed to specify when to conduct the smoke spot test. 81 FR 28588, 28596 (May 9, 2016). Specifically, DOE proposed to require determination of the smoke spot number after steady-state operation has been achieved, but prior to beginning measurement for the thermal efficiency test. For the thermal efficiency test, DOE proposed to require that the smoke spot number be determined after steady-state condition has been reached (with steady-state defined as being achieved when there is no variation of the outlet water temperature in excess of 2 °F over a 3-minute period). For the standby loss test, DOE proposed to require determination of the smoke spot number after the first cut-out [11] before beginning measurements for the standby loss test. DOE also proposed to require that the CO°reading, which is required to be measured when testing oil-fired CWH equipment under DOE's current test procedures specified at 10 CFR 431.106, also be measured at the time required for determination of the smoke spot number.

DOE also proposed to clarify that the smoke spot test and measurement of CO_2 reading are required before each thermal efficiency test or standby loss test (as applicable) of oil-fired CWH equipment unless no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously run efficiency test, in which case a second smoke spot test or CO_2 reading is not required prior to beginning another efficiency test (*i.e.,* thermal efficiency or standby loss). *Id.*

In response to the May 2016 NOPR, AHRI commented that the CO_2 reading and smoke spot number should only be measured once when input rate of the burner is being set, not before both the thermal efficiency and standby loss tests. (AHRI, No. 26 at pp. 8–9) A.O. Smith agreed with DOE's proposal regarding when the smoke spot test and measurement of CO_2 reading are not required, and agreed with DOE's proposal that the same requirement for when to measure apply to both CO_2 reading and the smoke spot test. (A.O. Smith, No. 27 at p. 2) Bock agreed with the proposal regarding when to conduct the smoke spot measurement before the thermal efficiency test, but disagreed with the proposal regarding when to conduct the measurement prior to the standby loss test. Specifically, Bock stated that confining the smoke spot measurement to the short time period between the second cut-in [12] and second cut-out would add unnecessary complexity to the procedure, and that the timing of the second cut-in varies. Bock suggested measurement of the smoke spot number 15 minutes into initial warm-up, before the first cut-out. (Bock, No. 19 at p. 1)

In this final rule, DOE is adopting a requirement similar to its proposal that the smoke spot test and CO_2 reading measurement be conducted before beginning the thermal efficiency test. However, given DOE's updated requirements that establish a steady-state verification period immediately preceding the thermal efficiency test (discussed in section III.F.1 of this final rule), the testing body may not know when the steady-state verification period ends and the thermal efficiency test begins until after testing is complete. Therefore, DOE is requiring that the smoke spot test and CO_2 reading measurement must be conducted with the burner firing prior to beginning measurements for the steady-state verification period.

In response to AHRI, DOE notes that the determination of the smoke spot number and measurement of the CO_2 reading is only required before the standby loss test if a thermal efficiency test or standby loss test was not previously conducted, or if the settings have been changed or the water heater turned off after a previously conducted test. Therefore, if efficiency tests are conducted consecutively, and the water heater settings are not changed or the water heater turned off between tests, the method adopted in this final rule is in line with AHRI's suggestion that the smoke spot test only be required once.

DOE also recognizes that there may be a short time period between the second cut-in and second cut-out for determining the smoke spot number, and that the timing of the second cut-in may not be easily predictable. Therefore, DOE agrees with Bock that measurement of the smoke spot number prior to the first cut-out would be less burdensome. When conducting the standby loss test when a thermal efficiency test was not conducted immediately prior, the thermostat must be set for the standby loss test prior to the first cut-out, but there is no specified duration for warm-up. For oil-fired CWH equipment for which a test was not previously conducted (or for which settings on the water heater have changed since the previous test), DOE is therefore specifying that the smoke spot number be determined with the burner firing prior to beginning the standby loss test. DOE is not adopting a requirement that the smoke spot test number be determined after any specific time before beginning the standby loss test, because DOE recognizes that different models will take different amounts of time to warm up.

Additionally, DOE is adopting specifications for the test procedure for the set-up for measuring the smoke density for oil-fired CWH equipment, as proposed in the May 2016 NOPR. 81 FR 28588, 28641 (May 9, 2016). Specifically, DOE is establishing a requirement that the smoke-measuring device be connected to an open-ended tube, and that this tube must project into the flue by ¼ to ½ of the pipe diameter. These requirements are the same as those specified for commercial space-heating boilers in AHRI 1500–2015, and DOE did not receive any comments related to this proposal.

3. ASTM Test Standards C177 and C518

DOE's current definition for ''R-value'' at 10 CFR 431.102 references two industry test methods: ASTM Standard Test Method C177–97 and ASTM Test Standard Method C518–91.

A more recent version of ASTM C177 was approved in September 2013 and published in October 2013 (ASTM C177–13). Additionally, a more recent version of ASTM C518 was approved in May 2010 and published in June 2010 (ASTM C518–10). After comparing both versions of each standard for the May 2016 NOPR, DOE tentatively concluded that, for both standards, there are no substantive differences in the procedures for measuring R-value between the new and old versions. Therefore, in the May 2016 NOPR, DOE proposed to incorporate by reference ASTM Standard Test Methods C177–13 and C518–10, and to update its references to these versions in the definition for ''R-value'' at 10 CFR 431.102. 81 FR 28588, 28592 (May 9, 2016).

In response to the May 2016 NOPR, several interested parties expressed support for updating references to ASTM C518 and C177. (Bradford White, No. 21 at p.1; AHRI, No. 26 at p. 13; A.

[11] Cut-out refers to the de-activation of the burner or heating element following a control signal that the stored water is heated to the thermostat set-point temperature or the call for hot water has ended. The thermostat that signals the burner to activate or de-activate may be located inside the unit or outside the unit at a remote location (*e.g.,* in an external hot water storage tank).

[12] Cut-in refers to the initiation of the burner or heating element operation based on a control signal to raise the temperature of stored hot water that has fallen below the required thermostat set-point temperature, or to meet an external demand for hot water.

O. Smith, No. 27 at p. 2; Rheem, No. 34 at p. 4) DOE did not receive any other comments on this proposal, and, therefore, DOE is incorporating by reference ASTM Standard Test Method C177–13. However, since publication of the May 2016 NOPR, DOE became aware of a more recent version of ASTM C518 that was approved in September 2015 and published in December 2015, ASTM C518–15. After careful review, DOE has determined that there are no substantive differences between ASTM C518–10 and ASTM C518–15. DOE received no feedback which disagreed with DOE's proposal to update its reference to ASTM C518 to the 2010 version. Since the 2015 version of ASTM C518 is not substantially different than the 2010 version and in order to maintain up-to-date references to industry test methods, DOE is incorporating by reference the most recent version of the standard, ASTM C518–15.

B. Ambient Test Conditions and Measurement Intervals

To improve the repeatability of the thermal efficiency and standby loss tests in DOE's current test procedures for CWH equipment, DOE proposed several changes to its required ambient test conditions. These proposals included: (1) Tightening the ambient room temperature tolerance from ± 10.0 °F to ± 5.0 °F and the allowed variance from mean ambient temperature from ± 7.0 °F to ± 2.0 °F; (2) requiring measurement of test air temperature—the temperature of entering combustion air—and requiring that the test air temperature not vary by more than ± 5 °F from the ambient room temperature at any measurement interval during the thermal efficiency and standby loss tests for gas-fired and oil-fired CWH equipment; (3) establishing a requirement for ambient relative humidity of 60 percent ± 5 percent during the thermal efficiency and standby loss tests for gas-fired and oil-fired CWH equipment; (4) setting a maximum air draft requirement of 50 ft/min as measured prior to beginning the thermal efficiency or standby loss tests; and (5) decreasing the time interval for data collection from one minute to 30 seconds for the thermal efficiency test and from 15 minutes to 30 seconds for the standby loss test. 81 FR 28588, 28597 (May 9, 2016).

In response to the May 2016 NOPR, several stakeholders disagreed with DOE's proposals to tighten requirements on ambient conditions and argued that DOE's proposals would be overly burdensome to manufacturers. (Bock, No. 19 at p. 1; Bradford White, No. 21 at p. 3; CA IOUs, No. 23 at pp. 2–3; HTP, No. 24 at p. 1; AHRI, No. 26 at pp. 6–8; A.O. Smith, No. 27 at p. 2; Raypak, No. 28 at pp. 5–6; Bradley, NOPR Public Meeting Transcript, No. 20 at p. 33; Rheem, No. 34 at pp. 4–6) Bock stated that it supports using the procedures in the most updated versions of ANSI Z21.10.3 and ASHRAE 118.1. (Bock, No. 19 at p. 1) Bradford White further argued that the proposed changes are not merited because they would not affect efficiency ratings. (Bradford White, No. 21 at p. 3) CA IOUs stated that the proposed tightening of requirements would not provide a significant improvement in accuracy. (CA IOUs, No. 23 at pp. 2–3)

A.O. Smith suggested that DOE's proposed modifications to the required ambient conditions would be very difficult to meet with large equipment with significant makeup air requirements. A.O. Smith also pointed out that a model of CWH equipment with a rated input of 2 million Btu/h would consume fresh air at a rate of 400 cfm, and that there are over 30 models of CWH equipment on the market with a rated input of 2 million Btu/h or greater. (A.O. Smith, No. 27 at p. 2) AHRI, A.O. Smith, and Raypak argued that laboratories in which CWH equipment is typically tested have multiple ongoing activities, with doors opening and closing, and that conditioning air in such a facility to meet DOE's proposed ambient condition requirements would be unduly burdensome to manufacturers. (AHRI, No. 26 at p. 7; A.O. Smith, No. 27 at p. 2; Raypak, No. 28 at p. 6) Bradford White indicated that costs per manufacturer to laboratory upgrades required to meet DOE's proposed requirements would be hundreds of thousands of dollars or require purchase of environmental chambers which cost at least $120,000 each; AHRI suggested that the cost of complying with the proposed requirements would range from $250,000 to $1 million per manufacturer; Raypak suggested the cost to upgrade its facility would be $500,000 to $1.5 million; Rinnai suggested that meeting DOE's proposed requirements would require environmental chambers which cost more than $250,000 each; and Rheem suggested that the cost for laboratory upgrades would be greater than $500,000. (Bradford White, No. 21 at p. 3; AHRI, No. 26 at p. 7; Raypak, No. 28 at p. 6; Rinnai, No. 34 at p. 1; Rheem, No. 34 at p. 5) NEEA agreed with DOE's proposed ambient condition requirements and suggested that the requirements would improve the consistency of DOE's test procedures with little or no additional test burden. (NEEA, No. 30 at p. 2)

In light of comments received, DOE is not adopting the more stringent ambient conditions (*i.e.,* tighter tolerance on ambient room temperature, ambient relative humidity requirements) that were proposed in the May 2016 NOPR that may have added to test burden for manufacturers. Therefore, DOE considers these comments mitigated. However, DOE is adopting changes related to its other proposals regarding test air temperature, maximum air draft, and data collection intervals, and the specific actions that DOE is taking on each of the proposed requirements and the potential test burden associated with each action are discussed separately in detail in this section.

Joint Advocates suggested that DOE should require collection and reporting of data for relative humidity, air temperature, and barometric pressure. (Joint Advocates, No. 32 at p. 2) CA IOUs commented that DOE should consider the impact of barometric pressure on the results of efficiency testing of CWH equipment because it affects how much moisture can be held in air. CA IOUs also requested that DOE conduct an uncertainty analysis to demonstrate that tighter temperature and humidity tolerances are warranted. (CA IOUs, No. 23 at p. 3) DOE is not aware of any data demonstrating that barometric pressure significantly affects the measured efficiency for CWH equipment, and has therefore not found it necessary to regulate the ambient barometric pressure of test rooms for any heating products. In response to the May 2016 NOPR, no commenters provided such data. Therefore, DOE is not adopting barometric pressure requirements in this final rule. Furthermore, with regard to the Join Advocates suggestion, DOE notes that reported values resulting from testing are typically based on test results of a sample that contains two or more units, which could have slightly different relative humidity and air temperatures during testing. Manufacturers then report representative values in accordance with the requirements of 10 CFR 429. Because reported values for relative humidity and air temperature would be based on multiple unit samples and would not correspond to a single efficiency rating resulting from a specific set of ambient conditions, this information would be of little value to commercial consumers. Therefore, DOE is declining to adopt these reporting requirements at this time.

The following subsections discuss the specific comments on each of the proposed changes for the ambient test conditions, along with DOE's response and decision.

1. Ambient Room Temperature

Bradford White, AHRI, and Rheem noted that DOE's proposal to tighten the ambient room temperature requirement from 75 °F ± 10.0 °F to 75 °F ± 5.0 °F would preclude the testing of both consumer water heaters and commercial water heating equipment in the same test laboratory, because DOE's test procedure for consumer water heaters requires that the ambient room temperature be maintained between 65 °F and 70 °F. (Bradford White, No. 19 at p. 3; AHRI, No. 26 at p. 7; Rheem, No. 34 at p. 5) While Bradford White, AHRI, and A.O. Smith argued that DOE's proposal to decrease the permitted variance from mean ambient temperature during testing from ± 7.0 °F to ± 2.0 °F would require costly upgrades to HVAC systems in testing facilities, they supported decreasing the allowed variance from ± 7.0 °F to ± 5.0 °F. (Bradford White, No. 19 at p. 3; AHRI, No. 26 at p. 7; A.O. Smith, No. 27 at p. 18) Bradford White further noted that most manufacturers could accommodate a decrease in the allowed variance to ± 5.0 °F using their existing laboratory HVAC systems. (Bradford White, No. 19 at p. 3) A.O. Smith further noted that decreasing the allowed variance to ± 5.0 °F would not be burdensome to manufacturers because rapid variations in supply air flow and temperature could be avoided. (A.O. Smith, No. 27 at p. 18)

DOE agrees with commenters that establishing a narrower range for ambient room temperature such that consumer water heaters and commercial water heating equipment cannot be tested at the same time could be overly burdensome to some manufacturers. Therefore, DOE is maintaining its current ambient room temperature requirement for testing of CWH equipment at 75 °F ± 10.0 °F. In light of comments from several commenters that a decrease in the permitted variance from mean ambient temperature during testing from ± 7.0 °F to ± 5.0 °F would not be burdensome to manufacturers, DOE is adopting a requirement that the ambient temperature must not vary from the mean temperature during testing by more than ± 5.0 °F. This requirement is consistent with the requirement in ANSI Z21.10.3–2015, but slightly more stringent to improve repeatability. Based on the comments received, DOE believes this change would not add undue burden and would improve the repeatability of the test.

In the May 2016 NOPR, DOE proposed that the ambient room temperature be measured at the same interval during the soak-in period as during the thermal efficiency and standby loss tests—30 seconds. 81 FR 28588, 28641, 289644 (May 9, 2016). However, DOE believes that measurement of the ambient room temperature at frequent intervals throughout the 12-hour soak-in period is unnecessary. Unlike for an efficiency test (*i.e.,* thermal efficiency or standby loss) or the steady-state verification period, measurements from the soak-in period are not used in calculation of an efficiency metric or in verification of steady-state operation. The purpose of the soak-in period is simply to allow the tank insulation of storage water heaters and storage-type instantaneous water heaters to reach thermal equilibrium between the ambient room temperature and the stored water temperature. DOE believes that as long as no actions are taken that would change the ambient room temperature during the soak-in period, the ambient room temperature need only be measured prior to beginning the soak-in period. Therefore, DOE is adopting a requirement that the ambient room temperature be maintained at 75 °F ± 10 °F during the soak-in period as measured prior to beginning the soak-in period, and that no actions be taken during the soak-in period that would cause the ambient room temperature to deviate from this range.

2. Test Air Temperature

In the May 2016 NOPR, DOE proposed to require measurement of test air temperature—the temperature of entering combustion air—and require that the test air temperature not vary by more than ± 5 °F from the ambient room temperature at any measurement interval during the thermal efficiency and standby loss tests for gas-fired and oil-fired CWH equipment. 81 FR 28588, 28597 (May 9, 2016). Bradford White and Raypak disagreed with DOE's proposed requirements for test air temperature. (Bradford White, No. 19 at pp. 3–4; Raypak, No. 28 at pp. 5–6) Bradford White and AHRI argued that measurement of test air temperature at each air inlet would be redundant given the required measurement of ambient room temperature, because DOE's ambient room temperature requirement would apply to entering combustion air. (Bradford White, No. 19 at pp. 3–4; AHRI, No. 26 at p. 8) Bradford White further argued that DOE's ambient room temperature requirement would apply to entering combustion air because most models of CWH equipment are tested with minimal vent length, and therefore the combustion air inlet would be very close to the water heater and location of ambient room temperature measurement. Bradford White also asserted that DOE's proposal would present complications for water heaters with air inlets on the bottom of the unit and for models that draw combustion air from the periphery of the water heater, and that at least three thermocouples would likely be needed in these cases to measure test air temperature. Braford White also stated that adding multiple additional thermocouples to a data acquisition system would be more burdensome than suggested by DOE. (Bradford White, No. 19 at pp. 3–4) AHRI commented that the requirement to measure test air temperature within 2 feet of the combustion air inlet would not be possible for models with concentric direct venting. AHRI also argued that measuring the test air temperature for each air inlet for water heaters with multiple air inlets would be an unnecessary burden, and that one properly located temperature sensor could adequately monitor incoming air temperature for such water heaters. (AHRI, No. 26 at pp. 7–8) Raypak questioned why DOE proposed to require measurement of test air temperature, arguing that it does not affect measured efficiency and that DOE has not provided evidence that test air temperature affects accuracy or repeatability of test results. (Raypak, No. 28 at pp. 5–6)

DOE believes that the temperature of entering combustion air, or test air temperature, can have a significant effect on the measured efficiency of a water heater. An increased combustion air temperature increases the enthalpy of the entering air to the water heater, and this increased combustion air enthalpy provides for additional heating of water that is not reflected in the calculation of thermal efficiency. While DOE's current test procedure for CWH equipment does include a requirement for ambient room temperature, this value is only measured at a single location. Therefore, it is possible that the air temperatures could differ between the locations of measurement of ambient room temperature and test air temperature. As mentioned by AHRI, some models of CWH equipment are tested with direct venting systems, and DOE notes that the combustion air intake vent for such equipment would likely not be located in the immediate vicinity of the CWH equipment. Therefore, measurement of ambient room temperature would not be representative of the test air temperature for such equipment. DOE notes that

Raypak did not provide a rationale to support its assertion that test air temperature does not affect the measured efficiency. DOE also notes that AHRI 1500–2015, the industry-consensus test standard for commercial packaged boilers, includes similar requirements for measurement of both ambient room temperature and test air temperature. DOE does not believe that there is a significant difference between testing CWH equipment and commercial packaged boilers that would make measuring and recording test air temperature overly burdensome for CWH equipment. DOE acknowledges that, in certain cases, the air inlet(s) to the water heater may be close enough to the required location for measurement of ambient room temperature that there may not be a significant difference in temperature measured at the two locations. However, after consultation with independent testing laboratories, requiring additional temperature sensors to a data acquisition system to record another air temperature measurement (or multiple measurements) for the combustion air does not appear to present a significant burden to manufacturers, as it would be a simple, one-time task.

In this final rule, for gas-fired and oil-fired CWH equipment, DOE is adopting a requirement that test air temperature be measured within 2 feet of the air inlet to the water heater. DOE also is adopting a requirement that the test air temperature may not vary by more than ± 5 °F from the ambient room temperature at any measurement interval during the thermal efficiency or standby loss tests, as applicable. DOE concludes that the additional requirements for test air temperature are consistent with the industry standard, ANSI Z21.10.3–2015, as these requirements do not change or conflict with any requirements in the industry standard. Instead, the requirements pertaining to test air temperature provide a more detailed approach to maintaining the room temperature and will ensure consistent and repeatable temperatures within the test area.

Regarding AHRI's comments with respect to measuring test air temperature for models with direct venting, DOE's intent by the phrase ''air inlet to the water heater'' in the proposed requirement was to refer to the site where combustion air enters either the water heater or air intake vent, if applicable. However, DOE acknowledges that more specific phrasing is warranted to clarify the measurement location for models tested with direct venting. Therefore, DOE is adopting language such that the test air temperature must be measured within two feet of the air inlet to the water heater or the inlet to the combustion air intake vent, as applicable.

In the May 2016 NOPR, DOE proposed a location for the measurement of the test air temperature for units without a dedicated air inlet. 81 FR 28588, 28597 (May 9, 2016). Specifically, DOE proposed that in this case, the test air temperature would be measured within two feet of a location on the water heater where combustion air would enter the unit. DOE believes that this provision provide adequate instruction as to how to test units that draw combustion air from the periphery of the water heater, which was raised as a potential issue by Bradford White. Therefore, DOE is adopting the language proposed in the May 2016 NOPR for how to measure test air temperature for units without a dedicated air inlet. For such a unit, the test air temperature must be measured within two feet of any location on the water heater where combustion air is drawn. Additionally, for such a unit, DOE's adopted requirements would only require measurement of test air temperature at one location, not three, as asserted by Bradford White. For example, if a unit draws combustion air through a gap between the burner tray and the bottom of the tank, then the test air temperature must be measured within two feet of that gap.

Regarding Bradford White's comment that test air temperature measurement would be complicated for units with an air inlet on the bottom of the water heater, DOE believes that its provisions adopted in this final rule adequately address this issue. For water heaters that draw air from the periphery of the bottom of the water heater, DOE's previously discussed provision for how to measure test air temperature for units without a dedicated air inlet would apply. DOE is unaware of any models of CWH equipment on the market with a dedicated air inlet on the bottom of the water heater (*i.e.,* in between the water heater bottom and the ground), and suspects that this would be a undesirable configuration, as the small clearance between the water heater bottom and the ground would likely obstruct adequate flow of entering combustion air. However, if such a configuration of CWH equipment exists, the test air temperature would be measured at any location within two feet of the air inlet on the bottom of the water heater under the procedure adopted in this final rule. DOE presumes that any clearance between the bottom of the water heater and the ground that is sufficiently large for providing adequate air flow would also be sufficiently large for installing a temperature sensor(s) for measurement of test air temperature.

DOE disagrees with AHRI that measurement of test air temperature should not be required at each air inlet for models of CWH equipment with multiple air inlets. For units that have multiple air inlets (such as stacked, modular units with multiple air inlets that each correspond to a separate burner and heat exchanger), DOE believes that the efficiency of the unit would be affected by the entering combustion air temperature to all air inlets, and that a requirement to measure test air temperature at each air inlet is justified. As previously discussed, DOE does not believe that installing multiple temperature sensors to measure test air temperature would present a significant burden to manufacturers. Therefore, DOE is adopting a requirement that test air temperature be measured at each air inlet for units with multiple air inlets, and that the specification for no variation of more than ± 5 °F from the ambient room temperature applies to the test air temperature measured at each air inlet.

Given the requirement to measure test air temperature within two feet of the air inlet to the water heater, the location of test air temperature measurement may be close to the water heater burner. Therefore, DOE suspects that the temperature sensor used to measure test air temperature might be subject to radiation from the burner. To prevent an impact from such radiation on the measurement of test air temperature, DOE is adopting a requirement that the temperature sensor used to measure test air temperature be shielded from radiation. DOE notes that such a requirement for shielding temperature measurement from radiation is included in ANSI Z21.10.3–2015 for the temperature sensor used to measure ambient room temperature. Additionally, DOE understands that shielding temperature measurements from radiation is common industry practice and would not present any significant burden to manufacturers.

3. Ambient Relative Humidity

In response to DOE's proposed requirements for ambient relative humidity, several commenters argued that relative humidity does not have an effect on results of efficiency testing of CWH equipment because the tests do not require collection of condensate. (Bradford White, No. 19 at p. 2; AHRI, No. 26 at p. 8; A.O. Smith, No. 27 at p. 2; Raypak, No. 28 at p. 6; Rinnai, No. 31

at p. 1) CA IOUs commented that the extent to which relative humidity affects the measured efficiency of condensing water heaters is unclear. (CA IOUs, No. 24 at p. 3) Joint Advocates suggested that relative humidity requirements should not apply to non-condensing gas-fired and oil-fired CWH equipment. (Joint Advocates, No. 32 at p. 2) Bradford White and Rheem commented that it would be difficult to meet DOE's proposed relative humidity requirements in all geographic locations at all times of the year, as these factors can result in significant variation in ambient relative humidity. (Bradford White, No. 21 at pp. 2–3; Rheem, No. 34 at p. 5) Rheem further argued that meeting DOE's proposed relative humidity requirements would likely require that a test room be maintained at a positive pressure, and asserted that it would be difficult to connect humidistats to a data acquisition system. Rheem also stated that a less stringent tolerance is needed for an ambient relative humidity requirement, and that more data showing any correlation between relative humidity and water heater performance are needed before DOE sets a requirement for relative humidity. (Rheem, No. 34 at p. 5)

In light of comments received, DOE has concluded that the potential burden of controlling ambient humidity is not justified at this time, given the amount of make-up air for combustion that would need to be conditioned to supply larger CWH equipment during testing. Manufacturers asserted that controlling the ambient humidity will not have a substantial impact on ratings and should not be held within a tolerance. In DOE's view any variation in the resulting energy efficiency rating from varying levels of ambient humidity would be adequately captured by the existing tolerances for both certification and enforcement in DOE's regulations. Therefore, DOE is not adopting a requirement that ambient relative humidity be maintained at any specific level for CWH equipment other than commercial heat pump water heaters. DOE is establishing a wet bulb temperature requirement for commercial heat pump water heaters based on relevant industry test standards, as discussed in section III.J of this final rule.

4. Maximum Air Draft

In the May 2016 NOPR, DOE proposed a maximum air draft requirement of 50 ft/min as measured prior to beginning the thermal efficiency or standby loss tests. 81 FR 28588, 28597 (May 9, 2016). Bradford White and A.O. Smith agreed with DOE's proposed maximum air draft requirement, but commented that the requirement should not necessitate the connection of the draft-measuring device to the data acquisition system. (Bradford White, No. 19 at p. 4; A.O. Smith, No. 27 at p. 17) A.O. Smith also stated that measurement of air draft may have a large uncertainty at 50 ft/min, and recommended that DOE assign a tolerance for the measurement of air draft and require the draft-measuring device to meet International Organization for Standardization (ISO) requirements. (A.O. Smith, No. 27 at p. 17) Raypak disagreed with DOE's proposed maximum air draft requirement, and argued that there is no evidence that such a requirement would affect results of testing of CWH equipment. Additionally, Raypak argued that most CWH manufacturers do not manufacture residential water heaters, and that DOE was therefore mistaken to presume that many CWH equipment manufacturers would not need to purchase devices for measuring air draft as these devices are already required for testing residential water heaters. (Raypak, No. 28 at p. 5) Rheem argued that DOE's proposed maximum air draft requirement would be appropriate for the standby loss test, but unnecessary for the thermal efficiency test. Rheem also asserted that maintaining a maximum air draft less than 50 ft/min would be difficult while also maintaining the stricter ambient conditions proposed by DOE in the May 2016 NOPR. (Rheem, No. 34 at p. 6)

In this final rule, DOE is adopting its proposed requirement for a maximum air draft of 50 ft/min to clarify the requirement in ANSI Z21.10.3–2015 that the test area be ''protected from drafts.'' Because ANSI Z21.10.3–2015 already includes a requirement for protecting the test area from drafts, DOE concludes that this change provides additional detail but is consistent with the industry standard. DOE believes that this clarification reduces ambiguity in ANSI Z21.10.3–2015 to allow for a more repeatable test. This requirement is also similar to the requirement that DOE adopted for testing consumer water heaters and certain commercial water heaters in the July 2014 final rule. 79 FR 40542, 40569 (July 11, 2014). Specifically, DOE is adopting a requirement that the air draft be measured prior to beginning the thermal efficiency and standby loss tests, within three feet of the jacket of the water heater, and that no actions can be taken during the conduct of the tests that would increase the air draft near the water heater being tested.

In response to Raypak's comment that there is no evidence that the air draft affects the performance of CWH equipment, DOE notes that Annex E.1 of ANSI Z21.10.3–2015 already requires that water heater placement in the test room shall be protected from drafts. DOE believes that if the draft had no impact on the test result, the industry test standard, ANSI Z21.10.3–2015, would not require the test to be done in an area protected from drafts. Therefore, DOE believes that there is an understanding amongst the majority of the industry that air draft from sources such as room ventilation registers, windows, or other external sources of air movement, during the test can affect the performance of CWH equipment. DOE also believes that 50 ft/min is a reasonable maximum value, as it is consistent with DOE's requirement for consumer water heaters. DOE also notes that many manufacturers of CWH equipment also manufacture consumer water heaters and residential-duty commercial water heaters. DOE identified at least 17 of 29 CWH equipment manufacturers (excluding rebranders) that also manufacture consumer water heaters or residential-duty commercial water heaters. For CWH equipment manufacturers who do not also manufacture water heaters subject to the Part 430, Appendix E test procedure (and therefore may not already have draft-measuring devices in their test labs), DOE expects the costs and burden associated with purchasing air draft-measuring devices that do not have the capability of connection to data acquisition system to be insignificant. DOE discusses the potential costs of these requirements as they pertain to small business manufacturers in section 0.

Regarding digital measurement of air draft, DOE's maximum air draft requirement does not require digital measurement. DOE is only adopting a requirement to measure the air draft once at the beginning of the test, so connection to a data acquisition system would be unnecessary. Additionally, DOE is not establishing any requirements on the type or accuracy of device used to measure the air draft. DOE notes that it currently prescribes a similar maximum air draft requirement for consumer and residential-duty commercial water heaters and has no such requirements on the draft-measuring device in that test procedure at appendix E to subpart B of 10 CFR part 430. DOE believes the test entity can determine the appropriate device and accuracy for this measurement.

Additionally, DOE is not establishing a tolerance on its maximum air draft requirement. DOE believes that a tolerance is unnecessary on a maximum value—the air draft must be no greater than 50 ft/min, but any draft below this value meets the requirement.

DOE acknowledges that the air draft may potentially have a greater impact on the results of the standby loss test than on those of the thermal efficiency test. However, once again noting the draft protection provision in ANSI Z21.10.3–2015, DOE has concluded that there may still be an effect on the results of the thermal efficiency test, and that the measurement of air draft, just once before the test begins, does not present a significant burden to manufacturers. Therefore, DOE is adopting the maximum air draft requirement for both the thermal efficiency and standby loss tests. DOE notes that it is not adopting in this final rule the more stringent ambient condition requirements (*i.e.,* narrower tolerance on ambient room temperature, requirement to maintain ambient relative humidity within a specified range) that Rheem argued would make the proposed maximum air draft requirement difficult to meet.

In the May 2016 NOPR, DOE proposed that the maximum draft requirement also apply to the soak-in period. 81 FR 28588, 28597 (May 9, 2016). However, DOE has determined that this requirement is not necessary for the soak-in period. The purpose of the maximum air draft requirement is to improve repeatability of the thermal efficiency and standby loss tests by preventing large air drafts that might cause significantly higher tank heat losses in some tests than in others. DOE believes that this concern does not apply to the soak-in period, the purpose of which is simply to establish thermal equilibrium in the tank insulation, and during which energy consumption is not measured. Therefore, DOE is not adopting a maximum air draft requirement for the soak-in period.

5. Measurement Intervals

Bradford White, AHRI, and Raypak opposed DOE's proposal to decrease the required data collection interval from 1 minute to 30 seconds for the thermal efficiency test and from 15 minutes to 30 seconds for the standby loss test. (Bradford White, No. 19 at p. 4; AHRI, No. 26 at pp. 6–7; Raypak, No. 28 at pp. 6–7) A.O. Smith and Rheem opposed DOE's proposal to decrease the time interval to 30 seconds specifically for the standby loss test. (A.O. Smith, No. 27 at p. 19; Rheem, No. 34 at p. 5)

AHRI and Raypak stated that DOE did not provide evidence or data to suggest that decreasing the time interval would improve accuracy or affect efficiency. (AHRI, No. 26 at pp. 6–7; Raypak, No. 28 at pp. 6–7) AHRI argued that measurements every 15 minutes during the standby loss test are sufficient, and that, if a measurement is within tolerance at two consecutive 15-minute readings, then it is reasonable to assume that the measurement was maintained within tolerance during the entire 15-minute period between measurements. (AHRI, NOPR Public Meeting Transcript, No. 20 at pp. 32–33)

Bradford White argued that DOE's proposal would make data files large and difficult to analyze. (Bradford White, No. 19 at p. 4) To accommodate DOE's proposed time intervals for data collection, AHRI commented that some manufacturers might need to upgrade their facilities, and Raypak and Rheem argued that small manufacturers might need to purchase or upgrade data acquisition systems. (AHRI, No. 26 at pp. 6–7; Raypak, No. 28 at pp. 6–7; Rheem, No. 34 at p. 5) A.O. Smith argued that no readings other than time and temperature should be required at intervals that would necessitate connection to a data acquisition system because most other measurement devices used for testing CWH equipment are not designed to communicate with a data acquisition system. (A.O. Smith, No. 27 at p. 18) Raypak argued that the costs for connecting devices to a data acquisition system are 4–5 times higher than suggested by DOE in the May 2016 NOPR. (Raypak, No. 28 at pp. 6–7) Rheem further acknowledged that data collection intervals can be reduced with current equipment. A.O. Smith and Rheem also asserted that DOE's proposed reduced measurement interval would lead to an increased likelihood that tests would have to be re-run if any parameters were to fall out of the allowable range during the test. (A.O. Smith, No. 27 at p. 18; Rheem, No. 34 at p. 5)

DOE proposed requirements for more frequent data collection to improve the resolution of test data, and therefore, to ensure that test conditions are adequately met throughout the test. DOE disagrees with AHRI that a value can be assumed to be maintained within tolerance in a 15-minute period between readings when measurements at each 15-minute interval are within tolerance, which is further supported by the comments of Rheem and A.O. Smith. DOE believes that 15 minutes is a sufficiently long time for variation in any one of several parameters to potentially have a significant effect on measured standby loss. DOE notes that the standby loss test measures a significantly lower energy consumption than does the thermal efficiency test, and that the measured standby loss is therefore particularly sensitive to fluctuations in ambient conditions. Therefore, DOE believes that recording measurements every 15 minutes does not provide sufficient resolution of test data to ensure that the test results accurately capture the variability in the measurement and could lead to inaccurate and/or inconsistent results. A requirement for data collection every minute ensures that only momentary fluctuations outside of the ambient condition tolerances (*i.e.,* those that occur between consecutive 1-minute readings and are therefore unlikely to have an effect on the measured efficiency) are permitted under DOE's test procedure.

DOE disagrees that its proposed measurement intervals for data collection would make data analysis significantly more burdensome. Analysis of whether all parameters were maintained within their allowable tolerances during testing should be quick and simple in spreadsheet software, and the time required for such analysis should not depend on the number of data entries to any significant extent.

DOE also disagrees that its proposed measurement intervals would require costly upgrades to laboratory facilities. Given that DOE's proposed measurement interval was only slightly different from the current requirement included in Exhibit G.1 of ANSI Z21.10.3–2011 (which DOE currently incorporates by reference for the thermal efficiency test)—30 seconds vs. 1 minute—DOE does not believe that this provision will require any upgrades. The duration of the standby loss test exceeds 24 hours and can reach up to 48 hours; therefore, DOE does not believe that any manufacturers are performing this test without an automated data acquisition system. The one-time cost of a data acquisition system would likely be much less than the recurring labor costs of having a lab technician constantly monitor and record measurements every 15 minutes for every standby loss test for up to 48 hours. Bradford White and Rheem acknowledged that they use data acquisition systems in their facilities, and no stakeholders have commented to DOE that they do not use data acquisition systems for testing of CWH equipment. (Bradford White, Rheem, NOPR Public Meeting Transcript, No. 20 at pp. 43–44) Additionally, DOE does not believe that increasing the frequency of data collection would require any significant upgrades to existing data acquisition systems. Rather, DOE believes that changing the measurement frequency would require a simple one-time software change and that the additional amount of data collected could be stored inexpensively given the low cost of computer storage. Additionally, DOE is not adopting any requirements in this final rule that would require measurement with a data acquisition system other than time and temperature.

DOE believes that more frequent data collection allows the capture of any variation in parameters that might affect the measured efficiency of CWH equipment. If variation is detected such that a parameter does not meet the DOE test procedure requirements, then DOE believes that re-running the test would be warranted. However, DOE acknowledges that there is a possibility that there could be momentary fluctuations in ambient conditions and/or water temperatures that do not have a significant effect on efficiency. In such a case, a single data point out of the allowable range of the DOE test procedure could require a test to be re-run. The likelihood of such a momentary fluctuation being captured in a test data point is directly proportional to the frequency of data collection. For this reason, DOE is not adopting the proposed 30-second data collection intervals and is instead maintaining the existing 1-minute data collection interval requirement for the thermal efficiency test and decreasing the required data collection interval for the standby loss test from 15 minutes to 1 minute. For the thermal efficiency test, the 1-minute time interval applies to the measurement of (1) ambient room temperature, (2) test air temperature, (3) supply water temperature, and (4) outlet water temperature. For the standby loss test, the 1-minute time interval applies to the measurement of (1) ambient room temperature, (2) test air temperature, (3) mean tank temperature for storage water heaters and storage type-instantaneous water heaters, and (4) outlet water temperature for instantaneous water heaters and hot water supply boilers other than storage type-instantaneous water heaters. DOE concludes that these changes to the data recording intervals improve repeatability, while maintaining consistency with the test method in ANSI Z21.10.3–2015.

This 1-minute data collection interval is consistent with the required 1-minute measurement interval for inlet and outlet water temperatures included in the 2011 and 2015 versions of ANSI Z21.10.3. For the standby loss test, DOE believes that the benefits of finer granularity in data collected from 1-minute intervals instead of 15-minute intervals will provide confirmation that variation in ambient conditions does not occur during the test that could have a significant impact on the measured standby loss. DOE believes that this benefit outweighs any potential burden that might occur from the possibility of having to re-run a test because momentary fluctuations of ambient conditions out of tolerance were captured that would not affect the measured standby loss.

As discussed in sections III.F.1 and III.L of this final rule, DOE is also adopting requirements that the gas consumption be measured at 10-minute intervals during the steady-state verification period and thermal efficiency test. These gas consumption measurements are used to determine fuel input rate. As discussed in section III.F.1 of this final rule, DOE does not expect its requirements that gas consumption be measured at 10-minute intervals during the steady-state verification period and thermal efficiency test to impose any significant burden on manufacturers.

C. Test Set-Up for Storage and Storage-Type Instantaneous Water Heaters

DOE's current test procedure for CWH equipment incorporates by reference the requirement in Exhibit G.1 of ANSI Z21.10.3–2011 that the inlet and outlet piping be immediately turned vertically downward from the connections on a tank-type water heater to form heat traps, and that the thermocouples for measuring supply and outlet water temperatures be installed before the inlet heat trap piping and after the outlet heat trap piping. DOE noted in the May 2016 NOPR that the absence of a clearly defined location for the thermocouples could contribute to variability in the test results. As a result, DOE proposed particular locations for installing the supply and outlet water temperature sensors based on piping distance from the water heater connections. Specifically, DOE proposed that the sensors be placed after a total vertical piping distance of 24 inches and total horizontal piping that is (1) two inches plus the piping distance between the water connection and the edge of the water heater with top and bottom openings for water connections and (2) 6 inches for horizontal opening water connections. DOE also provided separate figures for each configuration of storage water heaters (*i.e.,* top, bottom and horizontal opening water connections) and included them in the proposed appendix A to subpart G of part 431 of the regulatory text of the May 2016 NOPR. 81 FR 28588, 28598–28599 (May 9, 2016).

Rheem stated that it agrees with the standardization of the location of temperature measurements, but disagrees with the distance of 24 inches for measuring the water temperature. Rheem argued that having an outlet water temperature measured at the proposed distance would result in inclusion of the piping losses, which may also differ between the piping configurations and outlet water temperature sensor locations adopted by each lab, and recommended that the water temperature for storage water heaters should be measured at a distance of 5 inches away from the water heater to achieve comparable results with instantaneous water heaters. Last, Rheem stated that the proposed inlet water temperature location for CWH equipment with water connections on the side of the tank is not feasible in the case of some of its models that have inlet water openings only 6 inches above the floor. (Rheem, No. 34 at pp. 6–7)

DOE agrees with Rheem that the total piping distance from the water heater to the temperature sensors (particularly the outlet water temperature) should be consistent between both storage type and instantaneous type water heaters, so that any piping losses are comparable. In the May 2016 NOPR, DOE proposed to specify the measurement location for outlet water temperature at 5 inches from the enclosure for instantaneous water heaters, because that measurement was proposed to be used for both outlet water temperature for the thermal efficiency test and to approximate the water temperature of stored water within the heat exchanger for the standby loss test. 81 FR 28588, 28613–28615 (May 9, 2016) Thus, for the standby loss test, it was important for that measurement to occur close to the unit. However, as discussed in section III.I.1, in this final rule, DOE is adopting a separate temperature measurement location for measuring water to approximate the water temperature within the heat exchanger for the standby loss test, and for measuring the outlet water temperature for the thermal efficiency test. As a result, in section III.I.1 of this final rule, DOE has modified the test set-up for instantaneous water heaters and hot water supply boilers so that: (1) Outlet water temperature for the thermal efficiency test is measured at the second elbow in the outlet water piping; (2) heat exchanger outlet water temperature measured for the standby loss test is within one inch of the outlet water port (inside or outside); and (3) total piping distance between the water heater and supply and outlet water temperature sensors is consistent with that specified in the test set-up for water heaters with horizontal opening water connections. Rather than change the location of the temperature measurements for storage water heaters, as suggested by Rheem, DOE changed the measurement location for instantaneous water heaters. By using separate temperature sensors to measure the outlet water temperature for the standby loss test (within one inch of outlet) and the thermal efficiency test (at the second elbow), it is no longer necessary to have a temperature sensor for the outlet water temperature that is as close as possible to the water heater. Further, the additional piping length allows installation of two elbows in the piping and the measurement of the water temperature downstream (for outlet) and upstream (for supply) of the heat traps that are required for the test set-up. Installing the outlet water temperature sensor for the thermal efficiency test at the second elbow ensures that the water flow will be well mixed, resulting in more accurate temperature readings (as recommended by stakeholders). For a detailed explanation on test set up for instantaneous water heaters and hot water supply boilers and DOE's responses to public comments, see section III.I of this final rule.

With regard to Rheem's concerns about piping losses if the outlet water temperature is measured at a piping distance of 30 inches away from the water heater, DOE notes that the current and the proposed test set up both require the water piping to be insulated up to a distance of 4 feet from the water connections, which should minimize piping losses. In addition, water heaters with large pipe diameters may not be able to install outlet water temperature sensors with two elbows in the piping (to yield sufficient flow mixing) at 5 inches from the water heater.

DOE also considered Rheem's other comments on the inability of certain water heater models with horizontal water connections, to meet the vertical piping distance of 24 inches as proposed in May 2016 NOPR for the inlet water connection. To address this issue, DOE is adopting a requirement that the vertical piping distance be 24 inches, unless 24 inches is not possible, in which case the maximum possible distance for a given water heater model must be used.

Based on the foregoing, DOE is adopting the test set-ups shown in Figures III.1, III.2, and III.3 for gas-fired and oil-fired storage water heaters and gas-fired and oil-fired storage-type instantaneous water heaters. In addition, DOE uses very similar test set-ups for other types of CWH equipment. Specifically, as discussed in section III.I.5, the set-up for instantaneous water heaters and hot water supply boilers is the same as shown in Figures III.1, III.2, and III.3, except that an outlet water valve and heat exchanger outlet temperature sensor are required. DOE has concluded that these changes are consistent with the approach in ANSI Z21.10.3–2015, but will provide additional specificity and improve test repeatability. The test set-ups for electric storage water heaters and storage-type instantaneous water heaters are similar to the test set-ups shown in Figures III.1, III.2, and III.3, with the only difference being that the outlet water temperature sensor is not present. An outlet water temperature sensor is not needed for testing electric storage water heaters and storage-type instantaneous water heaters, because the outlet water temperature is not measured during the conduct of the test.

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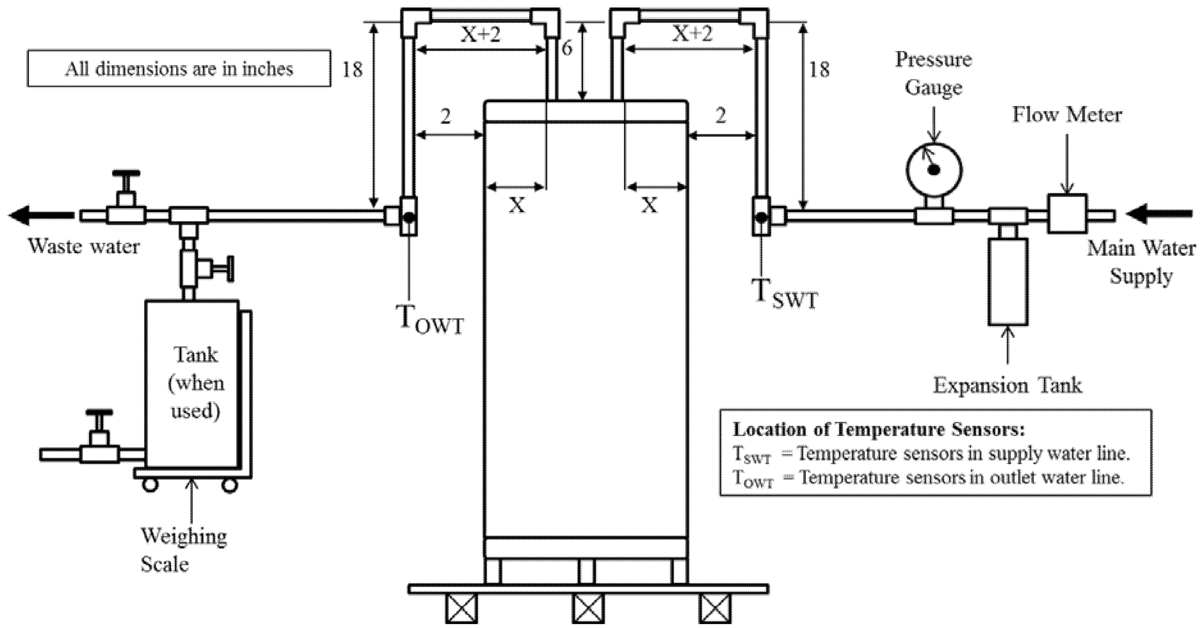

Figure III.1. Test set-up for gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters equipped with vertical (top) connections

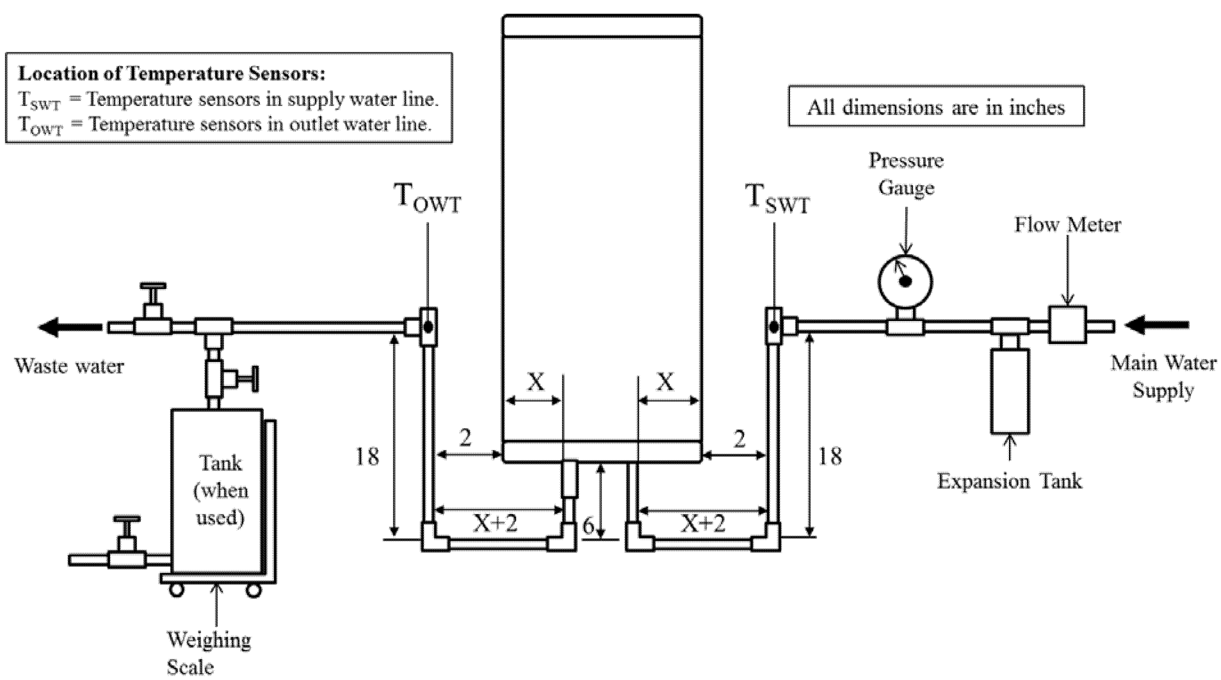

Figure III.2. Test set-up for gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters equipped with vertical (bottom) connections

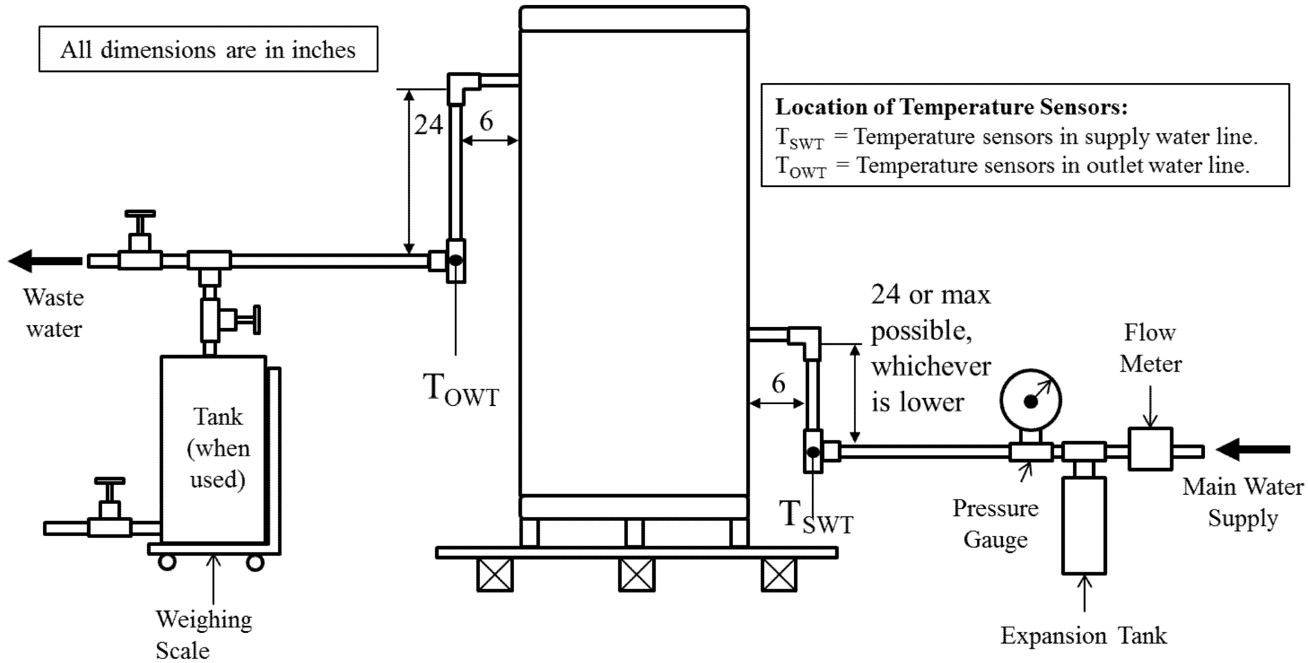

Figure III.3. Test set-up for gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters equipped with horizontal connections

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D. Test Method for Unfired Hot Water Storage Tanks

EPCA defines an ''unfired hot water storage tank'' (UFHWST) as a tank used to store water that is heated externally. (42 U.S.C. 6311(12)(C)) The current Federal standard for this equipment type requires a minimum thermal insulation (R-value) of 12.5. 10 CFR 431.110. DOE defines ''R-value'' as the thermal resistance of insulating material as determined based on ASTM Standard Test Method C177–97 or ASTM Standard Test Method C518–91 and expressed in °F·ft²·h/Btu. 10 CFR 431.102. In section III.A.3 of this rulemaking, DOE updates references to these standards in its definition for ''R-value'' by incorporating by reference ASTM C177–13 and ASTM C518–15. In the May 2016 NOPR, DOE proposed to adopt a method for testing the standby loss for UFHWSTs in lieu of relying on the current R-value metric and ASTM standards. DOE received numerous comments on this topic, and is still considering those comments. Therefore, DOE will address the comments and its proposed test procedure for UFHWSTs in a separate rulemaking notice.

DOE is aware that some manufacturers ship UFHWSTs without insulation and that uninsulated UFHWSTs may or may not then be insulated on-site. In the May 2016 NOPR, DOE clarified that UFHWSTs shipped without insulation are not compliant with the Federal R-value standard. 81 FR 28588, 28601–28602 (May 9, 2016). All UFHWSTs must either be shipped insulated to the R-value standard or shipped together with insulation meeting the R-value standard. Manufacturers of UFHWSTs must certify that the insulation meets the R-value standard prescribed in 10 CFR 431.110, and this certification must be based on testing according to the methods prescribed in the R-value definition. A UFHWST manufacturer may demonstrate compliance with the insulation requirements either by conducting testing itself or by using test data from the insulation material producer. Further, manufacturers of UFHWSTs are responsible for retaining records of the underlying test data used for certification in accordance with current maintenance of records requirements set forth at 10 CFR 429.71.

In response to the May 2016 NOPR, Bock and Raypak disagreed with DOE's clarification that all UFHWSTs must be shipped insulated or with insulation. (Bock, No. 19 at p. 2; Raypak, No. 28 at p. 3) Bock argued that some units have to be shipped without insulation to allow entry into a building, and that requiring shipping with insulation will increase expense and in some cases prevent installation. (Bock, No. 19 at p. 2) Raypak argued that tank insulation might be damaged beyond repair in shipping, and then require re-installation of insulation in the field. Raypak further suggested that DOE allow UFHWSTs with a volume greater than 200 gallons to be field-insulated. (Raypak, No. 28 at p. 3)

DOE disagrees with the commenters that manufacturers can distribute UFHWSTs in commerce without insulation. The standard, which was set by statute, requires a minimum thermal insulation (R-value) of 12.5 for UFHWSTs. The covered equipment must be compliant at the time the manufacturer distributes it in commerce. *See* 42 U.S.C. 6316, 6302. Therefore, if a manufacturer distributes a UFHWST without insulation, the manufacturer has distributed a UFHWST without a minimum thermal insulation of 12.5. DOE's interpretation gives manufacturers a great deal of flexibility and accommodates commenters' concerns that insulation already wrapped on the UFHWST may be damaged during shipment or that insulated UFHWSTs may not fit through the entryway to some buildings, as manufacturers can either ship the tank already wrapped in insulation or with insulation provided. Therefore, if there are any UFHWSTs that cannot be shipped already insulated, or if there are concerns of damage of insulation in shipping, then the insulation shipped with the unit can be applied upon installation. All UFHWSTs of all storage volumes must satisfy this requirement. Accordingly, in this final rule, DOE reiterates that all UFHWSTs must be shipped insulated or with insulation such that the installed UFHWST will meet the minimum standard.

E. Setting the Tank Thermostat for Storage and Storage-Type Instantaneous Water Heaters

DOE's test procedure for measuring the energy efficiency of CWH equipment currently requires that the thermostat be set to achieve specific conditions for the mean tank temperature before the test may begin. In particular, section g of Exhibit G.1 of ANSI Z21.10.3–2011 (which is currently incorporated by reference into the DOE test procedure) requires that before starting testing, the thermostat setting must be adjusted such that, when starting with the water in the system at 70 °F ± 2 °F, the maximum mean tank temperature would be 140 °F ± 5 °F after the thermostat reduces the gas supply to a minimum.

1. Gas-Fired and Oil-Fired Storage Water Heaters

DOE understands that some units may have difficulty achieving the current mean tank temperature requirement (*e.g.,* condensing water heaters), and in the May 2016 NOPR, DOE proposed to modify its requirements for setting the tank thermostat. 81 FR 28588, 28604 (May 9, 2016). Specifically, DOE proposed to modify the thermal efficiency and standby loss test procedures for gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters to require that before starting the required soak-in period, the thermostat setting be adjusted such that, when starting with the water in the system at 70 ± 2 °F, the maximum outlet water temperature will be 140 °F ± 5 °F after the thermostat reduces the gas supply to a minimum.

In response to the May 2016 NOPR, DOE received comments from several interested parties. Joint Advocates and Rheem agreed with changing from a mean tank temperature requirement to an outlet water temperature requirement for fossil fuel-fired storage water heaters. (Joint Advocates, No. 32 at p. 2; Rheem, No. 34 at p. 8) However, Rheem also stated that outlet water temperature is a poor indicator of standby loss, and that mean tank temperature should be used to determine heat loss. (Rheem, No. 34 at p. 8) AHRI stated that measurement of outlet water temperature will not work for setting the tank thermostat if measured more than 2 feet downstream of the water heater outlet because water is not flowing when setting the thermostat. Instead, AHRI suggested that the six tank temperature sensors be installed in the tank at the beginning of the test, as is currently required in ANSI Z21.10.3–2015, and that the tank thermostat be set based on the reading from the topmost tank temperature sensor used to calculate mean tank temperature. (AHRI, No. 26 at p. 8) A.O. Smith stated that, for the thermal efficiency test, setting the tank thermostat is irrelevant as long as the water heater is firing at full input rate and meeting the outlet water temperature requirement. A.O. Smith further suggested that, in order to measure the outlet water temperature for standby loss, the measurement location needs to be inside the tank within one inch of the tank outlet. (A.O. Smith, No. 27 at p. 5) Bradford White stated that the same thermostat setting should be used for both thermal efficiency and standby loss tests, and requested clarification on DOE's proposal, stating that the language in the NOPR preamble and the proposed appendix A in the NOPR regulatory text were not consistent. (Bradford White, No. 21 at p. 8)

DOE agrees with A.O. Smith that, for an outlet temperature requirement, as opposed to a mean tank temperature requirement, setting the tank thermostat for the thermal efficiency test is irrelevant as long as the water heater is firing continuously at full firing rate and all the specifications required for the steady-state verification period, including the outlet water temperature requirement, are met. However, because the thermostat setting does not affect the operation of the water heater during the thermal efficiency test as long as the burner is firing continuously at full firing rate, the thermostat setting used in the thermal efficiency test does not necessarily provide an outlet water temperature of 140 °F ± 5 °F when water is not flowing through the water heater. In order to ensure that this outlet water temperature requirement is met, DOE believes that the thermostat setting needs to be set such that the maximum outlet water temperature after cut-out is 140 °F ± 5 °F before beginning the standby loss test.

While the thermostat settings used during the thermal efficiency test do not affect the test results so long as the burner fires continuously at full firing rate, DOE understands that the standby loss test is often performed directly after the thermal efficiency test. In this final rule, DOE is adopting provisions such that a soak-in period is not required in between the thermal efficiency and standby loss tests, if no settings on the water heaters are changed and the water heater is not turned off. However, setting the tank thermostat between the thermal efficiency and standby loss tests would inherently require changing settings on the water heater, unless the thermostat was already set to achieve the required outlet water temperature after cut-out of 140 °F ± 5 °F. Therefore, DOE believes that the tank thermostat must be set to meet the outlet water temperature requirement before the thermal efficiency test. DOE notes that requiring the tank thermostat to be set prior to the thermal efficiency test is consistent with DOE's current test procedure, DOE's proposal in the May 2016 NOPR, and with AHRI's comment.

DOE agrees with AHRI and A.O. Smith that it would be difficult to set the tank thermostat without water flowing through the water heater such that the outlet water temperature after cut-out is 140 °F ± 5 °F, as measured downstream of a heat trap in the outlet water piping. Additionally, DOE believes that the tank thermostat must be set without water flowing through the water heater; otherwise, both the tank thermostat and water flow rate would affect the measured outlet water temperature, and the thermostat settings obtained might not ensure that the outlet water temperature requirement is met without water flowing. Therefore, DOE believes that the thermostat should be set based on the reading of a temperature sensor located inside the tank. However, commenters disagreed on the location of measurement, with AHRI suggesting using the temperature recorded at the topmost temperature sensor in the tank that is used for measurement of mean tank temperature, while A.O. Smith suggested the placement of a temperature sensor inside the tank within 1 inch of the water heater outlet. While a temperature sensor within one inch of the water heater outlet is closer to the temperature of the water delivered than is the topmost temperature sensor used for mean tank temperature calculation, the difference between these temperatures is likely insignificant, and therefore, the placement of an additional temperature sensor in the tank for the sole purpose of setting the tank thermostat would be an unnecessary burden to manufacturers. Consequently, DOE is adopting a requirement that the tank thermostat be set using the reading from the topmost tank temperature sensor used to calculate mean tank temperature. Based on the above, DOE concludes that there is evidence that setting the thermostat according to the mean tank temperature, as is done in

ANSI Z21.10.3–2015, does not provide an accurate reflection of the energy efficiency during a representative average use cycle for certain equipment. DOE further concludes that the method for setting the thermostat adopted in this final rule provides an accurate reflection of energy efficiency for all kinds of gas-fired and oil-fired storage water heaters on the market. Therefore, DOE concludes that the method adopted in this final rule is consistent with the industry standard, ANSI Z21.10.3–2015, but provides flexibility so that all designs of gas-fired and oil-fired storage water heaters can achieve the temperature requirement used for setting the tank thermostat. DOE also concludes that the method adopted in this final rule is not unduly burdensome to conduct. Therefore, the changes adopted are better aligned with the requirements of 42 U.S.C. 6314(a)(2).

In response to Rheem, while DOE proposed to use outlet water temperature for the purpose of setting the tank thermostat for the standby loss test, DOE still proposed to use mean tank temperature for determining heat loss during the standby loss test. 81 FR 28588, 28604 (May 9, 2016). In this final rule, DOE is adopting provisions for determining heat loss during the standby loss test using mean tank temperature, similar to those included in annex E.2 of ANSI Z21.10.3–2015.

For gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters, DOE is adopting a requirement that the tank thermostat be set prior to the steady-state verification period. The thermostat must be set starting with the tank full of water at the water supply temperature. The thermostat must be set such that the maximum water temperature measured at the topmost tank temperature sensor after cut-out (and while water is not flowing through the water heater) is 140 °F ± 5 °F. The thermostat also must be set such that with water flowing through the unit continuously, the outlet water temperature can be maintained at 70 °F ± 2 °F above the supply water temperature, as required during the thermal efficiency test. DOE's updated requirements for determining steady-state operation for the thermal efficiency test and the steady-state verification period are discussed in section III.F.1 of this final rule. If conducting a standby loss test after a thermal efficiency test, the thermostat setting established prior to the thermal efficiency test would be used for the standby loss test, and no separate procedure would be needed for setting the thermostat. However, if the standby loss test is run without a previously run thermal efficiency test, the thermostat would need to be set using the same procedure as required before the thermal efficiency test, such that the maximum top tank sensor water temperature after cut-out is 140 °F ± 5 °F. In this case, the tank thermostat must be set prior to the soak-in period.

2. Electric Storage Water Heaters

DOE proposed to maintain the mean tank temperature requirement for the standby loss test for electric storage water heaters, rather than adopt an outlet water temperature requirement, because of complications involved with setting multiple tank thermostats. 81 FR 28588, 28604 (May 9, 2016). Electric storage water heaters typically have multiple heating elements and thermostats, and each thermostat needs to be set prior to beginning the standby loss test. Therefore, DOE tentatively determined that electric storage water heaters are not well-suited to an outlet water temperature requirement because it is unclear how the lower thermostat(s) would be set to achieve a designated outlet water temperature. However, DOE proposed to clarify its language specifying the method for setting thermostats in an electric storage water heater with multiple thermostats. Specifically, DOE proposed to clarify that the thermostats are to be set in immediate succession, starting from the topmost thermostat. DOE also proposed to clarify that when setting each thermostat, the mean tank temperature is calculated using only temperature readings measured at locations higher in the tank than the heating element corresponding to the thermostat being set, with the exception of the bottommost thermostat. Finally, DOE proposed to clarify that all thermostats below the thermostat being tested must be turned off so that no elements below the thermostat being tested are in operation.

Several commenters agreed with DOE's proposal to maintain the existing mean tank temperature requirement for setting the tank thermostat for electric storage water heaters. (Bradford White, No. 21 at p. 8; AHRI, No. 26 at p. 13; A.O. Smith, No. 27 at p. 5; Joint Advocates, No. 32 at p. 2; Rheem, No. 34 at p. 9) A.O. Smith also agreed with DOE's proposed clarification regarding how to set thermostats for electric storage water heaters with multiple thermostats. (A.O. Smith, No. 27 at p. 5) However, AHRI, Rheem, and Bradford White disagreed with DOE's proposal on how to set thermostats for units with multiple thermostats. Specifically, AHRI and Rheem suggested that only the topmost and bottommost thermostats be set and used for the standby loss test. (AHRI, No. 26 at p. 10; Rheem, No. 24 at p. 9) AHRI stated that DOE's proposal is unnecessarily burdensome and complicated, and that it does not matter how many thermostats and associated heating elements are used to meet the mean tank temperature requirement for the standby loss test. (AHRI, No. 26 at p. 10) Rheem stated that using just the topmost and bottommost thermostats would simplify the test and improve consistency among units with different thermostat-to-element ratios. Additionally, Rheem commented that not all laboratories can supply power greater than 36 kW. (Rheem, No. 24 at p. 9) Bradford White recommended that the lowest thermostat be set first, and then the next highest, etc. Bradford White also did not support DOE's proposal to calculate mean tank temperature with only temperature readings measured higher than the heating element corresponding to the thermostat being set, with the exception of the bottom thermostat. (Bradford White, No. 21 at p. 8)

After review of stakeholder comments and consultation with several independent testing laboratories, DOE agrees with AHRI and Rheem that setting all thermostats for the standby loss test for commercial electric storage water heaters with multiple thermostats is unnecessary. DOE agrees with AHRI that setting fewer thermostats would reduce burden to manufacturers and would be unlikely to affect the results of the standby loss test, because it is unlikely that more than one heating element will experience a call for heat during the standby loss test. DOE also notes, based on its assessment of commercial electric storage water heaters on the market, most models have banks of heating elements grouped together such that a call for heat in the lowest thermostat will likely heat the water up to temperature at the nearby thermostats as well. Additionally, DOE agrees with Rheem that limiting the number of thermostats (and correspondingly the number of heating elements) used during the standby loss test may simplify the testing of higher input capacity units by limiting the total amperage draw to a level that most laboratories would be able to provide.

DOE believes that the topmost thermostat should be set using mean tank temperature calculated only with temperature readings measured at locations higher in the tank than the heating element corresponding to the thermostat being set. If the water lower in the tank is included in the mean tank temperature calculation and has not been previously heated by a lower element, as suggested by Bradford

White, the heating element(s) corresponding to the topmost thermostat would have to heat water at the top of the tank to a temperature much higher than the required mean tank temperature in order to achieve the mean tank temperature requirement.

In this final rule, DOE is maintaining a mean tank temperature requirement for the standby loss test for electric storage water heaters. DOE is adopting its proposed requirement that that the tank thermostat(s) be set prior to conducting the required soak-in period. DOE is also clarifying that the thermostat(s) for electric storage water heaters must be set while no water is flowing through the unit. DOE is also adopting requirements for setting tank thermostats for electric storage water heaters with multiple thermostats. Specifically, DOE is specifying that only the topmost and bottommost thermostats be set, and that all other thermostats and corresponding elements not operate while setting thermostats or during conduct of the standby loss test. DOE also specifies that when setting the topmost thermostat, only temperature readings measured at locations higher in the tank than the heating element corresponding to the topmost thermostat (the lowest heating element corresponding to the thermostat if the thermostat controls more than one element) should be used to calculate mean tank temperature. However, when setting the bottommost thermostat, DOE specifies that all temperature readings should be used to calculate mean tank temperature. These changes are consistent with the industry test method, ANSI Z21.10.3–2015, and simply provide additional detail regarding the method for setting the thermostat to improve consistency and repeatability.

F. Steady-State Requirements and Soak-In Period

1. Steady-State Verification

In the May 2016 NOPR, DOE noted that the required three-minute period for verifying steady-state operation prior to the thermal efficiency test, which is included in Exhibit G.1 of ANSI Z21.10.3–2011 (currently incorporated by reference in DOE's test procedure), may not be sufficiently long. 81 FR 28588, 28601 (May 9, 2016). Additionally, DOE noted that the current test procedure does not impose requirements for maximum variation in inlet water temperature or water flow rate during this period for verifying steady-state operation. Therefore, DOE requested information and data that might support a change to the provisions for establishing steady-state operation in its test procedure.

In response to the May 2016 NOPR, Bradford White stated that it is possible to meet the current criterion of no variation in outlet water temperature in excess of 2 °F over a 3-minute period before the water heater has reached steady-state conditions. (Bradford White, No. 19 at p. 4) Bradford White and AHRI both commented that verification of steady-state operation is an area in which the repeatability of the thermal efficiency test can be improved. (Bradford White, No. 19 at p. 4; AHRI, No. 26 at p. 9) Bradford White and AHRI also suggested that DOE adopt more stringent requirements for establishing steady-state operation prior to the thermal efficiency test, and included specific guidelines in their comments that they recommend DOE implement. Specifically, Bradford White and AHRI suggested establishing an hour-long period during which the requirements of DOE's current thermal efficiency test procedure would have to be met, along with additional requirements for maximum variation in: (1) Water flow rate (± 0.25 gallons per minute (gpm)); (2) gas higher heating value (± 5 percent, measured every 30 minutes); (3) inlet water temperature (± 0.50 °F, with respect to the initial reading); and (4) the difference between initial and final rise between inlet and outlet water temperatures (± 0.50 °F and ± 1 °F for units with input rates <500,000 Btu/h and ≥500,000 Btu/h, respectively). Bradford White and AHRI further suggested that the final 30 minutes of the hour-long period would be used to calculate the results of the thermal efficiency test. (Bradford White, No. 19 at p. 5; AHRI, No. 26 at pp. 9–10) AHRI also suggested that these measurements would be required at least every 60 seconds, except for gas higher heating value.

A.O. Smith commented that while an additional requirement for establishing steady-state operation could improve repeatability, it would be a new requirement that manufacturers would need to further analyze. (A.O. Smith, No. 27 at p. 3) However, A.O. Smith suggested revised guidelines for determining steady-state operation in case DOE proceeds with such modifications to its test procedure. Specifically, A.O. Smith suggested that steady-state be considered established once 30 minutes of consecutive readings confirm that: (1) Inlet water temperature is maintained at 70 °F ± 2 °F, (2) outlet water temperature is maintained at 70 °F ± 2 °F above supply water temperature, and (3) fuel input rate is within 2 percent of the rated input. A. O. Smith argued that the required measurement intervals should be one minute for storage-type water heaters but only 15 minutes for instantaneous water heaters because instantaneous water heaters do not experience a lasting effect from momentary variations in water temperature as do storage-type water heaters. (A.O. Smith, No. 27 at pp. 3–4)

Rheem commented that it typically monitors the outlet water temperature of storage-type water heaters for at least 20 minutes prior to testing but does not record this data. Rheem also stated that it typically runs three thermal efficiency tests after steady-state conditions are established prior to beginning the thermal efficiency test for which data are recorded. Additionally, Rheem asserted that instantaneous water heaters only require 5 minutes of operation before steady-state conditions are reached, and that different steady-state verification requirements may be warranted for different classes of CWH equipment. (Rheem, No. 34 at p. 7)

DOE agrees with the commenters that the guidelines for establishing steady-state operation that were suggested by Bradford White and AHRI would improve test repeatability. Specifically, DOE agrees with these commenters that extending the duration of the steady-state verification period from 3 minutes to 30 minutes prior to the start of the 30 minute period for the thermal efficiency test (for which steady-state conditions must also be maintained, equating to a total of one hour of continuous steady-state operation), and adding additional requirements for verification would improve the repeatability of the test. DOE notes these guidelines were suggested by a trade organization that represents manufacturers that produce over 90 percent of CWH equipment sold in the United States, indicating that the need for adopting these guidelines is widely understood across the industry. Additionally, Bradford White noted that its suggested guidelines for determining steady-state operation were developed by an industry working group, and that AHRI plans to adopt these test guidelines. (Bradford White, No. 21 at p. 5) Therefore, DOE concludes that the modifications to DOE's steady-state verification procedures adopted in this final rule do not require further analysis and comment from manufacturers, as suggested by A.O. Smith, because DOE's adopted requirements contain only minor deviations from the guidelines suggested by Bradford White and AHRI. However, DOE is open to stakeholder feedback regarding these procedural modifications related to establishment of steady-state operation, including experiences prior to the compliance date, and the Department would consider addressing any potential issues in a future test procedure rulemaking or guidance, as necessary.

DOE agrees with all of the conditions specified in the steady-state requirements recommended by Bradford White and AHRI, except for the requirement that there be no variation in the higher heating value of greater than ± 5 percent. DOE notes that AHRI and Bradford White recommended requirements for steady-state verification that include a maximum variation on the fuel higher heating value, while the guidelines suggested by A.O. Smith instead include a requirement that the fuel input rate be maintained within 2 percent of the rated input. While DOE recognizes that restricting variation in fuel higher heating value ensures consistency in the composition of fuel consumed (*e.g.,* ensuring steady-state operation in the case that the fuel source is changed during the test), DOE believes that restricting variation on fuel input rate would be more effective in terms of ensuring that steady-state operation is reached. Variation in fuel higher heating value is reflected in measurement of fuel input rate, along with variation in gas consumption. Additionally, section 2.3.3 of ANSI Z21.10.3–2011, which is referenced in exhibit G.1 of ANSI Z21.10.3–2011 (referenced in DOE's current test procedure), specifies that the burner shall be adjusted to achieve a measured input within ± 2 percent of the manufacturer's rated input 15 minutes after being placed in operation from a room temperature start. Therefore, DOE believes that including a similar requirement for restricting variation in fuel input rate when verifying steady-state operation is consistent with DOE's current test procedure and the industry consensus test standard (ANSI Z21.10.3).

DOE does not expect a requirement to measure fuel input rate during the steady-state verification period and thermal efficiency test to impose any significant burden to manufacturers. As discussed in section III.F.2 of this final rule, no commenters suggested that DOE's proposed clarification that full firing rate must be maintained throughout the thermal efficiency test would be burdensome or difficult to achieve. Determination of fuel input rate for each 10-minute interval simply requires recording the fuel consumption every ten minutes.

Consequently, DOE is adopting the requirements for determining that steady-state operation has been achieved, as recommended by AHRI and Bradford White with one modification. Specifically, DOE is declining AHRI and Bradford White's suggestion of a requirement for maintaining the fuel higher heating value within ± 5 percent in favor of adopting A.O. Smith's suggestion of a requirement to maintain the fuel input rate within ± 2 percent. Under the test procedure adopted in this final rule, the thermal efficiency test will be complete when there is a continuous, one-hour-long period (comprising the 30-minute ''steady-state verification period'' and 30-minute ''thermal efficiency test'') meeting the following requirements: (1) Outlet water temperature is maintained at 70 °F ± 2 °F above supply water temperature, (2) water flow variation is no greater than ± 0.25 gpm from the initial value, (3) fuel input rate is maintained within 2 percent of the rated input certified by the manufacturer, (4) the supply water temperature (or inlet water temperature if a recirculating loop is used for instantaneous water heaters and hot water supply boilers) is within ± 0.5 °F of its initial reading, and (5) the rise between the supply water temperature (or inlet water temperature if a recirculating loop is used for instantaneous water heaters and hot water supply boilers) and outlet water temperatures is within ± 0.50 °F of its initial value for the duration of the one-hour-long period for units with rated input less than 500,000 Btu/h, and within ± 1 °F of its initial value for units with rated input greater than or equal to 500,000 Btu/h. The final 30 minutes will be used to calculate thermal efficiency. DOE concludes that the method for determining steady-state operation adopted in this final rule is consistent with the industry test standard, ANSI Z21.10.3–2015, but provides more stringent requirements to improve consistency. Based on the comments received from stakeholders and the foregoing discussion, DOE concludes that the adopted method will produce results which better reflect the energy efficiency of CWH equipment during a representative average use cycle and will not be unduly burdensome to conduct, as required by EPCA. (42 U.S.C. 6314(a)(2))

In response to A.O. Smith's suggestion that DOE increase the measurement interval for instantaneous type water heaters, DOE disagrees and is maintaining 1-minute measurement intervals for the thermal efficiency test as currently included in DOE's test procedure. This interval applies to the new requirements for determining steady-state operation (adopted from the guidelines suggested by Bradford White and AHRI), except for fuel input rate, which has a 10-minute measurement interval. While DOE acknowledges it is possible that burner fluctuations may not have as much of a lasting effect on instantaneous water heaters (other than storage-type instantaneous water heaters) as suggested by A.O. Smith, DOE is not adopting a longer measurement interval for instantaneous water heaters than for storage water heaters. DOE believes that the 1-minute measurement interval included in DOE's current test procedure is appropriate for both storage water heaters and instantaneous water heaters, and that it is appropriate and not significantly burdensome to manufacturers to extend this measurement interval to the measurements taken during the steady-state verification period prior to the thermal efficiency test. DOE notes that this one-minute interval was included in the suggestion for determining steady-state operation from both Bradford White and AHRI. Measurement intervals for both the thermal efficiency and standby loss tests are further discussed in section III.B.5 of this final rule.

DOE disagrees with Rheem's suggestion that separate requirements may be warranted for verifying steady-state operation for instantaneous water heaters and storage water heaters, and is adopting the same requirements for both kinds of CWH equipment. Many storage water heaters, particularly those with a low input-volume ratio, may require a significant amount of time before steady-state conditions are reached and measurements can begin constituting the steady-state verification period. In contrast, instantaneous water heaters, with a much higher input-volume ratio, may reach steady-state conditions very quickly, and it may only take a short time after beginning water heater operation before measurements can be included in the steady-state verification period. However, DOE is not adopting any provisions or requirements regarding the duration of the period during which CWH equipment warms up to reach steady-state conditions. Nonetheless, DOE continues to believe that a 30-minute period for verifying steady-state operation is appropriate for both storage water heaters and instantaneous water heaters, and that the duration of this period should not depend upon the time it takes for the water heater to warm up. Thus, DOE is not adopting different verification requirements for instantaneous water heaters, as suggested by Rheem.

2. Clarifying Statements

DOE's current thermal efficiency test procedure for gas-fired and oil-fired CWH equipment, which incorporates by reference Exhibit G.1 of ANSI Z21.10.3–2011, requires the water heater to achieve steady-state conditions prior to beginning measurements for the thermal efficiency test. Specifically, the test procedure requires the outlet water temperature to be maintained at 70 °F ± 2 °F above the supply water temperature, with no variation in excess of 2 °F over a 3 minute period. However, DOE's current test procedure does not specify that this outlet water temperature requirement must be maintained throughout the thermal efficiency test.

In the May 2016 NOPR, DOE proposed adding clarifying statements to its test procedure regarding steady-state operation. Specifically, DOE proposed to require that the test entity must maintain the outlet water temperature at 70 °F ± 2 °F above the supply water temperature and ensure the burner fires continuously at the full firing rate (*i.e.,* no modulation or cut-outs) for the entire duration of the thermal efficiency test. Further, DOE proposed to clarify that once steady-state operation is achieved, as determined by no variation of the outlet water temperature in excess of 2 °F over a 3-minute period, no settings on the water heating equipment may be changed until measurements for the thermal efficiency test are finished. DOE also proposed a similar clarification for the standby loss test for CWH equipment other than flow-activated instantaneous water heaters, requiring that after the first cut-out before beginning the standby loss test, no settings may be changed on the water heater until measurements for the standby loss test are finished. 81 FR 28588, 28604–28605 (May 9, 2016).

In response to the May 2016 NOPR, several commenters agreed with DOE's proposed clarifications. (Bock, No. 19 at p. 2; Bradford White, No. 21 at p. 8, A.O. Smith, No. 27 at p. 6; Rheem, No. 34 at p. 9) Bradford White further noted that it believes that the content of DOE's clarifying statements are already understood and common industry practice. However, Bradford White noted that it did not agree with the 3-minute period for determining steady-state operation. (Bradford White, No. 21 at p. 8)

The provisions for establishing steady-state operation prior to the thermal efficiency test that DOE is adopting in this final rule (as discussed in section III.F.1 of this final rule) include, among other requirements, that the following conditions be maintained throughout the test: (1) The specified outlet water temperature, and (2) the fuel input rate within ± 2 percent of the manufacturer's rated input. This is in contrast to the existing requirement that there be no variation in outlet water temperature in excess of 2 °F over a 3-minute period prior to beginning the test. Therefore, additional clarifying statements addressing these conditions during the thermal efficiency test are no longer necessary, as they now must be maintained throughout the duration of the test. However, DOE is adopting its proposed provisions requiring that no settings may be changed on the CWH equipment being tested: (1) Once the steady-state conditions are established during the steady-state verification test and until the thermal efficiency test is completed; and (2) after the first cut-out before beginning the standby loss test until the measurements of the standby loss test are completed (for all CWH equipment, except for flow-activated instantaneous water heaters and externally thermostatically-activated instantaneous water heaters). (For more information on the standby loss test procedure adopted for flow-activated and externally thermostatically-activated instantaneous water heaters, see section III.H.3 of this final rule.) As noted above by commenters, these requirements to leave the settings on CWH equipment unchanged during certain portions of testing are already generally understood and common industry practice. DOE is adding these requirements to clarify the industry test method, and, therefore, concludes that these changes are consistent with ANSI Z21.10.3–2015.

3. Soak-In Period

DOE's current thermal efficiency test procedure for gas-fired and oil-fired CWH equipment, which incorporates by reference Exhibit G.1 of ANSI Z21.10.3–2011, requires the water heater to achieve steady-state conditions prior to beginning measurements for the thermal efficiency test. Specifically, the test procedure requires the outlet water temperature to be maintained at 70 °F ± 2 °F above the supply water temperature, with no variation in excess of 2 °F over a 3-minute period. DOE's current standby loss test procedure for gas-fired and oil-fired CWH equipment, which incorporates by reference Exhibit G.2 of ANSI Z21.10.3–2011, requires the water heater to reach a mean tank temperature of 140 °F and remain in standby mode after the first cut-out until the next cut-out before measurements for the standby loss test begin. However, as discussed in the May 2016 NOPR, DOE thought it possible that these provisions for both tests might be insufficient for ensuring that the tank insulation is fully heated before beginning test measurements.

In the May 2016 NOPR, DOE proposed to require a soak-in period prior to beginning the thermal efficiency and standby loss tests, in which the water heater would remain idle (*i.e.,* no water draws) for at least 12 hours with thermostat(s) maintained at settings that would achieve the required water temperature. 81 FR 28588, 28598 (May 9, 2016). However, DOE proposed not requiring a soak-in period prior to the beginning of an efficiency test (*i.e.,* thermal efficiency or standby loss) if no settings on the water heater were changed and the water heater had not been turned off since the end of a previously run efficiency test.

In response to the May 2016 NOPR, A.O. Smith stated that all proposed requirements for soak-in periods are unnecessary and would not improve test accuracy or repeatability, given the requirements for establishing steady-state operation. (A.O. Smith, No. 27 at p. 17) Several commenters stated that a soak-in period is unnecessary before a thermal efficiency test because DOE's test procedure requires that steady-state operation be reached prior to beginning measurements. (Bradford White, No. 19 at p. 4; AHRI, No. 26 at pp. 9–10; Raypak, No. 28 at p. 6; Rheem, No. 34 at p. 6) However, Bradford White, AHRI, and Raypak indicated that the soak-in period would be useful prior to a thermal efficiency test if the water heater were not stored in a conditioned space (*i.e.,* maintained at 75 °F ± 10 °F according to Bradford White, maintained at temperature above freezing according to Raypak, and unspecified according to AHRI). (Bradford White, No. 19 at p. 4; AHRI, No. 26 at pp. 9–10; Raypak, No. 28 at p. 6) Bradford White and AHRI also argued that a soak-in period should only be required before a standby loss test if the test is not begun within 3 hours of the end of a thermal efficiency test. (Bradford White, No. 19 at p. 4; AHRI, No. 26 at pp. 9–10) Raypak indicated that a soak-in period should only be required before a standby loss test if the water heater is not stored in a conditioned space. (Raypak, No. 28 at p. 6) Rheem stated that a soak-in period of 12 hours is sufficiently long before conducting a standby loss test without a previously run thermal efficiency test. (Rheem, No. 34 at p. 6)

A.O. Smith argued that while not requiring human interaction, a soak-in period would be burdensome to manufacturers because it would require lab space to be occupied and certain environmental conditions to be monitored and maintained. (A.O. Smith, No. 27 at p. 17) Rheem stated that the soak-in period would place an additional burden on manufacturers in terms of time, resources, and laboratory space, if required when a thermal efficiency test is performed in conjunction with a standby loss test. (Rheem, No. 34 at p. 6)

DOE acknowledges that a soak-in period would not be warranted before a thermal efficiency test if steady-state operation is assured prior to beginning the test. Given the more stringent provisions for determining steady-state operation that DOE is adopting in this final rule (discussed in section III.F.1), DOE agrees with commenters that a soak-in period is not needed before the thermal efficiency test, and is not adopting this requirement. While several commenters indicated that a soak-in period might be helpful if the water heater were not stored in a conditioned space, DOE believes that in this case, the water heater would simply take longer to reach the required steady-state conditions before beginning the thermal efficiency test, and that an additional soak-in period would not be necessary.

DOE believes that a soak-in period would improve test repeatability for the standby loss test if a thermal efficiency test were not previously conducted. In the May 2016 NOPR, DOE also proposed that a soak-in period be required if any settings on the water heater had been changed, or if the water heater had been turned off since the end of a previously run efficiency test. 81 FR 28588, 28598 (May 9, 2016). However, Bradford White and AHRI indicated that a soak-in period should only be required before the standby loss test if the standby loss test does not begin within three hours of the end of a previously run thermal efficiency test. (Bradford White, No. 19 at p. 4; AHRI, No. 26 at p. 9)

DOE disagrees with the suggestion that a soak-in period would not be necessary if a water heater were turned off after a thermal efficiency test but for three hours or less before beginning the standby loss test. DOE believes that the water heater should be turned on at all times between the end of the thermal efficiency test and the beginning of the standby loss test to ensure that the thermal equilibrium within the tank insulation, or ''soaking in,'' achieved during the thermal efficiency test is not lost before starting the standby loss test. DOE notes that water heaters likely vary significantly in the time required after ending the thermal efficiency test before the burner cuts in again. This variation includes factors such as storage volume, tank heat losses, and thermostat control algorithms. For certain water heaters, this time may even exceed three hours, in which case it would not matter if the water heater were turned on or off during this period. However, in other cases, the thermal equilibrium of the tank may be lost if the water heater is turned off between tests. A decrease in the insulation temperature between tests might require additional energy consumption to reheat the insulation during the standby loss test, which would result in higher calculated values of standby loss.

DOE also believes that a soak-in period requirement will improve the repeatability of the standby loss test for electric storage water heaters. Electric storage water heaters do not have a thermal efficiency test, so unless multiple standby loss tests are run consecutively, the soak-in period will ensure that the tank insulation has reached thermal equilibrium before measurements for the standby loss test begin. Therefore, to improve repeatability of the standby loss test for storage water heaters and storage-type instantaneous water heaters, DOE is adopting a requirement that a soak-in period of 12 hours be conducted before the standby loss test unless no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously run efficiency test. DOE concludes that adding requirements for the soak-in period (when required) will improve the repeatability of the test result, but is consistent with ANSI Z21.10.3–2015.

The provisions DOE is adopting that specify when a 12-hour soak-in period is required prior to the standby loss test (*i.e.,* required unless no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously run efficiency test) allow flexibility for the manufacturer or testing agency. After completion of the thermal efficiency test, as long as the water heater stays turned on and no settings are changed, the laboratory technician may choose to begin the standby loss test immediately, or allow the tank to soak in longer before beginning the standby loss test.

G. Definitions for Certain Consumer Water Heaters and Commercial Water Heating Equipment

1. Consumer Water Heaters

A statutory definition for consumer ''water heater'' was added to EPCA by the National Appliance Energy Conservation Act of 1987 (NAECA; Pub. L. 100–12, March 17, 1987), which specifies input ratings at or below which water heaters are to be classified as consumer water heaters (*e.g.,* 75,000 Btu/h for gas-fired storage water heaters; 12 kW for electric storage water heaters and electric instantaneous water heaters; 210,000 Btu/h for oil-fired instantaneous water heaters). (42 U.S.C. 6291(27)) NAECA also established standards for gas-fired consumer water heaters, oil-fired consumer water heaters, and electric consumer water heaters. (42 U.S.C. 6295(e)(1))

DOE restated the statutory definition of ''water heater'' in the appliance standards regulations applicable to consumer products at 10 CFR 430.2. In addition to adopting EPCA's definition of ''water heater'' for standards applicable to consumer products, DOE defined a variety of terms in the test procedure provisions applicable to consumer water heaters to help specify the test procedure provisions applicable to specific kinds of water heaters (*e.g.,* ''gas instantaneous water heater'' and ''electric storage water heater''). 55 FR 42162, 42169 (October 17, 1990). These test procedure definitions included provisions related to water temperature design characteristics and rated storage volume. The standards at 10 CFR 430.32 and the ''water heater'' definition at 10 CFR 430.2 did not include any such limitations.

In an effort to consolidate all relevant definitions in 10 CFR 430.2, DOE removed the definitions for specific kinds of consumer water heaters from its test method at appendix E to subpart B of part 430 (*i.e.,* ''electric heat pump water heater,'' ''electric storage water heater,'' ''gas-fired instantaneous water heater,'' ''gas-fired storage water heater,'' and ''oil-fired storage water heater'') and placed these definitions in the general definition section at 10 CFR 430.2, along with newly established definitions for ''gas-fired heat pump water heaters,'' ''oil-fired instantaneous water heater,'' and ''electric instantaneous water heater.'' 79 FR 40542, 40549, 40566–40567 (July 11, 2014). The reorganization of the existing definitions and the newly established definitions became effective on July 13, 2015, and these definitions excluded products with a rated storage capacity greater than 120 gallons and, in some cases, excluded products designed to heat and store water at a thermostatically controlled temperature greater than 180 °F. 79 FR 40542, 40566–40567 (July 11, 2014).

As noted previously, the standards and definition set forth in EPCA do not include any limitation related to the water temperature or storage capacity.

Therefore, prior to the effective date of the amendments in the July 2014 final rule, any product meeting the definition of a ''water heater'' as established under EPCA and restated in 10 CFR 430.2 would have been subject to the statutory standards applicable to consumer water heaters (*i.e.,* water heaters within the input limits established under EPCA would have been subject to the standards regardless of the water delivery temperature or storage capacity).

In the May 2016 NOPR, DOE proposed to amend the definitions for specific types of consumer water heaters included at 10 CFR 430.2 by removing from the definitions the specifications related to the water temperature and storage capacity. 81 FR 28588, 28605–28606 (May 9, 2016). Because a model that would otherwise meet the definition of a consumer water heater could not ''become'' commercial as the result of the unit's capability of producing water at temperatures above 180 °F or by having a rated capacity in excess of 120 gallons, the proposed definitions better reflect the statutory definitions and DOE's statutory authority. More generally, DOE clarified that a product that utilizes gas, oil, or electricity to heat potable water for use outside the heater upon demand that does not meet the statutory definition of ''water heater'' at 42 U.S.C. 6291(27) would be a commercial water heater, subject to the standards for such water heaters as set forth in 42 U.S.C. 6313(a)(5).

DOE received comments on the proposed removal of the temperature and the capacity criteria. A number of stakeholders disagreed with DOE's proposal to remove the 180 °F water delivery temperature from the consumer water heater definitions at 430.2. (HTP, No. 24 at p. 2; AHRI, No. 26 at pp. 4–5; Rinnai, No. 31 at p. 2; Bock, No. 19 at p. 2; Bradford White, No. 21 at pp. 8–9; Rheem, No. 34 at pp. 10–11) AHRI argued that by removing these criteria, specifically the 180 °F exclusion, from its consumer water heater definitions, DOE would be reversing a long-standing position that AHRI stated was determined valid in the July 2014 final rule. AHRI also stated that DOE did not provide sufficient explanation for reversing its long-standing position. (AHRI, No. 26 at pp. 4–5)

Contrary to AHRI's understanding, the relocation of definitions from the test procedure provisions to the general definitions section in the July 2014 final rule was not for the purpose of validating a long-standing position. As noted previously, ''water heater'' is defined by EPCA, and remains defined in 10 CFR 430.2, without restriction as to water temperature delivery or storage capacity. The addition of these exclusions to DOE's definitions at 10 CFR 430.2 was not intended to limit the applicability of the definition of ''water heater.'' As explained in the July 2014 final rule, definitions of ''gas-fired heat pump water heater,'' ''oil-fired instantaneous water heater,'' and ''electric instantaneous water heater'' were added in the context of the new test procedure. 79 FR 40542, 40549 (July 11, 2014). The notice also stated that all other definitions from the test procedure were being relocated. *Id.* The July 2014 final rule did not discuss restricting the statutory or regulatory definition of ''water heater.'' As opposed to validating a long-standing position, DOE recognizes that by relocating the definitions it furthered confusion regarding the applicability of the standards. As previously stated, prior to the effective date of the July 2014 final rule, any product meeting the definition of a ''water heater'' would have been subject to the statutory standards applicable to consumer water heaters, regardless of the water delivery temperature or storage capacity. The temperature and capacity restrictions were for the purpose of applying provisions of the test procedure, not the standard. Therefore, DOE considers removal of these exclusions as a correction to a recent change, and not as a reversal of a long-standing position. Additionally, as discussed in the following paragraphs, DOE has concluded use of such limitations would be inappropriate given, in part, the water heaters currently available on the market.

AHRI further argued that when interpreting the statutory definition applicable to consumer water heaters, DOE must first consider the definition of ''consumer product.'' When determining whether a product falls within the definition of ''water heater'' in the context of the consumer product standards, AHRI argued that DOE must first consider whether that product is a consumer product and that the temperature and capacity criteria inform that consideration. AHRI pointed to prior consideration by DOE of factors beyond those in the EPCA definition to distinguish between consumer and commercial products, citing the April 2010 final rule (75 FR 20112, 20127), in which DOE stated that pool heaters marketed as commercial equipment and that contain additional design modifications related to safety requirements for installation in commercial buildings would not be covered by DOE's consumer product standard for pool heaters. (AHRI, No. 26 at pp. 5–6) In the present case, AHRI essentially argued that water heaters that are designed to deliver water at temperatures greater than 180 °F or that have a rated volume in excess of 120 gallons are not to any significant extent marketed or sold for personal use by individuals, and therefore cannot be consumer products. Other commenters asserted that water delivery temperature provides a meaningful way to distinguish between consumer and commercial water heaters. (Bock, No. 19 at p. 2; Bradford White, No. 21 at p. 9; Rinnai, No. 31 at p. 2) HTP and AHRI stated that units that heat water above 180 °F are only used in commercial applications, and that water heated above 180 °F in a residential application presents a scald hazard. (HTP, No. 24 at p. 2; AHRI, No. 26 at p. 4) Bradford White stated that all of its commercial electric storage basic models would be mistakenly reclassified if DOE removed the 180 °F exclusion from its consumer water heater definitions, even though according to Bradford White, these models are not appropriate for residential applications. (Bradford White, No. 21 at p. 9) A.O. Smith stated that defining as consumer water heaters gas instantaneous water heaters with an input capacity less than or equal to 200,000 Btu/h and a water delivery temperature greater than 180 °F would make ratings inconsistent with other commercial water heaters. (A.O. Smith, No. 27 at p. 10)

Several manufacturers also disagreed with the removal of the storage capacity criterion. (Bradford White, No. 21 at p. 9; A.O. Smith, No. 27 at p. 6; Rheem, No. 34 at p. 11) Bradford White and A.O. Smith stated that models with storage volume greater than 120 gallons require American Society of Mechanical Engineers (ASME) pressure vessel certification in most jurisdictions and that these models would not be used in residential applications. Bradford White also commented that the cost of ASME certification is high enough to be cost-prohibitive for residential applications. (Bradford White, No. 21 at p. 9)

DOE reiterates that the relocation of definitions relevant to the test procedure to the general definition section at 10 CFR 430.2 was not intended to reflect a prior interpretation restricting the applicability of the standards for consumer water heaters. However, even if the removal of the water temperature delivery and volume capacity limitations were a change to a long standing practice of distinguishing between consumer and commercial water heaters, a recent survey of the market leads DOE to determine that such criteria would not be appropriate to distinguish between water heaters that are consumer products and those that are commercial products. While DOE acknowledges that water heaters with a water delivery temperature greater than 180 °F or with a storage volume greater than 120 gallons may not be commonly used in residential applications, the question is whether a water heater is of the type distributed in commerce to any significant extent for personal use by an individual. (42 U.S.C. 6291(1)) Consideration of whether an article is of a type distributed in commerce to any significant extent for personal use by an individual is made without regard to whether a specific article is in in fact distributed in such a manner. *Id.*

In surveying the market, DOE has identified several water heaters that demonstrate that a reliance on a 180 °F threshold would be inappropriate for distinguishing between consumer and commercial water heaters. Rheem markets a water heater under its commercial line that has input ratings below the 12 kW threshold specified in the statutory definition for consumer water heaters and has thermostat controls that provide maximum water temperatures greater than 180 °F. (Docket No. EERE–2014–BT–TP–0008–0041) This water heater's installation instructions reference installation in the ''home,'' indicating that the model is distributed for consumer use. (Docket No. EERE–2014–BT–TP–0008–0040, pp. 15, 21) A water heater offered by A.O. Smith has two 4.5 kW heating elements arranged in a configuration typical for consumer water heaters and provides an input capacity below the statutory 12 kW threshold, but has a thermostat adjustable up to 181 °F, one degree above the 180 °F threshold in the regulatory definition of ''electric storage water heater.'' (Docket No. EERE–2014–BT–TP–0008–0038) The manual for the A.O. Smith product references installation in the home, again suggesting that the product is distributed, at least to an extent, for residential use. (Docket No. EERE–2014–BT–TP–0008–0037, pp. 8–9)

With regard to the 180 °F criterion, DOE's understanding is that exceeding the temperature threshold for a water heater can be achieved through replacement of a single part, the thermostat, which DOE believes can be very easily and inexpensively changed to allow for heating water to greater than 180 °F. As noted by A.O. Smith in its comment, the 180 °F operating limit is not necessarily a satisfactory criterion for separating consumer and commercial water heaters, because a thermostat designed to deliver water temperatures in excess of 180 °F can be installed at no additional cost on products that are consumer water heaters in all other respects. (A.O. Smith, No. 27 at pp. 6–7) A.O. Smith suggested that removing the 180 °F criterion for electric storage water heaters could dissuade manufacturers from trying to avoid DOE's standard for large residential electric storage water heaters.[13] (A.O. Smith, No. 27 at pp. 6–7) Additionally, Rheem suggested that the 180 °F criterion for distinguishing between residential-duty commercial water heaters and other commercial water heaters allows manufacturers to move units in and out of the residential-duty commercial water heater classes using a thermostat. (Docket No. EERE–2014–BT–STD–0042–0020 at p. 18) DOE believes that the same allowance to move between classes would apply to a 180 °F criterion that distinguished between consumer water heaters and commercial water heaters. Bradford White stated in its comments that the only feature to distinguish some if its models as commercial is the temperature requirement. (Bradford White, No. 21 at p. 9) The ease at which water temperature in excess of 180 °F can be achieved by a water heater that is in all regards a consumer water heater demonstrate that the 180 °F threshold would circumvent the statutory definition of a consumer water heater. DOE also notes that the concern raised by commenters regarding scalding is applicable to lower water temperatures as well. Manufacturer warnings regarding scalding identify the danger at temperatures as low as 125 °F, and with an exposure time of 1 second at 155 °F. (Docket No. EERE–2014–BT–TP–0008–0037) The range of the temperatures at which warnings are issued indicate that 180 °F would not be an adequate threshold to delineate the risk of scalding, further demonstrating that a threshold of 180 °F does not provide a meaningful distinction between consumer and commercial water heaters.

GE supported DOE's proposal to remove the 180 °F exclusion from DOE's consumer water heater definitions, suggesting that the change would end the shift in shipments from residential electric storage water heaters to commercial electric storage water heaters. GE also stated that a rulemaking should not be necessary for these changes, and that DOE should make these changes in a guidance document. If these changes are made in a rulemaking, GE suggested that the effective date should be immediate. (GE, No. 25 at pp. 1–2)

With regard to the 120 gallon threshold, DOE has determined that in the interest of avoiding future confusion, it is not adding this criterion to the definition of consumer water heater. DOE has determined that the simplest way to maintain the distinction as established by Congress between consumer and commercial water heaters is to rely solely on the definition set forth in EPCA.

As explained previously, the 180 °F and 120 gallon rated volume criteria were for the purpose of defining terms in the context of the test procedures for consumer water heaters. Such distinctions are unnecessary under DOE's current test procedures for consumer water heaters, as adopted in the July 2014 final rule, which also applies to residential-duty commercial water heaters. To correct the application of such thresholds to the definitions pertaining to consumer water heaters, DOE is removing them from the definitions. Additionally, based on a survey of the market and based on several of the comments received, DOE has determined that these criteria would be inappropriate for distinguishing between consumer and commercial water heaters. EPCA delineates between consumer and commercial water heaters in the statutory definition through specified rated inputs. As evidenced by the discussion of the products surveyed, the addition of further criteria does not provide a meaningful distinction between consumer and commercial water heaters. To add a temperature or volume criterion would potentially exclude some consumer water heaters from the regulatory definition of a consumer water heater, but not the statutory definition, and such a result would be an inappropriate restriction on the definition of consumer water heater provided in EPCA.

DOE has previously considered adding criteria to its codified definitions beyond the statutory criteria to distinguish between consumer and commercial products. In the case of pool heaters, a consumer product, commenters and DOE recognized that there were performance and design characteristics that further informed a determination of whether a pool heater was a consumer product or a commercial product. 75 FR 20112, 20127 (April 16, 2010). For pool heaters, DOE declined to add those criteria to

[13] A.O. Smith did support maintaining the 180 °F criterion for other water heaters, but did not provide an explanation for why its statements provided in regards to electric storage water heaters would not apply to other water heaters. (A.O. Smith, No. 27 at p. 7)

the definition of pool heater, finding that amendments to the statutory definition were unnecessary and that marketing and design differences related to safety requirements for installation in commercial buildings sufficiently informed the distinction between consumer and commercial products. *Id.* That is, the definition established by EPCA did not require further clarification.

However, the consideration for pool heaters is not wholly analogous to the present case. Unlike the present case and the consideration of a temperature threshold, the additional criteria discussed for pool heaters would not have limited the application of the defined term ''pool heater'' established in statute (*i.e.,* the criteria discussed for pool heaters would not have excluded pool heaters that are otherwise consumer products from standards). Here, the addition of a temperature threshold would exclude water heaters from consideration as consumer water heaters that under the statutory definition are consumer water heaters, and are of the type distributed in commerce for personal use by individuals.

EPCA does not exclude water heaters based on water temperature delivery or volume in its definition for consumer ''water heater.'' Rather, the definition in EPCA relies on input criteria to define which water heaters fall under the consumer ''water heater'' definition, and DOE believes that in order to maintain consistency with EPCA, the inclusion of these criteria is not appropriate.

Several commenters asserted that the removal of the exclusion from the consumer water heater definitions of models with a water delivery temperature of 180 °F or higher is inconsistent with the definition of a ''residential-duty commercial water heater'' that DOE established in the July 2014 final rule for test procedures for consumer water heaters and certain commercial water heaters. 79 FR 40542, 40586 (July 11, 2014). Specifically, commenters noted that in that rule, DOE included water delivery temperature of 180 °F or higher as an indicator of non-residential application for commercial water heaters, and stated that such units would generally only be used in commercial settings. (AHRI, No. 26 at pp. 4–5; Rinnai, No. 31 at p. 2; Bradford White, No. 21 at pp. 8–9) Rheem also suggested that removing the 180 °F and 120 gallon criteria from the consumer water heater definitions while maintaining water delivery temperature of greater than 180 °F and storage volume greater than 120 gallons as distinguishing criteria for commercial water heaters not used in residential applications (*i.e.,* not residential-duty commercial water heaters) would lead to confusion in the market place. (Rheem, No. 34 at p. 10)

In the July 2014 final rule, DOE established a new class of commercial water heaters, ''residential-duty commercial water heater.'' 79 FR 40542, 40586 (July 11, 2014). EPCA, as amended by AEMTCA, allowed DOE to exclude from a uniform energy descriptor water heaters that do not have residential applications and that can be clearly described. (42 U.S.C. 6295(e)(5)(F)) Under this authority, DOE established several criteria to separate commercial water heaters that have residential applications (*i.e.,* residential-duty commercial water heaters) from commercial water heaters generally. *Id.* at 40586. When determining how to distinguish a residential-duty commercial water heater from other commercial water heaters, DOE relied on an outlet water temperature of 180 °F or lower as one of several dividing criteria. 79 FR 40542, 40546 (July 11, 2014). DOE noted that although residential-duty commercial water heaters could have residential applications, the ''residential-duty commercial water heater'' definition represents a type of water heater that, to a significant extent, is distributed in commerce for industrial or commercial use. *Id.* In its explanation for this criterion, DOE stated that a 180 °F water delivery temperature is a valuable distinguishing feature between commercial water heaters intended for residential use and those that are not. However, water delivery temperature serves in conjunction with other criteria to distinguish residential-duty commercial water heaters from other commercial water heaters (*i.e.,* rated storage volume, rated input, and for models requiring electricity, and use of a single-phase external power supply are also considered). *See* 10 CFR 431.102.

EPCA provides a criterion for distinguishing between water heaters that are consumer products and water heaters that are commercial and industrial equipment: The rated input. (42 U.S.C. 691(27)) Although water delivery temperature and rated storage capacity are useful as part of the analysis to differentiate between commercial water heater applications, as explained above, water delivery temperature and rated storage capacity are inappropriate to distinguish between consumer water heaters and commercial water heaters.

A. O. Smith and Raypak both argued that it was inappropriate to address the definitions of consumer water heaters in this rulemaking since this rulemaking primarily addresses test procedures for water heaters as commercial products. (A. O. Smith, No. 27 at p. 7; Raypak, No. 28 at p. 7) As noted by Raypak, the water heaters excluded under the consumer water heater definition in EPCA and 10 CFR 430.2 are subject to the commercial water heater standards in 10 CFR part 431. By removing the outlet water temperature and capacity criteria, DOE is clarifying the distinction between consumer water heaters and commercial water heaters as prescribed by EPCA. DOE believes removing the water temperature and volume references will simplify its regulations. Those water heaters with a rated input in excess of the applicable maximum specified in EPCA (42 U.S.C. 6311(12)) are commercial water heaters and will be regulated under EPCA as industrial equipment under 42 U.S.C. 6311(1), meaning that those commercial water heaters cannot be a covered consumer product under 42 U.S.C. 6291(1).

Additionally, contrary to Bradford White's suggestion, not all electric storage water heater basic models will need to be reclassified under this final rule. (Bradford White, No. 27 at p. 9) Only electric storage models with an input rating less than or equal to 12 kW must be classified as consumer water heaters. All electric storage models with an input rating greater than 12 kW are classified as commercial water heaters.

For the reasons previously discussed, DOE is removing the 180 °F water delivery temperature and 120 gallon storage volume exclusions from its consumer water heater definitions, as proposed in the May 2016 NOPR. Because DOE is modifying the regulations, such changes cannot be addressed through a guidance document. The effective date of these definition changes is 30 days after publication of this final rule in the **Federal Register**.

In the May 2016 NOPR, DOE also proposed to remove the terms ''electric heat pump water heater'' and ''Gas-fired heat pump water heater'' from its definitions at 10 CFR 430.2. 81 FR 28588, 28606 (May 9, 2016). DOE reasoned that these terms were unnecessary because they are not used in the energy conservation standards for consumer water heaters at 10 CFR 430.32(d), nor are they used in the Uniform Test Method for Measuring the Energy Consumption of Water Heaters at appendix E to subpart B of part 430.

In response to this proposal, Rheem disagreed with the removal of the terms ''electric heat pump water heater'' and ''gas-fired heat pump water heater'' from

DOE's definitions at 10 CFR 430.2. Rheem stated that heat pump water heaters have different defining factors than other kinds of consumer water heaters, and that the threshold input rate only represents the power being supplied from the non-heat pump technology involved with heating the stored water. (Rheem, No. 34 at pp. 11–12)

As proposed in the May 2016 NOPR, DOE is removing the definitions for ''electric heat pump water heater'' and ''gas-fired heat pump water heater'' from its regulations. DOE acknowledges that heat pump water heaters can have different defining factors than other consumer water heaters, but DOE is removing these definitions because they are not used in DOE's test procedures or energy conservations standards for consumer waters. Therefore, removing these definitions will have no effect on the implementation of DOE's regulations.

As discussed in the previous paragraphs, DOE is revising the definitions for ''electric instantaneous water heater,'' ''electric storage water heater,'' ''gas-fired instantaneous water heater,'' ''gas-fired storage water heater,'' ''oil-fired instantaneous water heater,'' and ''oil-fired storage water heater'' in its regulations of consumer water heaters at 10 CFR 430.2, as set out in the regulatory text at the end of this document.

2. Commercial Water Heating Equipment

DOE currently includes several definitions in its regulations for CWH equipment at 10 CFR 431.102 that include the terms ''rated input'' or ''input rating.'' These definitions include ''hot water supply boiler,'' ''instantaneous water heater,'' ''residential-duty commercial water heater,'' and ''storage water heater.'' In the May 2016 NOPR, DOE proposed a new definition for ''fuel input rate,'' a value to be certified for all gas-fired and oil-fired CWH equipment. 81 FR 28588, 28637 (May 9, 2016). Therefore, DOE also proposed replacing the terms ''rated input'' and ''input rating'' with the term ''fuel input rate'' for gas-fired and oil-fired CWH equipment in the definitions for CWH equipment at 10 CFR 431.102. 81 FR 28588, 28606 (May 9, 2016).

As discussed in section III.L.1 of this final rule, based on feedback from stakeholders regarding the rated input determined from safety certification, DOE is not adopting its proposed requirements regarding certification of fuel input rate. Therefore, in this final rule, DOE is not modifying its definitions for CWH equipment at 10 CFR 431.102 as proposed in the May 2016 NOPR. Instead, DOE is adopting the term ''rated input'' in its definitions to refer to the input capacity certified to DOE by the manufacturer and included on the equipment nameplate. In contrast, DOE is adopting the term ''fuel input rate'' in its regulations only to refer to the capacity of a unit determined in a particular test.

DOE's current definitions for ''storage water heater'' and ''instantaneous water heater'' in its regulations for CWH equipment codified at 10 CFR 431.102 do not include any criteria that exclude units that meet DOE's current definitions for consumer water heaters, as codified at 10 CFR 430.2. In the May 2016 NOPR, DOE proposed to clarify these definitions for commercial water heaters by adding the input capacity criteria that distinguish between consumer and commercial water heaters for each energy source, as specified in EPCA's definition for consumer water heater (42 U.S.C. 6291(27)). 81 FR 28588, 28637 (May 9, 2016). These changes are consistent with DOE's changes to its definitions for consumer water heaters, as discussed in section III.G.1.

In response to the May 2016 NOPR, Bradford White agreed with DOE's proposal to add the input criteria separating consumer and commercial water heaters to the definitions for commercial water heaters. (Bradford White, No. 21 at pp. 9, 12) Raypak commented that DOE should establish an upper limit of 5 million Btu/h in its definitions for commercial water heating equipment because of laboratory testing issues for larger equipment. Raypak also noted that while hot water supply boilers are restricted to under 12.5 million Btu/h, no similar restriction exists for commercial water heaters. (Raypak, No. 28 at p. 7)

As proposed in the May 2016 NOPR and for the reasons previously stated, in this final rule, DOE is clarifying its definitions for commercial water heaters by adding the input capacity criteria that distinguish between consumer and commercial water heaters for each energy source, as specified in EPCA's definition of consumer water heater. (42 U.S.C. 6291(27))

In response to Raypak's suggestion that DOE should establish an upper input capacity limit in its CWH equipment definitions, DOE notes that the statutory definitions of ''storage water heater'' and ''instantaneous water heater'' at 42 U.S.C. 6311(12)(A) do not set an upper-end input capacity limit in terms of coverage of commercial water heaters, so any large-scale models are already covered under DOE's existing energy conservation standards. Even so, DOE was unable to identify any models of CWH equipment currently on the market with an input capacity greater than 5 million Btu/h. In fact, Raypak noted that the largest input capacity of any CWH equipment that it manufactures is only 4 million Btu/h. (Raypak, No. 28 at p. 6) DOE would only consider modifying its regulations for large CWH equipment if there were such units on the market and if manufacturers demonstrated that DOE's existing test procedures could not be used for these units. If a manufacturer does produce a CWH equipment model with an input capacity greater than 5 million Btu/h that cannot be tested using DOE's test procedure, then the manufacturer should notify DOE and request a waiver from DOE's test procedures using the procedure at 10 CFR 431.401. If a waiver were granted, DOE would update its test procedure in the next test procedure rulemaking for CWH equipment.

DOE currently includes a definition for ''instantaneous water heater'' in its regulations for CWH equipment at 10 CFR 431.102. An instantaneous water heater is a water heater that has an input rating not less than 4,000 Btu/h per gallon of stored water, and that is industrial equipment, including products meeting this description that are designed to heat water to temperatures of 180 °F or higher.

DOE believes that the last clause of the definition for ''instantaneous water heater,'' which includes units capable of heating water to temperature at or above 180 °F, does not serve a purpose in the definition. Without this clause, it would be assumed that units with this capability would be included in the definition because there is no restriction indicating otherwise. Therefore, to simplify the definition, DOE is removing this clause from the definition for ''instantaneous water heater.'' Additionally, with DOE's addition of input criteria that distinguish between consumer and commercial water heaters previously discussed in this section, DOE believes that the clause ''that is industrial equipment'' does not serve to further clarify the scope of units covered by this definition. Therefore, in the May 2016 NOPR, DOE proposed to remove this clause from its definitions for ''instantaneous water heater'' and ''storage water heater.'' 81 FR 28588, 28606 (May 9, 2016). In response to the May 2016 NOPR, Bradford White agreed with removing the phrase ''that is industrial equipment.'' (Bradford White, No. 21 at p. 9) Bradley Corporation requested clarification from DOE on the removal of the phrase ''that is industrial equipment'' from the definition of instantaneous water heaters, and whether this phrase is actually in reference to the statutory definition for ''industrial equipment.'' (Bradley, NOPR Public Meeting Transcript, No. 20 at p. 23)

The term ''industrial equipment'' used in the definitions for ''instantaneous water heater'' and ''storage water heater'' at 10 CFR 431.102 does refer to the statutory definition for ''industrial equipment.'' (42 U.S.C. 6311(2)(A)) The phrase ''that is industrial equipment'' was included in DOE's codified definitions for ''instantaneous water heater'' and ''storage water heater'' to clarify that water heaters that are covered by EPCA's definition of ''water heater'' under ''consumer products'' (*see* U.S.C. 6291(27)) are not covered by DOE's definitions for ''instantaneous water heater'' and ''storage water heater'' in 10 CFR part 431. DOE believes that the phrase ''that is industrial equipment'' is no longer needed in DOE's definitions for ''instantaneous water heater'' and ''storage water heater'' to clarify that products regulated as consumer products are not covered under these definitions, because DOE is modifying these definitions to include the specific input capacity criteria that separate consumer water heaters and commercial water heaters, as previously discussed in this section. The statutory definition for ''industrial equipment'' also includes that equipment be of a type that is distributed, to any significant extent, in commerce for commercial or industrial applications. (42 U.S.C. 6311(2)(A)(ii)) However, EPCA also defines ''covered equipment'' to include any of several types of industrial equipment, including storage water heaters, instantaneous water heaters, and unfired hot water storage tanks. (42 U.S.C. 6311(1)) Therefore, covered commercial water heating equipment is, by statutory definition, industrial equipment. Consequently, DOE believes that the phrase ''that is industrial equipment'' is not needed in DOE's codified definitions for ''instantaneous water heater'' and ''storage water heater.'' Therefore, in this final rule, DOE is removing this clause from its definitions for ''instantaneous water heater'' and ''storage water heater.''

In its regulations for CWH equipment at 10 CFR 431.102, DOE currently includes a definition for ''packaged boiler'' that is identical to that included for commercial packaged boilers at 10 CFR 431.82. DOE includes this definition for ''packaged boiler'' at 10 CFR 431.102 because the regulations for CWH equipment also include a definition for ''hot water supply boiler,'' and this definition specifies that a hot water supply boiler is a kind of packaged boiler. To simplify its regulations and reduce repetition, in the May 2016 NOPR, DOE proposed to remove the definition for ''packaged boiler'' from its regulations for CWH equipment at 10 CFR 431.102, to be replaced with a reference to the definition for ''packaged boiler'' included at 10 CFR 431.82. 81 FR 28588, 28606 (May 9, 2016). In response to the May 2016 NOPR, Bradford White agreed with removing the definition of ''packaged boiler,'' as long as this change is consistent with the commercial packaged boiler rulemakings. (Bradford White, No. 21 at p. 9) DOE notes that replacement of a duplicated definition with a reference to the regulations for commercial packaged boilers inherently aligns DOE's regulations for commercial packaged boilers and CWH equipment, such that there is no potential for differences between two versions of the ''packaged boiler'' definition. Therefore, DOE is removing the definition of ''packaged boiler'' from its regulations for CWH equipment at 10 CFR 431.102. Correspondingly, in its definition of ''hot water supply boiler'' at 10 CFR 431.102, DOE is replacing the term ''packaged boiler'' with the term ''packaged boiler (as defined in § 431.82).''

In section III.H of this final rule, DOE establishes a separate test procedure for water heaters and hot water supply boilers that require flow of water to activate the burner or heating element, and establishes a definition for ''flow-activated water heater,'' along with separate standby loss test provisions for flow-activated water heaters as set out in the regulatory text at the end of this document.

In section III.J of this final rule, DOE establishes a definition for ''commercial heat pump water heater,'' as well as a test procedure for commercial heat pump water heaters as set out in the regulatory text at the end of this document.

3. Residential-Duty Commercial Water Heaters

As required by AEMTCA, DOE established a uniform efficiency descriptor and accompanying test method for consumer water heaters and certain commercial water heaters in the July 2014 final rule. 79 FR 40542 (July 11, 2014). Specifically, AEMTCA required that the uniform efficiency descriptor and test method apply to all covered water heaters, including both consumer and commercial water heaters, except for certain commercial water heaters that do not have a residential use, and can be clearly described and are effectively rated using the thermal efficiency and standby loss descriptors. (42 U.S.C. 6295(e)(5)(F)) In the July 2014 final rule, DOE established input and volume criteria to distinguish commercial water heaters that do not have residential applications, based on comments from stakeholders. 79 FR 40542, 40586 (July 11, 2014). However, for four classes of residential-duty commercial water heaters—electric storage water heaters, heat pump water heaters, gas-fired instantaneous water heaters, and oil-fired instantaneous water heaters—the input criteria established to separate residential-duty commercial water heaters from commercial water heaters are identical to those codified at 10 CFR 430.2, which separate consumer water heaters from commercial water heaters. The criteria for these classes are shown in Table III–1. Because these input criteria are identical, by definition, no models can be classified under these four residential-duty equipment classes. Therefore, to eliminate potential confusion, in the May 2016 NOPR, DOE proposed to remove these classes from the definition of ''residential-duty commercial water heater'' codified at 10 CFR 431.102. 81 FR 28588, 28607 (May 9, 2016).

TABLE III—1 INDICATOR OF NON-RESIDENTIAL APPLICATION FOR CERTAIN CLASSES OF CWH EQUIPMENT

Water heater class	Indicator of non-residential application
Electric storage	Rated input >12 kW; Rated storage volume >120 gallons.
Heat pump with storage	Rated input >12 kW; Rated current >24A at a rated voltage of not greater than 250 V; Rated storage volume >120 gallons.
Gas-fired instantaneous	Rated input >200 kBtu/h; Rated storage volume >2 gallons.
Oil-fired instantaneous	Rated input >210 kBtu/h; Rated storage volume >2 gallons.

In response to the May 2016 NOPR, several commenters agreed with DOE's proposal to revise the definition of ''residential-duty commercial water heater.'' (Bradford White, No. 21 at p. 9; CA IOUs, No. 23 at p. 2; AHRI, No. 26 at p. 13; A.O. Smith, No. 27 at p. 10) Rheem, however, disagreed, asserting that there should be a residential-duty commercial class corresponding to each equipment class of commercial water heaters. Rheem argued that only having residential-duty commercial classes for certain kinds of water heaters is arbitrary, and that all classes of commercial water heaters have units that are installed in residential applications. Further, Rheem stated that it would be extremely costly and burdensome to implement a heat pump water heater standard for commercial water heaters, and that a class for residential-duty commercial electric storage water heaters is necessary to maintain the ability to install electric storage water heaters using electric resistance heating elements in certain commercial applications. Rheem suggested that the class of residential-duty commercial electric storage water heaters should include units with an input capacity less than or equal to 13 kW and a storage volume no greater than 120 gallons. (Rheem, No. 34 at pp. 13–14)

In response to Rheem, DOE notes that it did not propose to change any of the criteria for classifying residential-duty commercial water heaters in the May 2016 NOPR, only to remove classes for which no units could be classified given the existing criteria. Further, the existing capacity criteria for defining non-residential application for commercial water heaters were established in the July 2014 final rule based on feedback from stakeholders, including Rheem. 79 FR 40542, 40545–40549 (July 11, 2014). Having classes of residential-duty commercial water heaters for only certain classes of commercial water heaters is not inherently arbitrary, as suggested by Rheem. Rather, it reflects that for certain equipment classes of commercial water heaters (as defined by the statutory criteria separating consumer water heaters and commercial water heaters), commenters in the prior rulemaking generally agreed that there is no capacity range in which units are distributed to residential applications to a significant extent.

On May 31, 2016, DOE published a NOPR for amended energy conservation standards for certain classes of CWH equipment. 81 FR 34440. For commercial electric storage water heaters, DOE only proposed to amend the standby loss standard in that NOPR. Therefore, DOE does not have any current or proposed energy conservation standards that would require commercial electric storage water heaters to use heat pump technology instead of electric resistance heating elements. Consequently, DOE disagrees with Rheem's statement that a class of residential-duty commercial electric storage water heaters is warranted for the purpose of excluding a certain group of commercial water heaters from coverage under a standard that requires heat pump technology. Additionally, DOE notes that Rheem's suggested input capacity limit for residential-duty electric storage water heaters of 13 kW differs only slightly from the statutory input capacity criterion separating consumer water heaters from commercial water heaters—12 kW. DOE was only able to identify one electric storage water heater on the market with an input capacity both greater than 12 kW and less than or equal to 13 kW. (Docket No. EERE–2014–BT–TP–0008–0039) Because this unit, sold by Rheem, is marketed as a commercial water heater and included in the same model line as units with input capacities of 18 kW and 24 kW, DOE believes that this 12.4 kW unit is appropriately classified as a commercial electric storage water heater under the statute and DOE is not at liberty to modify those definitions. Since all three of these water heaters are marketed by the manufacturer in the product literature as commercial electric storage water heaters, DOE does not see the basis for differential treatment as Rheem is suggesting.

Accordingly, in this final rule, as proposed in the May 2016 NOPR, DOE is removing four classes of residential-duty commercial water heaters—electric storage water heaters, heat pump water heaters, gas-fired instantaneous water heaters, and oil-fired instantaneous water heaters—from the definition of ''residential-duty commercial water heater'' codified at 10 CFR 431.102.

4. Storage-Type Instantaneous Water Heaters

The definitions of ''instantaneous water heater'' and ''hot water supply boiler'' set forth in 10 CFR 431.102 include CWH equipment with an input rating of at least 4,000 Btu/h per gallon of stored water. These definitions, therefore, include both instantaneous water heaters and hot water supply boilers without integral storage tanks, as well as instantaneous water heaters with integral storage tanks (but with at least 4,000 Btu/h of input per gallon of stored water). DOE believes these two groups of equipment—water heaters with and without integral storage tanks—are fundamentally different in their construction and application, and have different energy losses that need to be accounted for during efficiency testing. Consequently, DOE believes that instantaneous water heaters with an integral storage tank (''storage-type instantaneous water heaters'') should be tested in a manner similar to commercial storage water heaters. Therefore, in the May 2016 NOPR, DOE proposed to define ''storage-type instantaneous water heater,'' and to require that storage-type instantaneous water heaters be tested using the same test procedure as used for commercial storage water heaters. 81 FR 28588, 28607 (May 9, 2016). Specifically, DOE proposed to define ''storage-type instantaneous water heater'' as an instantaneous water heater that includes a storage tank with a submerged heat exchanger(s) or heating element(s).

In response to the May 2016 NOPR, NEEA and Joint Advocates agreed that storage-type instantaneous water heaters should be tested in a similar manner to storage water heaters. (NEEA, No. 30 at p. 1; Joint Advocates, No. 32 at p. 2) NEEA also agreed with DOE's proposed definition for ''storage-type instantaneous water heater.'' (NEEA, No. 30 at p. 1) Bradford White and A.O. Smith stated that a definition and equipment class for storage-type instantaneous water heaters are unnecessary. (Bradford White, No. 21 at p. 9; A.O. Smith, NOPR Public Meeting Transcript, No. 20 at p. 17) A.O. Smith also stated that storage-type instantaneous water heaters have always been tested like storage water heaters. (A. O. Smith, NOPR Public Meeting Transcript, No. 20 at p. 17) Several commenters stated that the definition of ''storage-type instantaneous water heater'' should not include a submerged heat exchanger or heating element because there are models on the market without a submerged heat exchanger that should be included in this class. (Bradford White, No. 21 at p. 12; AHRI, No. 26 at p. 13; A.O. Smith, No. 27 at p. 11; Raypak, No. 28 at p. 7; Rheem, No. 34 at p. 14)

While DOE's existing test procedures do not distinguish between storage water heaters and instantaneous water heaters, in this final rule, DOE is separating its test procedures for storage water heaters and instantaneous water heaters. Therefore, DOE disagrees with Bradford White and A.O. Smith, and believes a clarification of which test procedure to use for testing storage-type instantaneous water heaters and a definition for classifying storage-type instantaneous water heaters are warranted so as to eliminate any ambiguity.

After further assessment of tank-type water heaters currently on the market, DOE agrees with commenters that its proposed definition of ''storage-type instantaneous water heater'' excludes certain kinds of water heaters that should be included in this class. Specifically, the proposed requirement that a storage-type instantaneous water heater contain a submerged heat exchanger or heating element excludes units such as those with a water-tube heat exchanger located outside the tank, or models comprising a storage tank and a tankless water heater mounted to the side of the tank. Therefore, DOE is not including this specification for a submerged heat exchanger or heating element in the definition for ''storage-type instantaneous water heater'' established in this final rule.

In the absence of a specification for a submerged heat exchanger or heating element, DOE believes that the definition of ''storage-type instantaneous water heater'' needs an alternative specification to distinguish between tank-type water heaters and instantaneous-type water heaters that include a small holding tank (*e.g.,* 1–2 gallons). Both of these categories of water heaters would meet a definition that specifies only that a storage-type instantaneous water heater includes a tank. DOE believes that a storage volume of ten gallons effectively separates these two categories of water heaters, and this criterion aligns with DOE's current energy conservation standards, which include a standby loss standard for instantaneous water heaters with a storage volume greater than or equal to ten gallons.

Accordingly, in this final rule, DOE is adopting test procedures in the regulatory text at the end of this document that require testing of storage water heaters and storage-type instantaneous water heaters using the same procedures. DOE is also defining ''storage-type instantaneous water heater'' as an instantaneous water heater including a storage tank with a storage volume of ten gallons or greater.

H. Standby Loss Test for Instantaneous Water Heaters and Hot Water Supply Boilers

The current Federal standby loss test method for CWH equipment incorporates by reference Exhibit G.2 of ANSI Z21.10.3–2011 for determining the standby loss of instantaneous water heaters and hot water supply boilers with greater than 10 gallons of storage volume. 10 CFR 431.110. This test method assumes that the water heater would automatically initiate the next firing cycle when the internal water temperature (measured using the internal tank thermostat) falls below its allowable minimum value. This control system operation applies to some CWH equipment, but is not applicable to certain instantaneous water heaters and hot water supply boilers that require continuous water flow through the heat exchanger in order to activate the next firing cycle. Accordingly, in the May 2016 NOPR, DOE proposed a separate test method for ''flow-activated instantaneous water heaters,'' which DOE proposed to define as an instantaneous water heater or hot water supply boiler that does not activate the burner or heating element if no heated water is drawn from the unit. 81 FR 28588, 28607–28613 (May 9, 2016). DOE's proposed test method and the method adopted in this final rule are discussed in further detail in section III.H.3.

In addition to the proposed test procedure for flow-activated instantaneous water heaters, DOE also proposed in the May 2016 NOPR to update the standby loss test procedure for instantaneous water heaters and hot water supply boilers (other than flow-activated instantaneous water heaters and storage-type instantaneous water heaters). The existing Federal standby loss test procedure requires the measurement of the mean tank temperature to calculate the standby loss. Instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) are not equipped with an integral storage tank, and instead, most of the stored water is within the heat exchanger. Therefore, obtaining a measurement for the mean tank temperature would not be possible for such units, because heat exchanger geometry generally prevents an accurate internal stored water measurement that would be comparable to a mean tank temperature in tank-type models. DOE notes that the mean tank temperature for storage and storage-type instantaneous water heaters represents the hot water stored in the heat exchanger and that is subject to heat loss during the standby loss test. However, unlike storage water heaters and storage-type instantaneous water heaters, instantaneous water heaters and hot water supply boilers generally have water-tube heat exchangers [14] and do not store water at a uniform temperature inside the heat exchanger. Consequently, DOE proposed in the May 2016 NOPR to use the outlet water temperature as an approximation for the stored water temperature (instead of the mean tank temperature as required by Annex E.2 of ANSI Z21.10.3–2015, the latest industry test method). 81 FR 28588, 28615–28617 (May 9, 2016). In the May 2016 NOPR, DOE also proposed a storage volume determination test for all instantaneous water heaters and hot water supply boilers (including flow-activated instantaneous water heaters), similar to the method specified in section 5.27 of ANSI Z21.10.3–2015. 81 FR 28588, 28612 (May 9, 2016).

The following sections discuss the comments received in response to each of these proposals.

1. Definition of Flow-Activated Instantaneous Water Heater

As noted previously, in the May 2016 NOPR, DOE proposed to define ''flow-activated instantaneous water heater'' as an instantaneous water heater or hot water supply boiler that does not activate the burner or heating element if no heated water is drawn from the unit. 81 FR 28588, 28608 (May 9, 2016).

In response, NEEA and Bradley supported DOE's proposed definition for ''flow-activated instantaneous water heater.'' NEEA stated that the definition would allow such equipment to have a better delineation of efficiency. Bradley agreed that the proposed definition captures the types of water heaters that exist on the market. (NEEA, No. 30 at p. 1; Bradley, No. 33 at p. 1) A.O. Smith suggested that the proposed definition for flow-activated instantaneous water heater is not necessary and may cause confusion. (A.O. Smith, No. 27 at p. 11) Rheem suggested amending the definition of flow-activated instantaneous water heaters such that it does not include double-negative wording, and recommended defining ''flow-activated instantaneous water heater'' as a unit that activate the burner or heating element when water is drawn from the unit. Rheem also stated that, provided that the proposed definition is simplified, it encompasses all designs and models for which a separate standby loss test is warranted and would not inadvertently include models that do not need a separate standby loss test procedure from other CWH equipment. (Rheem, No. 34 at p. 15)

DOE disagrees with A.O. Smith's assertion that the definition could be unnecessary and cause confusion. On the contrary, DOE believes that adopting a definition for flow-activated water heaters will clarify the models for which the test procedure for flow-activated

[14] By water-tube heat exchangers, DOE refers to a heat exchanger where water flows inside heat exchanger tubes and is heated by a source of energy external to the tubes.

instantaneous water heaters is applicable. DOE considered the comments submitted by Rheem with regard to the language used in the proposed definition for ''flow-activated instantaneous water heater.'' DOE notes that the purpose of the proposed definition is to carve out water heaters that will activate the burner or heating elements only if hot water is drawn from the unit. Rheem's recommended wording would include any models that activate the burner or heating element when water is drawn from the unit, which could include some water heaters that are both flow-activated and thermostatically-activated. DOE notes that Rheem's suggestion changes the meaning of the proposed text; to achieve the same meaning as DOE's proposal would require the addition of ''only'' (*i.e.,* those water heaters where the burner or heating element activates *only* when water is drawn from the unit). Therefore, DOE adopts Rheem's suggestion to remove the double negative from the definition, and defines flow-activated water heaters as those that will only activate the burner or heating element if water is drawn from the unit.

2. Storage Volume Determination for Instantaneous Water Heaters and Hot Water Supply Boilers (Excluding Storage-Type Instantaneous Water Heaters)

The existing Federal standby loss test procedure for CWH equipment references Exhibit G.2 of ANSI Z21.10.3–2011, which in turn references section 2.26 of that standard to measure the storage volume of the water heater. The test method in 2.26 of ANSI Z21.10.3–2011 (renumbered to 5.27 of ANSI Z21.10.3–2015, the most recent version of the standard) is a weight-based method that requires the water heater to be weighed empty and then completely filled with water and weighed again. The total storage volume in the water heater is calculated using the difference in the weight of the water heater when full and empty. The 2015 version of ANSI Z21.10.3 includes a test method for measuring storage volume for tube-type water heaters in section 5.28. DOE reviewed this section and noticed that it does not provide a specific method to conduct the test and instead only states that the ''volume of water contained within the water heater shall be determined.'' In the May 2016 NOPR, DOE declined to propose adoption of section 5.28, noting that it would leave the decision of the appropriate method (*e.g.,* direct measurement, calculation) to individual manufacturers or testing agencies, who may choose different methods for determining the storage volume, which could produce inconsistent results. Rather, DOE proposed to continue using a weight-based test method to measure the storage volume of all instantaneous water heaters and hot water supply boilers excluding storage-type instantaneous water heaters. 81 FR 28588, 28607–28613 (May 9, 2016)

In response to this issue, AHRI, A.O. Smith, Bradley, Bradford White, and Rheem opposed DOE's proposal to require use of a test method similar to section 5.27 of ANSI Z21.10.3–2015 (*i.e.,* a weight-based method), to measure the storage volume of instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters). Specifically, AHRI and Bradley commented that they do not agree with the proposed test method because it is limited to the weight-based test method to determine the volume. Both commenters also stated that the determination of volume is critical only to determine whether the unit is subject to standby loss standards, and that many models currently have their stored water volume determined using calculations based on physical dimensions of water-containing parts. Both commenters argued that the alternative method of calculating the stored water volume based on physical dimensions eliminates the concern of residual water encountered in the weight-based test. Furthermore, the commenters stated that this method is useful in all cases except those with a calculated result that is approximately 10 gallons. (AHRI, No. 26 at p. 14; Bradley, No. 33 at pp. 3–4) A.O. Smith commented that DOE should accept the rated volume for appliances and allow volume determination other than through a weight-based method for small water heaters, and recommended using section 5.28 of ANSI Z21.10.3–2015 to measure the storage volume. A.O. Smith and Bradford White argued that many manufacturers purchase heat exchangers which will have residual water left over from hydrostatic testing. A.O. Smith stated that many water heaters have water passageways that do not allow the removal of water, and that such water heaters are filled for leak and operational testing before shipment. Therefore, manufacturers will never be able to test a completely dry water heater, thereby leading to inaccuracies in the measurement of the storage volume and standby loss. (A.O. Smith, No. 27 at p. 12; Bradford White, No. 21 at p. 10) A.O. Smith further argued that allowing the use of section 5.28 of ANSI Z21.10.3–2015 would not prohibit independent test laboratories from using a weight-based test method when no suitable alternative is available, and that manufacturers would be able to use more accurate test methods such as solid modeling and calculation-based methods. (A.O. Smith, No. 27 at p. 12) Bradford White suggested that DOE could include a weight-based test procedure for determining storage volume, but that it must include steps that include supplying pressurized air and tipping the product in different directions to assist the removal of residual water. However, Bradford White added that even with these measures, not all the water would be removed. (Bradford White, No. 21 at p. 10) Similarly, Rheem stated that due to hydrostatic testing, the water heater can never be emptied completely, so the dry weight can never be achieved. Rheem added that there are different methods of measuring volume of CWH equipment allowed by ANSI that include mathematical calculations and software modeling. Rheem recommended that DOE allow theoretical methods to determine water volume or that DOE set tolerances to account for residual water. (Rheem, No. 34 at p. 15)

DOE generally agrees with the concerns raised by the manufacturers. In particular, DOE is concerned that the weight-based test method specified in section 5.27 of ANSI Z21.10.3–2015 could lead to inaccurate representation of the storage volume due to the presence of residual water in the heat exchanger. Therefore, in this final rule, DOE is adopting provisions to allow for the determination of stored water volume based on calculations of the physical dimensions or design drawings (including computer-aided design (CAD) drawings) of the water-containing parts for instantaneous water heaters and hot water supply boilers. Despite the concerns with establishing a specific test method to determine the storage volume of instantaneous water heaters and hot water supply boilers, DOE notes that it must specify a test method that can be used to classify a basic model in the appropriate equipment class and to determine the applicable standard. DOE does not agree with AHRI's comment that the determination of storage volume is only necessary to determine whether the water heater is subject to standby loss standards (*i.e.,* whether it has a storage volume greater than or equal to 10 gallons). DOE notes that the measured storage volume is also required in the equations used to calculate the standby loss of CWH equipment. Therefore, DOE cannot leave the storage volume determination to the discretion of the manufacturer or testing/certifying agency. To address this issue, DOE has decided to adopt two test methods, either of which may be used to determine the storage volume of instantaneous water heaters and hot water supply boilers. Specifically, DOE has decided to allow for use of the weight-based test method (similar to section 5.27 of ANSI Z21.10.3–2015) as proposed in the May 2016 NOPR as one option, and to also permit the use of calculations for determining the stored water volume based on the physical dimensions or design drawings (including CAD drawings) of water-containing parts. DOE believes that these changes are generally consistent with the approaches used in ANSI Z21.10.3–2015, as discussed immediately above.

Along with changes in the test method, DOE is also making a corresponding amendment to its certification requirements for CWH equipment at 10 CFR 429.44, to require the certification of the method used to determine the storage volume of an instantaneous water heater or hot water supply boiler. DOE is also updating 10 CFR 429.72 with provisions to permit the use of physical dimensions (including design drawing and/or CAD models) to determine the storage volume based on calculations. In addition, DOE is requiring the retention of supplemental documents, including any design drawings and/or computer models, as well as documentation of the calculations performed to determine the water-carrying parts inside the water heater for any water heater models where the storage volume is determined based on calculations.

3. Standby Loss Test Procedures for Instantaneous Water Heaters and Hot Water Supply Boilers (Other Than Storage-Type Instantaneous Water Heaters)

DOE proposed two separate standby loss test procedures in the May 2016 NOPR—one for flow-activated instantaneous water heaters, and one for instantaneous water heaters and hot water supply boilers (other than flow-activated instantaneous water heaters and storage-type instantaneous water heaters). 81 FR 28588, 28607–28615 (May 9, 2016). The following sections describe the comments received in response to the proposed standby loss test methods, along with DOE's response.

DOE's proposed test method in the May 2016 NOPR would include the electricity consumed by the pump in the recirculating loop, if applicable, consistent with ANSI Z21.10.3–2015. In response to this proposal, Bradford White disagreed with including the electricity consumed by the pump in the recirculating loop (if used) in calculating the thermal efficiency of CWH equipment, stating that the recirculating loop would not be used in the field, and, thus, the pump energy should not be considered. (Bradford White, No. 21 at p. 11) DOE notes, however, that paragraph h.2 of Exhibit G.1 of ANSI Z21.10.3–2011 (currently incorporated by reference into DOE's test procedures) and Annex E.1 of ANSI Z21.10.3–2015 (the most recent update of the industry standard) require the measurement of the quantity of electricity consumed by the water heater components and the recirculating pump for conducting the thermal efficiency test. In this final rule, DOE is not promulgating a different set of requirements, instead DOE is only retaining the provisions that already exist in the current test procedure for electricity consumed by the recirculating loop. Therefore, DOE does not agree with Bradford White's suggestion that the energy used by the recirculating pump should not be measured for any type of water heater because this is part of the industry recognized test procedure in ANSI Z21.10.3.

a. Applicability of the Test Method

AHRI, A.O. Smith, and Rheem commented that the proposed test procedure for instantaneous water heaters and hot water supply boilers other than flow-activated instantaneous water heaters will not work for models that the test procedure intends to cover. (AHRI, No. 26 at p. 11; A.O. Smith, No. 27 at p. 14; Rheem, No. 34 at p. 17) AHRI and Rheem stated that many models, although not flow-activated, will act like a flow-activated instantaneous water heater during the standby loss test for which there will be no cut-in and subsequent cut-out. AHRI and Rheem recommended that the test procedure proposed for flow-activated instantaneous water heaters apply to all instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters). (AHRI, No. 26 at p. 11; Rheem, No. 34 at p. 17) A.O. Smith stated that circulating instantaneous water heaters are primarily operated based on a remote temperature sensor, which is not mentioned in DOE's test method and is presumed to be left in a state that would require the burner to fire continuously. (A.O. Smith, No. 27 at p. 14) Raypak commented that the equation presented in the NOPR for the standby loss test procedure for instantaneous water heaters and hot water supply boilers can result in negative standby loss values if the unit does not fire at any point during the standby loss test. (Raypak, No. 28 at p. 3) Lochinvar sought feedback on how the test method would work for instantaneous water heaters that do not have an internal call for heating. Specifically, Lochinvar stated that instantaneous water heaters that do not have a call for heating internally require an outside thermostat or aquastat to provide a call for heating, and that for such water heaters, there will be no second call for heating to end the test based on the proposal in the May 2016 NOPR. (Lochinvar, Public Meeting Transcript, No. 20 at p. 97)

DOE also received several comments that related only to the proposed test procedure for flow-activated instantaneous water heaters. A.O. Smith commented that the proposed test procedure for flow-activated instantaneous water heaters is not necessary and may cause confusion. A.O. Smith suggested that the test methods for all instantaneous water heaters and hot water supply boilers must be consistent, adding that demand-based controls and lack of a storage tank makes the traditional standby loss test impossible to use. To address this issue, A.O. Smith suggested a standby loss test that incorporates demand-based operation and measures inlet and outlet temperature, and stated that, if DOE does not accept the test procedure in ANSI Z21.10.3–2015, then the test procedure proposed for flow-activated instantaneous water heaters should be applied to all instantaneous water heaters and hot water supply boilers. A.O. Smith added that a common thermal efficiency and standby loss test should be used for both the flow-activated instantaneous water heaters and temperature-activated instantaneous water heaters to ensure a level playing field, and that no special arrangements are required for flow-activated instantaneous water heaters. (A.O. Smith, No. 27 at pp. 11–12 and 15) Rheem supported the proposal to base the test procedure for flow-activated instantaneous water heaters on the second part of the 2016 AHRI-recommended test method with some modifications. (Rheem, No. 34 at p. 16) Conversely, Bradley commented that it does not support basing the flow-activated instantaneous water heater standby loss test method on the second part of the 2016 AHRI-recommended test method; instead, it recommended using an alternative test method described in its comments. (Bradley, No. 33 at p. 4)

Based on the comments, it appears that instantaneous water heaters and hot water supply boilers can be categorized into three major categories based on the kind of feedback-control operation used: (1) Thermostatically-activated based on an internal call for heating (internally-activated instantaneous water heaters); (2) thermostatically-activated based on an external call for heating; and (3) flow-activated based on an external call for heating. As discussed previously, in the May 2016 NOPR, DOE proposed separate standby loss test procedures for flow-activated instantaneous water heaters (81 FR 28588, 28607–28613 (May 9, 2016)) and for instantaneous water heaters (excluding storage-type instantaneous water heaters) that are not flow-activated (81 FR 28588, 28615–28617 (May 9, 2016)). The standby loss test procedure proposed for instantaneous water heaters and hot water supply boilers that are not flow-activated only addressed units that are thermostatically-activated by an *internal* call for heating (or demand) and did not address units that are thermostatically-activated by an *external* call for heating. DOE agrees that the test procedure proposed for instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) that are not flow-activated, as proposed in the May 2016 NOPR, would not work for units that are thermostatically-activated based on an *external* call for heating. DOE understands that, for field applications of units that are activated by an *external* demand, the thermostat is typically placed in a remote location, such as in an unfired hot water storage tank, and is activated when the water in the tank cools down below the set point. In the context of the proposed standby loss test, unless the external control provides a call for heating (such a call for heating is not specified in either the existing or proposed standby loss test), the unit under test would not activate the burner or heating element during the standby loss test. Thus, the standby loss test proposed for instantaneous water heaters and hot water supply boilers (other than flow-activated instantaneous water heaters) would not be applicable to instantaneous water heaters that are thermostatically-activated by an external demand, because these units would not experience a call for heating, and therefore the burner or heating element(s) would not activate during the test. The test method for determining the standby loss of flow-activated instantaneous water heaters was designed to address units where the burner or heating element(s) may not activate during the test. Considering the comments received from the stakeholders, DOE agrees that the standby loss test procedure proposed for flow-activated instantaneous water heaters in the May 2016 NOPR can be used for externally thermostatically-activated instantaneous water heaters, as neither of these types of water heater would cut-in (*i.e.,* have the heating element or burner turn on) during the standby loss test. Therefore, DOE is making the test method adopted in this final rule for flow-activated instantaneous water heaters apply to externally thermostatically-activated instantaneous water heaters as well.

To address operational characteristics of externally thermostatically-activated instantaneous water heaters, the proposed standby loss test procedure in the May 2016 NOPR for flow-activated instantaneous water heaters must be modified slightly. These amendments include: (1) Adding provisions that require either removing the external call for heating, or turning off the fuel supply to the burners or electricity supply to the heating element (as applicable) after the steady-state conditions as specified in section III.F.1 are achieved prior to initiating the standby loss test; and (2) removing the fuel consumption terms from the equation to calculate the standby loss. Adopting the provisions to remove the external call for heating or turn off the fuel and electricity will ensure that there will be no fuel consumption (or electricity consumption for the purpose of heating water) during the course of the standby loss test. Therefore, the equations would not require the fuel consumption terms in the calculation for standby loss.

To simplify the regulatory text, DOE has decided to include all test procedures related to gas-fired and oil-fired instantaneous water heaters and hot water supply boilers under one appendix (*i.e.,* appendix C to subpart G of part 431). This differs from the approach proposed in the May 2016 NOPR, which would have provided a separate appendix for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers other than flow-activated instantaneous water heaters (proposed appendix C) and flow-activated instantaneous water heaters (proposed appendix E). Within appendix C adopted in this final rule, the thermal efficiency test and the steps prior to starting the standby loss test (*e.g.,* for verifying steady-state conditions) are common to all gas-fired and oil-fired instantaneous water heaters and hot water supply boilers. The standby loss tests for (1) thermostatically-activated instantaneous water heaters with internal thermostat; and (2) thermostatically-activated instantaneous water heaters with external thermostat and flow-activated instantaneous water heaters are described separately in the regulatory text.

In the May 2016 NOPR, DOE also proposed standby loss test procedures for electric instantaneous water heaters (contained in proposed appendix D) and electric flow-activated instantaneous water heaters (contained in proposed appendix E). 81 FR 28588, 28649–28650 (May 9, 2016). In this final rule, DOE has decided to include the standby loss test procedures for all electric instantaneous water heaters in appendix D to subpart G of part 431. Similar to the structure in appendix C, the steps in the standby loss test procedure prior to initiating the measurements for the standby loss test are the same for all electric instantaneous water heaters. The steps describing the conduct of the standby loss test are different for internally thermostatically-activated electric instantaneous water heaters and those that are either externally thermostatically-activated or flow-activated.

b. Applicability to Models With Less Than 10 Gallons of Stored Water Volume

In the May 2016 NOPR, DOE proposed standby loss test procedures for all gas-fired, oil-fired, and electric instantaneous water heaters and did not limit the use of the test procedure to less than 10 gallons of rated storage volume. 81 FR 28588, 28607, 28615 (May 9, 2016).

In response, Bradford White stated that it agrees with adopting a standby loss test applicable to units with rated storage volume less than 10 gallons, only if compliance with maximum standby loss standards is not required for such units. (Bradford White, No. 21 at p. 11) Bradley stated that flow-activated instantaneous water heaters having capacity less than 10 gallons contain little thermal energy, and that developing a test procedure for such units is unnecessary. According to Bradley, the thermal energy loss of their electric-instantaneous flow-activated models with less than 10 gallons of storage capacity is less than 600 Btu/h (157 Watts). Bradley stated that these units will not function effectively unless water in the unit is minimized and that typically these units contain small volumes—often less than two gallons of water. Bradley argued that, due to low volumes, the units have a very limited amount of stored energy, and suggested that DOE should simplify the test method based on an assumption that the temperature of the water stored in the unit will drop to the ambient temperature within a one-hour time period. Bradley further stated that due to the nature of its water heaters, the burden to test them for standby loss would be high, while not resulting in any meaningful energy savings, but that its suggested clarifications and simplifications to the test procedure would help in reducing the burden. (Bradley, No. 33 at pp. 1–3)

In response to these comments, DOE notes that the current maximum standby loss standards for instantaneous water heaters are only applicable to gas-fired and oil-fired instantaneous water heater models with rated storage volume greater than or equal to 10 gallons. 10 CFR 431.110. Therefore, manufacturers are currently not required to test and certify their instantaneous water heaters and hot water supply boilers for standby loss, if the model has a rated storage volume less than 10 gallons. DOE further notes that in the NOPR for energy conservation standards for CWH equipment that was published in the **Federal Register** on May 31, 2016, DOE did not propose to prescribe standby loss standards for electric instantaneous water heaters and gas-fired and oil-fired instantaneous water heaters with rated storage volume less than 10 gallons. 81 FR 34440. Although in this test procedure final rule, DOE is prescribing a test procedure that could be used to test all instantaneous water heaters for standby loss, manufacturers are not required to test and certify units that are not subject to energy conservation standards. However, if a manufacturer chooses to make representations for standby loss for an instantaneous water heater or hot water supply boiler with a rated storage volume less than 10 gallons, then it must do so using DOE's test procedures specified in Appendix C or Appendix D to subpart G of part 431 (as applicable). In this final rule, DOE is adopting standby loss test procedures for all gas-fired, oil-fired, and electric instantaneous water heaters without limiting its applicability based on rated storage volume.

DOE also considered the simplified test method suggested by Bradley in its comments. The test procedure suggested by Bradley restricts the time period of the standby loss test to one hour and removes the electricity consumption terms from the standby loss equation. DOE addressed similar issues related to the test duration in the May 2016 TP NOPR, in which it discussed the disadvantages of having a set time duration to conduct the standby loss test. 81 FR 28588, 28611 (May 9, 2016) As discussed in the May 2016 NOPR, the standby mode operation of flow-activated instantaneous water heaters resembles a complete cool-down test where the main burner or heating element does not activate at any point during the test. Simply assuming that the water heater loses all stored thermal energy over a one-hour period ignores the fact that the rate of heat loss is dependent on the insulation and design of the water heater itself, and models with different insulation thicknesses and heat exchanger designs will lose heat at different rates. 81 FR 28588, 28611 (May 9, 2016). Accordingly, if the duration of the test were set to one hour, this could lead to an inaccurate comparison of the standby loss between two water heaters that lose heat at different rates because some water heaters may reach ambient temperature much more quickly than that and others much more slowly. For example, a water heater that cools to ambient temperature in 5 minutes would have the same standby loss rating as a water heater that reaches ambient in a period of 50 minutes. In addition to yielding the same standby loss for two models that would otherwise have significantly different standby loss ratings, the assumption would likely understate the standby loss by assuming the loss occurs over the full duration of an hour, rather than the actual amount of time it takes for the thermal energy to be lost, which according to Bradley is generally less than an hour. The suggested simplified test method also does not account for electrical consumption during the course of the test. The electrical consumption during the standby loss test is mainly due to electricity provided to keep the controls and non-water-heating functions running during the standby loss test. This electricity consumption is also accounted for in the current standby loss equations in the test procedures in Exhibit G.2 of ANSI Z21.10.3–2011, incorporated by reference as DOE's standby loss test procedure for storage and instantaneous water heaters and set forth in 10 CFR 431.106. Therefore, in this final rule, DOE has decided not to make changes to its proposed standby loss equations based on the comments provided by Bradley.

c. Turning Off Supply and Outlet Water Valves Simultaneously

The standby loss test procedures for flow-activated instantaneous water heaters and all other instantaneous water heaters and hot water supply boilers (except storage-type instantaneous water heaters) proposed in the May 2016 NOPR required the water pump and supply and outlet water valves to be shut off simultaneously to start the standby loss test. 81 FR 28588, 28607, 28615 (May 9, 2016) This proposal was related to DOE's tentative decision in the May 2016 NOPR to install the supply water valve at a distance of 5 inches away from the water heater in the supply water connection and the outlet water valve at a distance of 10 inches away from the water heater in the outlet water connection in order to reduce the effect of heat loss due to mixing with water in the piping during the standby loss test. 81 FR 28588, 28613–28615 (May 9, 2016). DOE received several comments on the placement of the supply and outlet water valves that are discussed and addressed in section III.I.3 of this final rule. The following paragraphs discuss the comments received with regard to turning off the supply and outlet water valves simultaneously at the start of the standby loss test.

AHRI, A.O. Smith, Bradford White, and Raypak opposed the proposed requirement that the supply water valve and outlet water valve (and water pump) be turned off simultaneously when initiating the standby loss test for instantaneous water heaters and hot water supply boilers. The commenters stated that the proposed test method may lead to unsafe operating conditions and/or may trigger the relief valve to open if the water heater burner or elements activate to satisfy a call for heating during the standby loss test. AHRI, A.O. Smith, Bradford White, Raypak, and Rheem recommended that only the outlet water valve be closed at the start of the standby loss test and the supply valve be kept open at all times. (AHRI, No. 26 at p. 11; A.O. Smith, No. 27 at p. 13; Bradford White, No. 21 at p. 11; Raypak, No. 28 at p. 3; Rheem, No. 34 at p. 16) AHRI and Rheem stated that the outlet valve is sufficient to stop the flow while allowing thermal expansion to occur during the test. (AHRI, No. 26 at p. 11; Rheem, No. 34 at p. 16) Similarly, A.O. Smith commented that, if there is heat added to the heat exchanger after the flow is stopped, there must be an allowance for thermal expansion of the water. A.O. Smith added that in the proposed test procedure, the closing of the supply and outlet water valves isolates the water heater, and if the control is set to a call for heating at all times, the water heater may continue to fire until the water temperature reaches the high safety limit. This could result in the formation of superheated steam and blow off the pressure relief valve. (A.O. Smith, No. 27 at pp. 14–15)

DOE agrees with the comments received from the stakeholders citing safety concerns while conducting the standby loss test as proposed in the May 2016 NOPR. To address this issue, DOE has decided to remove the requirement to turn off the supply water valve during the conduct of the standby loss test. Instead, the standby loss test procedures adopted for instantaneous water heaters and hot water supply boilers only require turning off the outlet water valve and the water pump at the start of the test. DOE has also made several amendments to its test set-up proposed in the May 2016 NOPR, including ones related to the standby loss test procedure. These amendments and the related comments are discussed in section III.I of this final rule.

d. Approximation of Stored Water Temperature Based on Water Temperature at the Outlet

As discussed previously, in the May 2016 NOPR DOE tentatively decided to use the outlet water temperature as an approximation for the mean tank temperature to conduct the standby loss test for flow-activated instantaneous water heaters and other instantaneous water heaters (except for storage-type instantaneous water heaters). 81 FR 28588, 28607, 28615 (May 9, 2016).

In response to this proposal, Raypak stated that because DOE proposed not to adopt the test procedures in ANSI Z21.10.3–2015 for flow-activated instantaneous water heaters and instantaneous water heaters and hot water supply boilers (other than flow-activated instantaneous water heaters and storage-type instantaneous water heaters), it does not support the use of outlet water temperature as a conservative estimate for the mean tank temperature. Instead, Raypak recommended using the average of the supply and outlet water temperature (Raypak, No. 28 at p. 4) Raypak also stated that it supported DOE's decision to not use an external tank to measure the mean tank temperature. (Raypak, No. 28 at p. 7) Rheem also recommended that instead of using the outlet water temperature as an approximation for the stored water temperature, DOE use an average of the inlet and outlet water temperature. Rheem added that DOE's proposal is better suited for gas-fired flow-activated instantaneous water heaters than for electric flow-activated instantaneous water heaters. (Rheem, No. 34, at pp. 16–17) Bradley supported using the outlet water temperature as an approximation for the stored water temperature, but also reiterated that the calculation of standby loss for water heaters with very low volume is wasteful, burdensome, and unnecessary (see section III.H.3.b for further discussion of Bradley's comment on standby loss for water heaters with very low volumes). (Bradley, No. 33 at p. 4) The Joint Advocates supported DOE's determination that outlet water temperature is an appropriate reference for the standby loss test (rather than the mean tank temperature). (Joint Advocates, No. 32 at p. 2)

A.O. Smith stated that the assumption that stored water temperature is the key to standby loss for instantaneous water heaters does not take into consideration that: (1) More heat may be stored in the heat exchanger than the water itself; (2) there is a non-uniform water temperature in the heat exchanger which increases from inlet to outlet; and (3) gravity circulation may lead to a decrease in the outlet water temperature that is not due to the heat loss to the atmosphere. A.O. Smith suggested using the average of the inlet and outlet water temperature to approximate the stored water temperature. (A.O. Smith, No. 27 at p. 13)

DOE also received several comments on this issue at the NOPR public meeting. Bradley stated that for electric instantaneous water heaters with a 70 °F inlet and 140 °F outlet, assuming the outlet water temperature as an approximation for stored water temperature would be a large penalty. However, Bradley also agreed that inserting temperature probes in the heat exchanger would be difficult. (Bradley, Public Meeting Transcript, No. 20 at p. 103) AHRI stated that inserting a temperature probe inside the heat exchanger is difficult and suggested that the outlet water temperature probe be used as point of reference for the standby loss test since a temperature probe is already required for measurement of the water close to the outlet of the water heater in the thermal efficiency test. (AHRI, Public Meeting Transcript, No. 20 at pp. 104–105)

In the May 2016 NOPR, DOE considered several options for estimating the stored water temperature inside the water heater for developing the proposed standby loss test procedure for instantaneous water heaters and hot water supply boilers. 81 FR 28588, 28616 (May 9, 2016). Among the options, DOE considered using an average of the supply and outlet water temperature as an estimation of the stored water temperature inside the heat exchanger. DOE weighed this option against the option of using the outlet water temperature as an approximation for the stored water temperature inside the heat exchanger. Ultimately, DOE proposed to use the outlet water temperature as an approximation, because it was included in the industry-adopted test method for flow-activated instantaneous water heaters, specifically in Annex E.3 of ANSI Z21.10.3–2015. DOE notes that using the average of the supply and outlet water temperature as an estimate for the stored water temperature is only valid if the water temperature inside the heat exchanger has a linear increase in temperature as it moves from the inlet to the outlet. Considering the kinds of heat exchangers that are typically used in instantaneous water heaters and hot water supply boilers (*e.g.,* fin-tube, helical condensing heat exchangers), DOE does not believe this assumption to be valid. Instead, DOE expects that the mass-weighted average temperature of the water inside the heat exchanger is likely to be higher than the simple average of the water temperature between the supply and the outlet, because the rate of heat transfer from the burner to the water decreases as the water temperature rises in the heat exchanger. Therefore, as the water moves through the heat exchanger and approaches the required outlet water temperature, it takes longer for its temperature to rise further, and thus, the mass-weighted average of the water in the heat exchanger is higher than the simple average between supply and outlet water temperature.

DOE agrees that using the average between the supply and outlet water temperature is a simple approach; however, this method is not sufficiently accurate to represent the temperature of water stored in the heat exchanger. Further, inserting probes deep inside the heat exchanger to accurately capture the stored water temperature would result in a more accurate reading of the water temperature within the heat exchanger, but would be significantly burdensome to achieve and difficult to ensure consistency in the placement of the temperature sensor, thereby decreasing repeatability. Using the outlet water temperature as an approximation for the stored water temperature should be more representative of the stored water temperature than using a simple average between the supply and outlet water temperature and less burdensome than inserting probes deep inside the heat exchanger. After careful consideration and based on the discussion above, DOE is not adopting the simple average of the supply and outlet water temperature as an approximation for the stored water temperature. Instead, the outlet water temperature serves as an approximation for the stored water temperature. This is consistent with the industry test method specified in Annex E.3 of ANSI Z21.10.3–2015 and provides for a conservative test result where a large amount of uncertainty exists in estimating the stored water temperature in the heat exchanger.

e. Pump Purge

The proposed standby loss test procedure for instantaneous water heaters and hot water supply boilers (including the proposed test procedure for flow-activated instantaneous water heaters) in the May 2016 NOPR would require the test to be initiated immediately after turning off the supply and outlet water valves and water pump. 81 FR 28588, 28613 (May 9 2016).

DOE received several comments from stakeholders opposing a requirement to start the test immediately following the close of the supply and outlet water valves and the water pump. Specifically, Raypak argued that the proposed test procedure for instantaneous water heaters and hot water supply boilers does not take into consideration pump purge functionality,[15] and there are several models on the market that include such functionality. Raypak recommended that the standby loss test be started only after the pump purge period has ended. (Raypak, No. 28 at pp. 3,4,7; Raypak, Public Meeting Transcript, No. 20 at p. 90) Rheem stated that post-purge operation of the water heater needs to be addressed in the test procedure because the functionality is used to reduce standby loss by removing residual heat from the water heater. (Rheem, No. 34 at p. 16) AHRI stated that some models use pump purge to remove heat from a water heater that is used to service the hot water system, so the standby loss test should not start until the pump purge operation is complete. (AHRI, No. 26 at p. 12) A. O. Smith stated that many instantaneous water heaters have an integral pump with a delay that continues to circulate water through the heat exchanger for a limited time (30 seconds to 3 minutes) to move residual hot water from the heat exchanger to the storage tank. A. O. Smith recommended that the outlet water valve and water pump be turned off after the pump delay is complete. (A. O. Smith, No. 27 at p. 13)

DOE agrees with commenters that pump purge functionality is useful in removing the hot water stored in the water heater for use in the system. Thus, DOE also agrees with the recommendations from the stakeholders that the unit should be tested after the pump purge has ended. To accommodate pump purge operation, DOE will require the outlet water valve to remain open after the burner has cutout until the water pump has turned off. Further, DOE will require the loss in thermal energy recorded during the standby loss test and represented by the temperature difference term ΔT_1, to be measured after the pump purge operation ends. Specifically, DOE modifies the definition of the term 'ΔT_1' to refer to the heat exchanger outlet water temperature measured at the end of pump purge minus the heat exchanger outlet water temperature measured at the end of the test.

Therefore, in this final rule DOE adopts the following updates to the standby loss test for instantaneous water heaters and hot water supply boilers that are equipped with pump purge functionality: (1) Require the outlet valve to remain open until the pump purge operation is complete and then close the outlet water valve after the pump shuts down; (2) measure the thermal energy loss after the pump purge operation is complete and (3) end the standby loss test after the pump purge operation is completed and when the heat exchanger outlet water temperature has decreased by 35 °F from its value measured at the start of the test (*i.e., starting from the point* when the main burner(s) or heating element(s) cut-out). If, after a pump purge operation, the outlet water temperature has dropped by 35 °F or more, from its value after the burner(s) or heating element(s) cuts-out, then the test must be stopped after the pump purge is complete. All the required parameters must be recorded for the entire standby loss test, including the pump purge operation.

Considering the comments received, DOE revises the standby loss test procedure proposed in the May 2016 NOPR for flow-activated instantaneous water heaters to include additional provisions that account for pump purge functionality. DOE adds a requirement to measure the heat exchanger outlet water temperature immediately after the main burner(s) or heating element(s) cut out and clarifies that the outlet water valve must be kept open until the water pump shuts down. After the water pump shuts down, the outlet water valve must be closed and the recording of all required parameters for the standby loss test is started. The test is stopped once the heat exchanger outlet water temperature decreases by 35 °F from the temperature measured when the burner(s) or heating element(s) cut-out before the pump purge operation. DOE has included these modifications to the test procedure in Appendix C (for gas-fired and oil-fired equipment) and Appendix D (for electric equipment) to subpart G of part 431.

DOE also adopts provisions at 10 CFR 429.44 to require certifying whether the unit has pump purge functionality. These amendments are discussed further in section III.N of this final rule.

f. Temperature Rise Requirement and End of Test Criteria for Instantaneous Water Heaters

The proposed standby loss test procedures for instantaneous water heaters and hot water supply boilers (including flow-activated and externally thermostatically-activated instantaneous water heaters) would require water to be supplied at a temperature of 70 °F ± 2 °F; the fuel supply to be at the unit's full firing rate; and the water flow rate to be adjusted to achieve and maintain 70 °F ± 2 °F above the supply water temperature before achieving steady-state condition prior to the standby loss test. 81 FR 28588, 28613 (May 9, 2016). The proposed standby loss test for flow-activated and externally thermostatically activated instantaneous water heaters would be stopped once the outlet water temperature decreases by 35 °F ± 2 °F Id. at 28612–28613. DOE received several comments on the criteria for determining the end of the test and the requirement to achieve steady state with a temperature rise of 70 °F ± 2 °F.

With regard to the criteria for determining the end of the standby loss test, A. O. Smith stated that the 35 °F ± 2 °F decrease in outlet water temperature is inappropriate because a greater proportion of heat is stored in the mass of the heat exchanger rather than the water stored in the heat exchanger, which according to A. O. Smith is not equal to the outlet water temperature. A. O. Smith further stated that internal circulation within the water heater equalizes the temperature in the heat exchanger without actually losing heat to the ambient air. (A. O. Smith, No. 27 at pp. 12–13). Bradley supported the 35 °F drop in outlet water temperature as the criterion for ending the test, but noted that for water heaters with small volumes, the decrease in outlet water temperature will be due to

[15] Pump purge functionality allows the water pump to remain on for a short period after the main burner cuts out, which purges heated water from the unit, thereby reducing standby losses.

internal mixing and not losses to the ambient air. (Bradley, No. 33 at p. 1–3)

In the May 2016 NOPR, DOE considered the merits of establishing a specific temperature decrease criterion to stop the standby loss test as compared to a specific time duration. 81 FR 28588, 28611–28612 (May 9, 2016). In the May 2016 NOPR DOE noted that setting a specific time criterion ignores the fact that different water heaters could lose heat to the ambient air at different rates. Although DOE recognizes A. O. Smith's concerns regarding heat contained in the heat exchanger and possible mixing, DOE notes that the commenter did not suggest an alternative stopping criterion. Furthermore, DOE maintains its conclusion and rationale from the NOPR that setting a specific time criterion is not appropriate, and agrees with Bradley that a 35 °F drop in outlet water temperature as the criterion for ending the test is appropriate. Therefore, in this final rule, DOE has decided to adopt the proposed stopping criteria: That the standby loss test for all externally thermostatically-activated and flow-activated instantaneous water heaters be stopped when the outlet water temperature decreases by 35 °F ± 2 °F (as was proposed in the May 2016 NOPR for flow-activated instantaneous water heaters).

On the issue of achieving an outlet water temperature of 70 °F ± 2 °F above the supply water temperature, Bradley stated that certain of its water heater models have physical and tertiary temperature limit safety devices that cannot be safely overridden and will not be able to meet the proposed 140 °F outlet temperature condition. (Bradley, No. 33 at p. 4) Rheem and AHRI commented that certain water heating technologies cannot achieve the 70 °F temperature rise to reach the 140 °F outlet water temperature condition, and suggested the use of 70 °F temperature rise or the maximum designed outlet water temperature, whichever is greater. (Rheem, No. 34 at p. 16; AHRI, No. 26 at p. 11)

In response, DOE acknowledges the concerns raised and adopts the changes suggested by AHRI and Rheem with regards to instantaneous water heaters that are unable to achieve the required outlet water temperature due to in-built safety mechanisms. In this final rule, DOE adopts provisions that would allow such units to be tested using the maximum outlet water temperature that the unit is capable of achieving.

I. Test Set-Up for Commercial Instantaneous Water Heaters and Hot Water Supply Boilers

In the May 2016 NOPR, DOE proposed several amendments to the current test set-up for commercial instantaneous water heaters and hot water supply boilers (including flow-activated instantaneous water heaters). These proposed amendments include: (1) Specifying the location for measuring the outlet water temperature; (2) specifying the location for placing the supply and outlet water valves; (3) adding provisions for commercial equipment with multiple outlet water connections; and (4) adding conditions for using a recirculating loop. 81 FR 28588, 28613–28615 (May 9, 2016). DOE received several comments from manufacturers and industry representatives in response to each proposed amendment in the test set-up, which are discussed in detail in the sections immediately below.

1. Location of Outlet Water Temperature Measurement

The existing thermal efficiency and standby loss test methods as described in ANSI Z21.10.3–2011 and incorporated by reference into DOE's test procedures at 10 CFR 431.107 require commercial instantaneous water heaters and hot water supply boilers to be set up in accordance with Figure 2 of ANSI Z21.10.3–2011. Neither Figure 2 nor the text of DOE's test method, provide an exact location for measuring the outlet water temperature. If the outlet water temperature is measured at a significant distance away from the water heater, it could lead to an inaccurate representation of the outlet water temperature due to heat loss in the piping, particularly during the standby loss test. Thus, to ensure consistency and repeatability of the test, in the May 2016 NOPR, DOE proposed to specify a requirement for the distance of the outlet temperature sensor from the water heater jacket. Further, in the May 2016 NOPR, DOE proposed to use the outlet water temperature as an approximation for the temperature of stored water contained in the heat exchanger. Therefore, it was important in the context of the May 2016 NOPR proposal that the outlet water temperature be measured as close as possible to the water heater to minimize the effect of piping heat losses and to obtain a more accurate approximation of the stored water temperature inside the heat exchanger, while conducting the standby loss test. Specifically, in the May 2016 NOPR, DOE proposed that the tip or junction of the temperature sensor be placed at a distance of less than or equal to 5 inches from the water heater jacket, at the central axis of the water pipe, and with a radiation protection shield. The proposal left the type and number of temperature-sensing instruments to the discretion of the testing operator. 81 FR 28588, 28614 (May 9, 2016).

Bradford White, AHRI, A. O. Smith, Raypak, Rheem, and Lochinvar disagreed with DOE's proposed location for measuring the outlet water temperature for both the thermal efficiency and standby loss tests. The commenters argued against moving the outlet water temperature sensor from its current location, because the current location includes two elbows in the outlet water piping connection, before the outlet water temperature measurement, which induces turbulent flow and improves mixing of water in the pipes, leading to a better representation of the outlet water temperature. (Bradford White, No. 21 at p. 10; AHRI, No. 26 at p. 10–11; A. O. Smith, No. 27 at p. 14; Raypak, No. 28 at p. 3; Rheem, No. 34 at p. 17; Lochinvar, Public Meeting Transcript, No. 20 at p. 87) Bradford White stated that measuring the outlet water temperature a significant distance away from the water heater would not lead to an inaccurate representation unless the pipes are poorly insulated. (Bradford White, No. 21 at p. 10) Raypak commented that requiring the outlet water temperature sensor to be within 5 inches of the water heater during the thermal efficiency test would make the measurement extremely difficult or physically impossible, especially for larger fuel input rates. However, Raypak suggested that, for the standby loss test, the outlet water temperature could be measured at the outlet or possibly inside the water heater jacket, and recommended adopting separate test set-up figures for conducting the thermal efficiency and standby loss tests. (Raypak, No. 28 at pp. 3–4) Bradford White suggested requiring additional thermocouples to be inserted into the outlet of the water heater for the standby loss test. (Bradford White, No. 21 at p. 10) AHRI also suggested adding another temperature-sensing means, and suggested that it be installed one-inch inside the water heater's outlet to measure the maximum temperature of the water in the unit. (AHRI, No. 26 at p. 11) Raypak stated that as a unit size increases, it may become increasingly difficult to add temperature-sensing means and water valves at the distances proposed in the May 2016 NOPR, and recommended that DOE consider specifying the locations in terms of pipe diameters rather than exact distances. (Public Meeting Transcript, No. 20 at pp. 86–87)

AHRI recommended that DOE require an instantaneous water heater to be tested using the test set up in figures 1, 2 and 3 proposed for storage water heaters in the May 2016 NOPR (*see* 81 FR 28588, 28599–28600). (AHRI, No. 26 at p. 10)

Bradley Corporation suggested that the requirements for test set-up should include the phrase ''water heater jacket or enclosure,'' to specify the location for measuring ambient room temperature, test air temperature, ambient relative humidity, and air draft, because there are no jackets for instantaneous water heaters. (Bradley, NOPR Public Meeting Transcript, No. 20 at p. 33) After considering these comments, DOE has decided to retain the two elbow fittings in the outlet water piping before the outlet water temperature measurement for the thermal efficiency test, as DOE agrees with the suggestions from the commenters that the elbows will improve the water mixing and allow for a more accurate measurement of the outlet water temperature during the thermal efficiency test. Nevertheless, DOE continues to believe that specifying the distance of the measurement from the water heater will improve repeatability without adding burden to the test, as it will ensure consistent placement of the outlet water temperature sensor. As a result, DOE has modified Figure III.4 as proposed in the May 2016 NOPR to require the outlet water temperature sensor be installed at the second elbow in the outlet water piping for the thermal efficiency test. DOE is also adopting AHRI's recommendation to permit the use of the test set-ups specified in Figure III.1, Figure III.2, and Figure III.3 of the May 2016 NOPR (and shown as figures 2.1, 2.2, and 2.3 in Appendix A to subpart G in the regulatory text of this document) to test instantaneous water heaters that do not require a recirculating loop for testing (see section III.I.5). As a result, DOE has also modified the piping configuration in Figure III.4 of the May 2016 NOPR to match the total piping lengths specified for the test set-up for water heaters with horizontal opening water connections (as shown in Figure III.3 of this final rule). Specifically, DOE is specifying a measurement location for the outlet water temperature sensor, similar to storage water heaters at a horizontal piping length of 6 inches and vertical piping length of 24 inches from the outlet port of the water heater. These distances are comparable to the distances specified for storage water heaters and address Rheem's concern about equitable distances for both storage and instantaneous water heaters. DOE concludes that these changes are consistent with the industry test method, ANSI Z21.10.3–2015, and simply provide additional detail and clarification to improve the repeatability of the test. The amended test set-up for instantaneous water heaters and hot water supply boilers to be tested with a recirculating loop is shown in Figure III.4 of this final rule.

Further, in response to Raypak's comment regarding specifying the pipe length in terms of multiples of pipe diameter, DOE believes that given the increase in distance of the outlet water temperature sensor from the outlet water port adopted in this final rule, specifying distance in terms of pipe diameters is not necessary. In addition, DOE is not aware of any units for which it would not be possible to measure the outlet water temperature at the distance adopted in this final rule. Therefore, DOE has decided to maintain the required distance for installing the outlet water temperature sensor in terms of total piping length rather than pipe diameter.

For the standby loss test, DOE believes and as noted in the comments, there is merit to installing the outlet water temperature measurement probe as close as possible to the water heater to accurately represent the temperature of water stored inside the heat exchanger during the standby loss test. Thus, DOE has decided to adopt separate locations for measuring outlet water temperature for the thermal efficiency test and standby loss test for instantaneous water heaters and hot water supply boilers. Specifically, for the standby loss test, based on the recommendations of commenters, the outlet water temperature sensors must be installed in the outlet water piping within one inch (either inside or outside) of the outlet water port. To avoid confusion with the outlet water temperature measured in the thermal efficiency test, DOE designates this temperature measurement ''heat exchanger outlet water temperature,'' denoted as ''T_{OHX}.'' As a result, DOE has modified Figure III.1, Figure III.2, Figure III.3, and Figure III.4 proposed in the May 2016 NOPR by adding an extra temperature sensor, T_{OHX}, at a distance of one-inch from the outlet port of the water heater (either inside or outside).

With regard to Bradley's comment on including the term ''enclosure'' with the term ''water heater jacket,'' DOE agrees that the suggested phrase better encompasses the range of instantaneous water heater designs and is adding the term to the ambient condition measurement location requirements adopted in this final rule for instantaneous water heaters.

Figure III.1, Figure III.2, Figure III.3, and Figure III.4 (for units tested with a recirculating loop) of this final rule show the required location of the outlet water temperature measurement and the heat exchanger outlet water temperature measurement that DOE adopts in this final rule for the thermal efficiency test and standby loss test, respectively, for instantaneous water heaters and hot water supply boilers.

2. Multiple Outlet Water Connections

In the May 2016 NOPR, DOE proposed that for instantaneous water heaters with multiple outlet water connections, the outlet water temperature be maintained at 70 °F ± 2 °F at each outlet connection, and the average outlet temperature for use in the subsequent calculations be determined as the average of the values measured at each connection leaving the water heater jacket. 81 FR 28588, 28614 (May 9, 2016). In response, Bradford White disagreed with DOE's proposal to require measurement of the outlet temperature at each outlet connection, arguing that the proposed changes are overly burdensome due to the addition of more thermocouples and complex piping configurations that the proposed changes may result in. Bradford White stated that multiple outlets are sometimes included on products to accommodate different field piping configurations that may be encountered in replacement installations, and that not all connections are intended to be used in the field. (Bradford White, No. 21 at p. 11)

DOE clarifies that the provisions proposed for multiple outlet water connections were intended to apply to equipment that is designed to use both (or multiple) outlet water connections simultaneously during field operation, such as models that contain two individual units assembled or stacked together and are sold as a single, larger unit. Such units typically employ external piping to combine the multiple supply and outlet water connections (respectively) to form a single supply and single outlet water connection for the entire water heater. To achieve the fuel input rate for which the model is designed and rated, both sub-units need to be supplied with water and fired at their respective full firing capacities. If a model consists of redundant outlet water connections that can be used optionally to accommodate various field piping configurations, and the outlet water connection does not need to be operated to achieve the rated input for the model, then the outlet water provisions are not required to be applied to such outlet water connections. Therefore, in this final rule, DOE retains the provisions for placement of temperature sensors for measuring outlet water temperatures for the thermal efficiency and standby loss tests for instantaneous water heaters and hot water supply boilers equipped with multiple outlet water connections, and DOE clarifies in the regulatory text that these requirements are only applicable if the simultaneous use of those outlet connections is necessary to achieve the rated input during testing.

DOE also adopts changes for water heaters with multiple outlet water connections to reflect the changes discussed in section III.I.1 with regard to the placement of the outlet water temperature sensors for the thermal efficiency and standby loss test. The outlet water temperature sensor placement provisions discussed in section III.I.1 (as applicable) must be applied to all outlet water connections leaving the water heater that are required to be used to achieve the designed fuel input rate for the thermal efficiency and standby loss test.

3. Supply and Outlet Water Valves

The current test procedure for instantaneous water heaters and hot water supply boilers does not clearly indicate the location and installation of the supply and outlet water valves. In the May 2016 NOPR, DOE proposed to require supply and outlet water valves to be installed within a specified distance of the water heater. Specifically, for instantaneous water heaters and hot water supply boilers shipped without external piping installed at the point of manufacture, DOE proposed to require that the supply water valve be installed within 5 inches of the jacket, and the outlet water valve be installed within 10 inches of the jacket. For instantaneous water heaters and hot water supply boilers with external piping assembled at the manufacturer's premises prior to shipment, DOE proposed to require that the supply and outlet water valves be installed within 5 inches of the end of the piping shipped with the unit. 81 FR 28588, 28614 (May 9, 2016).

Bradford White disagreed with DOE's proposed changes, stating that moving the inlet and outlet water valves closer to the unit being tested would not provide more accurate test results. Bradford White also expressed concern with the depiction of the pressure relief valve outside the outlet water valve in DOE's proposal. (Bradford White, No. 21 at p. 11)

As discussed in section III.H.3, DOE received several comments from stakeholders on its proposal to require that testers turn off both the supply and outlet water valves while conducting the standby loss test for instantaneous water heaters and hot water supply boilers (including flow-activated instantaneous water heaters). In summary, after considering those comments DOE has decided to not adopt the proposed requirement to turn off the supply water valve during the standby loss test to address concerns expressed by stakeholders about safety and thermal expansion of the water inside the water heater. As a result of this decision, DOE will not require the supply water valve to be placed at a distance of 5 inches away from the water heater jacket. With regards to the outlet water valve, DOE believes there is merit in placing the valve close to the unit and turning it off during the standby loss test. Locating the outlet water valve close to the unit would prevent the outlet water from mixing with water in the downstream water piping and thereby reduce heat lost from mixing with water contained in the piping, which DOE believes will result in a more repeatable test since the distance of piping before the valve (and therefore the volume of water in the piping) would be consistent across tests. DOE also believes that installing the outlet water valve close to the unit and turning it off during test will more accurately account for the standby loss of the unit, as it would reduce the effect of piping losses during the test. Therefore, while DOE agrees with not requiring the supply water valve to be placed close to the unit, DOE has decided to adopt provisions for placing the outlet water valve close to the water heater. In section III.I.1of this final rule, based on the comments received, DOE decided to permit instantaneous water heaters and hot water supply boilers to be set up as per Figure III.1, Figure III.2, and Figure III.3 (as applicable) for conducting the thermal efficiency and standby loss test (see section 2.2 of Appendix C to Subpart G and section 2.2 of Appendix D to Subpart G). As a result of this amendment, the water heaters would be required to be installed with heat traps in the inlet and outlet water piping connected to the water heater. Due to the inclusion of heat traps in the outlet water piping, installing a valve at a distance of 10 inches from the outlet water connection would not be required, as the heat trap would restrict the convective movement of hot water from the water heater. As a result, DOE is requiring the installation of the outlet water valve downstream of the outlet water heat trap, within a distance of 10 inches downstream from the outlet water temperature sensor placed at the second elbow from the water heater in the outlet water piping. These amendments to the location of the outlet water valve are depicted in the test set ups in Figure III.1, Figure III.2, Figure III.3, and Figure III.4 of this final rule.

To address Bradford White's concern regarding the pressure relief valve being installed downstream from the outlet water valve, DOE is adding provisions in the test procedure that the pressure relief valve must be installed between the outlet water valve and the water heater. Figure III.4 of this final rule that shows the set-up for testing instantaneous water heaters and hot water supply boilers depicts the pressure relief valve between the outlet water valve and the water heater being tested.

4. Additional Comments

In addition to comments related to the test set-up, DOE also received comments about measuring the gas line temperature as indicated by temperature probe T_4 in Figure III.4 of the May 2016 NOPR for instantaneous water heaters and hot water supply boilers. DOE received comments from Raypak and Rheem stating that the T_4 is generally part of the gas meter or otherwise must be measured at the gas meter and not elsewhere in the gas line. (Raypak, No. 28 at p. 3; Rheem, No. 34 at p. 17) Raypak commented that most of the thermocouples used to measure the temperature in the gas line are actually mounted in the gas meter and recommended indicating the location of the temperature sensor in the gas meter itself, located in the gas connection in Figure III.4 in the May 2016 NOPR. (Public Meeting Transcript, No. 20 at p. 88)

DOE agrees with the comments on the gas temperature measurement and has modified the test set-up to have the gas temperature measured at the gas meter. DOE concludes that this clarification is consistent with ANSI Z21.10.3–2015.

Rheem sought clarification on using a radiation shield for temperature probes. (Rheem, No. 34 at p. 17) A radiation shield is generally applied on a temperature probe to prevent potential radiative heat transfer from the hot surfaces that are close to or in direct contact with the burner flame to the temperature probe. If a probe is located in the vicinity of a surface at a very high temperature, then there could be some heat transferred from the hot surface to the temperature probe in the form of radiation. This would lead to an inaccurate representation of the temperature that the probe is intended to measure. Therefore, in experimental tests, it is typical to use a radiation shield to protect against unwanted radiation and to provide a more accurate measurement of the temperature that is intended to be measured. DOE's current test procedure requires using a radiation shield for temperature sensors used to measure the ambient temperature. In this final rule, DOE is also adopting the use of radiation shield(s) to measure the test air temperature. DOE concludes that these changes are consistent with ANSI Z21.10.3–2015.

5. Test Set-Up for Instantaneous Water Heaters and Hot Water Supply Boilers

As initially discussed in section III.I.1, AHRI recommended that DOE require an instantaneous water heater to be tested using the test set-up in Figures 1, 2, and 3 proposed for storage water heaters in the May 2016 NOPR (*see* 81 FR 28588, 28599–28600). (AHRI, No. 26 at p. 10)

After considering this and all of the other comments related to the test set-up for instantaneous water heaters and hot water supply boilers, DOE has decided to allow the use of the same piping configuration adopted for storage water heaters to be used for testing instantaneous water heaters and hot water supply boilers that do not require a recirculating loop. As a result, the piping arrangements in Figure III.1, Figure III.2, and Figure III.3 adopted in this final rule (see section III.C) are also applicable to instantaneous water heaters and hot water supply boilers that do not require a recirculating loop for testing. Although the same piping arrangements are being adopted for instantaneous water heaters and hot water supply boilers, there are some variations in the setup needed to accommodate testing of instantaneous water heaters and hot water supply boilers. Specifically, instantaneous water heaters and hot water supply boilers require the addition of an outlet water valve and the inclusion of an additional temperature sensor to measure the heat exchanger outlet water temperature. Figure III.1, Figure III.2, and Figure III.3 show the test setup for gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters, and are generally applicable to electric storage and storage-type instantaneous water heaters and to instantaneous water heaters and hot water supply boilers (that are not tested with a recirculating loop), with the exceptions that an outlet water valve and heat exchanger outlet temperature sensor are present. In this final rule, for clarity, DOE is adopting separate figures within each appendix, with the slight variations to outlet valve and temperature sensors discussed herein.

In addition, for instantaneous water heaters and hot water supply boilers, DOE is adopting Figure III.4, which must be used for the installation of the recirculating loop to conduct the thermal efficiency and standby loss test (as applicable).

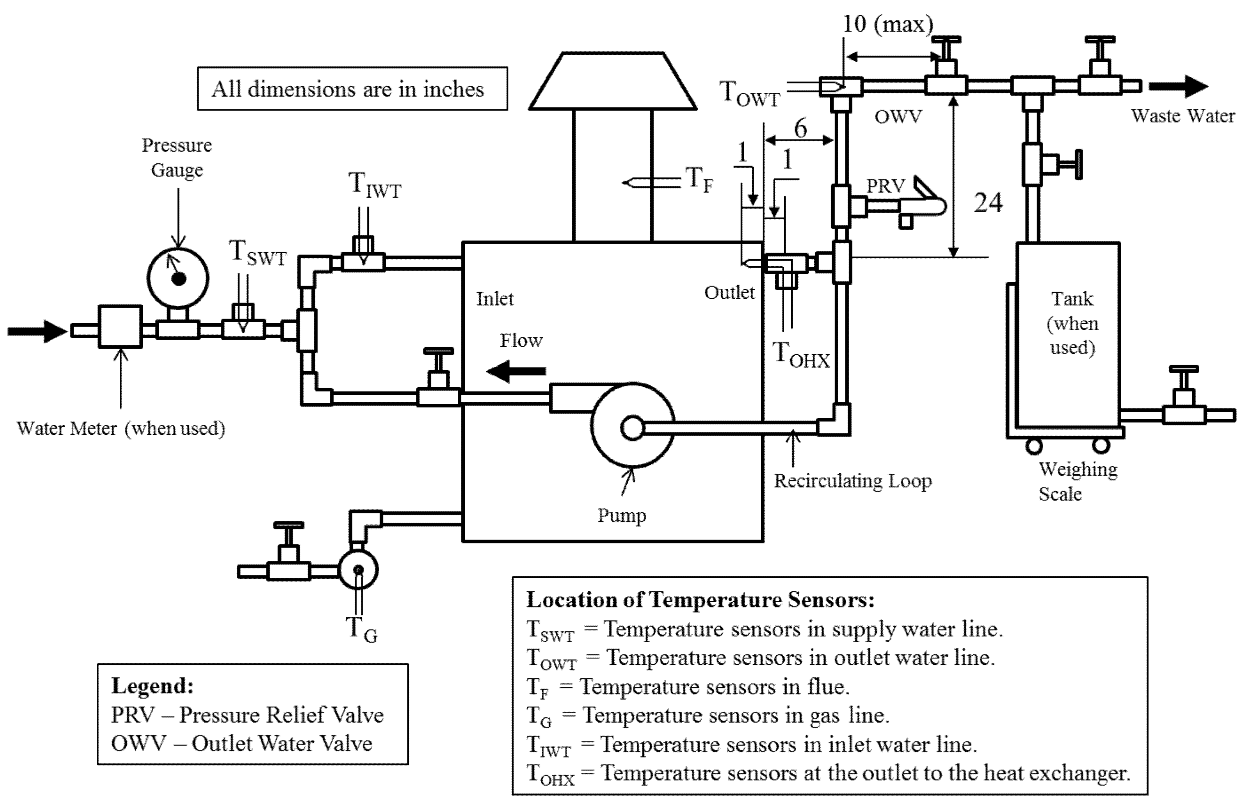

Figure III.4. Test Set-up for Instantaneous Water Heaters and Hot Water Supply Boilers (Other Than Storage-Type Instantaneous Water Heaters) When Tested With a Recirculating Loop

J. Test Procedure for Rating Commercial Heat Pump Water Heaters

In the May 2016 NOPR, DOE proposed definitions and test procedures for CHPWHs. 81 FR 28588, 28617–28622 (May 9, 2016). The comments received on DOE's proposals for CHPWH are discussed in the following sections.

1. Definitions of CHPWH

In the May 2016 NOPR, DOE proposed a definition for ''commercial heat pump water heater'' and associated definitions for ''air-source commercial heat pump water heater,'' ''direct geo-exchange commercial heat pump water heater,'' ''ground water-source commercial heat pump water heater,'' and ''indoor water-source commercial heat pump water heater.'' 81 FR 28588, 28617–28619 (May 9, 2016).

In response, CA IOUs, Bradford White, NEEA, and EEI expressed support for the proposed definition of CHPWH. (CA IOUs, No. 23 at p. 2; Bradford White, No. 21 at p. 11; NEEA, No. 30 at p. 1; and EEI, No. 29 at p. 3) CA IOUs added that the proposed definition of CHPWH accurately categorizes the equipment and is similar to the definition used by AHRI in AHRI Standard 1300, ''*2013 Standard for Performance Rating of Commercial Heat Pump Water Heaters*'' *(AHRI 1300–2013),* and that the definitions for proposed categories for CHPWH add more clarity. (CA IOUs, No. 23 at p. 2)

DOE also received comments recommending several modifications to the definitions related to CHPWH. AHRI stated that the proposed definitions for CHPWH, air-source CHPWH, direct geo-exchange CHPWH, and water-source CHPWH are inconsistent with the definitions in AHRI 1300–2013 and ASHRAE 118.1, because the proposed definition for CHPWH does not include ancillary equipment and the proposed 12 kW threshold excludes CHPWH units that are intended to deliver hot water above 180 °F, but have lower inputs. Further, AHRI argued that DOE has: (1) Added language for defining direct geo-exchange CHPWH; (2) split the water-source CHPWH definition into two parts (*i.e.,* ground water and indoor water); and (3) changed ''indoor or outdoor air'' to ''surrounding air'' for air-source CHPWH. Finally, AHRI stated that the definitions in AHRI 1300 and ASHRAE 118.1 were developed through consultations with industry experts and stakeholders; AHRI recommended maintaining consistency with the industry test standards. (AHRI, No. 26 at p. 14) Rheem commented that 12 kW threshold for commercial classification of heat pump water heaters does not adequately identify the source of the power input and does not account for total power consumption for hybrid heating technology used exclusively or in conjunction with electric resistive heating elements. Rheem stated that the 12 kW threshold is a good indicator for power consumption by electric resistance water heaters but is not applicable to models that use only heat pump technology and argued that the physical size of a compressor to with 12 kW of input power to heat the water would be too large and physically impossible to fit in the current CHPWH systems. Rheem recommended that a water heater with heat pump technology be classified as commercial equipment if the compressor uses between 7 and 10 amps of electric current or more than 12 kW of input power for electric resistance heating. Rheem also commented on the proposed definition of air-source CHPWH, suggesting that it does not differentiate between the sources of surrounding air and does not account for ducted air flow. (Rheem, No. 34 at p. 18) The Joint Advocates stated that the definition of ground-water source CHPWH is potentially confusing and inconsistent with the nomenclature used in the ground-source heat pump industry. According to the Joint Advocates, the definition of ground-source CHPWHs is commonly understood to include both direct geo-exchange and ground water-source CHPWHs. The Joint Advocates recommended that DOE either adopt definitions listed in ASHRAE's *Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (GSHP)*[16], or divide ground-source CHPWH into three sub-categories: (1) Closed-loop systems that extract heat from the ground by circulating water or anti-freeze; (2) open-loop systems that extract heat from water pumped from a well or surface pond; and (3) direct expansion systems that circulate refrigerant in closed-loops to extract heat directly from the ground. (Joint Advocates, No. 32, at p. 3) Earthlinked Technologies also questioned why ground-source closed-loop CHPWHs (which use the test procedure for water-source CHPWH, but are rated to a different evaporator entering water temperature in ASHRAE 118.1–2012) are not included in DOE's categorizations of CHPWH. (Earthlinked, No. 37 at p. 3) Earthlinked Technologies also suggested modifying the proposed definition for CHPWH to include additional provisions for the type of power supplied to the unit. Specifically, the commenters suggest that proposed definition must encompass all units with minimum 12 kW power supply (which is included in the proposed definition) and a minimum rated current condition of >24 A with single phase power supply; a maximum voltage condition of not greater than 250V; and all units with three phase power supply as rated input. (Earthlinked, No. 37 at pp. 1–2)

DOE's proposed definition for CHPWH includes the term ''low temperature heat source,'' and EEI suggested modifying the word ''low'' to ''lower'' and further recommended that, when DOE decides to prescribe energy conservation standards for CHPWHs, the standards should be different from those prescribed for commercial electric resistance storage water heaters and commercial electric resistance instantaneous water heaters. (EEI, No. 29 at p. 3) NEEA recommended expanding the definition of CHPWH to include gas absorption heat pump water heaters. (NEEA, No. 20 at p. 2)

DOE reviewed all comments received in response to this issue and, after careful consideration, is adopting the definitions for direct geo-exchange CHPWH, ground water-source CHPWH, and indoor water-source CHPWH as proposed in the May 2016 NOPR. For the definition for CHPWH, DOE is incorporating additional language regarding ''ancillary equipment'' as suggested by AHRI, so as to make the definition consistent with the definition of that term in ASHRAE 118.1–2012. For similar reasons, for air-source CHPWH, DOE replaces ''surrounding air'' with ''indoor or outdoor air.'' DOE believes that the definitions of CHPWH and its categories sufficiently represent the kinds of CHPWH available on the market. DOE considered NEEA's suggestion to expand the definitions to include those CHPWH with gas absorption technology, but has not identified any equipment commercially available on the market that utilizes gas-fired absorption technology for heating potable water. Therefore, in this final rule, the definitions are limited to include electrically operated heat pump technology.

With regard to the threshold for commercial equipment, DOE notes that EPCA classifies electric water heaters with less than 12 kW rated electrical input as consumer water heaters (42 U.S.C. 6291(27)), and that a heat pump water heater with a rated input of less than 12 kW would, therefore, be a

[16] ASHRAE's *Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems,* can be purchased from: *https://www.ashrae.org/resources--publications/bookstore/geothermal-heating-and-cooling-design-of-ground-source-heat-pump-systems.*

consumer water heater. The 12 kW limitation refers to the total electrical power input to the heat pump water heater which could either be only the input to the heat pump if no backup electric resistance elements are present, or a combination of heat pump technology and electric resistance elements. DOE does not agree with Rheem and Earthlinked Technologies' comments on adopting additional power supply specifications (such as electrical current range for the compressor or voltage and phase requirements) to differentiate commercial heat pump water heaters from residential heat pump water heaters. The suggested range of 7 to 10 amps in Rheem's comments could result in a heat pump water heater with less than 12 kW being classified as commercial equipment, which would be contrary to EPCA's definitions. Thus, the most appropriate parameter that accounts for both the electric current and voltage in a single term is the electrical power input.

Regarding comments from the Joint Advocates and Earthlinked Technologies on ground-source closed-loop CHPWH, DOE agrees that such systems are a category of water-source CHPWH that are different from ground water-source CHPWH in the manner that they extract heat from the earth. As the name indicates, a ground-source closed-loop CHPWH uses a closed water loop to extract heat from the earth and transfer it to the CHPWH unit. This is different from a ground water-source CHPWH that uses an open water loop system, where the unit pulls in water from a lake or a pond and uses it as a heat source. Considering the differences between the CHPWH systems, DOE agrees that ground-source closed-loop CHPWH must be rated at conditions different from both, ground and indoor water-source CHPWHs.[17] Therefore, in this final rule, DOE adopts separate rating conditions and definitions for ground-source closed-loop CHPWHs as sub-categories of water-source CHPWHs. DOE disagrees with comments from Joint Advocates of combining the ground-source closed-loop CHPWH, ground water-source CHPWH and direct geo-exchange CHPWH into a single category. DOE notes that ground-source closed-loop CHPWH and ground water-source CHPWH, both use water as a medium to extract heat from the ground or a water body. Direct-geo-exchange CHPWHs, extract heat directly from the earth from refrigerant tubing, which is embedded inside the ground. Therefore, ground water-source CHPWH and ground-source closed-loop CHPWH must be grouped together under water-source CHPWH, while direct-geo-exchange CHPWH must be under a separate category. These definitions and categories are same as those in ASHRAE 118.1–2012, align with DOE's categorization of test procedures adopted in this final rule, and are consistent with the industry test standards. Combining the ground water-source CHPWH and direct geo-exchange into one category, as suggested by the Joint Advocates, may result in confusion as to the applicable rating conditions and corresponding test procedure. Therefore, DOE is retaining this aspect of the proposed definitions.

In response to AHRI's comment that DOE has added language for defining direct geo-exchange CHPWH, DOE notes that AHRI 1300–2013 defines a direct geo-exchange commercial heat pump water heater as a commercial heat pump water heater ''that utilizes the earth as the heat source,'' while DOE's proposed definition in the May 2016 NOPR defines the term as a commercial heat pump water heater ''that utilizes the earth as a heat source and allows for direct exchange of heat between the earth and the refrigerant in the evaporator coils.'' DOE believes that the additional language further clarifies the types of models that qualify as direct geo-exchange commercial heat pump water heaters. The definition adopted for CHPWH and associated definitions for the kinds of CHPWH are contained in the regulatory text at the end of this final rule.

2. Test Procedure for CHPWH

In the May 2016 NOPR, DOE proposed a test method for CHPWH that would incorporate by reference an industry test method, ASHRAE 118.1–2012, but with modifications to adopt rating conditions in another industry test method, AHRI 1300–2013. (Note, that AHRI 1300–2013 references ASHRAE 118.1–2012 for specifying the actual conduct of the test, but specifies different rating conditions than those specified by ASHRAE 118.1–2012.) 81 FR 28588, 28617–28622 (May 9, 2016). In this final rule DOE is incorporating by reference certain sections, figures, and tables from ASHRAE 118.1–2012 in its test procedure for CHPWHs, as discussed in the following sections.

ASHRAE 118.1–2012 classifies CHPWHs into two types, with a separate test method for each: (1) ''Type IV''—equipment that can be operated without requiring a connection to a storage tank; and (2) ''Type V''—equipment that includes an integral storage tank or requires connection to a storage tank for operation. The test procedure in ASHRAE 118.1–2012 for Type V equipment requires units to be connected to a tank that is either supplied by the manufacturer along with the unit or is specified by the manufacturer, while the test procedure in ASHRAE 118.1–2012 for Type IV equipment does not require connection to a tank. After reviewing product literature, DOE noted that most of CHPWH available on the market are Type V equipment in that they require connection to a storage tank for operation. However, manufacturers of such CHPWH typically neither supply nor specify a storage tank appropriate for that equipment. ASHRAE 118.1–2012 does not include a test method for Type V units for which an appropriate tank is neither supplied nor specified by the manufacturer. After considering several options, DOE ultimately proposed in the May 2016 NOPR to utilize a method similar to the test method for Type IV equipment for all CHPWH. 81 FR 28617–28622 (May 9, 2016). As noted above, DOE also proposed to use the rating conditions specified by AHRI 1300–2013. AHRI 1300–2013 contains multiple rating conditions, so DOE selected those it believed to be most representative of conditions encountered in the field during actual use. In addition, DOE also received comments from AHRI recommending a specific set of rating conditions that are also listed in AHRI 1300–2013. In reviewing the market, DOE noted that some CHPWH are capable of achieving various temperature rises based on the intended application. As a result, DOE proposed that air-source CHPWH be tested with a supply water temperature of 70 °F and, if the tested model is unable to achieve the required outlet water temperature condition, that the supply water temperature be changed to 110 °F.

Rheem commented that ASHRAE 118.1–2012 is sufficient as a testing standard to represent the performance of CHPWH and recommended adopting the testing standard in full. Rheem also stated that DOE's proposed deviations and additions to ASHRAE 118.1–2012 are too burdensome to implement, and that the only exception to the ASHRAE 118.1–2012 testing standard that it supports is to specify the requirements in AHRI 1300–2013 for CHPWH that can operate with multiple voltages. AHRI 1300–2013 requires such units to be tested at the lowest voltage specified on the nameplate and specifies that, at the manufacturer's option, the test may be

[17] For more information on ground-source closed-loop CHPWH and ground water-source CHPWH, see *http://energy.gov/energysaver/geothermal-heat-pumps*.

repeated at a higher voltage. (Rheem, No. 34 at pp. 18–19)

AHRI recommended that the entering water temperature for air-source CHPWH be maintained at 110 °F to remain consistent with all other categories of CHPWH and allow a basis for comparison of different categories of CHPWH. AHRI argued that the NOPR acknowledges that a test conducted with an inlet water temperature of 70 °F and 110 °F will provide the same results. (AHRI, No. 26 at p. 12) CA IOUs also argued against adopting two inlet water temperatures for air-source CHPWHs, stating that having two temperatures would result in some equipment with a lower efficiency being tested to a less stringent rating condition. (CA IOUs, No. 23 at p. 4) Earthlinked Technologies also commented on this issue stating that rating certain air-source CHPWHs with an entering water temperature of 70 °F while testing all other CHPWHs (including CHPWHs that are not air-source) with an entering water temperature of 110 °F would not provide a fair comparison between products and prevent contractors from helping customers make informed decisions. The commenters suggest using 110 °F as the single entering water temperature rating condition for all CHPWH equipment, which is also in line with the AHRI-recommended rating conditions. (Earthlinked, No. 37 at p. 2)

The Joint Advocates questioned whether requiring testing without a specified storage tank would create an inherent disadvantage for self-contained units with integrated tanks. The Joint Advocates recommended that instead, DOE should require the CHPWH to be paired with a storage tank with a volume proportional to the steady-state heating output of the CHPWH. The Joint Advocates stated that this would ensure consistency between CHPWH with integrated and non-integrated storage tanks. (Joint Advocates, No. 32 at p. 3) NEEA commented that DOE proposed separate test procedures for air, water, and direct geo-exchange CHPWH but did not specify a test procedure or test conditions for self-contained versus remote air condensers. (NEEA, No. 30 at p. 2) EEI agreed with the use of ASHRAE 118.1–2012, which was developed through ASHRAE's standards development processes which uses a consensus based approach. (EEI, No. 29 at p. 3) CA IOUs commented in support of establishing separate test procedures for different categories of CHPWH based on ASHRAE 118.1–2012 and AHRI 1300–2013. With regard to the rating conditions for air-source CHPWH, CA IOUs stated that the rating condition of 80.6 °F dry-bulb temperature and 71.2 °F wet-bulb temperature may be too warm for CHPWH, and recommended using a temperature that is higher than 50 °F dry-bulb temperature and 44.3 °F wet-bulb temperature, but lower than the proposed rating condition. CA IOUs also recommended reviewing the study titled, *West Village Community: Quality Management Processes and Preliminary Heat Pump Water Heater Performance,* completed by Davis Energy Group for NREL as a starting point to establish rating conditions.[18] (CA IOUs, No. 23 at p. 3)

In response to these comments, DOE notes that the test procedure proposed for air-source CHPWH is based on investigative testing that was carried out as part of the preparation of the May 2016 NOPR, the results of which are discussed in extensive detail in that document. Based on the test results, DOE noticed that several CHPWH models may be designed to achieve a lower temperature rise (from 110 °F supply water temperature to 120 °F outlet water temperature), while some models may be able to achieve a higher temperature rise (from 70 °F supply water temperature to 120 °F outlet water temperature), depending on the intended application. If DOE were to adopt a supply water temperature of 110 °F for all air-source CHPWH, then there would be some air-source CHPWH units on the market that would not be able to achieve the required outlet water temperature condition (120 °F ± 5 °F), as DOE observed during its investigative testing. By allowing different supply water temperature conditions based on the capabilities of a CHPWH, the test procedure will be capable of testing all kinds of air-source CHPWH units currently available on the market. Therefore, in this final rule, DOE retains the additional proposed provisions for air-source CHPWH, *i.e.,* to require units to be tested with a supply water temperature of 70 °F, and use supply water at 110 °F only if the unit is unable to meet the required outlet water temperature conditions at 70 °F.

In response to the comments on the evaporator entering air rating conditions being too high for CHPWH, DOE notes that these conditions are included in the industry-accepted test standard AHRI 1300–2013, and are also similar to the rating conditions specified in another industry-accepted testing standard, ASHRAE 118.1–2012 (80 °F dry-bulb temperature and 67 °F wet-bulb temperature). In addition, DOE conducted tests using the proposed evaporator entering air rating conditions and found that all the tested air-source CHPWH units were able to operate under these ambient conditions. DOE explored lower entering air temperatures and discovered that certain CHPWH models do not operate at low ambient temperatures, and would not operate at lower entering air temperatures. Therefore, in order to have a test method that is both representative and that can be used for all types of CHPWH currently on the market, DOE is adopting the rating conditions for evaporator entering air temperature that were proposed in the May 2016 NOPR.

DOE also considered comments received from the Joint Advocates about the comparison of CHPWH models with and without an integral storage tank, and whether requiring testing without requiring a storage tank would be a disadvantage for CHPWH units that are equipped with an integral storage tank. As discussed in the May 2016 NOPR, DOE proposed that CHPWHs that are intended to be operated in-field with a separately attached storage tank must be tested using a test procedure similar to that prescribed for Type IV equipment in ASHRAE 118.1–2012, which does not require a storage tank. DOE generally agrees that COP_h ratings of two CHPWH units, one equipped with an integral storage tank and the other not equipped with an integral storage tank, both tested using DOE's proposed test procedure, may be different from each other. DOE does not see this difference as an advantage of one unit over the other because of the test procedure, but rather as a fundamental difference between the designs and operational characteristics of different CHPWH units. Further, DOE noted in the May 2016 NOPR that adding a separate storage tank to test a Type IV CHPWH would be an incorrect representation of the efficiency ratings of the unit itself and would include the losses in the external tank. For CHPWHs equipped with a storage tank, the tank is an integral component of the CHPWH as packaged and shipped by the manufacturer. Therefore, any losses in performance due to the inclusion of the tank must be included as part of the efficiency ratings of such CHPWHs. DOE is not aware of any commercial heat pump water heaters with an integrated storage tank currently available on the market. In addition, DOE still has concerns regarding specifying the characteristics of the storage tank with which the CHPWH would be tested. The Joint Advocates suggest pairing CHPWH with a storage tank with a volume proportional to the

[18] *http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/west_village_hpwh.pdf.*

steady-state heating output of the CHPWH, but this does not address the other characteristics of the tank that can affect efficiency and operation, such as the insulation thickness, number of ports, and tank aspect ratio. Based on the foregoing, DOE has decided to continue to require testing without attaching an external tank for CHPWHs that are not integrated with a storage tank. For CHPWH models equipped with an integral storage tank, DOE adds clarifying provisions to the test procedure for CHPWHs proposed in the May 2016 NOPR, which is based on the test procedure in ASHRAE 118.1–2012 for Type IV equipment. These added provisions incorporate by reference certain sections applicable to the test procedure for Type V equipment in ASHRAE 118.1–2012. DOE is adding these provisions to better represent the field energy use and installation requirements for CHPWHs equipped with an integral storage tank. Specifically, in addition to the sections included in DOE's proposed test procedure, DOE has decided to incorporate by reference sections 7.3.1 (pertaining to setting up of temperature sensors inside the tank), 7.7.8 (pertaining to input requirements of water-heating mode test), and 8.7.1 (pertaining to setting the storage tank thermostats) of ASHRAE 118.1–2012, with the exception that the provisions will only apply to Type V equipment that is equipped with an integral storage tank. Further, DOE has also decided to incorporate by reference Figures 6, 7, and 8, which pertain to the test set-up of Type V equipment in ASHRAE 118.1–2012.

As suggested by Rheem, DOE considered adopting the provision in AHRI 1300–2013 for CHPWHs that are capable of operating at multiple voltages, which is not included in ASHRAE 118.1–2012. DOE agrees with the comment and has decided to include provisions that require CHPWHs that can operate at multiple voltages to be tested and rated at the lowest rated voltage. The test procedure adopted for CHPWH in this final rule is included in appendix E to subpart G of part 431 in the regulatory text.

Finally, in response to Rheem's assertion that the deviations and additions to ASHRAE 118.1–2012 proposed in the May 2016 NOPR are too burdensome to implement, DOE notes that the procedures adopted by this final rule incorporate by reference various sections of ASHRAE 118.1–2012 and are largely based on that procedure. Thus, DOE does not believe that the test method adopted in this final rule is significantly more burdensome than ASHRAE 118.1–2012, which Rheem recommended that DOE adopt.

As discussed in section III.J.1, DOE is adopting separate definitions for ground-source closed-loop CHPWHs. In light of these changes, DOE also adds separate rating conditions for ground-source closed-loop CHPWH, which are the same as those specified in Table B–3 of ASHRAE 118.1–2012 and require an evaporator entering water temperature of 32 °F. To achieve sub-freezing temperatures required for such units, DOE also adds requirements that the evaporator entering water be mixed with 15-percent methanol by-weight. The test procedure used to rate such units is the same test procedure adopted in this final rule for water-source CHPWHs. The rating condition for condenser water supply temperature in maintained 110 °F, which is the same for all other water-source CHPWH units.

K. Gas Pressure

In the May 2016 NOPR, DOE included proposed requirements for gas pressure in its proposed test procedures for gas-fired and oil-fired CWH equipment. 81 FR 28588, 28641, 28646, 28651 (May 9, 2016). In its proposal, DOE included requirements that the outlet pressure of the gas appliance regulator be within the range specified by the manufacturer. In response to the May 2016 NOPR, Bradford White and AHRI commented that the proposed term ''outlet pressure'' should be changed to ''gas supply pressure'' because manufacturers specify a range for gas supply pressure, but only a single value for gas outlet pressure. (Bradford White, No. 21 at p. 21; AHRI, No. 26 at p. 6)

DOE acknowledges that manufacturers specify a range for gas supply pressure and a single value for gas outlet pressure, as required for certification to ANSI Z21.10.3–2015. Therefore, in this final rule, DOE is adopting requirements regarding both gas supply pressure and gas outlet pressure for gas-fired CWH equipment. First, DOE is requiring that gas supply pressure must be within the range specified by the manufacturer. This requirement was suggested by Bradford White and AHRI, and is consistent with the requirements for nameplate ratings included in ANSI Z21.10.3–2015. Regarding gas outlet pressure, after an assessment of manufacturer literature for models currently on the market, DOE notes that the gas outlet pressure specified by the manufacturer is often a very low value (*e.g.,* 0.0 inches water column (in. w.c.) or 0.05 in. w.c.) for models that include a premix burner. DOE believes that achieving and measuring a gas pressure value within ± 10 percent of such a low value would be difficult given the typical accuracy of gas pressure measurement devices (*i.e.,* the accuracy for gas pressure measurement included in ASHRAE 118.1–2012 is ± 0.1 in. w.c.). Therefore, DOE will also require that the difference between the outlet pressure of the gas appliance pressure regulator and the value specified by the manufacturer on the nameplate of the unit being tested must not exceed the greater of: ± 10 percent of the nameplate value or ± 0.2 in. w.c.

DOE is adopting a gas outlet pressure requirement to maintain consistency with ANSI Z21.10.3 (both the 2011 version that is currently incorporated by reference and the 2015 version that is being incorporated by reference by this final rule), and, therefore, DOE's existing test procedure. While a provision for an absolute tolerance (*i.e.,* ± 0.2 in. w.c.) is not included in ANSI Z21.10.3–2015, DOE believes that this tolerance is warranted given that many units on the market have low rated gas outlet pressure values. DOE notes that the addition of this absolute tolerance renders this gas outlet pressure requirement more lenient than the requirement included in both DOE's current test procedure and ANSI Z21.10.3–2015; therefore, this adopted requirement for gas outlet pressure will not result in any additional test burden for manufacturers.

L. Fuel Input Rate

In DOE's existing regulations, equipment classes and the standards that apply to them are determined, in part, by the input capacity of the CWH equipment. However, several terms are used in the existing DOE test procedures and energy conservation standards to describe the input capacity of the CWH equipment, each of which is derived from the maximum rated fuel input rate of the CWH equipment. To standardize terminology throughout its regulations for CWH equipment, in the May 2016 NOPR, DOE proposed to define the term ''fuel input rate'' as the maximum rate at which gas-fired or oil-fired CWH equipment consumes energy during a given test, and to use the term ''fuel input rate'' in its test procedures for CWH equipment. 81 FR 28588, 28622 (May 9, 2016).

1. Certification Provisions

DOE proposed using the term ''fuel input rate'' in the division of equipment classes and proposed applicable testing provisions to determine the fuel input rate. DOE's proposal would have required manufacturers to measure the fuel input rate during certification testing and use the mean of the measured values, after applying the applicable rounding provisions, in certification reports pursuant to 10 CFR 429.44(c)(2).

DOE also proposed including equations for determining the fuel input rate in its test procedures for gas-fired and oil-fired CWH equipment. DOE proposed including Equations C2 and C3 from section C7.2.3 of AHRI 1500–2015 in its test procedures for calculation of fuel input rate for gas-fired and oil-fired CWH equipment, respectively. DOE also proposed that the fuel input rate be determined by measuring fuel consumption at 3 consecutive 10-minute intervals during the 30-minute thermal efficiency test. The overall fuel input rate for the thermal efficiency test would be calculated using the fuel consumption over the entire 30-minute test. DOE proposed that during the thermal efficiency test, the measured fuel input rate must not vary by more than ± 2 percent between 10-minute interval readings.

CA IOUs agreed with DOE's proposed definitions and provisions regarding fuel input rate. (CA IOUs, No. 23 at p. 2) However, several commenters disagreed with DOE's proposal that the certified fuel input rate be based on the mean of measured values obtained during efficiency testing. (Bock, No. 19 at p. 2; Bradford White, No. 21 at p. 12; AHRI, No. 26 at pp. 1–3; A. O. Smith, No. 27 at pp. 9–10; Raypak, No. 28 at pp. 4–5; Rinnai, No. 31 at p. 2; Rheem, No. 34 at pp. 12–13) Instead, these commenters suggested that the certified input rate should be a fixed value rather than a value that could vary from test to test and that the input rate is determined as part of the model's safety certification testing. Bradford White, AHRI, and A. O. Smith further stated that there is no confusion in the industry regarding fuel input rate terminology and that DOE's proposed fuel input rate regulations would harm the industry. (Bradford White, No. 21 at p. 9; AHRI, No. 26 at p. 2; A. O. Smith, No. 27 at p. 10) AHRI stated that DOE's proposal would mean that every unit of a model would have a unique input rating, and that a model would no longer have a single input rating. (AHRI, No. 26 at p. 2) AHRI and Rheem further argued that DOE's proposal would create a distinction without a difference—comparable models capable of meeting the same design load would be rated with slightly different input rates. (AHRI, No. 26 at p. 3; Rheem, No. 34 at pp. 12–13)

AHRI and A. O. Smith stated that the maximum input rate 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 input capacity be certified as the rated input on the nameplate. AHRI and A. O. Smith stated that a manufacturer's first requirement is to design a model that will comply with all the safety standards and codes applicable to that model, and that part of this design phase is establishing the maximum input rate of the water heater. AHRI and A. O. Smith further argued that manufacturers do not conduct efficiency tests until they are certain of the model's compliance with the applicable safety requirements and, therefore, cannot wait until efficiency tests are conducted to determine the rated input. AHRI and A. O. Smith also commented that DOE's proposal would create an illogical situation where the manufacturer does not know what test to conduct based on its equipment class until after the test is conducted. (AHRI, No. 26 at pp. 1–3; A. O. Smith, No. 27 at p. 10)

Bradford White, AHRI, and A. O. Smith noted that there are several factors that affect the firing rate of a unit during a test, including the fuel higher heating value. (Bradford White, No. 21 at p. 12; AHRI, No. 26 at p. 2; A. O. Smith, No. 27 at p. 9) AHRI and A. O. Smith added that the actual higher heating value of gas delivered during testing may vary by ± 7 percent around the nominal value for natural gas, and that manufacturers must design products that have flexibility to safely use fuels with various energy densities. (AHRI, No. 26 at p. 2; A. O. Smith, No. 27 at p. 9) Bradford White further noted that barometric pressure, gas meter temperature, and gas meter pressure can also affect the measured fuel input rate during a given test. (Bradford White, No. 21 at p. 12)

AHRI commented that determination of fuel input rate during the thermal efficiency test is unnecessary. (AHRI, No. 26 at p. 10) AHRI and A. O. Smith stated that the rate at which fuel is consumed does not matter, and that measurement of fuel consumed and amount of energy delivered as heated water would reflect any variation in input rate during the test. (AHRI, No. 26 at p. 10; A. O. Smith, No. 27 at p. 9)

In light of comments received, DOE is not adopting its proposed certification provisions for the fuel input rate. DOE believes the safety certification process during the design and development of CWH equipment models is sufficient for determining the rated input for CWH equipment. Safety certification through industry test standards, such as ANSI Z21.10.3–2015, typically requires that manufacturers 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. DOE is adopting the term ''rated input'' to mean the maximum rate CWH equipment is rated to use energy as specified on the nameplate, and is adopting the term ''fuel input rate'' to mean the rate at which any particular unit of CWH equipment consumes energy during testing.

However, DOE disagrees with AHRI and A. O. Smith that variation in fuel input rate during the test does not affect results. The thermal efficiency test is a steady-state test, and, consequently, all parameters that affect efficiency should be held constant throughout the test. Therefore, DOE is adopting its proposed requirement that the fuel input rate be determined by measuring fuel consumption at consecutive 10-minute intervals during the 30-minute steady-state verification period and the 30-minute thermal efficiency test. DOE's adopted provisions regarding the steady-state verification period and associated requirements for establishing steady-state operation are discussed in section III.F.1 of this final rule. The overall fuel input rate for the thermal efficiency test will be calculated using the fuel consumption over the entire 30-minute test, and must be within ± 2 percent of the rated input certified by the manufacturer. During the thermal efficiency test and the 30-minute steady-state verification period, the measured fuel input rates for these 10-minute periods must not vary by more than ± 2 percent between any two readings. As discussed in section III.F.1 of this final rule, DOE does not expect its requirements for measuring fuel input rate during the steady-state verification period and thermal efficiency test to impose a significant burden on manufacturers.

DOE is adopting the equations for calculation of fuel input rate that were proposed in the May 2016 NOPR and are based on equations included in AHRI 1500–2015 for testing of commercial packaged boilers. DOE notes that the equations in AHRI 1500–2015 calculate input rate using the same variables as the calculation of gas consumption in the denominator of the equation for calculating thermal efficiency in ANSI Z21.10.3–2015, with the addition of a time term to yield an input rate rather than a gas consumption value. In the May 2016 NOPR, DOE proposed adding a requirement to the DOE test procedure that values of fuel input rate for each unit tested be rounded to the nearest 1,000 Btu/h. 81 FR 28588, 28622–28623 (May 9, 2016).

Bradford White, Raypak, and Rheem stated that the fuel input rate should not be rounded to the nearest 1,000 Btu/h. (Bradford White, No. 21 at p. 12; Raypak, No. 28 at pp. 4–5; Rheem, No. 34 at p. 13) Raypak and Rheem argued that if rounding to the nearest 1,000 Btu/h were of value to the end user for distinguishing amongst models of CWH equipment, then there would already be units rated with such precision on the market. (Raypak, No. 28 at pp. 4–5; Rheem, No. 34 at p. 13) Because DOE is not adopting its proposed regulations regarding certification of fuel input rate, DOE is also not adopting the proposed requirement that the certified fuel input rate be rounded to the nearest 1,000 Btu/h.

2. Enforcement Provisions

In the May 2016 NOPR, DOE also proposed provisions regarding fuel input rate during DOE enforcement testing. 81 FR 28588, 28623 (May 9, 2016). Specifically, DOE proposed that the overall fuel input rate for the thermal efficiency test would be measured and compared against the fuel input rate certified by the manufacturer. DOE proposed that if the measured fuel input rate determined during an enforcement test is within ± 2 percent of the certified value, then DOE would use the certified value when determining the applicable equipment class for a model. If the measured fuel input rate is not within ± 2 percent of the certified value, then DOE would attempt to bring the fuel input rate to within ± 2 percent of the certified value. To do so, DOE would first adjust the gas pressure within the range allowed by the test procedure in an attempt to increase or decrease the fuel input rate to achieve ± 2 percent of the rated input certified by the manufacturer. If the fuel input rate is still not within ± 2 percent of the rated input, DOE would then attempt to modify the gas inlet orifice (*e.g.,* drill) accordingly. Finally, if these measures do not bring the fuel input rate to within ± 2 percent of the rated input, DOE would use the measured fuel input rate when determining the equipment class. DOE proposed these provisions to provide manufacturers with additional information about how DOE will evaluate compliance with its energy conservation standards for CWH equipment.

Several commenters disagreed with DOE's proposed provisions related to fuel input rate in enforcement testing, and argued that DOE should contact the manufacturer if unable to reach the certified input rate during enforcement testing. (Bock, No. 19 at p. 2; Bradford White, No. 21 at p. 12; AHRI, No. 26 at p. 3; Rheem, No. 34 at p. 13) Bock further stated that by running an efficiency test at an input rate varying by more than ± 2 percent from the certified value, DOE would essentially be testing a new model. (Bock, No. 19 at p. 2) AHRI further argued that the enforcement provisions are unnecessary, and that AHRI has never had any issues achieving the manufacturer-specified input rating during testing. AHRI also asserted that a unit that cannot be put "on-rate" is not representative of the model, assuming there are no issues with the fuel supply. (AHRI, No. 26 at p. 3) Rheem further stated that a model should not be penalized if the fuel used in DOE's enforcement testing has a higher heating value such that the input rating could not be achieved within ± 2 percent of the rated input. (Rheem, No. 34 at p. 13) Bradford White also stated that if the rated input cannot be achieved, there must be an underlying reason, and that the model cannot be fairly evaluated. (Bradford White, No. 21 at p. 12) Joint Advocates commented that DOE should use the measured fuel input rate for all enforcement testing, while allowing for adjustment of gas pressure. (Joint Advocates, No. 32 at p. 2)

DOE's proposed enforcement provisions regarding fuel input rate were intended to avoid invalid tests, such that even if DOE could not achieve a fuel input rate within ± 2 percent of the certified value, a unit could still be tested and compliance with the corresponding energy conservation standard(s) could still be determined. DOE disagrees with AHRI's point that the enforcement provisions for fuel input rate are unnecessary because AHRI has never had an issue achieving the rated input. DOE attempts to ensure that it is able to obtain a valid test result in all cases, and these provisions provide manufacturers of notice how DOE will proceed in the event that the test cannot achieve the rated input. DOE notes that, if units are always shipped by manufacturers such that the rated input ± 2 percent can be achieved during enforcement testing, then DOE will have no cause to apply these provisions. DOE also disagrees with Rheem's assertion that DOE would be penalizing a model because of the higher heating value of fuel used in DOE's enforcement testing. As noted by A. O. Smith and AHRI, manufacturers must design products that have flexibility to safely use fuels with various energy densities. When issues arise during enforcement testing, such as being unable to achieve the certified input rating, DOE evaluates the decision of whether to proceed with testing or whether to involve the manufacturer on a case-by-case basis. If DOE carries out a test on a unit despite not achieving the manufacturer's rated input as part of enforcement testing or as part of an assessment test on a model for which DOE subsequently chooses to pursue an enforcement case, DOE would provide the manufacturer with the test results, including the fuel input rate and higher heating value during the test, and the manufacturer will have an opportunity to discuss the test with the Department. DOE disagrees that testing a unit at a fuel input rate other than the rated input necessarily would not be representative of the model.

DOE disagrees with Joint Advocates that DOE should use the measured fuel input rate for all enforcement testing. DOE believes that, given unit-to-unit variation and variability in the higher heating value of fuels as pointed out by other commenters, a ± 2 percent tolerance for fuel input rate is reasonable and that, within that tolerance, any slight deviation should not affect a CWH equipment model's classification under DOE's equipment class structure (and as a result affect the stringency of the applicable energy conservation standards). Additionally, using rated input in enforcement testing if the measured fuel input rate is within ± 2 percent of the rated input allows manufacturers some flexibility in the fuel input rate at which the individual unit may operate. This allowance may be beneficial because, as indicated by stakeholders, the higher heating value of gas varies based on geographic location.

Bradford White recommended that the following steps be taken in order to adjust a model's input rate: adjust the manifold pressure, change the gas pressure, if necessary, and modify the gas orifice(s). (Bradford White, No. 21 at p. 12) DOE agrees with Bradford White that adjusting the manifold pressure (*i.e.,* gas outlet pressure) of CWH equipment could affect the fuel input rate during testing to allow it to be adjusted within ± 2 percent of the rated input, and, therefore, DOE is adopting this step in its regulations. (DOE's approach already encompasses Bradford White's latter suggestions.)

Raypak disagreed with DOE's proposal to modify the gas orifice when attempting to achieve the certified fuel input rate during enforcement testing. Specifically, Raypak argued that several of its products use an engineered nozzle with a built-in venturi instead of a simple orifice. Raypak also stated that DOE should follow manufacturer's instructions and input regarding making adjustments to achieve the manufacturer's rated input. (Raypak, No. 28 at p. 5)

In response to Raypak's comments, DOE notes that its proposed language states that DOE would attempt each modification; therefore, DOE would use its expertise and discretion as well as that of the third-party test laboratory in attempting each modification as may be required to achieve within ± 2 percent of the rated input. Should a model use 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).

Therefore, DOE is adopting its proposed enforcement regulations for fuel input rate, with the additions discussed in this section. DOE also clarifies that the steps it is adopting that may be attempted to achieve a fuel input rate that is ± 2 percent of the rated input (*e.g.,* varying gas pressure, modifying the gas inlet orifice) apply only to gas-fired CWH equipment, and that DOE would not attempt such steps for oil-fired CWH equipment.

M. Default Values for Certain Test Parameters for Commercial Water Heating Equipment

DOE currently incorporates by reference Exhibits G.1 and G.2 of ANSI Z21.10.3–2011 (which correspond to Annexes E.1 and E.2 of ANSI Z21.10.3–2015) in its current test procedure for thermal efficiency and standby loss for CWH equipment. Some of the equipment settings for performing the test procedures as per Annex E.1 of ANSI Z21.10.3–2015 (*e.g.,* water supply pressure, venting requirements) are required to be specified by manufacturers. In the May 2016 NOPR, DOE proposed to include default values for these parameters in its test procedures, to be used if values are not specified in manufacturer literature shipped with the unit [19] or supplemental test information. 81 FR 28588, 28623 (May 9, 2016). Specifically, DOE proposed: (1) A default value for maximum water supply pressure for all CWH equipment, (2) default ranges of allowable gas supply pressure for CWH equipment powered with natural gas and propane, (3) a default value for fuel pump pressure for oil-fired CWH equipment, and (4) a default range for CO_2 reading for oil-fired CWH equipment. DOE determined these values from examination of values reported for models currently on the market.

In response to the May 2016 NOPR, Bradford White, AHRI, A. O. Smith, and Rheem disagreed with DOE's proposal and stated that default values are unnecessary. (Bradford White, No. 21 at p. 8; AHRI, No. 26 at p. 15; A. O. Smith, No. 27 at p. 15, Rheem, No. 34 at p. 19) AHRI indicated that these values are always provided by the manufacturer. (AHRI, No. 26 at p. 15) Bradford White, A. O. Smith, and Rheem stated that these values would always be included on the nameplate as required by ANSI certification. (Bradford White, No. 21 at p. 8; A. O. Smith, No. 27 at p. 15, Rheem, No. 34 at p. 19) Rheem further argued that establishing a default value for maximum water supply pressure that differs from the maximum water supply pressure certified by some manufacturers is invalidating the design and construction of the water heater, and that the water supply pressure default value should be more reflective of the particular kind of CWH equipment being tested. (Rheem, No. 34 at p. 19)

DOE recognizes that such safety certification requires certain parameters to be included on the nameplate of every model. ANSI Z21.10.3–2015 requires that the maximum water supply pressure and allowable range of gas supply pressure be included on the model nameplate. Therefore, DOE is not adopting default values for these parameters, because DOE believes that the nameplate for every model of CWH equipment includes these parameters. However, ANSI Z21.10.3–2015 does not require the inclusion of oil pump pressure or CO_2 reading for oil-fired CWH equipment. Additionally, the nameplates of several models of oil-fired CWH equipment that DOE purchased for testing did not include these parameters. Therefore, DOE believes default values for these parameters are warranted. In this final rule, for oil-fired CWH equipment, DOE is adopting a default value of 100 psig fuel pump pressure and a default allowable range of 9–12 percent for CO_2 reading. DOE notes that these default values were chosen based on an assessment of values reported for models on the market, and that DOE did not receive any specific feedback on these values in response to the May 2016 NOPR. Additionally, these default values would only be used if values for these parameters are not included in any of the following: (1) Product nameplate, (2) manufacturer literature shipped with the unit, or (3) supplemental testing instructions, if submitted to DOE with the certification report. These default values apply to oil-fired commercial water heating equipment other than residential-duty commercial water heaters.

N. Certification Requirements

In the May 2016 NOPR, DOE proposed several changes to its certification requirements for commercial water heating equipment [20] at 10 CFR part 429. 81 FR 28588, 28635–28636 (May 9, 2016). Specifically, DOE proposed to add two requirements to 10 CFR 429.44 for certification of instantaneous water heaters and hot water supply boilers. First, DOE proposed to add that manufacturers must certify whether instantaneous water heaters or hot water supply boilers contain submerged heat exchangers or heating elements, in order to allow for proper classification of units under DOE's proposed definition for ''storage-type instantaneous water heater.'' Second, DOE proposed to add that manufacturers must certify whether instantaneous water heaters or hot water supply boilers require flow of water through the water heater to initiate burner ignition.

AHRI argued that DOE's proposed certification requirements are unnecessary given AHRI's comments on DOE's other proposals in the May 2016 NOPR. Specifically, AHRI argued that when all of AHRI's comments are considered, six separate appendices might not be needed in the test procedures for CWH equipment, and some of the proposed certification requirements might not be needed for determining which test procedure to use. (AHRI, No. 26 at p. 15) Regarding the proposed certification requirement for classifying storage-type instantaneous water heaters, A. O. Smith and Rheem objected to the term ''submerged heat exchanger'' being used to define storage-type instantaneous water heaters, and Bradford White argued that the storage-type instantaneous water heater class is unnecessary. (Bradford White, No. 19 at pp. 12–13; A. O. Smith, No. 27 at p. 16; Rheem, No. 34 at p. 20) A. O. Smith further commented that manufacturers should also certify whether a water heater is activated by a remote control or sensor, and if present, the default

[19] Manufacturer literature includes any information on settings, installation, and operation that is shipped with the equipment. This information can be in the form of installation and operation manuals, settings provided on a name plate, or product-specific literature.

[20] DOE is also making an editorial change to the certification report provisions in 10 CFR 429.44(c) for commercial water heating equipment by replacing of the term ''water heater'' and abbreviations of water heater (*i.e.,* WH) with the term ''water heating.''

duration of the off delay for any integral pump off delay switch. (A. O. Smith, No. 27 at p. 16) Raypak commented that it generally supported DOE's proposed changes to the certification requirements, but that DOE should also consider: (1) Other kinds of water heaters that require flow-through to initiate burner ignition, and (2) water heaters that are activated by a remotely-located thermostat. (Raypak, No. 28 at p. 4)

Given the test procedure amendments DOE is adopting in this final rule, DOE disagrees with AHRI and continues to believe that additional certification requirements for instantaneous water heaters are warranted. DOE's definition for ''storage-type instantaneous water heater'' adopted in this final rule does not include the term ''submerged heat exchanger,'' to which commenters objected, and instead includes a provision that the water heater includes a storage tank with a storage volume greater than or equal to 10 gallons. DOE's definition of ''storage-type instantaneous water heater'' is further discussed in section III.G.4 of this final rule. Therefore, for the equipment class of instantaneous water heaters with a storage volume of greater than or equal to 10 gallons, DOE is adopting a certification requirement of whether the water heater includes a storage tank with a storage volume greater than or equal to 10 gallons. DOE's adopted definition for ''storage-type instantaneous water heater'' is discussed in section III.G.4 of this final rule.

DOE agrees with the comments on flow-activated instantaneous water heaters, specifically that the certification requirements should identify water heaters activated by a remote temperature sensor and if present, the default duration of the off delay for any integral pump off delay switch. Section III.I of this final rule explains that DOE has decided to adopt separate standby loss test procedures for internally-activated instantaneous water heaters than for flow-activated instantaneous water heaters and remote-sensor-based thermostatically activated (or externally-thermostatically activated) instantaneous water heaters. To ensure that the appropriate standby loss test procedure was used to rate instantaneous water heaters and hot water supply boilers, DOE is adding certification requirements to differentiate between the two kinds of CWH equipment. In addition, DOE is also adopting two modifications to the standby loss test procedure for instantaneous water heaters and hot water supply boilers that include: (1) Allowing two options for the methodology to determine the storage volume (either a weight-based method or a calculation-based method; see section III.H.2 for additional details); and (2) allowing a delay in the starting of the standby loss test to account for pump purge (see section III.H.3.e). Therefore, in this final rule, DOE requires certification of which methodology was used to determine the certified value for storage volume, and whether the water heater is equipped with an integral pump purge functionality, and if so, the default duration of the pump off delay. The certification for pump purge functionality is only required for instantaneous water heaters that are either flow-activated or externally-thermostatically activated and that have a storage capacity greater than or equal to ten gallons.

O. Other Issues

Several stakeholders expressed legal, procedural, and practical concerns regarding the amendments proposed in the May 2016 NOPR. These comments are discussed in detail in the subsections below.

1. Timing of the Test Procedure and Energy Conservation Standards Rulemakings

Several commenters expressed concerns regarding the timing of the test procedure and energy conservation standards revisions for CWH equipment, and requested that DOE delay (or suspend) its energy conservation standards rulemaking until after the finalization of the test procedure. (AHRI, No. 26 at p. 15; EEI, No. 29 at p. 2; Gas Associations, No. 22 at p. 2; Raypak, No. 28 at p. 1; Bradford White, No. 21 at p. 1) The commenters also opined that DOE has violated the procedures established in 10 CFR part 430, subpart C, Appendix A, Section 7(c) (which commenters referred to as the ''Process Rule''), which states that a final test procedure will be issued prior to the NOPR for proposed standards. (EEI, No. 29 at p. 2; Gas Associations, No. 22 at p. 2; Raypak, No. 28 at p. 1; Bradford White, No. 21 at p. 1) Bradford White also disagreed with DOE's assertion in the May 2016 NOPR that it is not aware of any rules or regulations that duplicate, overlap, or conflict with the proposed test procedure rule.

Rheem stated that it believes that the proposed definitional changes to CWH equipment and applicable test procedure changes will alter the efficiency ratings of CWH equipment and noted that DOE must determine if the minimally-compliant models will continue to meet the current energy conservation standards if the proposed test procedure changes are finalized. Further, Rheem argued that in the May 2016 NOPR, DOE concluded that the proposed changes would not ''significantly alter'' the current ratings, but that the statute does not require a ''significant'' standard. (Rheem, No. 34 at pp. 3–4)

In response, 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 May 2016 NOPR proposed amendments to incorporate provisions of the latest industry standard (*i.e.,* ANSI Z21 10.3–2015), which was developed by a consensus-based ANSI process, and was released in November 2015. The test procedures proposed in the May 2016 NOPR and adopted in this final rule either reference ANSI Z21.10.3–2015 directly or are largely based on ANSI Z21.10.3–2015. In the May 2016 NOPR, DOE also addressed several issues raised by stakeholders in response to the February 2014 RFI. For example, the standby loss test procedure for flow-activated instantaneous water heaters adopted in this final rule was identified as an issue by AHRI in response to the February 2014 RFI. In response to the May 2016 NOPR, stakeholders provided detailed, insightful comments on all aspects of the proposal, including those proposals which are not included in ANSI Z21.10.3–2015, which shows that industry was able to carefully consider the proposed method and how it compared to the current Federal method of test. Further, DOE has also incorporated several recommendations received from stakeholders in response to the May 2016 NOPR (*e.g.,* adopting a calculation-based test to determine storage volume, adding steady-state requirements instead of soak-in period for thermal efficiency test of storage water heaters, and using AHRI-recommended rating conditions for the CHWPH test procedure). Furthermore, DOE granted a 30-day extension of the comment period (Docket EERE–2014–BT–STD–0042) to ensure stakeholders had sufficient time to consider the proposed test procedure changes in relation to the proposed standards. 81 FR 51812 (August 5, 2016). Therefore, DOE concluded that stakeholders have had adequate time to provide meaningful comments on DOE's analysis and results in this test procedure rule.

Regarding the commenters' assertions that DOE has violated the provisions of 10 CFR 430, subpart C, appendix A, DOE notes that Appendix A established procedures, interpretations, and policies to guide DOE in the consideration and promulgation of new or revised appliance efficiency standards under EPCA. (*See* section 1 of 10 CFR 430 subpart C, appendix A) These procedures are a general guide to the steps DOE typically follows in promulgating energy conservation standards. The guidance recognizes that DOE can and will, on occasion, deviate from the typical process. (*See* 10 CFR part 430, subpart C, appendix A, section 14(a)) In this particular instance, DOE deviated from its typical process due to statutorily prescribed deadlines for both the test procedure and standards rulemaking. As discussed previously in this notice, there have recently been updates to the industry testing standard (ANSI Z21.10.3), as well as petitions for waiver submitted to DOE by stakeholders requesting an alternative test method for flow-activated instantaneous water heaters. DOE is also aware of issues with the existing DOE test method having certain ambiguous provisions in the test set-up, conditions, and operation that could allow for inconsistent application and could lead to differing results across different test labs. DOE believes it is imperative to update the test method to remedy these issues as soon as possible. Therefore, DOE decided to amend the existing test procedure while continuing with the energy conservation standards rulemaking in parallel. The comments pertaining to the timing of the energy conservation standards rulemaking are addressed separately in the final rule for the energy conservation standards of CWH equipment.

In response to Rheem's comment, DOE notes that by ''significantly alter,'' DOE meant that the measured energy efficiency or consumption would not be altered from the current test method to an extent that the current minimum standard must be adjusted. All of the provisions being adopted in this final rule either clarify the existing test method, improve repeatability of the existing test method, or establish a test method for equipment that either previously did not have a method (*e.g.,* CHPWH) or for which the test method did not work (*e.g.,* flow-activated instantaneous water heaters). However, the actual procedure for measuring the thermal efficiency and standby loss remains largely the same, and, thus, DOE continues to believe that efficiency ratings are not affected. Rheem did not provide any information as to which specific changes it believes would have an effect on efficiency ratings, other than the ''definitional changes.'' While definitions are an integral part of determining equipment classification, and thus, the applicability of the test method, DOE notes that they do not change the actual test method, and thus, would not impact the ratings. DOE understands that the changes to the definitions may cause certain water heaters that manufacturers currently classify as commercial equipment to be classified as consumer products. However, as discussed in section III.G.1, DOE has concluded that under EPCA, these products have always been covered consumer products. Therefore, this is not a change that would warrant reconsideration of the energy conservation standards under 42 U.S.C.6293(e).

2. Other Comments

The Gas Associations recommended that DOE adopt additional electrical consumption requirements, stating that the current test procedure only measures fossil fuel energy consumption without considering electrical usage. The Gas Associations further stated that the electrical energy consumption should be calculated using a source-based method rather than a site-based method. (Gas Associations, No. 22 at p. 2)

DOE disagrees with the comments from the Gas Associations. Both the current and the amended test procedures require the measurement of the electricity consumption by CWH equipment during the thermal efficiency and standby loss test, and the thermal efficiency and standby loss metrics account for the electricity use during the test. The equations for calculating the thermal efficiency and standby losses of storage and instantaneous water heaters require the addition of the measured electrical energy consumption to the total fossil fuel consumption, so electrical energy use is taken into account. Regarding the suggestion to use a source-based value for electrical energy consumption, DOE notes that such an approach would be inconsistent with the accounting of the gas consumption, which is based on site energy consumption, and inconsistent with the approach used in ANSI Z21.10.3–2015 to account for electrical energy consumption. Therefore, DOE does not believe an additional source-based electrical consumption metric is necessary.

CA IOUs requested that DOE release anonymized equipment testing data to allow stakeholders to provide stronger comments and strengthen the rulemaking process. (CA IOUs No. 23 at p. 3) Several proposals to which DOE believes this comment was likely directed are not adopted in this final rule (*i.e.,* narrowing the tolerance on ambient room temperature from 10 °F to 5 °F, establishing an ambient humidity requirement, and the standby loss test procedure for unfired hot water storage tanks). In regards to DOE's testing of flow-activated instantaneous water heaters, DOE notes that these tests were conducted in order to ensure that DOE's proposed test procedures could be conducted as written. For CHPWHs, DOE described in extensive detail in the May 2016 NOPR the evaporator entering air conditions, the capacities of the units, and the entering water temperatures that helped inform the rating conditions that were proposed for rating CHPWHs. DOE has not provided information on the units tested and the efficiency or standby loss results obtained to protect the confidentiality of the manufacturers of these products. Further, DOE did not conduct any additional testing as part of this final rule. Therefore, this final rule does not include any additional testing data that were not presented in the May 2016 NOPR.

3. Waiver Requests

DOE received waiver requests or interim waiver requests from A. O. Smith, HTP, Thermal Solutions, Raypak, and RBI.[21] The petitioners asserted that DOE's existing test method for determining standby loss applies to thermostatically activated models only, and is not appropriate for flow-activated models. The petitioners requested the use of alternative procedures for measuring the standby loss of flow-activated instantaneous water heaters. As described in section III.H, DOE is adopting a test procedure specifically for commercial instantaneous CWH equipment that is flow activated or externally thermostatically activated. Therefore, DOE believes that this final rule addresses the petitioners' concerns. Because the need for a waiver has been overtaken by DOE's adoption of a method of test for the basic models for which each of the petitioners sought a waiver, DOE is denying these petitions for waiver. Petitioners must begin using

[21] A.O. Smith: Case No. WH–001, requested interim waiver (no notice was published for this request). HTP: Case No. WH–002, 81 FR 36295 (June 6, 2016).

Thermal Solutions: Case No. WH–003, 81 FR 36284 (June 6, 2016).

Raypak: Case No. WH–004, 81 FR 36288 (June 6, 2016).

RBI: Case No. WH–005, requested interim waiver (no notice was published for this request).

this test procedure as of the effective date of the final rule.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 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 regulatory 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.,* as amended by the Small Business Regulatory Enforcement Fairness Act of 1996) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment and a final regulatory flexibility analysis (FRFA) for any such rule that an agency adopts as a final rule, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities.

A regulatory flexibility analysis examines the impact of the rule on small entities and considers alternative ways of reducing negative effects. Also, as required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's Web site at: *http://energy.gov/gc/office-general-counsel.*

The IRFA was published as part of the May 2016 NOPR. 81 FR 28588 (May 9, 2016). The FRFA has five sections and is published below:

1. Need for, and Objectives of, the Rule

The Energy Independence and Security Act of 2007 (EISA 2007), Public Law 110–140, amended EPCA to require that at least once every 7 years, DOE must review test procedures for each type of covered equipment, including CWH equipment, and either: (1) Amend the test procedures if the Secretary determines that the amended test procedures would more accurately or fully comply with the requirements of 42 U.S.C. 6314(a)(2)–(3),[22] or (2) publish a notice of determination not to amend a test procedure. (42 U.S.C. 6314(a)(1)(A)) Under this requirement, DOE must review the test procedures for CWH equipment no later than May 16, 2019, which is 7 years after the most recent final rule amending the Federal test method for CWH equipment.[23]

This final rule prescribes test procedure amendments that will be used to determine compliance with energy conservation standards for CWH equipment (except for CHPWHs, residential-duty commercial water heaters, and electric instantaneous water heaters with a storage capacity less than 10 gallons). The amendments will: (1) Update the referenced industry test standards by incorporating by reference ASTM D2156–09, ASTM C177–13, ASTM C518–15, and sections c and f of Annex E.1 of ANSI Z21.10.3–2015; (2) modify the required ambient conditions and measurement intervals for CWH equipment; (3) change the required test set-up for storage water heaters and storage-type instantaneous water heaters; (4) change the method for setting the thermostat for gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters from measurement of mean tank temperature to measurement of top tank sensor water temperature and clarify the method for setting thermostats on electric storage water heaters with multiple thermostats; (5) establish new requirements for establishing steady-state operation and a soak-in period; (6) define ''storage-type instantaneous water heater'' and modify several definitions for consumer water heaters and commercial water heating equipment included at 10 CFR 430.2 and 10 CFR 431.102, respectively; (7) include a new test method for measurement of standby loss for instantaneous water heaters and hot water supply boilers (including internally thermostatically-activated, externally thermostatically-activated and flow-activated instantaneous water heaters); (8) specify temperature-sensing locations, water valve locations, and clarifications for using a recirculating loop for thermal efficiency and standby loss testing of instantaneous water heaters and hot water supply boilers; (9) include a new test method for rating commercial heat pump water heaters; (10) establish a procedure for determining the fuel input rate of gas-fired and oil-fired CWH equipment and specify DOE's measures to verify fuel input rate; (11) add default values for certain testing parameters for oil-fired commercial water heating equipment; and (12) modify DOE's certification requirements for commercial water heating equipment. DOE reviewed all of these amendments to the existing test procedure under the provisions of the Regulatory Flexibility Act and the policies and procedures published on February 19, 2003. 68 FR 7990. Accordingly, DOE has prepared the following FRFA for the equipment that is the subject of this rulemaking.

2. Significant Issues Raised in Response to the IRFA

The Department did not received any comment that directly addressed the IRFA. However, DOE received several comments from stakeholders that referenced the impact of amended test procedures for CWH equipment on small businesses.

In the May 2016 NOPR, DOE proposed to establish a requirement to maintain ambient relative humidity at 60 percent ± 5 percent during the thermal efficiency and standby loss test for gas-fired and oil-fired CWH equipment. 81 FR 28588, 28597–28598 (May 9, 2016). HTP commented that complying with this proposed humidity requirement would impose a significant burden to small businesses such as HTP, and would require substantial renovations to their testing lab that cost $100,000–$250,000. (HTP, No. 24 at p. 1) In this final rule, DOE is not adopting an ambient relative humidity requirement; therefore, DOE believes that this concern of impact to small manufacturers is mitigated.

In the May 2016 NOPR, DOE also proposed to decrease the length of required measurement intervals to 30 seconds for both the thermal efficiency and standby loss tests. 81 FR 28588, 28597 (May 9, 2016). To accommodate DOE's proposed time intervals for data collection, AHRI commented that some manufacturers might need to upgrade

[22] 42 U.S.C. 6314(a)(2) requires that test procedures be reasonably designed to produce test results which reflect energy efficiency, energy use, and estimated operating costs of a type of industrial equipment (or class thereof) during a representative average use cycle (as determined by the Secretary), and not be unduly burdensome to conduct.

42 U.S.C. 6314(a)(3) requires that if the test procedure is a procedure for determining estimated annual operating costs, such procedure must provide that such costs are calculated from measurements of energy use in a representative average-use cycle (as determined by the Secretary), and from representative average unit costs of the energy needed to operate such equipment during such cycle. The Secretary must provide information to manufacturers of covered equipment regarding representative average unit costs of energy.

[23] DOE published a final rule in the **Federal Register** on May 16, 2012, that, in relevant part, amended its test procedure for commercial water-heating equipment. 77 FR 28928.

their facilities, and Raypak and Rheem argued that small manufacturers might need to purchase or upgrade data acquisition systems. (AHRI, No. 26 at pp. 6–7; Raypak, No. 28 at pp. 6–7; Rheem, No. 34 at p. 5)

DOE disagrees that its proposed measurement intervals would require costly upgrades to lab facilities for any manufacturers, including small businesses. Given that DOE's proposed measurement interval was only slightly different from the current requirement for the thermal efficiency test—30 seconds vs 1 minute—DOE does not believe that this proposal would require any upgrades. The duration of the standby loss test exceeds 24 hours and can reach up to 48 hours; therefore, DOE does not believe it is likely that any manufacturers, including small businesses, are performing this test without an automated data acquisition system. The one-time cost of a data acquisition system would likely be much less than the recurring labor costs of having a lab technician constantly monitor and record measurements for every standby loss test for up to 48 hours. DOE notes that no stakeholders have commented to DOE that they do not use data acquisition systems for testing of CWH equipment. Additionally, DOE does not believe that increasing the frequency of data collection would require significant upgrades to existing data acquisition systems. Rather, DOE believes that changing the measurement frequency would require a simple one-time software change and that the additional amount of data collected could easily be stored given the low cost of computer storage. Additionally, DOE is not adopting any requirements in this final rule that would require measurement with a data acquisition system other than time and temperature. Therefore, DOE does not expect the required data collection intervals adopted in this final rule—1 minute for both the thermal efficiency and standby loss tests—to impose a significant burden on any manufacturers, including small businesses.

In the May 2016 NOPR, DOE also proposed to adopt a standby loss test for unfired hot water storage tanks. 81 FR 28588, 28597 (May 9, 2016). DOE received numerous comments on this topic, and is still considering those comments. Therefore, DOE will address the comments and its proposed test procedure for unfired hot water storage tanks in a separate rulemaking notice.

In the May 2016 NOPR, DOE proposed a standby loss test method for flow-activated instantaneous water heaters. 81 FR 28588, 28607–28615 (May 9, 2016) DOE received comments from Bradley expressing concern with the complexity and burden associated with the test procedure. Bradley notes that it manufactures highly specialized water heaters and the burden to test their products with DOE's proposed test procedure would be an extreme financial burden to the business while not resulting in meaningful energy savings for customers. Bradley also expressed concern with the test procedure, specifically with regards to the method of test (including the standby loss equation) and the method proposed to determine the storage volume. Bradley suggested simplifying the test procedure would reduce the burden on small businesses that manufacture these specialized water heaters. (Bradley, No. 33 at pp. 1, 3–4)

The concerns expressed by Bradley with regards to the testing burden, pertain to instantaneous water heaters and hot water supply boilers that have a storage volume less than 10 gallons. DOE notes that maximum standby loss standards are currently only prescribed for instantaneous water heaters and hot water supply boilers with rated storage volume greater than or equal to 10 gallons. In the NOPR for the ongoing energy conservation standards rulemaking for CWH equipment, DOE did not propose standby loss standards for instantaneous water heaters with rated storage volume less than 10 gallons. 81 FR 34440 (May 31, 2016). Consequently, manufacturers are not required to test or certify their instantaneous water heaters and hot water supply boilers for standby loss, if the model is an either an electric instantaneous water heater or is a gas or oil-fired instantaneous water heater with a storage volume less than 10 gallons.

With regard to the technical concerns expressed by Bradley, DOE notes that it has responded to these comments in section III.H of this final rule. Specifically, DOE notes that in section III.H.2 of the final rule notice it has permitted the use of calculations based on physical dimensions and design drawings to determine the storage volume of instantaneous water heaters and hot water supply boilers (including flow-activated instantaneous water heaters). DOE has also decided to include additional provisions to allow water heaters that are not capable of meeting the required outlet water temperature (due to in-built safety features that restrict the maximum temperature within the unit), to conduct the test using the maximum water temperature the unit is capable of achieving. DOE believes that if manufacturers choose to rate their products using the test procedure adopted by DOE in this final rule, then these provisions will be beneficial in simplifying the test procedure particularly for the CWH equipment with in-built safety features that restrict the rise in water temperature.

3. Description and Estimate of the Number of Small Entities Affected

For manufacturers of covered CWH equipment, the Small Business Administration (SBA) has set a size threshold, which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. (see 13 CFR part 121) The size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at: *https://www.sba.gov/sites/default/files/Size_Standards_Table.pdf.* Manufacturing of CWH equipment is classified under NAICS 333318, ''Other Commercial and Service Industry Machinery Manufacturing.'' [24] The SBA sets a size threshold of 1,000 employees or fewer for a manufacturer that falls under this category to qualify as a small business.

To estimate the number of companies that could be small business manufacturers of equipment covered by this rulemaking, DOE conducted market research and created a database of CWH equipment manufacturers. DOE's research involved industry trade association membership directories (including AHRI [25]), public databases (*e.g.,* the California Energy Commission Appliance Efficiency Database,[26] DOE's Compliance Certification Database [27]), individual company Web sites, and market research tools (*e.g.,* Hoovers reports [28]) to create a list of companies that manufacture equipment covered by this rulemaking. DOE screened out companies that do not manufacture equipment affected by this rule, do not meet the definition of a ''small business,'' or are foreign owned and

[24] On October 1, 2012, the NAICS code for ''Other Commercial and Service Industry Machinery Manufacturing,'' which includes manufacturing of commercial water heating equipment, changed from 333319 to 333318.

[25] The AHRI Directory is available at: *www.ahridirectory.org/ahriDirectory/pages/home.aspx.*

[26] The CEC database is available at: *http://www.energy.ca.gov/appliances/.*

[27] DOE's Compliance Certification Database is available at: *https://www.regulations.doe.gov/certification-data/.*

[28] Hoovers Inc., Company Profiles, Various Companies (Available at: *www.hoovers.com/*).

operated. Based upon this analysis and comprehensive search, DOE identified 29 manufacturers of CWH equipment affected by this rulemaking (excluding rebranders). Of these, DOE identified 18 as domestic small manufacturers.

4. Description and Estimate of Compliance Requirements

In the following sections, DOE discusses the potential burdens that could be faced by manufacturers of CWH equipment, particularly small businesses, as a result of each of the test procedure amendments being adopted in this final rule.

Updated Industry Test Methods

In this final rule, DOE is updating the referenced industry test method in its test procedures for CWH equipment from ANSI Z21.10.3–2011 (Exhibits G.1 and G.2) to sections c and f of Annex E.1 of ANSI Z21.10.3–2015. DOE does not expect that this update will impact the requirements, conditions, or duration of DOE's test procedures. DOE only identified one substantive difference in ANSI Z21.10.3–2015 from the currently referenced version ANSI Z21.10.3–2011—the standby loss equation. Because DOE concluded that the equation in the currently referenced ANSI Z21.10.3–2011 is correct and retains that equation in its test procedures, this updated reference to the industry test method will not affect conduct of or ratings from DOE's test procedure.

DOE's current test procedure, specified at 10 CFR 431.106, also requires that flue gases from oil-fired CWH equipment not contain smoke that exceeds No. 1 smoke, as determined by ASTM Standard D2156–80. In this final rule, DOE is incorporating by reference the most recent version of this test method, ASTM D2156–09. DOE did not identify any significant differences between the two versions of this test method; therefore, DOE concluded that this updated reference should not affect results from its test procedure.

Additionally, DOE is adopting several clarifications to the procedure for determining smoke spot number because the current procedure as specified in 10 CFR 431.106 does not specify the timing or location of measuring the smoke spot number. DOE considers conduct of the smoke spot test and measurement of CO_2 reading before the thermal efficiency test begins to be a less burdensome method than measuring during the test. Therefore, the Department does not consider this clarification likely to increase testing burden to manufacturers. Additionally, DOE clarifies situations when the smoke spot test and measurement of CO_2 reading are not needed to reduce burden. Finally, DOE specifies the location within the flue for determination of smoke spot number. Given that this requirement was adopted from an industry-accepted test method for similar commercial HVAC equipment, DOE selected this location because it was the least likely to increase burden to manufacturers, DOE's current definition for ''R-value'' at 10 CFR 431.102 references two industry test methods, ASTM C177–97 and ASTM C518–91. DOE is incorporating by reference the most recent versions of these test methods: ASTM C177–13 and ASTM C518–15. DOE did not identify any significant differences in the procedures for measuring R-value between the two versions of ASTM C177 or between the two versions of ASTM C518. Therefore, this updated reference should not affect results for calculation of R-value per DOE's definition at 10 CFR 431.102.

Ambient Test Conditions

DOE is adopting several amendments to its required ambient conditions for CWH equipment. Specifically, DOE is making the following modifications: (1) Setting a maximum air draft requirement of 50 ft/min as measured prior to beginning the steady-state verification period or the standby loss test; (2) decreasing the allowed variance from mean ambient temperature from ± 7.0 °F to ± 5.0 °F; (3) requiring measurement of test air temperature—the temperature of entering combustion air—and requiring the test air temperature not vary by more than ± 5 °F from the ambient room temperature at any measurement interval during the steady-state verification period and the thermal efficiency and standby loss tests for gas-fired and oil-fired CWH equipment; and (4) decreasing the time interval for data collection from fifteen minutes to one minute for the standby loss test.

For the first modification, depending on the conditions in the manufacturer's testing area, the manufacturer may need to protect the testing area from drafts greater than 50 ft/min. This draft protection could be accomplished by using wind barriers such as moveable walls, minimizing the opening and closing of doors near the test stand, or sealing windows. To measure draft velocity, manufacturers may have to purchase instrumentation that DOE estimates could cost up to $250. However, any manufacturer of residential water heaters should already have this instrumentation and be able to comply with this requirement, because it is similar to the requirement established for testing residential water heaters in the July 2014 final rule. 79 FR 40542, 40569 (July 11, 2014). DOE notes that measurement of air draft is only required at the beginning of each test; therefore, draft-measuring devices used for testing of CWH equipment do not need the capability to connect to a data acquisition system.

For the second modification, manufacturers need to maintain a slightly more stringent allowed variance from the average ambient room temperature over the course of the test. DOE received several comments suggesting that DOE adopt this decreased variance, indicating that this decrease in the allowed variance would not be burdensome to manufacturers, and that manufacturers could accommodate this decrease in the allowed variance with their existing lab HVAC systems. Therefore does not anticipate that this modification will impose a significant burden to manufacturers, including small businesses.

For the third modification, manufacturers need to measure the test air temperature, which is measured within two feet of the combustion air inlet. While this requirement was adopted from an industry test method for commercial packaged boilers, AHRI 1500–2015, it was not previously required for testing of CWH equipment. Therefore, manufacturers need to install temperature sensors in close proximity to the air intake. However, DOE believes that a requirement for this temperature measurement will not present any significant testing burden to manufacturers, because it simply involves taking more temperature measurements than are already being conducted, and the temperature readings could be recorded using the same data acquisition software that is used for measuring the ambient room temperature. DOE anticipates that adding additional temperature sensors to an existing data acquisition system would be a simple, one-time task and not present a significant burden to manufacturers.

Finally, DOE proposes reducing the time interval for data collection during the standby loss test from 15 minutes to 1 minute. Because the standby loss test duration is between 24 to 48 hours, DOE reasons that manufacturers already use a computer-connected data acquisition system. Additionally, manufacturers are already required to measure at one-minute intervals in DOE's existing thermal efficiency test procedure. DOE believes that changing the measurement frequency would require a simple one-time software change and that the additional amount of data collected could easily be stored given the low cost of computer storage. Therefore, manufacturers were not expected to incur any additional testing costs due to the change in the relevant data recording time intervals, and DOE does not anticipate the one-time software change to impose any significant burden to manufacturers, including small businesses.

Test Set-Up for Storage and Storage-Type Instantaneous Water Heaters

In this final rule, DOE specifies the location for measurement of supply and outlet water temperature for storage water heaters and storage-type instantaneous water heaters. Specifically, in the test set-ups adopted in this final rule, DOE has specified exact locations for placement of the temperature sensors in terms of total piping length. DOE expects these lengths to align with the piping set-ups currently used in most testing of CWH equipment. If the test set-up changes adopted in this final rule are different from the set-ups currently used, DOE believes that these differences would be minor and would simply involve adding or removing several inches of piping. Additionally, DOE is adopting set-ups for tank-type water heaters with connections on the top, side, or bottom—thereby minimizing the likelihood that a significant change to the set-up currently used by manufacturers would be needed. Further, for certain water heaters with horizontal water connections that cannot meet the inlet side vertically downward piping distance of 24 inches (as proposed in the May 2016 NOPR), DOE allows such piping to be extended vertically downwards to the maximum extent possible. This would reduce the burden on manufacturers and small businesses from having to raise the water heater platform or have piping embedded under the flooring, to meet the 24 inches of vertically downward piping distance. Therefore, DOE concludes that the changes adopted with regards to the test set-up for storage and storage-type instantaneous water heaters would not present a significant burden to manufacturers, including small businesses.

Unfired Hot Water Storage Tanks

DOE is not adopting a test procedure for unfired hot water storage tanks in this final rule, and, therefore, there will be not any burden from test procedure amendments for this equipment.

Thermostat Settings for Storage Water Heaters

DOE is modifying its procedure for setting the tank thermostat for gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters by adopting a top tank sensor water temperature requirement rather than a mean tank temperature requirement. This change was suggested by manufacturers so that their models can more easily meet the specified conditions in the test procedure without having to sacrifice thermal efficiency gains when designing equipment. Because the top tank sensor water temperature (*i.e.,* the highest of six temperature sensors used to calculate mean tank temperature) is already measured in the current test method, this proposal would simplify DOE's test procedure, and would not create any additional test burden for manufacturers, including small businesses. DOE is also adopting a requirement that the tank be re-filled with supply water before re-adjusting the thermostat if the top tank sensor temperature requirement is not achieved. While this requirement may add to test time in certain cases, DOE believes that it is common industry practice, because this requirement is consistent with requirements in an industry-consensus test method, ASHRAE 118.1–2012, and DOE's test procedure for consumer water heaters and residential-duty commercial water heaters at appendix E to subpart B of 10 CFR part 430.

DOE is also clarifying its procedure for setting thermostats for electric storage water heaters with multiple thermostats. DOE is specifying that only the top-mosttopmost and bottom-mostbottommost thermostats be set, and that all other thermostats and corresponding heating elements not operate while setting thermostats or during conduct of the standby loss test. DOE believes that some manufacturers already use DOE's adopted method, and that this method simply clarifies which thermostats (and corresponding heating elements) to use during the test. DOE's clarifications are based upon comments from a manufacturer and industry trade organization; based on these comments, DOE does not anticipate that this procedure will impose a significant test burden to manufacturers, including small businesses.

Steady-State Requirements and Soak-In Period

DOE is adopting more stringent provisions for establishing steady-state operation prior to the thermal efficiency test. These provisions require a 30-minute verification period, rather than the 3-minute period in DOE's current test procedure. However, these provisions, with minor modifications, were suggested by multiple commenters as being supported by an industry working group, as an improvement to the repeatability of testing of CWH equipment. DOE also understands that many manufacturers, including small businesses, already often run CWH equipment for longer than required by DOE's current test procedure to ensure steady-state operation prior to beginning the thermal efficiency test. Therefore, DOE does not expect that these more-stringent provisions will impose a significant burden to manufacturers, including small businesses.

DOE has also added clarifying statements to its thermal efficiency and standby loss test procedures. Specifically, DOE is clarifying that during the steady-state verification period, the thermal efficiency test, and the standby loss test (as applicable), no settings on the water heating equipment can be changed until measurements for the test have finished. As discussed in section III.F.2, several manufacturers agreed to include the clarifying statements. Additionally, DOE expects that the majority of manufacturers already perform the thermal efficiency and standby loss tests in a manner as clarified in DOE's proposal. Therefore, DOE has concluded that its clarifying statements would only serve to remove any potential confusion regarding its test procedures, and would not add any burden to manufacturers, including small businesses.

DOE is adopting a requirement that a soak-in period be conducted prior to the standby loss test for storage water heaters in which the water heater must sit without any draws taking place for at least 12 hours from the end of a recovery from a cold start, unless the unit has been in operation and no settings have been changed since the end of a previously run efficiency test. While this soak-in period would add to the time required to conduct the test, it would not require extra personnel and would not necessitate the development of additional test platforms. DOE understands that a preconditioning period is already implemented by manufacturers as a best practice to allow the water heater to achieve operational temperature, so the added burden from the 12-hour soak-in is expected to be minimal. In addition, these tests can be conducted in the same facilities used for the current energy testing of these products, so there would be no additional facility costs required by this amendment.

Storage-Type Instantaneous Water Heaters

DOE is adopting a new definition for ''storage-type instantaneous water heater,'' which includes instantaneous water heaters with integral storage tanks that have a tank volume greater than or equal to 10 gallons. DOE believes this kind of water heater should be tested similar to storage water heaters. However, DOE does not currently prescribe separate test procedures for storage water heaters and instantaneous water heaters. Only in the test procedures established in this final rule does DOE prescribe separate standby loss test procedures for storage water heaters and instantaneous water heaters. Additionally, DOE's research suggests that manufacturers already categorize units falling under DOE's proposed definition for ''storage-type instantaneous water heater'' with storage water heaters. Therefore, DOE does not anticipate that applying the test procedure prescribed for storage water heaters to storage-type instantaneous water heaters will present a burden for manufacturers, including small businesses.

Instantaneous Water Heaters and Hot Water Supply Boilers (Other Than Storage-Type Instantaneous Water Heaters)

Currently, all instantaneous water heaters and hot water supply boilers having a capacity of 10 gallons or more are required to undergo the same standby loss test that is prescribed in Exhibit G.2 of ANSI Z21.10.3–2011. In this final rule, DOE is adopting a separate standby loss test procedures for: (1) Internally thermostatically-activated instantaneous water heaters and (2) instantaneous water heaters that are either flow-activated or thermostatically activated by an external thermostat. In addition, DOE is adopting changes to the test set-up for instantaneous water heaters and hot water supply boilers.

For the changes in the test set-up, DOE is adopting: (1) Slight variations of Figure III.1, Figure III.2, and Figure III.3 of this final rule as the test set-ups for instantaneous water heaters and hot water supply boilers tested without a recirculating loop, and (2) Figure III.4 as the test set-ups for instantaneous water heaters and hot water supply boilers tested with a recirculating loop. Allowing the water heaters to be tested to the different configurations in the figures would be beneficial to all manufacturers, including small businesses, as it would allow them to use the test set-up most appropriate to the equipment being tested. In this final rule, DOE has decided to require three changes in the test set-up for instantaneous water heaters and hot water supply boilers: (1) Installation of an additional temperature sensor near the outlet of the water heater at a distance of one-inch (inside or outside) from the outlet port for the standby loss test; (2) installation of a temperature sensor in the outlet water piping at the second elbow (as per the test set-ups in Figure III.1, Figure III.2,Figure III.3, and Figure III.4 of this final rule); and (2) installation of an outlet water valve downstream of the outlet water heat trap, within a distance of 10 inches downstream from outlet water temperature sensor which is placed at the second elbow in the outlet water piping.

These modifications in the test set-up require: (1) Addition of a pipe fitting to hold the outlet water temperature-sensing instrument to a location immediately outside the CWH equipment; (2) addition of a temperature sensor near the outlet to the water heater; and (2) movement of the outlet water valve that is already installed further downstream in the piping, to a location closer to the CWH equipment. DOE estimates that a fitting to hold the temperature sensor would cost approximately $50, while the temperature sensor itself would cost about $100 (for a thermocouple). DOE reasons that the benefits of better representation of the outlet water temperature and close proximity of the water valves that need to be shut off to retain the hot water in the water heater during the standby loss test outweighs the small potential cost of an additional pipe fitting and temperature sensor. In addition to these changes, DOE is also clarifying the conditions for using a recirculating loop. The use of a recirculating loop is allowed in the current test procedure, and, thus, this modification would not cause an increase in testing cost. Therefore, DOE concluded that the adjustments described in this paragraph would not impose a significant burden on manufacturers, including small businesses.

The standby loss test procedure adopted for internally thermostatically-activated instantaneous water heaters is similar to the current test procedure in Exhibit G.2 of ANSI Z21.10.3–2011 (and Annex E.2 of ANSI Z21.10.3–2015) that is incorporated by reference as DOE's test procedure. The adopted test procedure requires the use of the heat exchanger outlet water temperature as an approximation for the stored water temperature instead of the mean tank temperature which is required by the current test procedure. DOE notes that this adopted modification to the current test procedure would only change the terms that are used in calculating standby loss. In the previous section, DOE discussed the cost involved in installing an additional temperature sensor to record the heat exchanger outlet water temperature. Therefore, the only change that manufacturers will be required to make is to record the heat exchanger outlet water temperature during the standby loss test. Accordingly, DOE has concluded that these changes will not be unduly burdensome to manufacturers, including small businesses.

For externally thermostatically-activated instantaneous water heaters and flow-activated instantaneous water heaters, DOE has adopted a test procedure that is similar to the current test procedure in Exhibit G.2 of ANSI Z21.10.3–2011. Similar to internally-activated instantaneous water heaters, the adopted test procedure for flow-activated and externally thermostatically-activated instantaneous water heaters uses the outlet water temperature as an approximation for the stored water temperature. In addition, the adopted test procedure would not require the water heater to cycle-on at any point in the course of the test. Therefore, the amount of fuel consumption is not required to be recorded for standby loss calculations. As a result, these two modifications will simplify the test and reduce the amount of data processing required for calculating the standby loss metric. As a result, this modification will be beneficial to all manufacturers, including small businesses.

The second difference pertains to the duration of the test. In the current test procedure, the equipment is tested until the first cut-out that occurs after 24 hours or 48 hours, whichever comes first. In the adopted standby loss test procedure for flow-activated instantaneous water heaters, the test ends when the outlet water temperature drops by 35 °F or after 24 hours, whichever comes first. DOE has concluded that it is very likely that a 35 °F drop in outlet water temperature will occur before 24 hours. Therefore, this modification will likely be beneficial to all manufacturers, including small businesses, as it would reduce the time required to conduct the standby loss test. In addition, DOE notes that the maximum test length of 24 hours in the test method is the same as the current minimum test length in the existing test procedure, so the adopted test will always result in a test length either shorter or equal to that of the current test.

The third difference is with regard to the pump purge functionality. The current test procedure requires the outlet water valve to be closed immediately after the burner cuts out at the beginning of the standby loss test. In the test procedure adopted in this final rule, DOE has decided to allow units to use the integrated pump purge functionality (if so equipped) by delaying the closing of the outlet water valve until after the pump purge operation is completed. During this operation, the electricity consumed is not recorded for calculating the standby loss. DOE notes that the addition of this provision only changes the sequence of steps in the test procedure. As a result, DOE does not believe this modification will impose a significant burden on manufacturers, including small businesses. Rather, DOE believes that by allowing this modification, manufacturers will be able to benefit from the pump purge technology that is intended to reduce standby loss in the water heater.

Finally, in the adopted test procedure, DOE has permitted the use of calculations based on CAD designs and physical dimensions to rate the storage volume of instantaneous water heaters and hot water supply boilers. The current test procedure requires the use of the weight-based test specified in section 2.26 of ANSI Z21.10.3–2011 to determine the storage volume. The weight-based test requires the water heater to be weighed dry and then weighed after it is filled with water. The difference between the two weights is used to calculate the storage volume. DOE expects that allowing manufacturers to use their design drawing or physical dimensions to determine storage volume will be beneficial to manufacturers and save them time and cost. Therefore, DOE believe that this modification will be beneficial to all manufacturers, including small businesses.

In summary, DOE has concluded that the standby loss test procedure adopted in this final rule for flow-activated, externally thermostatically activated and internally thermostatically activated instantaneous water heaters will not impose any significant additional burden on manufacturers.

Commercial Heat Pump Water Heaters

DOE previously did not prescribe a test procedure for commercial heat pump water heaters. In this final rule, DOE adopts a new test procedure for measurement of the COP_h of CHPWHs. However, manufacturers are not required to certify COP_h for CHPWHs until DOE establishes energy conservation standards for this equipment based on a COP_h metric. Therefore, manufacturers are not required to certify for COP_h using the test procedure adopted in this final rule. However, DOE acknowledges that in the absence of a Federal COP_h standard, some manufacturers may choose, at their discretion, to rate the efficiency of their CHPWHs to help distinguish their equipment from competitor offerings.

DOE believes that manufacturers of CHPWHs already have the equipment, instrumentation, and facilities (including psychrometric chambers) for testing their units according to the adopted test method, because these will be needed for product development and measurement of COP_h values absent a DOE test method. However, DOE acknowledges that some manufacturers may need to purchase equipment, instrumentation, or test stands for measurement of COP_h according to the test method. For testing air-source CHPWH units, DOE estimates that the cost to build a test stand and a surrounding psychrometric chamber for the testing of CHPWHs will cost no more than $300,000. While the duration of the test for air-source CHWPHs is 30 minutes, DOE estimates the total time, including the time needed for set-up and stabilizing the outlet water temperatures prior to the test, may reach five hours. At a rate of $40 per hour for a laboratory technician, DOE estimates the cost for this labor will be $200 per model tested.

Given the small market size of air-source CHPWHs, DOE believes that most manufacturers without test facilities capable of testing air-source CHPWHs according to DOE's test procedure will choose to conduct testing at a third-party lab. DOE estimates that the average air-source CHPWH manufacturer sells six models, and that the cost of testing an air-source CHPWH would not exceed $11,000. Therefore, the average testing burden for manufacturers of air-source CHPWHs without testing facilities should not exceed $66,000.

For indoor water-source, ground-source closed-loop, and ground water-source CHPWHs, water solution conditioning and recirculation equipment similar to a chiller would be required for testing, in addition to the common instrumentation needed for testing air-source CHPWHs (*e.g.,* standard piping, instrumentation, a data acquisition system, and test stand). DOE expects most manufacturers already have such equipment in order to test and provide ratings for their current product offerings. However, DOE acknowledges that there may be some manufacturers that do not currently have equipment sufficient for conducting DOE's adopted test procedure. DOE estimates the total cost of a chiller to be about $20,000. The cost of instrumentation, piping, and a data acquisition unit could add up to an additional $5,000. Therefore, DOE does not expect capital investments would exceed $25,000 per manufacturer. DOE estimates that following the test procedure, it would take approximately 5–6 hours to set up the unit and to conduct the test. At a lab technician labor cost of $40 per hour, DOE estimates the total labor cost incurred to test each unit would be between $200 and $240. Alternatively, some manufacturers, including small businesses, may choose to test their units at third-party laboratories instead of investing in in-house testing facilities. DOE estimates that the cost of such testing would not exceed $3,000 per unit. DOE estimates that manufacturers may test about 6 models annually at third-party laboratories. Therefore, the total estimated cost burden for any such manufacturers would not be more than $18,000.

Based on the adopted test procedure, the test set-up for ground-source closed-loop, ground water-source, or indoor water-source CHPWHs will be similar to that for direct geo-exchange CHPWHs, with the only difference being that the test set-up for direct geo-exchange CHPWHs includes an additional solution heat exchanger. Similar to water-source CHPWHs, DOE expects that most manufacturers of direct geo-exchange CHPWHs already have such equipment in order to test and provide ratings for their current product offerings. DOE understands that the cost of this solution heat exchanger will be the only cost to be added to the total estimated cost for testing ground and indoor water-source CHPWHs in order to arrive at the estimated cost of testing a direct geo-exchange CHPWH. DOE estimates the cost of a liquid-to-liquid heat exchanger to be not more than $30,000. Therefore, the total estimated capital investment cost for testing a direct geo-exchange CHPWH should not exceed $55,000. Similar to water-source CHPWH manufacturers, DOE understands that many manufacturers of direct geo-exchange CHPWHs, including small businesses, may choose to test their units at third-party laboratories instead of investing in in-house testing facilities. DOE estimates the cost of such testing will not exceed $5,000 per unit.

Gas Pressure

DOE is adopting requirements that the gas supply pressure must be within the range specified by the manufacturer, and that the difference between the outlet pressure of the gas appliance pressure regulator and the value specified by the manufacturer on the nameplate of the unit being tested must not exceed the greater of: ± 10 percent of the nameplate value or ± 0.2 in. w.c. The first requirement was suggested by commenters and is consistent with the industry-consensus test method, ANSI Z21.10.3–2015. The second requirement is also consistent with ANSI Z212.10.3–2015 except for the addition of an absolute tolerance. However, this absolute tolerance only serves to make the requirement more lenient than that included in ANSI Z21.10.3–2015. Therefore, DOE does not anticipate that these changes will impose a significant burden to manufacturers, including small businesses.

Fuel Input Rate

DOE is adopting provisions that the fuel input rate be determined at 10-minute intervals during the steady-state verification period and the thermal efficiency test. This requirement to determine fuel input rate simply requires measuring gas consumption every 10 minutes during the test, a change DOE expects will impose no significant burden. Additionally, DOE is requiring that the measured fuel input rates for these 10-minute periods must not vary by more than ± 2 percent between any two readings. However, DOE believes that this requirement is consistent with the requirement in ANSI Z21.10.3–2015, and does not expect this requirement to impose a significant burden to manufacturers, including small businesses.

Default Values for Certain Test Parameters

DOE is adding to its test procedure at 10 CFR 431.106 default values for certain test parameters for oil-fired CWH equipment, to be used if manufacturers do not report these in any of the following: (1) Product nameplate, (2) the literature that is shipped with the unit (*e.g.,* installation and operations manual), or (3) their supplemental instructions. Specifically, DOE is adopting default values for fuel pump pressure and a range for CO_2 reading for oil-fired CWH equipment. DOE does not expect these default values to present a significant burden to manufacturers because these are basic parameters needed for proper use of CWH equipment and are, therefore, typically specified by the manufacturer on the product nameplate and in manufacturer literature shipped with the unit.

4. Significant Alternatives to the Rule

DOE considered alternative test methods and modifications to the test procedures for CWH equipment, and determined that there are no better alternatives than the modifications and procedures established in this final rule. DOE examined relevant industry test standards, and incorporated these standards in the final test procedures whenever appropriate to reduce test burden to manufacturers. Specifically, in this final rule DOE updates its test procedures for CWH equipment to incorporate by reference the following updated standards: ASTM D2156–09, ASTM C177–13, ASTM C518–15, and sections c and f of Annex E.1 of ANSI Z21.10.3–2015. Additionally, DOE is incorporating by reference certain sections, figures, and tables in ASHRAE 118.1–2012 in the test procedure for measurement of COP_h of commercial heat pump water heaters that DOE establishes in this final rule.

Additional compliance flexibilities may be available through other means. For example, individual manufacturers may petition for a waiver of the applicable test procedure. (See 10 CFR 431.401) 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 430, subpart E, and part 1003 for additional details.

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of CWH equipment must certify to DOE that their equipment complies with any applicable energy conservation standards. In certifying compliance, manufacturers must test their equipment according to the DOE test procedures for CWH equipment, including any amendments adopted for those test procedures, on the date that compliance is required. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including CWH equipment. 76 FR 12422 (March 7, 2011); 80 FR 5099 (Jan. 30, 2015). The collection-of-information requirement for certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910–1400. Public reporting burden for the certification is estimated to average 30 hours per 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 procedures for commercial water heating equipment. 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 the existing test procedure 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 (CX) 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, DOE has made a CX determination for this rulemaking, and neither an environmental assessment nor an environmental impact statement is required. DOE's CX determination for this final rule is available at: *http://energy.gov/nepa/categorical-exclusion-cx-determinations-cx/.*

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism,'' 64 FR 43255 (August 10, 1999), imposes certain requirements on Federal 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 equipment that is 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)) Therefore, Executive Order 13132 requires no further action.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' 61 FR 4729 (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. Regarding the review required by section 3(a), 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 proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. (This policy is also available at *www.energy.gov/gc/office-general-counsel* under ''Guidance & Opinions'' (Rulemaking)) 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 by State, local, and Tribal governments, in the aggregate, or by the private sector, of $100 million or more in any year. Accordingly, no further assessment or analysis is required under UMRA.

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

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This 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

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

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

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for Federal agencies to review most disseminations of information to the public under information quality 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 the 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 OIRA at OMB, a Statement of Energy Effects for any significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgates 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.

DOE has concluded that the regulatory action in this document, which adopts amendments to the test procedure for commercial water heating equipment, 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.

Accordingly, DOE has not prepared a Statement of Energy Effects for this final rule.

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

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101 *et seq.*), DOE must comply with all laws applicable to the former Federal Energy Administration, including section 32 of the Federal Energy Administration Act of 1974 (Pub. L. 93–275), as amended by the Federal Energy Administration Authorization Act of 1977 (Pub. L. 95–70). (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairwoman of the Federal Trade Commission (FTC) concerning the impact of the commercial or industry standards on competition.

This final rule incorporates testing methods contained in certain sections, figures, and tables in the following commercial standards: (1) ANSI Z21.10.3–2015/CSA 4.3–2015, ''Gas-fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous''; (2) ANSI/ASHRAE Standard 118.1–2012, ''Method of Testing for Rating Commercial Gas, Electric, and Oil Service Water-Heating Equipment''; (3) ASTM D2156–09, ''Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels''; (4) ASTM C177–13, ''Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus''; and (5) ASTM C518–15, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.'' While the amended test procedures are not exclusively based on these standards, DOE's amended test procedures adopt several provisions from these standards without amendment. The Department has evaluated these standards and is unable to conclude whether they fully comply with the requirements of section 32(b) of the FEAA, (*i.e.,* that they were 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 concerning the impact of these test procedures on competition 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 final 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 test standards:

(1) ANSI Z21.10.3–2015/CSA 4.3–2015, ''Gas-fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous,'' Annex E (normative) Efficiency test procedures, E.1 ''Method of test for measuring thermal efficiency'';

(2) ANSI/ASHRAE Standard 118.1–2012, ''Method of Testing for Rating Commercial Gas, Electric, and Oil Service Water-Heating Equipment,'' Section 3 ''Definition and Symbols,'' Section 4 ''Classifications by Mode of Operation,'' Section 6 ''Instruments,'' Section 7 ''Apparatus,'' Section 8 ''Methods of Testing,'' Section 9.1.1 ''Full Input Rating'', and Section 10.3.1 ''Type IV and Type V Full-Capacity Test Method'';

(3) ASTM C177–13, ''Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus''; and

(4) ASTM C518–15, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.''

(5) ASTM D2156–09, ''Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels'';

ANSI Z21.10.3–2015/CSA 4.3–2015 is an industry-accepted test procedure for measuring the performance of commercial water heaters. In this final rule, DOE incorporates by reference sections of this test procedure that address test set-up, instrumentation, test conditions, and test conduct. ANSI Z21.10.3–2015/CSA 4.3–2015 is available on ANSI's Web site at *http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI+Z21.10.3-2015%2fCSA+4.3-2015.*

ANSI/ASHRAE Standard 118.1–2012 is an industry-accepted test procedure for measuring the performance of commercial water heaters. ANSI/ASHRAE 118.1–2012 is available on ANSI's Web site at *http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2FASHRAE+Standard+118.1-2012.*

ASTM C177–13 is an industry-accepted test procedure for determining the R-value of a sample using a guarded-hot-plate apparatus. ASTM C177–13 is available on ASTM's Web site at *http://www.astm.org/Standards/C177.htm.*

ASTM C518–15 is an industry-accepted test procedure for determining the R-value of a sample using a heat flow meter apparatus. ASTM C518–15 is available on ASTM's Web site at *http://www.astm.org/Standards/C518.htm.*

ASTM D2156–09 is an industry-accepted test procedure for determining the smoke spot number of flue gases. ASTM D2156–09 is available on ASTM's Web site at *http://www.astm.org/Standards/D2156.htm.*

V. Approval of the Office of the Secretary

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

List of Subjects

10 CFR Part 429

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

10 CFR Part 430

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

10 CFR Part 431

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

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

Kathleen B. Hogan,

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

For the reasons set forth in the preamble, DOE amends parts 429, 430, and 431 of chapter II, subchapter D of title 10, Code of Federal Regulations, as set forth below:

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

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

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

■ 2. Section 429.44 is amended by:

■ a. Revising paragraphs (b) and (c);

■ b. Redesignating paragraph (d) as (e) and revising newly redesignated paragraph (e); and

■ c. Adding a reserved paragraph (d).

The revisions read as follows:

§ 429.44 Commercial water heating equipment.

* * * * *

(b) *Determination of represented values for all types of commercial water heaters except residential-duty commercial water heaters.* Manufacturers must determine the represented values, which includes the certified ratings, for each basic model of commercial water heating equipment except residential-duty commercial water heaters, either by testing, in conjunction with the applicable sampling provisions, or by applying an AEDM as set forth in § 429.70.

(1) *Units to be tested.* If the represented value for a given basic model is determined through testing:

(i) The general requirements of § 429.11 apply; and

(ii) A sample of sufficient size must be randomly selected and tested to ensure that:

(A) Any represented value of energy consumption or other measure of energy use of a basic model for which consumers would favor lower values must be greater than or equal to the higher of:

(*1*) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

And, $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the ith sample; or,

(*2*) The upper 95-percent confidence limit (UCL) of the true mean divided by 1.05, where:

$$UCL = \bar{x} + t_{.95}\left(\frac{s}{\sqrt{n}}\right)$$

And $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95-percent one-tailed confidence interval with n-1 degrees of freedom (from appendix A to subpart B of this part). And,

(B) Any represented value of energy efficiency or other measure of energy consumption of a basic model for which consumers would favor higher values must be less than or equal to the lower of:

(*1*) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

And, $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the ith sample; or,

(*2*) The lower 95-percent confidence limit (LCL) of the true mean divided by 0.95, where:

$$LCL = \bar{x} - t_{.95}\left(\frac{s}{\sqrt{n}}\right)$$

And $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95-percent one-tailed confidence interval with n-1 degrees of freedom (from appendix A to subpart B of this part).

(2) *Alternative efficiency determination methods.* In lieu of testing, a represented value of efficiency or consumption for a basic model must be determined through the application of an AEDM pursuant to the requirements of § 429.70 and the provisions of this section, where:

(i) Any represented value of energy consumption or other measure of energy use of a basic model for which consumers would favor lower values must be greater than or equal to the output of the AEDM and less than or equal to the Federal standard for that basic model; and

(ii) Any represented value of energy efficiency or other measure of energy consumption of a basic model for which consumers would favor higher values must be less than or equal to the output of the AEDM and greater than or equal to the Federal standard for that basic model.

(3) *Rated input.* The rated input for a basic model reported in accordance with paragraph (c)(2) of this section must be the maximum rated input listed on the nameplate for that basic model.

(c) *Certification reports.* For commercial water heating equipment other than residential-duty commercial water heaters:

(1) The requirements of § 429.12 apply; and

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

(i) Commercial electric storage water heaters with storage capacity less than or equal to 140 gallons: The standby loss in percent per hour (%/h) and the measured storage volume in gallons (gal).

(ii) Commercial gas-fired and oil-fired storage water heaters with storage capacity less than or equal to 140 gallons: The thermal efficiency in percent (%), the standby loss in British thermal units per hour (Btu/h), the rated storage volume in gallons (gal), and the rated input in British thermal units per hour (Btu/h).

(iii) Commercial water heaters and hot water supply boilers with storage capacity greater than 140 gallons: The thermal efficiency in percent (%); whether the storage volume is greater than 140 gallons (Yes/No); whether the tank surface area is insulated with at least R–12.5 (Yes/No); whether a standing pilot light is used (Yes/No); for gas or oil-fired water heaters, whether the basic model has a fire damper or fan-assisted combustion (Yes/No); and, if applicable, pursuant to § 431.110 of this chapter, the standby loss in British thermal units per hour (Btu/h); the measured storage volume in gallons (gal); and the rated input in British thermal units per hour (Btu/h).

(iv) Commercial gas-fired and oil-fired instantaneous water heaters with storage capacity greater than or equal to 10 gallons and gas-fired and oil-fired hot water supply boilers with storage capacity greater than or equal to 10 gallons: The thermal efficiency in percent (%); the standby loss in British thermal units per hour (Btu/h); the rated storage volume in gallons (gal); the rated input in British thermal units per hour (Btu/h); whether the water heater includes a storage tank with a storage volume greater than or equal to 10 gallons (Yes/No). For equipment that does not meet the definition of storage-type instantaneous water heaters (as set forth in 10 CFR 431.102), in addition to the requirements discussed previously in this paragraph (c)(2)(iv), the following must also be included in the certification report: whether the measured storage volume is determined using weight-based test in accordance with § 431.106 of this chapter or the calculation-based method in accordance with § 429.72; whether the water heater will initiate main burner operation based on a temperature-controlled call for heating that is internal to the water heater (Yes/No); whether the water heater is equipped with an integral pump purge functionality (Yes/No); if the water heater is equipped with integral pump purge, the default duration of the pump off delay (minutes).

(v) Commercial gas-fired and oil-fired instantaneous water heaters with storage capacity less than 10 gallons and gas-fired and oil-fired hot water supply boilers with storage capacity less than 10 gallons: The thermal efficiency in percent (%); the rated storage volume in gallons (gal), the rated input in British thermal units per hour (Btu/h); and whether the measured storage volume is determined using weight-based test in accordance with § 431.106 of this chapter or the calculation-based method in accordance with § 429.72.

(vi) Commercial unfired hot water storage tanks: The thermal insulation (*i.e.,* R-value) and stored volume in gallons (gal).

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

(i) Whether the basic model is engineered-to-order; and

(ii) For any basic model rated with an AEDM, whether the manufacturer elects the witness test option for verification testing. (See § 429.70(c)(5)(iii) for options.) However, the manufacturer may not select more than 10 percent of AEDM-rated basic models to be eligible for witness testing.

(4) Pursuant to § 429.12(b)(13), a certification report may include supplemental testing instructions in PDF format. If necessary to run a valid test, the equipment-specific, supplemental information must include any additional testing and testing set-up instructions (*e.g.,* whether a bypass loop was used for testing) for the basic model and all other information (*e.g.,* operational codes or overrides for the control settings) necessary to operate the basic model under the required conditions specified by the relevant test procedure. A manufacturer may also include with a certification report other supplementary items in PDF format for DOE's consideration in performing testing under subpart C of this part. For example, for oil-fired commercial water heating equipment (other than residential-duty commercial water heaters): The allowable range for CO_2 reading in percent (%) and the fuel pump pressure in pounds per square inch gauge (psig).

* * * * *

(e) Alternative methods for determining efficiency or energy use for commercial water heating equipment can be found in § 429.70 of this subpart.

■ 3. Section 429.72 is amended by adding paragraph (e) to read as follows:

§ 429.72 Alternative methods for determining non-energy ratings.

* * * * *

(e) *Commercial gas-fired and oil-fired instantaneous water heaters and hot water supply boilers.* The storage volume of a commercial gas-fired or oil-fired instantaneous water heater or a commercial gas-fired or oil-fired hot water supply boiler basic model may be determined by performing a calculation of the stored water volume based upon design drawings (including computer-aided design (CAD) models) or physical dimensions of the basic model. Any value of storage volume of a basic model reported to DOE in a certification of compliance in accordance with § 429.44(c)(2)(iv) and (v) must be calculated using the design drawings or physical dimensions, or measured as per the applicable provisions in the test procedures in 10 CFR 431.106. The storage volume determination must include all water contained within the water heater from the inlet connection to the outlet connection(s). The storage volume of water contained in the water heater must then be computed in gallons.

■ 4. Section 429.134 is amended by adding paragraph (n) to read as follows:

§ 429.134 Product-specific enforcement provisions.

* * * * *

(n) *Commercial water heating equipment other than residential-duty commercial water heaters*—(1) *Verification of fuel input rate.* The fuel input rate of each tested unit of the basic model will be measured pursuant to the test requirements of § 431.106 of this chapter. The measured fuel input rate (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) will be compared to the rated input certified by the manufacturer. The certified rated input will be considered valid only if the measured fuel input rate is within two percent of the certified rated input.

(i) If the certified rated input is found to be valid, then the certified rated input will serve as the basis for determination of the appropriate equipment class and calculation of the standby loss standard (as applicable).

(ii) If the measured fuel input rate for gas-fired commercial water heating equipment is not within two percent of the certified rated input, DOE will first attempt to increase or decrease the gas outlet pressure within 10 percent of the value specified on the nameplate of the model of commercial water heating equipment being tested to achieve the certified rated input (within 2 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 supply pressure within the range specified on the nameplate of the model of commercial water heating equipment being tested. If the measured 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 measured fuel input rate still is not within two percent of the certified rated input, the measured fuel input rate will serve as the basis for determination of the appropriate equipment class and calculation of the standby loss standard (as applicable).

(iii) If the measured fuel input rate for oil-fired commercial water heating equipment is not within two percent of the certified rated input, the measured fuel input rate will serve as the basis for determination of the appropriate equipment class and calculation of the standby loss standard (as applicable).

(2) [Reserved]

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

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

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

■ 6. Section 430.2 is amended by:

■ a. Removing the definition of ''Electric heat pump water heater'';

■ b. Revising the definitions of ''Electric instantaneous water heater'' and ''Electric storage water heater'';

■ c. Removing the definition of ''Gas-fired heat pump water heater''; and

■ d. Revising the definitions of ''Gas-fired instantaneous water heater'', ''Gas-fired storage water heater'', ''Oil-fired instantaneous water heater'', and ''Oil-fired storage water heater''.

The revisions read as follows:

§ 430.2 Definitions.

* * * * *

Electric instantaneous water heater means a water heater that uses electricity as the energy source, has a nameplate input rating of 12 kW or less, and contains no more than one gallon of water per 4,000 Btu per hour of input.

* * * * *

Electric storage water heater means a water heater that uses electricity as the energy source, has a nameplate input rating of 12 kW or less, and contains more than one gallon of water per 4,000 Btu per hour of input.

* * * * *

Gas-fired instantaneous water heater means a water heater that uses gas as the main energy source, has a nameplate input rating less than 200,000 Btu/h, and contains no more than one gallon of water per 4,000 Btu per hour of input.

Gas-fired storage water heater means a water heater that uses gas as the main energy source, has a nameplate input rating of 75,000 Btu/h or less, and contains more than one gallon of water per 4,000 Btu per hour of input.

* * * * *

Oil-fired instantaneous water heater means a water heater that uses oil as the main energy source, has a nameplate input rating of 210,000 Btu/h or less, and contains no more than one gallon of water per 4,000 Btu per hour of input.

Oil-fired storage water heater means a water heater that uses oil as the main energy source, has a nameplate input rating of 105,000 Btu/h or less, and contains more than one gallon of water per 4,000 Btu per hour of input.

* * * * *

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

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

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

■ 8. Section 431.102 is amended by:

■ a. Revising the section heading;

■ b. Adding in alphabetical order a definition for ''Air-source commercial heat pump water heater;''

■ c. Removing the definition of ''ASTM–D–2156–80;''

■ d. Adding in alphabetical order definitions for ''Coefficient of performance,'' ''Commercial heat pump water heater,'' ''Direct geo-exchange commercial heat pump water heater,'' ''Flow-activated instantaneous water heater,'' ''Fuel input rate,'' ''Ground-source closed-loop commercial heat pump water heater,'' and ''Ground water-source commercial heat pump water heater;''

■ e. Revising the definition of ''Hot water supply boiler;''

■ f. Adding in alphabetical order a definition for ''Indoor water-source commercial heat pump water heater;''

■ g. Revising the definition of ''Instantaneous water heater;''

■ h. Removing the definition of ''Packaged boiler;''

■ i. Adding in alphabetical order a definition for ''Rated input;''

■ j. Revising the definitions of ''R-value,'' ''Residential-duty commercial water heater,'' and ''Standby loss,''

■ k. Adding in alphabetical order a definition for ''Storage-type instantaneous water heater;''

and

■ l. Revising the definition of ''Storage water heater.''

The revisions and additions read as follows:

§ 431.102 Definitions concerning commercial water heaters, hot water supply boilers, unfired hot water storage tanks, and commercial heat pump water heaters.

Air-source commercial heat pump water heater means a commercial heat pump water heater that utilizes indoor or outdoor air as the heat source.

* * * * *

Coefficient of performance (COP_h) means the dimensionless ratio of the rate of useful heat transfer gained by the water (expressed in Btu/h), to the rate of electric power consumed during operation (expressed in Btu/h).

Commercial heat pump water heater (CHPWH) means a water heater (including all ancillary equipment such as fans, blowers, pumps, storage tanks, piping, and controls, as applicable) that uses a refrigeration cycle, such as vapor compression, to transfer heat from a low-temperature source to a higher-temperature sink for the purpose of heating potable water, and has a rated electric power input greater than 12 kW. Such equipment includes, but is not limited to, air-source heat pump water heaters, water-source heat pump water heaters, and direct geo-exchange heat pump water heaters.

Direct geo-exchange commercial heat pump water heater means a commercial heat pump water heater that utilizes the earth as a heat source and allows for direct exchange of heat between the earth and the refrigerant in the evaporator coils.

Flow-activated instantaneous water heater means an instantaneous water heater or hot water supply boiler that activates the burner or heating element only if heated water is drawn from the unit.

Fuel input rate means the maximum measured rate at which gas-fired or oil-fired commercial water heating equipment uses energy as determined using test procedures prescribed under § 431.106 of this part.

Ground-source closed-loop commercial heat pump water heater means a commercial heat pump water heater that utilizes a fluid circulated through a closed piping loop as a medium to transfer heat from the ground to the refrigerant in the evaporator. The piping loop may be buried inside the ground in horizontal trenches or vertical bores, or submerged in a surface water body.

Ground water-source commercial heat pump water heater means a commercial heat pump water heater that utilizes ground water as the heat source.

Hot water supply boiler means a packaged boiler (defined in § 431.82 of this part) that is industrial equipment and that:

(1) Has a rated input from 300,000 Btu/h to 12,500,000 Btu/h and of at least 4,000 Btu/h per gallon of stored water;

(2) Is suitable for heating potable water; and

(3) Meets either or both of the following conditions:

(i) It has the temperature and pressure controls necessary for heating potable water for purposes other than space heating; or

(ii) The manufacturer's product literature, product markings, product marketing, or product installation and operation instructions indicate that the boiler's intended uses include heating potable water for purposes other than space heating.

Indoor water-source commercial heat pump water heater means a commercial heat pump water heater that utilizes indoor water as the heat source.

Instantaneous water heater means a water heater that uses gas, oil, or electricity, including:

(1) Gas-fired instantaneous water heaters with a rated input both greater than 200,000 Btu/h and not less than 4,000 Btu/h per gallon of stored water;

(2) Oil-fired instantaneous water heaters with a rated input both greater than 210,000 Btu/h and not less than 4,000 Btu/h per gallon of stored water; and

(3) Electric instantaneous water heaters with a rated input both greater than 12 kW and not less than 4,000 Btu/h per gallon of stored water.

* * * * *

Rated input means the maximum rate at which commercial water heating equipment is rated to use energy as specified on the nameplate.

R-value means the thermal resistance of insulating material as determined using ASTM C177–13 or C518–15 (incorporated by reference; see § 431.105) and expressed in ($°F·ft^2·h/Btu$).

Residential-duty commercial water heater means any gas-fired storage, oil-fired storage, or electric instantaneous commercial water heater that meets the following conditions:

(1) For models requiring electricity, uses single-phase external power supply;

(2) Is not designed to provide outlet hot water at temperatures greater than 180 °F; and

(3) Does not meet any of the following criteria:

Water heater type	Indicator of non-residential application
Gas-fired Storage	Rated input >105 kBtu/h; Rated storage volume >120 gallons.
Oil-fired Storage	Rated input >140 kBtu/h; Rated storage volume >120 gallons.
Electric Instantaneous	Rated input >58.6 kW; Rated storage volume >2 gallons.

Standby loss means:

(1) For electric commercial water heating equipment (not including commercial heat pump water heaters), the average hourly energy required to maintain the stored water temperature expressed as a percent per hour (%/h) of the heat content of the stored water above room temperature and determined in accordance with appendix B or D to subpart G of part 431 (as applicable), denoted by the term ''S''; or

(2) For gas-fired and oil-fired commercial water heating equipment, the average hourly energy required to maintain the stored water temperature expressed in British thermal units per hour (Btu/h) based on a 70 °F temperature differential between stored water and ambient room temperature and determined in accordance with appendix A or C to subpart G of part 431 (as applicable), denoted by the term ''SL.''

Storage-type instantaneous water heater means an instantaneous water heater that includes a storage tank with a storage volume greater than or equal to 10 gallons.

Storage water heater means a water heater that uses gas, oil, or electricity to heat and store water within the appliance at a thermostatically-controlled temperature for delivery on demand, including:

(1) Gas-fired storage water heaters with a rated input both greater than 75,000 Btu/h and less than 4,000 Btu/h per gallon of stored water;

(2) Oil-fired storage water heaters with a rated input both greater than 105,000 Btu/h and less than 4,000 Btu/h per gallon of stored water; and

(3) Electric storage water heaters with a rated input both greater than 12 kW and less than 4,000 Btu/h per gallon of stored water.

* * * * *

§ 431.104 [Removed]

■ 9. Section 431.104 is removed.

■ 10. Section 431.105 is amended by revising paragraph (b) and adding paragraphs (c) and (d) to read as follows:

§ 431.105 Materials incorporated by reference.

* * * * *

(b) *ASHRAE.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle NE. Atlanta, GA 30329, (800) 527–4723, or go to *https://www.ashrae.org.*

(1) ANSI/ASHRAE Standard 118.1–2012, ''Method of Testing for Rating Commercial Gas, Electric, and Oil Service Water-Heating Equipment,'' approved by ASHRAE on October 26, 2012, IBR approved for appendix E to this subpart, as follows:

(i) Section 3—Definitions and Symbols;

(ii) Section 4—Classifications by Mode of Operation (sections 4.4, and 4.5 only);

(iii) Section 6—Instruments (except sections 6.3, 6.4 and 6.6);

(iv) Section 7—Apparatus (except section 7.4, Figures 1 through 4, section 7.7.5, Table 2, and section 7.7.7.4);

(v) Section 8—Methods of Testing:

(A) Section 8.2—Energy Supply, Section 8.2.1—Electrical Supply;

(B) Section 8.7—Water Temperature Control;

(vi) Section 9—Test Procedures: 9.1—Input Rating, Heating Capacity, Thermal Efficiency, Coefficient of Performance (COP), and Recovery Rating; 9.1.1—Full Input Rating;

(vii) Section 10—Calculation of Results: Section 10.3—Heat-Pump Water Heater Water-Heating Capacity, Coefficient of Performance (COP), and Recovery Rating; Section 10.3.1—Type IV and Type V Full-Capacity Test Method.

(2) [Reserved]

(c) *ASTM.* ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428–2959, (610) 832–9585, or go to *http://www.astm.org.*

(1) ASTM C177–13, ''Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus,'' approved September 15, 2013, IBR approved for § 431.102.

(2) ASTM C518–15, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus,'' approved September 1, 2015, IBR approved for § 431.102t.

(3) ASTM D2156–09 (Reapproved 2013), ''Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels,'' approved October 1, 2013, IBR approved for appendices A and C to this subpart.

(d) CSA Group, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6, 800–463–6727, or go to *http://www.csagroup.org/.*

(1) ANSI Z21.10.3–2015 * CSA 4.3–2015 (''ANSI Z21.10.3–2015''), ''Gas-fired water heaters, volume III, storage water heaters with input ratings above 75,000 Btu per hour, circulating and instantaneous,'' approved by ANSI on October 5, 2015, IBR approved for appendices A, B, and C to this subpart, as follows:

(i) Annex E (normative) Efficiency test procedures—E.1—Method of test for measuring thermal efficiency, paragraph c—Vent requirements; and

(ii) Annex E (normative) Efficiency test procedures—E.1—Method of test for measuring thermal efficiency, paragraph f—Installation of temperature sensing means.

(2) [Reserved]

■ 11. Section 431.106 is revised to read as follows:

§ 431.106 Uniform test method for the measurement of energy efficiency of commercial water heating equipment.

(a) *Scope.* This section contains test procedures for measuring, pursuant to EPCA, the energy efficiency of commercial water heating equipment.

(b) *Testing and calculations.* Determine the energy efficiency of commercial water heating equipment by conducting the applicable test procedure(s):

(1) *Residential-duty commercial water heaters.* Test in accordance with appendix E to subpart B of part 430 of this chapter.

(2) *Commercial water heating equipment other than residential-duty commercial water heaters.* Test in accordance with the appropriate test procedures in appendices to subpart G of this part.

(i) *Gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters.* Test according to appendix A to subpart G of this part.

(ii) *Electric storage water heaters and storage-type instantaneous water heaters.* Test according to appendix B to subpart G of this part.

(iii) *Gas-fired and oil-fired instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters).* Test according to appendix C to subpart G of this part.

(iv) *Electric instantaneous water heaters (other than storage-type instantaneous water heaters).* Test according to appendix D to subpart G of this part.

(v) *Commercial heat pump water heaters.* Test according to appendix E to subpart G of this part.

§ 431.107 [Removed]

■ 12. Section 431.107 is removed.

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

Appendix A to Subpart G of Part 431—Uniform Test Method for the Measurement of Thermal Efficiency and Standby Loss of Gas-Fired and Oil-Fired Storage Water Heaters and Storage-Type Instantaneous Water Heaters

Note: Prior to November 6, 2017, manufacturers must make any representations with respect to the energy use or efficiency of the subject commercial water heating equipment in accordance with the results of testing pursuant to this appendix or the procedures in 10 CFR 431.106 that were in place on January 1, 2016. On and after November 6, 2017, manufacturers must make any representations with respect to energy use or efficiency of gas-fired and oil-fired storage water heaters and storage-type instantaneous water heaters in accordance with the results of testing pursuant to this appendix to demonstrate compliance with the energy conservation standards at 10 CFR 431.110.

1. General

Determine the thermal efficiency and standby loss (as applicable) in accordance with the following sections of this appendix. Certain sections reference sections of Annex E.1 of ANSI Z21.10.3–2015 (incorporated by reference; see § 431.105). Where the instructions contained in the sections below conflict with instructions in Annex E.1 of ANSI Z21.10.3–2015, the instructions contained in this appendix control.

2. Test Set-Up

2.1. *Placement of Water Heater.* A water heater for installation on combustible floors must be placed on a ¾-inch plywood platform supported by three 2 x 4-inch runners. If the water heater is for installation on noncombustible floors, suitable noncombustible material must be placed on the platform. When the use of the platform for a large water heater is not practical, the water heater may be placed on any suitable flooring. A wall-mounted water heater must be mounted on a simulated wall section.

2.2. *Installation of Temperature Sensors.* Inlet and outlet water piping must be turned vertically downward from the connections on the water heater so as to form heat traps. Temperature sensors for measuring supply and outlet water temperatures must be installed upstream from the inlet heat trap piping and downstream from the outlet heat trap piping, respectively, in accordance with Figure 2.1, 2.2, or 2.3 (as applicable based on the location of inlet and outlet piping connections) of this section.

The water heater must meet the requirements shown in Figure 2.1, 2.2, or 2.3 (as applicable) at all times during the conduct of the thermal efficiency and standby loss tests. Any factory-supplied heat traps must be installed per the installation instructions while ensuring the requirements in Figure 2.1, 2.2, or 2.3 are met. All dimensions specified in Figure 2.1, 2.2, and 2.3 and in this section are measured from the outer surface of the pipes and water heater outer casing (as applicable).

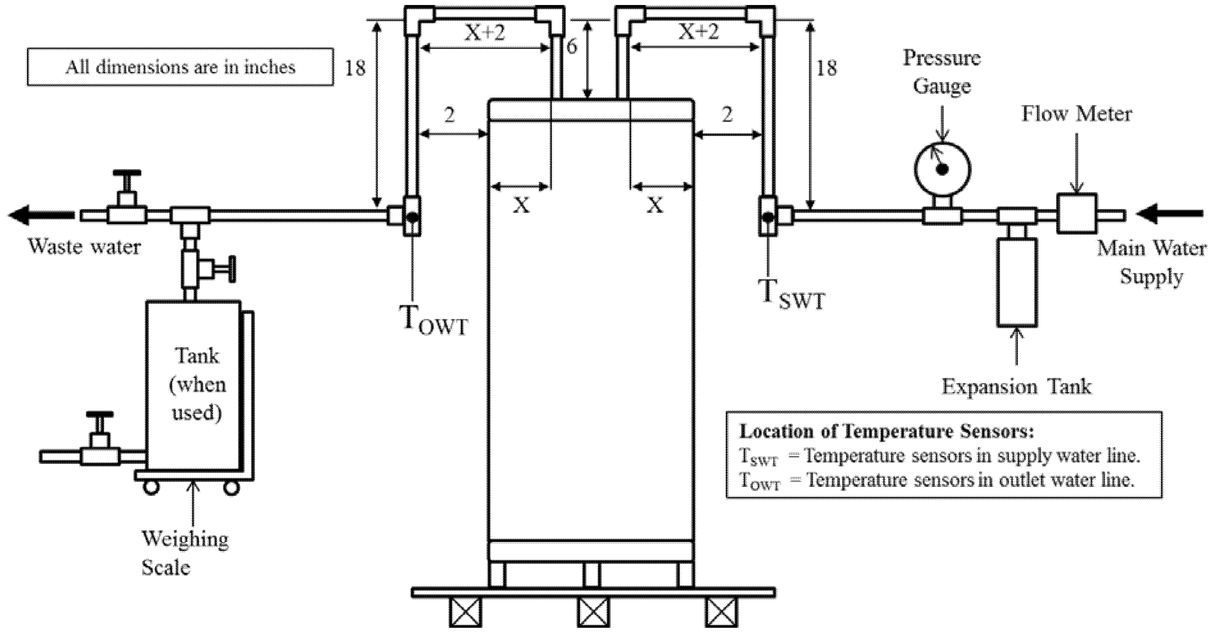

Figure 2.1. Set-up for thermal efficiency and standby loss test for water heaters equipped with vertical (top) connections

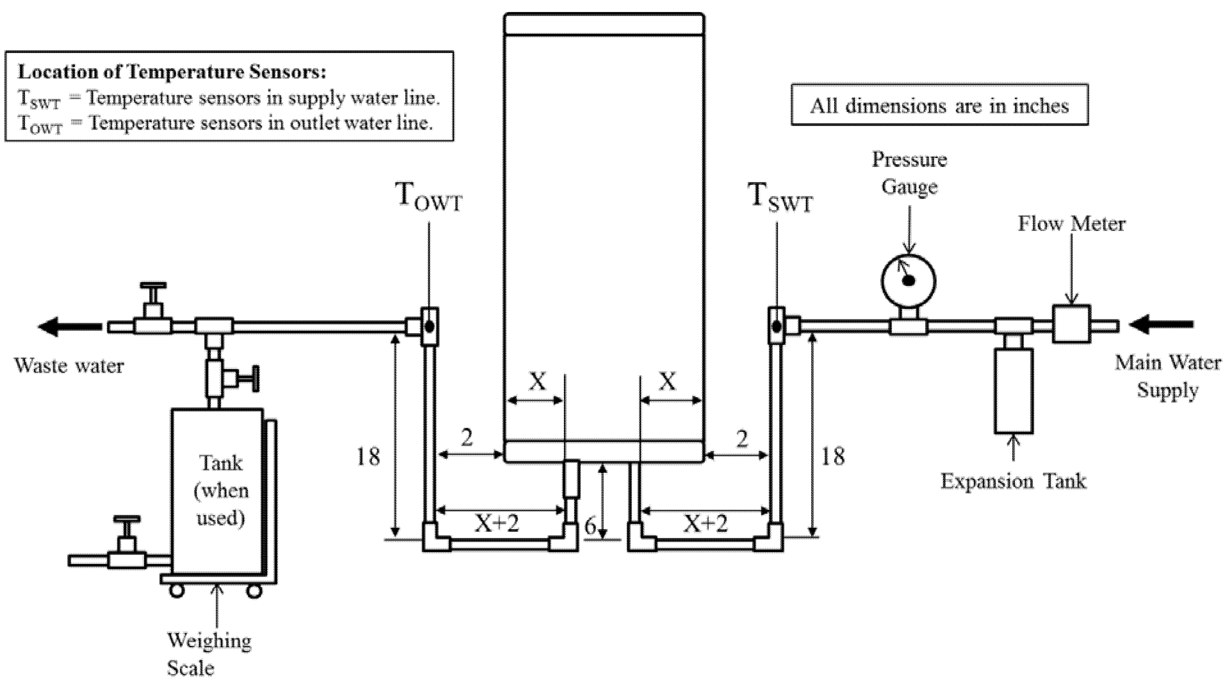

Figure 2.2. Set-up for thermal efficiency and standby loss test for water heaters equipped with vertical (bottom) connections

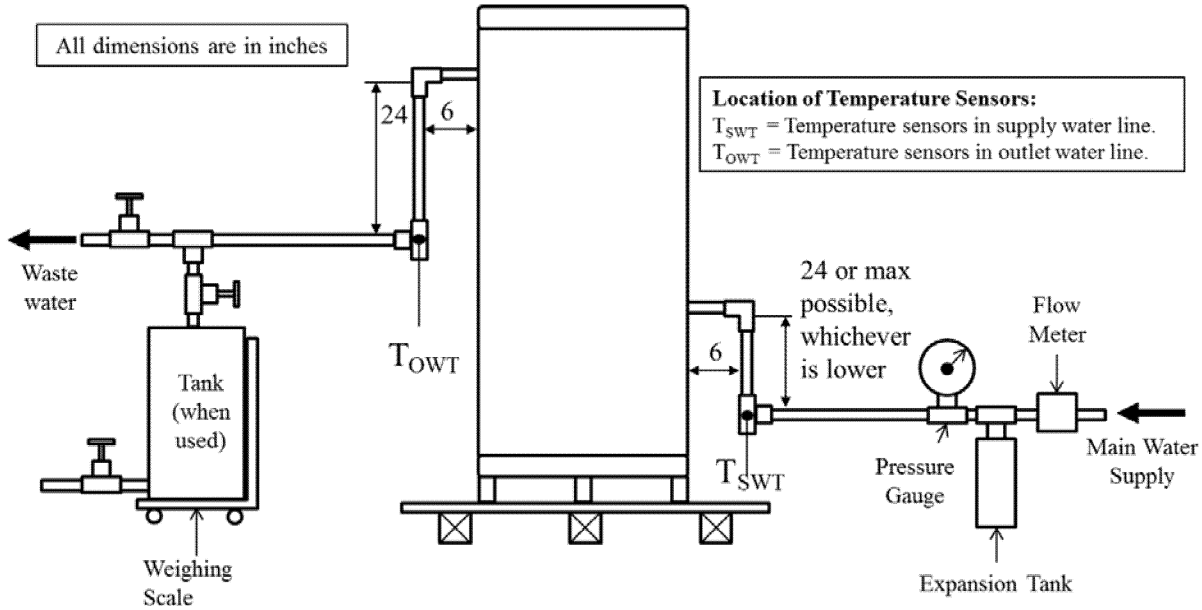

Figure 2.3. Set-up for thermal efficiency and standby loss test for water heaters equipped with horizontal connections

2.3 *Installation of Temperature Sensors for Measurement of Mean Tank Temperature.* Install temperature sensors inside the tank for measurement of mean tank temperature according to the instructions in paragraph f of Annex E.1 of ANSI Z21.10.3–2015 (incorporated by reference; see § 431.105). Calculate the mean tank temperature as the average of the six installed temperature sensors.

2.4. *Piping Insulation.* Insulate all water piping external to the water heater jacket, including heat traps and piping that are installed by the manufacturer or shipped with the unit, for at least 4 ft of piping length from the connection at the appliance, with material having an R-value not less than 4 °F·ft^2·h/Btu. Ensure that the insulation does not contact any appliance surface except at the location where the pipe connections penetrate the appliance jacket or enclosure.

2.5. *Temperature and Pressure Relief Valve Insulation.* If the manufacturer has not provided a temperature and pressure relief valve, one shall be installed and insulated as specified in section 2.4 of this appendix.

2.6. *Vent Requirements.* Follow the requirements for venting arrangements specified in paragraph c of Annex E.1 of ANSI Z21.10.3–2015 (incorporated by reference; see § 431.105).

2.7. *Energy Consumption.* Install equipment that determines, within ± 1 percent:

2.7.1. The quantity and rate of fuel consumed.

2.7.2. The quantity of electricity consumed by factory-supplied water heater components.

3. Test Conditions

3.1. *Water Supply*

3.1.1. *Water Supply Pressure.* The pressure of the water supply must be maintained between 40 psi and the maximum pressure specified by the manufacturer of the unit being tested. The accuracy of the pressure-measuring devices must be within ± 1.0 pounds per square inch (psi).

3.1.2. *Water Supply Temperature.* During the steady-state verification period and the thermal efficiency test, the temperature of the supply water must be maintained at 70 °F ± 2 °F.

3.1.3. Isolate the water heater using a shutoff valve in the supply line with an expansion tank installed in the supply line downstream of the shutoff valve. There must be no shutoff means between the expansion tank and the appliance inlet.

3.2. *Gas Pressure for Gas-Fired Equipment.* The supply gas pressure must be within the range specified by the manufacturer on the nameplate of the unit being tested. The difference between the outlet pressure of the gas appliance pressure regulator and the value specified by the manufacturer on the nameplate of the unit being tested must not exceed the greater of: ± 10 percent of the nameplate value or ± 0.2 inches water column (in. w.c.). Obtain the higher heating value of the gas burned.

3.3. *Ambient Room Temperature.* During the soak-in period (as applicable), the steady-state verification period, the thermal efficiency test, and the standby loss test, maintain the ambient room temperature at 75 °F ± 10 °F at all times. Measure the ambient room temperature at 1-minute intervals during these periods, except for the soak-in period. Measure the ambient room temperature once before beginning the soak-in period, and ensure no actions are taken during the soak-in period that would cause the ambient room temperature to deviate from the allowable range. Measure the ambient room temperature at the vertical mid-point of the water heater and approximately 2 feet from the water heater jacket. Shield the sensor against radiation. Calculate the average ambient room temperature separately for the thermal efficiency test and standby loss test. During the thermal efficiency and standby loss tests, the ambient room temperature must not vary by more than ± 5.0 °F at any reading from the average ambient room temperature.

3.4. *Test Air Temperature.* During the steady-state verification period, the thermal efficiency test, and the standby loss test, the test air temperature must not vary by more than ± 5 °F from the ambient room temperature at any reading. Measure the test air temperature at 1-minute intervals during these periods and at a location within two feet of the air inlet of the water heater or the combustion air intake vent, as applicable. Shield the sensor against radiation. For units with multiple air inlets, measure the test air temperature at each air inlet, and maintain the specified tolerance on deviation from the ambient room temperature at each air inlet. For units without a dedicated air inlet, measure the test air temperature within two feet of any location on the water heater where combustion air is drawn.

3.5. *Maximum Air Draft.* During the steady-state verification period, the thermal efficiency test, and the standby loss test, the water heater must be located in an area protected from drafts of more than 50 ft/min. Prior to beginning the steady-state verification period and the standby loss test, measure the air draft within three feet of the jacket or enclosure of the water heater to ensure this condition is met. Ensure that no other changes that would increase the air draft are made to the test set-up or conditions during the conduct of the tests.

3.6. *Setting the Tank Thermostat.* Before starting the steady-state verification period (as applicable) or before the soak-in period (as applicable), the thermostat setting must first be obtained by starting with the water in the system at 70 °F ± 2 °F. Set the thermostat to ensure:

3.6.1. With the supply water temperature set as per section 3.1.2 of this appendix (*i.e.,* 70 °F ± 2 °F), the water flow rate can be varied so that the outlet water temperature is constant at 70 °F ± 2 °F above the supply water temperature while the burner is firing at full firing rate; and

3.6.2. After the water supply is turned off and the thermostat reduces the fuel supply to a minimum, the maximum water temperature measured by the topmost tank temperature sensor (*i.e.,* the highest of the 6 temperature sensors used for calculating mean tank temperature, as required by section 2.3 of this appendix) is 140 °F ± 5 °F.

3.7. *Additional Requirements for Oil-Fired Equipment.*

3.7.1. *Venting Requirements.* Connect a vertical length of flue pipe to the flue gas outlet of sufficient height so as to meet the minimum draft specified by the manufacturer.

3.7.2. *Oil Supply.* Adjust the burner rate so that the following conditions are met:

3.7.2.1. The CO_2 reading is within the range specified by the manufacturer;

3.7.2.2. The fuel pump pressure is within ± 10 percent of manufacturer's specifications;

3.7.2.3. If either the fuel pump pressure or range for CO_2 reading are not specified by the manufacturer on the nameplate of the unit, in literature shipped with the unit, or in supplemental test report instructions included with a certification report, then a default value of 100 psig is to be used for fuel pump pressure, and a default range of 9–12 percent is to be used for CO_2 reading; and

3.7.2.4. Smoke in the flue does not exceed No. 1 smoke as measured by the procedure in ASTM D2156–09 (Reapproved 2013) (incorporated by reference, see § 431.105). To determine the smoke spot number, connect the smoke measuring device to an open-ended tube. This tube must project into the flue ¼ to ½ of the pipe diameter.

3.7.2.5. If no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously run thermal efficiency or standby loss test, measurement of the CO_2 reading and conduct of the smoke spot test are not required prior to beginning a test. Otherwise, measure the CO_2 reading and determine the smoke spot number, with the burner firing, before the beginning of the steady-state verification period prior to the thermal efficiency test, and prior to beginning the standby loss test.

3.8. *Data Collection Intervals.* Follow the data recording intervals specified in the following sections.

3.8.1. *Soak-In Period.* For units that require a soak-in period, measure the ambient room temperature, in °F, prior to beginning the soak-in period.

3.8.2. *Steady-State Verification Period and Thermal Efficiency Test.* For the steady-state verification period and the thermal efficiency test, follow the data recording intervals specified in Table 3.1 of this appendix.

TABLE 3.1—DATA TO BE RECORDED BEFORE AND DURING THE STEADY-STATE VERIFICATION PERIOD AND THERMAL EFFICIENCY TEST

Item recorded	Before steady-state verification period	Every 1 minute [a]	Every 10 minutes
Gas supply pressure, in w.c.	X		
Gas outlet pressure, in w.c.	X		
Barometric pressure, in Hg	X		
Fuel higher heating value, Btu/ft³ (gas) or Btu/lb (oil)	X		
Oil pump pressure, psig (oil only)	X		
CO_2 reading, % (oil only)	X [b]		
Oil smoke spot reading (oil only)	X [b]		
Air draft, ft/min	X		
Time, minutes/seconds	....	X	
Fuel weight or volume, lb (oil) or ft³ (gas)	....	....	X [c]
Supply water temperature (T_{SWT}), °F	....	X	
Outlet water temperature (T_{OWT}), °F	....	X	
Ambient room temperature, °F	....	X	
Test air temperature, °F	....	X	
Water flow rate, (gpm)	....	X	

Notes:

[a] These measurements are to be recorded at the start of the steady-state verification period and the end of the thermal efficiency test, as well as every minute during both periods.

[b] The smoke spot test and CO_2 reading are not required prior to beginning the steady-state verification period if no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously-run efficiency test (*i.e.,* thermal efficiency or standby loss).

[c] Fuel and electricity consumption over the course of the entire thermal efficiency test must be measured and used in calculation of thermal efficiency.

3.8.3. *Standby Loss Test.* For the standby loss test, follow the data recording intervals specified in Table 3.2 of this appendix. Additionally, the fuel and electricity consumption over the course of the entire test must be measured and used in calculation of standby loss.

TABLE 3.2—DATA TO BE RECORDED BEFORE AND DURING THE STANDBY LOSS TEST

Item recorded	Before test	Every 1 minute [a]
Gas supply pressure, in w.c.	X	
Gas outlet pressure, in w.c.	X	
Barometric pressure, in Hg	X	
Fuel higher heating value, Btu/ft^3 (gas) or Btu/lb (oil)	X	
Oil pump pressure, psig (oil only)	X	
CO_2 reading, % (oil only)	X [b]	
Oil smoke spot reading (oil only)	X [b]	
Air draft, ft/min	X	
Time, minutes/seconds		X
Mean tank temperature, °F		X [c]
Ambient room temperature, °F		X
Test air temperature, °F		X

Notes:

[a] These measurements are to be recorded at the start and end of the test, as well as every minute during the test.

[b] The smoke spot test and CO_2 reading are not required prior to beginning the standby loss test if no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously-run efficiency test (*i.e.,* thermal efficiency or standby loss).

[c] Mean tank temperature is calculated as the average of the 6 tank temperature sensors, installed per section 2.3 of this appendix.

4. *Determination of Storage Volume.* Determine the storage volume by subtracting the tare weight, measured while the system is dry and empty, from the weight of the system when filled with water and dividing the resulting net weight of water by the density of water at the measured water temperature. The volume of the water contained in the water heater must be computed in gallons.

5. *Thermal Efficiency Test.* Before beginning the steady-state verification period, record the applicable parameters as specified in section 3.8.2 of this appendix. Begin drawing water from the unit by opening the main supply, and adjust the water flow rate to achieve an outlet water temperature of 70 °F ± 2 °F above supply water temperature. The thermal efficiency test shall be deemed complete when there is a continuous, one-hour-long period where the steady-state conditions specified in section 5.1 of this appendix have been met, as confirmed by consecutive readings of the relevant parameters recorded at 1-minute intervals (except for fuel input rate, which is determined at 10-minute intervals, as specified in section 5.4 of this appendix). During the one-hour-long period, the water heater must fire continuously at its full firing rate (*i.e.,* no modulations or cut-outs) and no settings can be changed on the unit being tested at any time. The first 30 minutes of the one-hour-period where the steady-state conditions in section 5.1 of this appendix are met is the steady-state verification period. The final 30 minutes of the one-hour-period where the steady-state conditions in section 5.1 of this appendix are met is the thermal efficiency test. The last reading of the steady-state verification period must be the first reading of the thermal efficiency test (*i.e.,* the thermal efficiency test starts immediately once the steady-state verification period ends).

5.1. *Steady-State Conditions.* The following conditions must be met at consecutive readings taken at 1-minute intervals (except for fuel input rate, for which measurements are taken at 10-minute intervals) to verify the water heater has achieved steady-state operation during the steady-state verification period and thermal efficiency test.

5.1.1. The water flow rate must be maintained within ± 0.25 gallons per minute (gpm) of the initial reading at the start of the steady-state verification period;

5.1.2. Outlet water temperature must be maintained at 70 °F ± 2 °F above supply water temperature;

5.1.3. Fuel input rate must be maintained within ± 2 percent of the rated input certified by the manufacturer;

5.1.4. The supply water temperature must be maintained within ± 0.50 °F of the initial reading at the start of the steady-state verification period; and

5.1.5. The rise between the supply and outlet water temperatures must be maintained within ± 0.50 °F of its initial value taken at the start of the steady-state verification period for units with rated input less than 500,000 Btu/h, and maintained within ± 1.00 °F of its initial value for units with rated input greater than or equal to 500,000 Btu/h.

5.2. *Water Flow Measurement.* Measure the total weight of water heated during the 30-minute thermal efficiency test with either a scale or a water flow meter. With either method, the error of measurement of weight of water heated must not exceed 1 percent of the weight of the total draw.

5.3. *Determination of Fuel Input Rate.* During the steady-state verification period and the thermal efficiency test, record the fuel consumed at 10-minute intervals. Calculate the fuel input rate over each 10-minute period using the equations in section 5.4 of this appendix. The measured fuel input rates for these 10-minute periods must not vary by more than ± 2 percent between any two readings. Determine the overall fuel input rate using the fuel consumption for the entire duration of the thermal efficiency test.

5.4. *Fuel Input Rate Calculation.* To calculate the fuel input rate, use the following equation:

$$Q = \frac{Q_s * C_s * H}{t}$$

Where,

Q = Fuel input rate, expressed in Btu/h

Q_s = Total fuel flow as metered, expressed in ft^3 for gas-fired equipment and lb for oil-fired equipment

C_s = Correction applied to the heating value of a gas H, when it is metered at temperature and/or pressure conditions other than the standard conditions for which the value of H is based. Cs=1 for oil-fired equipment.

H = Higher heating value of fuel, expressed in Btu/ft^3 for gas-fired equipment and Btu/lb for oil-fired equipment.

t = Duration of measurement of fuel consumption

5.5. *Thermal Efficiency Calculation.* Thermal efficiency must be calculated using data from the 30-minute thermal efficiency test. Calculate thermal efficiency, E_t, using the following equation:

$$E_t = \frac{K * W * (\theta_2 - \theta_1)}{(C_s * Q * H) + E_c}$$

Where,

K = 1.004 Btu/lb·°F, the nominal specific heat of water at 105 °F

W = Total weight of water heated, expressed in lb

θ_1 = Average supply water temperature, expressed in °F

θ_2 = Average outlet water temperature, expressed in °F

Q = Total fuel flow as metered, expressed in ft^3 for gas-fired equipment and lb for oil-fired equipment.

C_s = Correction applied to the heating value of a gas H, when it is metered at temperature and/or pressure conditions other than the standard conditions for which the value of H is based. C_s=1 for oil-fired equipment

H. = Higher heating value of the fuel, expressed in Btu/ft^3 for gas-fired equipment and Btu/lb for oil-fired equipment.

E_c = Electrical consumption of the water heater and, when used, the test set-up recirculating pump, expressed in Btu

6. Standby Loss Test

6.1. If no settings on the water heater have changed and the water heater has not been turned off since a previously run thermal efficiency or standby loss test, skip to section 6.3 of this appendix. Otherwise, conduct the soak-in period according to section 6.2 of this appendix.

6.2. *Soak-In Period.* Conduct a soak-in period, in which the water heater must sit without any draws taking place for at least 12 hours. Begin the soak-in period after setting the tank thermostat as specified in section 3.6 of this appendix, and maintain these thermostat settings throughout the soak-in period.

6.3. Begin the standby loss test at the first cut-out following the end of the soak-in period (if applicable); or at a cut-out following the previous thermal efficiency or standby loss test (if applicable). Allow the water heater to remain in standby mode. Do not change any settings on the water heater at any point until measurements for the standby loss test are finished. Begin recording the applicable parameters specified in section 3.8.3 of this appendix.

6.4. At the second cut-out, record the time and ambient room temperature, and begin measuring the fuel and electricity consumption. Record the initial mean tank temperature and initial ambient room temperature. For the remainder of the test, continue recording the applicable parameters specified in section 3.8.3 of this appendix.

6.5. Stop the test after the first cut-out that occurs after 24 hours, or at 48 hours, whichever comes first.

6.6. Immediately after conclusion of the standby loss test, record the total fuel flow and electrical energy consumption, the final ambient room temperature, the duration of the standby loss test, and if the test ends at 48 hours without a cut-out, the final mean tank temperature, or if the test ends after a cut-out, the maximum mean tank temperature that occurs after the cut-out. Calculate the average of the recorded values of the mean tank temperature and of the ambient room temperature taken at each measurement interval, including the initial and final values.

6.7. *Standby Loss Calculation.* To calculate the standby loss, follow the steps below:

6.7.1. The standby loss expressed as a percentage (per hour) of the heat content of the stored water above room temperature must be calculated using the following equation:

$$S = \frac{E_c + (C_s)(Q_s)(H) - \left(\frac{k(V_a)(\Delta T_4)}{E_t/100}\right)}{k(V_a)(\Delta T_3)(t)} \times 100$$

Where,

ΔT_3 = Average value of the mean tank temperature minus the average value of the ambient room temperature, expressed in °F

ΔT_4 = Final mean tank temperature measured at the end of the test minus the initial mean tank temperature measured at the start of the test , expressed in °F

k = 8.25 Btu/gallon·°F, the nominal specific heat of water

V_a = Volume of water contained in the water heater in gallons measured in accordance with section 4 of this appendix

E_t = Thermal efficiency of the water heater determined in accordance with this appendix, expressed in %

E_c = Electrical energy consumed by the water heater during the duration of the test in Btu

t = Total duration of the test in hours

C_s = Correction applied to the heating value of a gas H, when it is metered at temperature and/or pressure conditions other than the standard conditions for which the value of H is based. C_s=1 for oil-fired equipment.

Q_s = Total fuel flow as metered, expressed in ft^3 (gas) or lb (oil)

H = Higher heating value of fuel, expressed in Btu/ft^3 (gas) or Btu/lb (oil)

S = Standby loss, the average hourly energy required to maintain the stored water temperature expressed as a percentage of the heat content of the stored water above room temperature

6.7.2. The standby loss expressed in Btu per hour must be calculated as follows:

SL (Btu per hour) = S (% per hour) × 8.25 (Btu/gal-°F) × Measured Volume (gal) × 70 (°F).

Where, SL refers to the standby loss of the water heater, defined as the amount of energy required to maintain the stored water temperature expressed in Btu per hour

14. Add appendix B to subpart G of part 431 to read as follows:

Appendix B to Subpart G of Part 431—Uniform Test Method for the Measurement of Standby Loss of Electric Storage Water Heaters and Storage-Type Instantaneous Water Heaters

Note: Prior to November 6, 2017, manufacturers must make any representations with respect to the energy use or efficiency of the subject commercial water heating equipment in accordance with the results of testing pursuant to this appendix or the procedures in 10 CFR 431.106 that were in place on January 1, 2016. On and after November 6, 2017, manufacturers must make any representations with respect to energy use or efficiency of electric storage water heaters and storage-type instantaneous water heaters in accordance with the results of testing pursuant to this appendix to demonstrate compliance with the energy conservation standards at 10 CFR 431.110.

1. General

Determine the standby loss in accordance with the following sections of this appendix. Certain sections reference sections of Annex E.1 of ANSI Z21.10.3–2015 (incorporated by reference; see § 431.105). Where the instructions contained in the sections below conflict with instructions in Annex E.1 of ANSI Z21.10.3–2015, the instructions contained in this appendix control.

2. Test Set-Up

*2.*1. *Placement of Water Heater.* A water heater for installation on combustible floors must be placed on a ¾-inch plywood platform supported by three 2 × 4-inch runners. If the water heater is for installation on noncombustible floors, suitable noncombustible material must be placed on the platform. When the use of the platform for a large water heater is not practical, the water heater may be placed on any suitable flooring. A wall-mounted water heater must be mounted on a simulated wall section.

*2.*2. *Installation of Temperature Sensors.* Inlet and outlet piping must be turned vertically downward from the connections on a tank-type water heater so as to form heat traps. Temperature sensors for measuring supply water temperature must be installed upstream of the inlet heat trap piping, in accordance with Figure 2.1, 2.2, or 2.3 (as applicable) of this appendix.

The water heater must meet the requirements shown in either Figure 2.1, 2.2, or 2.3 (as applicable) at all times during the conduct of the standby loss test. Any factory-supplied heat traps must be installed per the installation instructions while ensuring the requirements in Figure 2.1, 2.2, or 2.3 are met. All dimensions specified in Figure 2.1, 2.2, and 2.3 are measured from the outer surface of the pipes and water heater outer casing (as applicable).

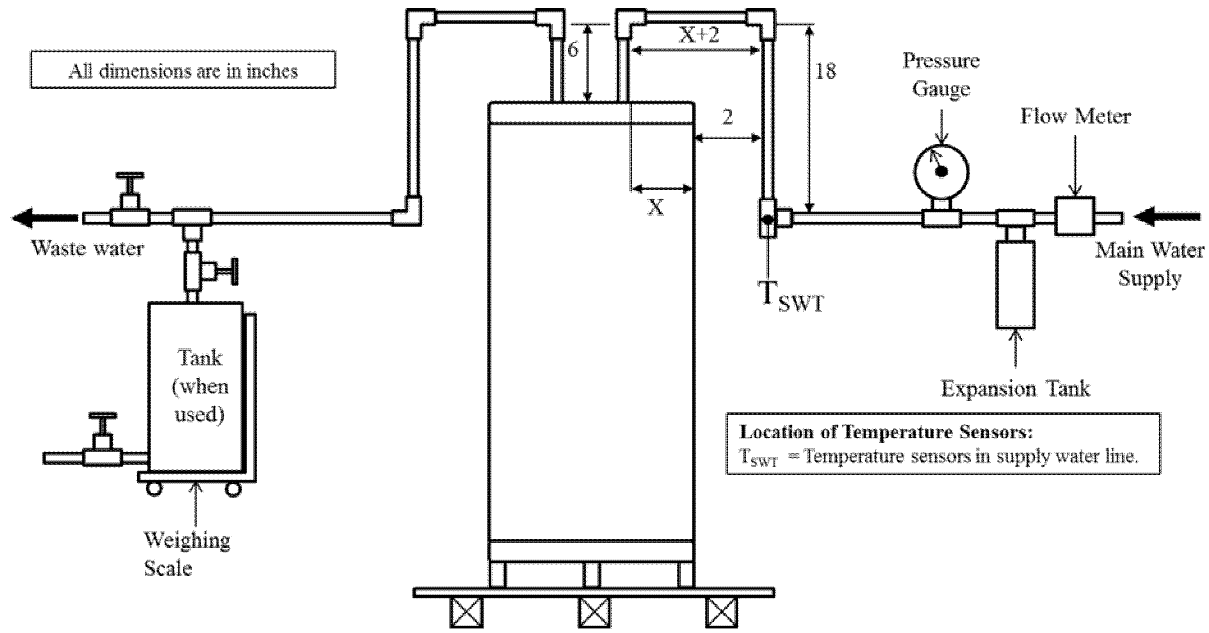

Figure 2.1. Set-up for standby loss test for electric storage water heaters equipped with vertical (top) connections

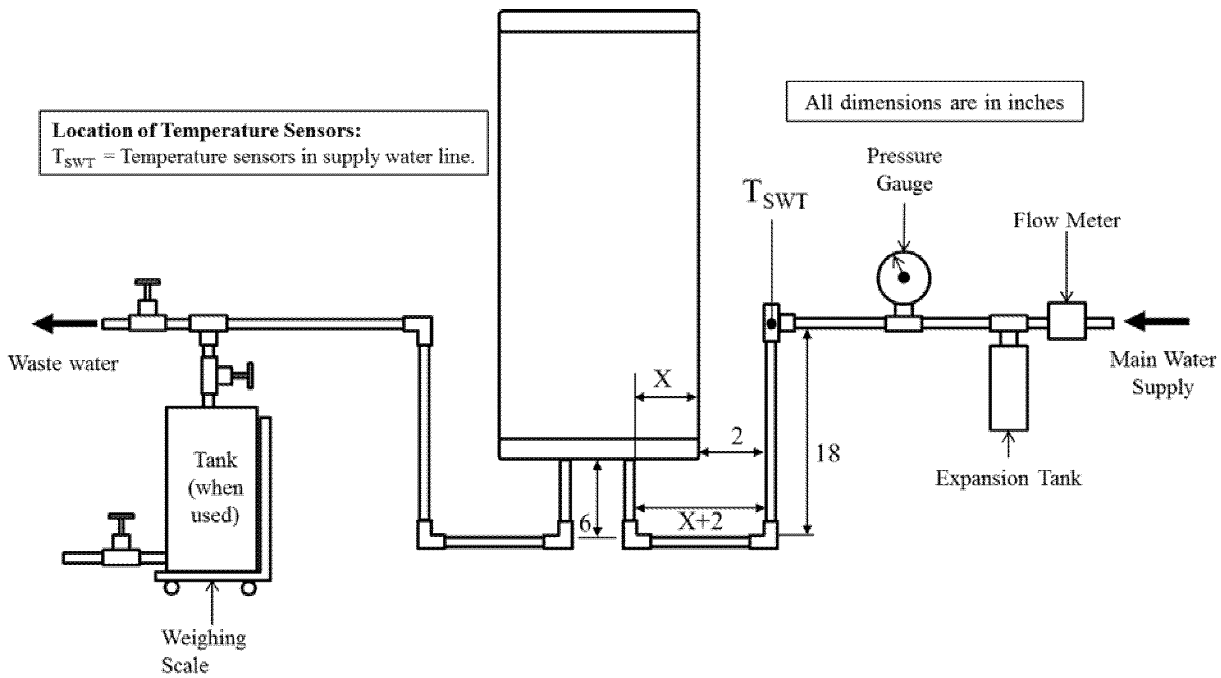

Figure 2.2. Set-up for standby loss test for electric storage water heaters equipped with vertical (bottom) connections

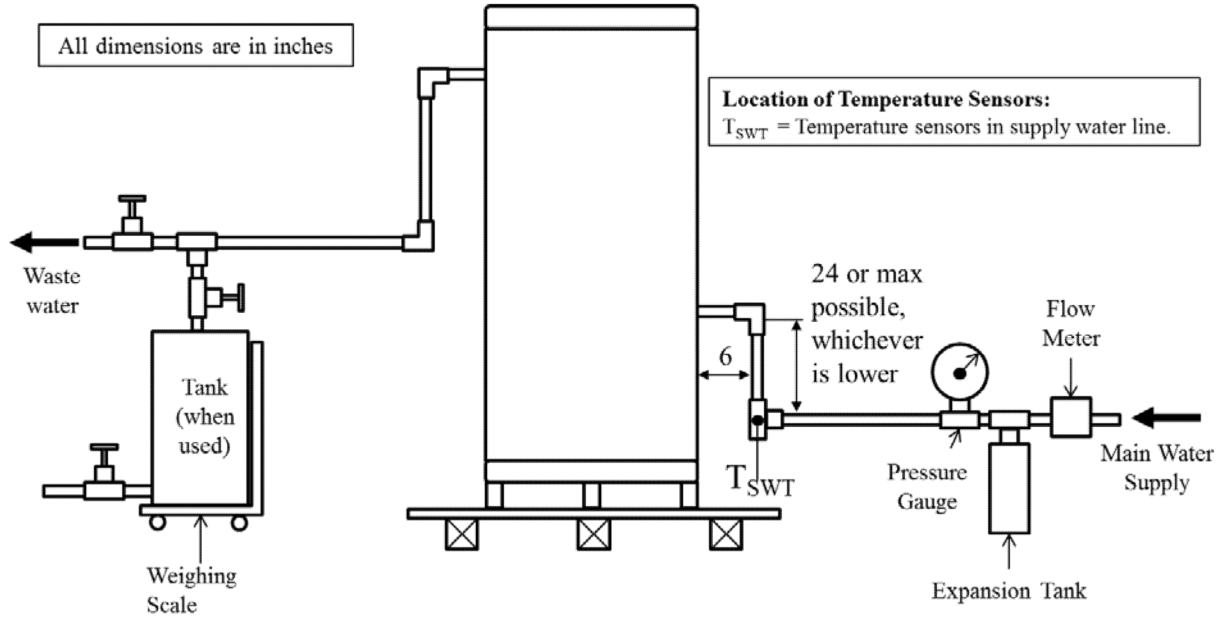

Figure 2.3. Set-up for standby loss test for electric storage water heaters equipped with horizontal connections

2.3. Installation of *Temperature Sensors for Measurement of Mean Tank Temperature.* Install temperature sensors inside the tank for measurement of mean tank temperature according to the instructions in paragraph f of Annex E.1 of ANSI Z21.10.3–2015 (incorporated by reference; see § 431.105 rt). Calculate the mean tank temperature as the average of the six installed temperature sensors.

2.4. *Piping Insulation.* Insulate all water piping external to the water heater jacket, including heat traps and piping that is installed by the manufacturer or shipped with the unit, for at least 4 ft of piping length from the connection at the appliance, with material having an R-value not less than 4 °F·ft²·h/Btu. Ensure that the insulation does not contact any appliance surface except at the location where the pipe connections penetrate the appliance jacket or enclosure.

2.5. *Temperature and Pressure Relief Valve Insulation.* If the manufacturer or has not provided a temperature and pressure relief valve, one shall be installed and insulated as specified in section 2.4 of this appendix.

2.6. *Energy Consumption.* Install equipment that determines, within ± 1 percent, the quantity of electricity consumed by factory-supplied water heater components.

3. Test Conditions

3.1. Water Supply

3.1.1. *Water Supply Pressure.* The pressure of the water supply must be maintained between 40 psi and the maximum pressure specified by the manufacturer of the unit being tested. The accuracy of the pressure-measuring devices must be within ± 1.0 pounds per square inch (psi).

3.1.2. *Water Supply Temperature.* When filling the tank with water prior to the soak-in period, maintain the supply water temperature at 70 °F ± 2 °F.

3.1.3. Isolate the water heater using a shutoff valve in the supply line with an expansion tank installed in the supply line downstream of the shutoff valve. There must be no shutoff means between the expansion tank and the appliance inlet.

3.2. *Electrical Supply.* Maintain the electrical supply voltage to within ± 5 percent of the voltage specified on the water heater nameplate. If a voltage range is specified on the nameplate, maintain the voltage to within ± 5 percent of the center of the voltage range specified on the nameplate.

3.3. *Ambient Room Temperature.* During the soak-in period and the standby loss test, maintain the ambient room temperature at 75 °F ± 10 °F at all times. Measure the ambient room temperature at 1-minute intervals during these periods, except for the soak-in period. Measure the ambient room temperature once before beginning the soak-in period, and ensure no actions are taken during the soak-in period that would cause the ambient room temperature to deviate from the allowable range. Measure the ambient room temperature at the vertical mid-point of the water heater and approximately 2 feet from the water heater jacket. Shield the sensor against radiation. Calculate the average ambient room temperature for the standby loss test. During the standby loss test, the ambient room temperature must not vary by more than ± 5.0 °F at any reading from the average ambient room temperature.

3.4. *Maximum Air Draft.* During the standby loss test, the water heater must be located in an area protected from drafts of more than 50 ft/min. Prior to beginning the standby loss test, measure the air draft within three feet of the jacket of the water heater to ensure this condition is met. Ensure that no other changes that would increase the air draft are made to the test set-up or conditions during the conduct of the test.

3.5. *Setting the Tank Thermostat(s).* Before starting the required soak-in period, the thermostat setting(s) must first be obtained as explained in the following sections. The thermostat setting(s) must be obtained by starting with the tank full of water at 70 °F ± 2 °F. After the tank is completely filled with water at 70 °F ± 2 °F, turn off the water flow, and set the thermostat(s) as follows.

3.5.1. For water heaters with a single thermostat, the thermostat setting must be set so that the maximum mean tank temperature after cut-out is 140 °F ± 5 °F.

3.5.2. For water heaters with multiple adjustable thermostats, set only the topmost and bottommost thermostats, and turn off any other thermostats for the duration of the standby loss test. Set the topmost thermostat first to yield a maximum mean water temperature after cut-out of 140 °F ± 5 °F, as calculated using only the temperature readings measured at locations in the tank higher than the heating element corresponding to the topmost thermostat (the lowermost heating element corresponding to the topmost thermostat if the thermostat controls more than one element). While setting the topmost thermostat, all lower thermostats must be turned off so that no elements below that (those) corresponding to the topmost thermostat are in operation. After setting the topmost thermostat, set the bottommost thermostat to yield a maximum mean water temperature after cut-out of 140 °F ± 5 °F. When setting the bottommost thermostat, calculate the mean tank temperature using all the temperature sensors installed in the tank as per section 2.3 of this appendix.

3.6. *Data Collection Intervals.* Follow the data recording intervals specified in the following sections.

3.6.1. *Soak-In Period.* Measure the ambient room temperature, in °F, every minute during the soak-in period.

3.6.2. *Standby Loss Test.* Follow the data recording intervals specified in Table 3.1 of this appendix. Additionally, the electricity consumption over the course of the entire test must be measured and used in calculation of standby loss.

TABLE 3.1—DATA TO BE RECORDED BEFORE AND DURING THE STANDBY LOSS TEST

Item recorded	Before test	Every 1 minute [a]
Air draft, ft/min	X	
Time, minutes/seconds		X
Mean tank temperature, °F		X [b]
Ambient room temperature, °F		X

Notes:
[a] These measurements are to be recorded at the start and end of the test, as well as every minute during the test.
[b] Mean tank temperature is calculated as the average of the 6 tank temperature sensors, installed per section 2.3 of this appendix.

4. Determination of Storage Volume. Determine the storage volume by subtracting the tare weight, measured while the system is dry and empty, from the weight of the system when filled with water and dividing the resulting net weight of water by the density of water at the measured water temperature. The volume of water contained in the water heater must be computed in gallons.

5. Standby Loss Test

5.1. If no settings on the water heater have changed and the water heater has not been turned off since a previously run standby loss test, skip to section 5.3 of this appendix. Otherwise, conduct the soak-in period according to section 5.2 of this appendix.

5.2. *Soak-In Period.* Conduct a soak-in period, in which the water heater must sit without any draws taking place for at least 12 hours. Begin the soak-in period after setting the tank thermostat(s) as specified in section 3.5 of this appendix, and maintain these settings throughout the soak-in period.

5.3. Begin the standby loss test at the first cut-out following the end of the soak-in period (if applicable), or at a cut-out following the previous standby loss test (if applicable). Allow the water heater to remain in standby mode. At this point, do not change any settings on the water heater until measurements for the standby loss test are finished. Begin recording applicable parameters as specified in section 3.6.2 of this appendix.

5.4. At the second cut-out, record the time and ambient room temperature, and begin measuring the electric consumption. Record the initial mean tank temperature and initial ambient room temperature. For the remainder of the test, continue recording the applicable parameters specified in section 3.6.2 of this appendix.

5.5. Stop the test after the first cut-out that occurs after 24 hours, or at 48 hours, whichever comes first.

5.6. Immediately after conclusion of the standby loss test, record the total electrical energy consumption, the final ambient room temperature, the duration of the standby loss test, and if the test ends at 48 hours without a cut-out, the final mean tank temperature, or if the test ends after a cut-out, the maximum mean tank temperature that occurs after the cut-out. Calculate the average of the recorded values of the mean tank temperature and of the ambient air temperatures taken at each measurement interval, including the initial and final values.

5.7. *Standby Loss Calculation.* To calculate the standby loss, follow the steps below:

5.7.1 The standby loss expressed as a percentage (per hour) of the heat content of the stored water above room temperature must be calculated using the following equation:

$$S = \frac{E_c - \left(\frac{k(V_a)(\Delta T_4)}{E_t/100}\right)}{k(V_a)(\Delta T_3)(t)} \times 100$$

Where,

ΔT_3 = Average value of the mean tank temperature minus the average value of the ambient room temperature, expressed in °F

ΔT_4 = Final mean tank temperature measured at the end of the test minus the initial mean tank temperature measured at the start of the test, expressed in °F

k = 8.25 Btu/gallon·°F, the nominal specific heat of water

V_a = Volume of water contained in the water heater in gallons measured in accordance with section 4 of this appendix

E_t = Thermal efficiency = 98 percent for electric water heaters with immersed heating elements

E_c = Electrical energy consumed by the water heater during the duration of the test in Btu

t = Total duration of the test in hours

S = Standby loss, the average hourly energy required to maintain the stored water temperature expressed as a percentage of the heat content of the stored water above room temperature

■ 15. Add appendix C to subpart G of part 431 to read as follows:

Appendix C to Subpart G of Part 431—Uniform Test Method for the Measurement of Thermal Efficiency and Standby Loss of Gas-Fired and Oil-Fired Instantaneous Water Heaters and Hot Water Supply Boilers (Other Than Storage-Type Instantaneous Water Heaters)

Note: Prior to November 6, 2017, manufacturers must make any representations with respect to the energy use or efficiency of the subject commercial water heating equipment in accordance with the results of testing pursuant to this appendix or the procedures in 10 CFR 431.106 that were in place on January 1, 2016. On and after November 6, 2017, manufacturers must make any representations with respect to energy use or efficiency of gas-fired and oil-fired instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) in accordance with the results of testing pursuant to this appendix to demonstrate compliance with the energy conservation standards at 10 CFR 431.110.

1. General

Determine the thermal efficiency and standby loss (as applicable) in accordance with the following sections of this appendix. Certain sections reference sections of Annex E.1 of ANSI Z21.10.3–2015 (incorporated by reference; see § 431.105). Where the instructions contained in the sections below conflict with instructions in Annex E.1 of ANSI Z21.10.3–2015, the instructions contained in this appendix control.

2. Test Set-Up

2.1. Placement of Water Heater. A water heater for installation on combustible floors must be placed on a ¾-inch plywood platform supported by three 2 x 4-inch runners. If the water heater is for installation on noncombustible floors, suitable noncombustible material must be placed on the platform. When the use of the platform for a large water heater is not practical, the water heater may be placed on any suitable flooring. A wall-mounted water heater must be mounted on a simulated wall section.

2.2. Test Configuration. If the instantaneous water heater or hot water supply boiler is not required to be tested using a recirculating loop, then set up the unit in accordance with Figures 2.1, 2.2, or 2.3 of this appendix (as applicable). If the unit is required to be tested using a recirculating loop, then set up the unit as per Figure 2.4 of this appendix.

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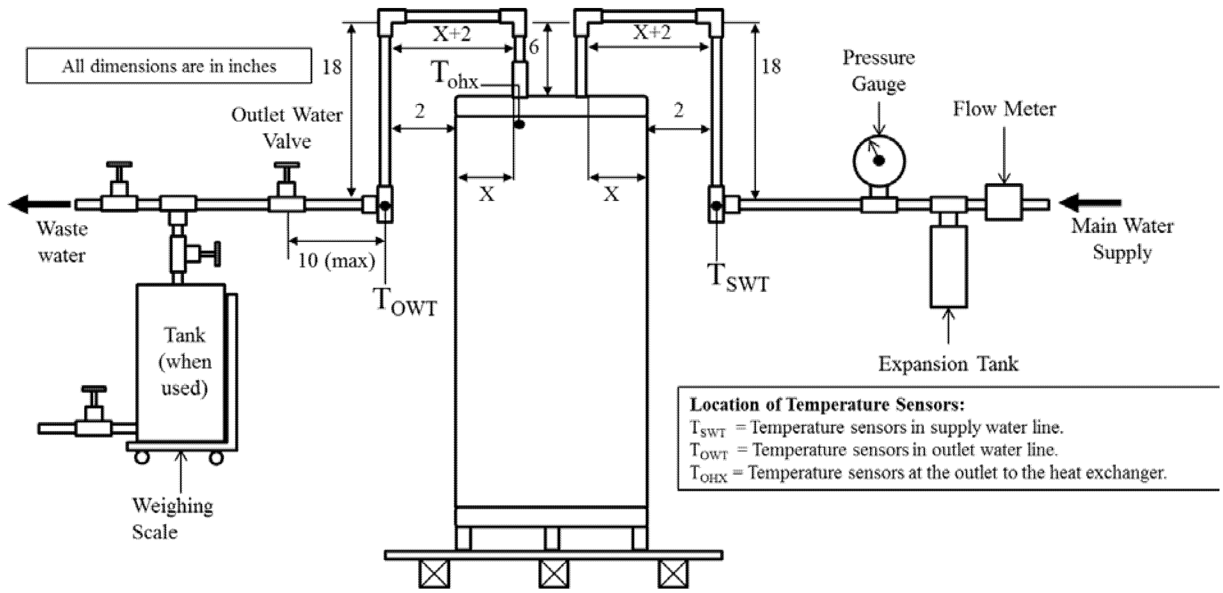

Figure 2.1. Set-up for thermal efficiency and standby loss test for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) equipped with vertical (top) connections not requiring a recirculating loop.

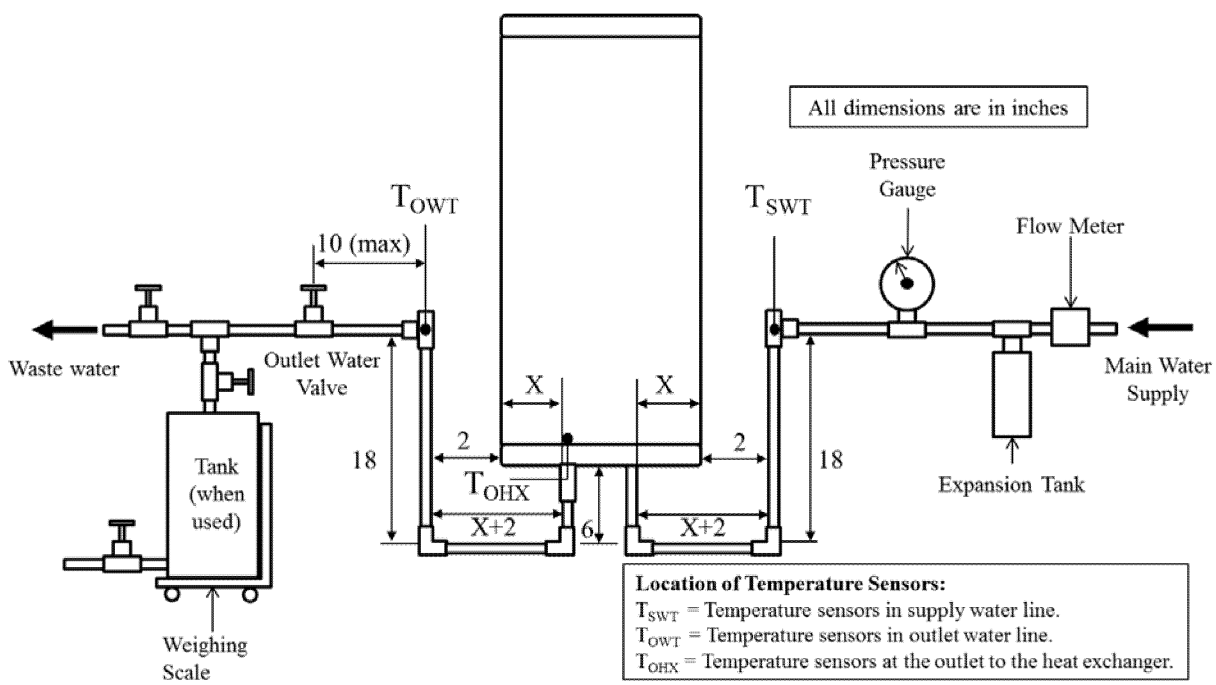

Figure 2.2. Set-up for thermal efficiency and standby loss test for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) equipped with vertical (bottom) connections not requiring a recirculating loop.

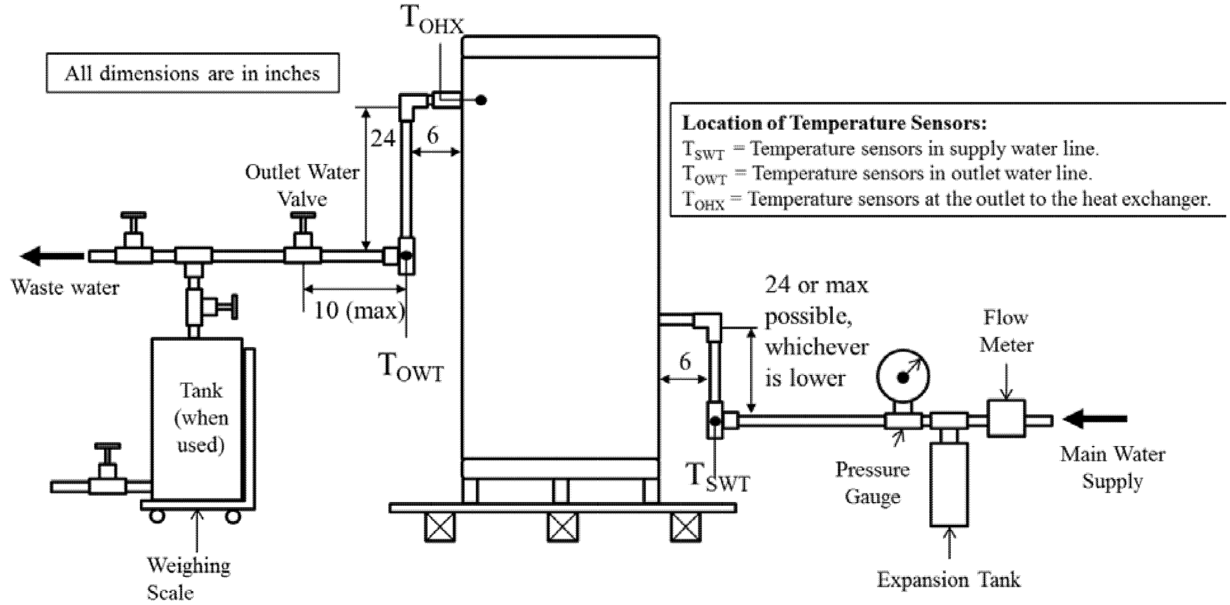

Figure 2.3. Set-up for thermal efficiency and standby loss test for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) equipped with horizontal connections not requiring a recirculating loop.

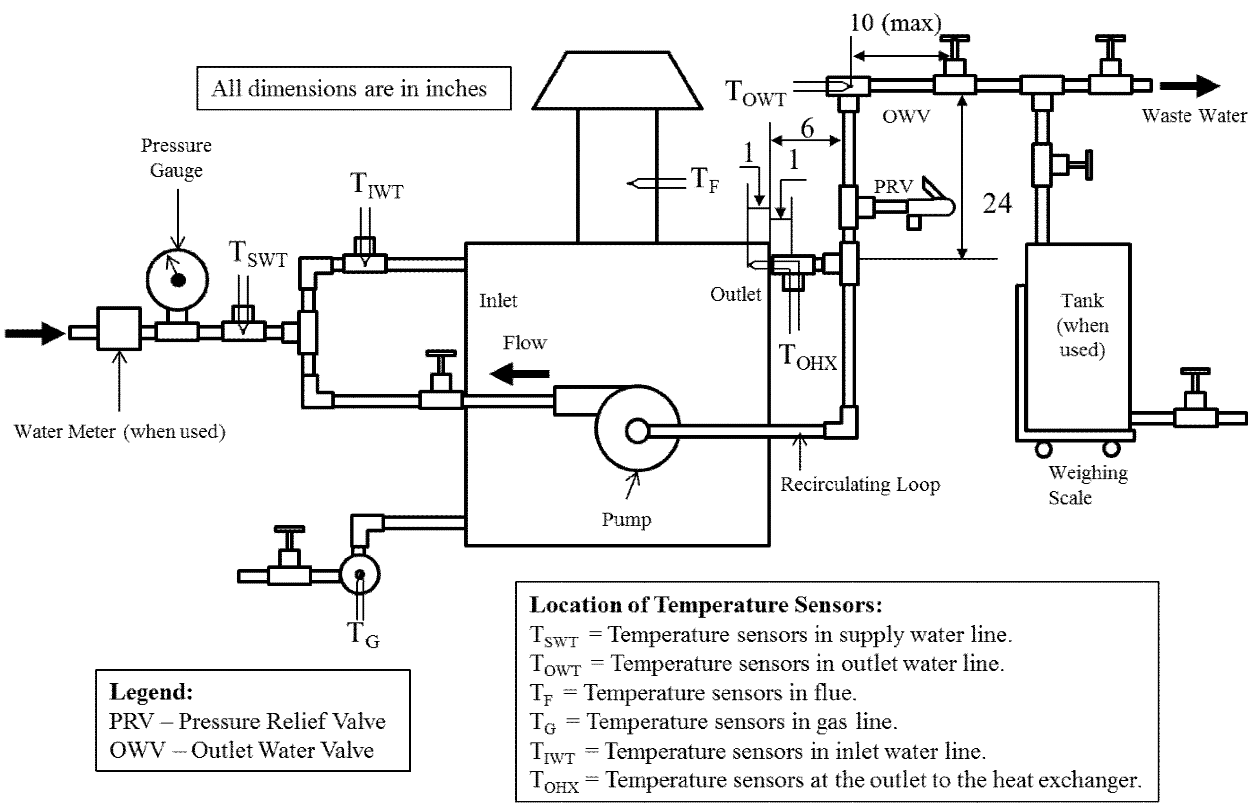

Figure 2.4. Set-up for thermal efficiency and standby loss test for gas-fired and oil-fired instantaneous water heaters and hot water supply boilers (other than storage-type instantaneous water heaters) requiring a recirculating loop for testing.

2.2.1. If the instantaneous water heater or hot water supply boiler does not have any external piping, install an outlet water valve within 10 inches of piping length of the water heater jacket or enclosure. If the instantaneous water heater or hot water supply boiler includes external piping assembled at the manufacturer's premises prior to shipment, install water valves in the outlet piping within 5 inches of the end of the piping supplied with the unit.

2.2.2. If the water heater is not able to achieve an outlet water temperature of 70 °F ± 2 °F (T_{OWT}) above the supply water temperature at full firing rate, a recirculating loop with pump as shown in Figure 2.4 of this appendix must be used.

2.2.2.1. If a recirculating loop with a pump is used, then ensure that the inlet water temperature labeled as T_{IWT} in Figure 2.4 of this appendix, is greater than or equal to 70 °F and less than or equal to 120 °F at all times during the thermal efficiency test and steady-state verification period (as applicable).

2.3. Installation of Temperature Sensors

2.3.1. *Without Recirculating Loop.*

2.3.1.1. *Vertical Connections.* Use Figure 2.1 (for top connections) and 2.2 (for bottom connections) of this appendix.

2.3.1.2. *Horizontal Connections.* Use Figure 2.3 of this appendix.

2.3.2. *With Recirculating Loop.* Set up the recirculating loop as shown in Figure 2.4 of this appendix.

2.3.3. For water heaters with multiple outlet water connections leaving the water heater jacket that are required to be operated to achieve the rated input, temperature sensors must be installed for each outlet water connection leaving the water heater jacket or enclosure that is used during testing, in accordance with the provisions in sections 2.3.1 and 2.3.2 of this appendix (as applicable).

2.4. Piping Insulation. Insulate all water piping external to the water heater jacket or enclosure, including piping that is installed by the manufacturer or shipped with the unit, for at least 4 ft of piping length from the connection at the appliance with material having an R-value not less than 4 °F·ft²·h/Btu. Ensure that the insulation does not contact any appliance surface except at the location where the pipe connections penetrate the appliance jacket or enclosure.

2.5. *Temperature and Pressure Relief Valve Insulation.* If the manufacturer has not provided a temperature and pressure relief valve, one shall be installed and insulated as specified in section 2.4 of this appendix. The temperature and pressure relief valve must be installed in the outlet water piping, between the unit being tested and the outlet water valve.

2.6. Vent Requirements. Follow the requirements for venting arrangements specified in paragraph c of Annex E.1 of ANSI Z21.10.3–2015 (incorporated by reference; see § 431.105).

2.7. Energy Consumption. Install equipment that determines, within ± 1 percent:

2.7.1. The quantity and rate of fuel consumed.

2.7.2. The quantity of electricity consumed by factory-supplied water heater components, and of the test loop recirculating pump, if used.

3. Test Conditions

3.1. Water Supply

3.1.1. *Water Supply Pressure.* The pressure of the water supply must be maintained between 40 psi and the maximum pressure specified by the manufacturer of the unit being tested. The accuracy of the pressure-measuring devices must be within ± 1.0 psi.

3.1.2. Water Supply Temperature. During the thermal efficiency test and steady-state verification period (as applicable), the temperature of the supply water (T_{SWT}) must be maintained at 70 °F ± 2 °F.

3.2. Gas Pressure for Gas-Fired Equipment. The supply gas pressure must be within the range specified by the manufacturer on the nameplate of the unit being tested. The difference between the outlet pressure of the gas appliance pressure regulator and the value specified by the manufacturer on the nameplate of the unit being tested must not exceed the greater of: ± 10 percent of the nameplate value or ± 0.2 inches water column (in. w.c.). Obtain the higher heating value of the gas burned.

3.3. *Ambient Room Temperature.* Maintain the ambient room temperature at 75 °F ± 10 °F at all times during the steady-state verification period, the thermal efficiency test, and the standby loss test (as applicable). Measure the ambient room temperature at 1-minute intervals during these periods. Measure the ambient room temperature at the vertical mid-point of the water heater and approximately 2 feet from the water heater jacket or enclosure. Shield the sensor against radiation. Calculate the average ambient room temperature separately for the thermal efficiency test and the standby loss test. During the thermal efficiency and standby loss tests, the ambient room temperature must not vary by more than ± 5.0 °F at any reading from the average ambient room temperature.

3.4. *Test Air Temperature.* During the steady-state verification period, the thermal efficiency test, and the standby loss test (as applicable), the test air temperature must not vary by more than ± 5 °F from the ambient room temperature at any reading. Measure the test air temperature at 1-minute intervals during these periods and at a location within two feet of the air inlet of the water heater or the combustion air intake vent, as applicable. Shield the sensor against radiation. For units with multiple air inlets, measure the test air temperature at each air inlet, and maintain the specified tolerance on deviation from the ambient room temperature at each air inlet. For units without a dedicated air inlet, measure the test air temperature within two feet of any location on the water heater where combustion air is drawn.

3.5. Maximum Air Draft. During the steady-state verification period, the thermal efficiency test, and the standby loss test (as applicable), the water heater must be located in an area protected from drafts of more than 50 ft/min. Prior to beginning the steady-state verification period and the standby loss test, measure the air draft within three feet of the jacket or enclosure of the water heater to ensure this condition is met. Ensure that no other changes that would increase the air draft are made to the test set-up or conditions during the conduct of the tests.

3.6. Primary Control

3.6.1. *Thermostatically-Activated Water Heaters With an Internal Thermostat.* Before starting the thermal efficiency test and the standby loss test (unless the thermostat is already set before the thermal efficiency test), the thermostat setting must be obtained. Set the thermostat to ensure:

3.6.1.1. With supply water temperature set as per section 3.1.2 of this appendix (*i.e.,* 70 °F ± 2 °F) the water flow rate can be varied so that the outlet water temperature is constant at 70 °F ± 2 °F above the supply water temperature, while the burner is firing at full firing rate; and

3.6.1.2. After the water supply is turned off and the thermostat reduces the fuel supply to a minimum, the maximum heat exchanger outlet water temperature (T_{OHX}) is 140 °F ± 5 °F.

3.6.1.3. If the water heater includes a built-in safety mechanism that prevents it from achieving a heat exchanger outlet water temperature of 140 °F ± 5 °F, adjust the thermostat to its maximum setting.

3.6.2. *Flow-Activated Instantaneous Water Heaters and Thermostatically-Activated Instantaneous Water Heaters With an External Thermostat.* Energize the primary control such that it is always calling for heating and the burner is firing at the full firing rate. Maintain the supply water temperature as per section 3.1.2 of this appendix (*i.e.,* 70 °F ± 2 °F). Set the control so that the outlet water temperature (T_{OWT}) is 140 °F ± 5 °F. If the water heater includes a built-in safety mechanism that prevents it from achieving a heat exchanger outlet water temperature of 140 °F ± 5 °F, adjust the control to its maximum setting.

3.7. Units With Multiple Outlet Water Connections

3.7.1. For each connection leaving the water heater that is required for the unit to achieve the rated input, the outlet water temperature must not differ from that of any other outlet water connection by more than 2 °F during the steady-state verification period and thermal efficiency test.

3.7.2. Determine the outlet water temperature representative for the entire unit at every required measurement interval by calculating the average of the outlet water temperatures measured at each connection leaving the water heater jacket or enclosure that is used during testing. Use the outlet water temperature representative for the entire unit in all calculations for the thermal efficiency and standby loss tests, as applicable.

3.8. *Additional Requirements for Oil-Fired Equipment.*

3.8.1. *Venting Requirements.* Connect a vertical length of flue pipe to the flue gas outlet of sufficient height so as to meet the minimum draft specified by the manufacturer.

3.8.2. *Oil Supply.* Adjust the burner rate so that the following conditions are met:

3.8.2.1. The CO_2 reading is within the range specified by the manufacturer;

3.8.2.2. The fuel pump pressure is within ± 10 percent of manufacturer's specifications;

3.8.2.3. If either the fuel pump pressure or range for CO_2 reading are not specified by the manufacturer on the nameplate of the unit, in literature shipped with the unit, or in supplemental test report instructions included with a certification report, then a default value of 100 psig is to be used for fuel pump pressure, and a default range of 9–12 percent is to be used for CO_2 reading; and

3.8.2.4. Smoke in the flue does not exceed No. 1 smoke as measured by the procedure in ASTM D2156–09 (Reapproved 2013) (incorporated by reference, see § 431.105). To determine the smoke spot number, the smoke measuring device shall be connected to an open-ended tube. This tube must project into the flue ¼ to ½ of the pipe diameter.

3.8.2.5. If no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously run thermal efficiency (or standby loss test for thermostatically-activated instantaneous water heaters with an internal thermostat), measurement of the CO_2 reading and conduct of the smoke spot test are not required prior to beginning a test. Otherwise, measure the CO_2 reading and determine the smoke spot number, with the burner firing, before beginning measurements for the steady-state verification period (prior to beginning the thermal efficiency test or standby loss test, as applicable). However, measurement of the CO_2 reading and conduct of the smoke spot test are not required for the standby loss test for thermostatically-activated instantaneous water heaters with an external thermostat and flow-activated instantaneous water heaters.

3.9. *Data Collection Intervals.* Follow the data recording intervals specified in the following sections.

3.9.1. *Steady-State Verification Period and Thermal Efficiency Test.* For the steady-state verification period and the thermal efficiency test, follow the data recording intervals specified in Table 3.1 of this appendix. These data recording intervals must also be followed if conducting a steady-state verification period prior to conducting the standby loss test.

TABLE 3.1—DATA TO BE RECORDED BEFORE AND DURING THE STEADY-STATE VERIFICATION PERIOD AND THERMAL EFFICIENCY TEST

Item recorded	Before steady-state verification period	Every 1 minute [a]	Every 10 minutes
Gas supply pressure, in w.c.	X		
Gas outlet pressure, in w.c.	X		
Barometric pressure, in Hg	X		
Fuel higher heating value, Btu/ft^3 (gas) or Btu/lb (oil)	X		
Oil pump pressure, psig (oil only)	X		
CO_2 reading, % (oil only)	X [b]		
Oil smoke spot reading (oil only)	X [b]		
Air draft, ft/min	X		
Time, minutes/seconds		X	
Fuel weight or volume, lb (oil) or ft^3 (gas)			X [c]
Supply water temperature (T_{SWT}), °F		X	
Inlet water temperature (T_{IWT}), °F		X [d]	
Outlet water temperature (T_{OWT}), °F		X	
Ambient room temperature, °F		X	
Test air temperature, °F		X	
Water flow rate, gpm		X	

Notes:

[a] These measurements are to be recorded at the start and end of both the steady-state verification period and the thermal efficiency test, as well as every minute during both periods.

[b] The smoke spot test and CO_2 reading are not required prior to beginning the steady-state verification period if no settings on the water heater have been changed and the water heater has not been turned off since the end of a previously-run efficiency test (*i.e.,* thermal efficiency or standby loss).

[c] Fuel and electricity consumption over the course of the entire thermal efficiency test must be measured and used in calculation of thermal efficiency.

[d] Only measured when a recirculating loop is used.

3.9.2. *Standby Loss Test.* For the standby loss test, follow the data recording intervals specified in Table 3.2 of this appendix. (Follow the data recording intervals specified in Table 3.1 of this appendix of the steady-state verification period, if conducted prior to the standby loss test.) Additionally, the fuel and electricity consumption over the course of the entire test must be measured and used in calculation of standby loss.

TABLE 3.2—DATA TO BE RECORDED BEFORE AND DURING THE STANDBY LOSS TEST

Item recorded	Before test	Every 1 minute [a]
Gas supply pressure, in w.c.	X	
Gas outlet pressure, in w.c.	X	
Barometric pressure, in Hg	X	
Fuel higher heating value, Btu/ft^3 (gas) or Btu/lb (oil)	X	
Oil pump pressure, psig (oil only)	X	
Air draft, ft/min	X	
Time, minutes/seconds		X
Heat exchanger outlet water temperature (T_{OHX}), °F		X
Ambient room temperature, °F		X
Test air temperature, °F		X
Water flow rate, gpm	X [b]	
Inlet water temperature (T_{IWT}), °F	X [b]	

Notes:

[a] These measurements are to be recorded at the start and end of the test, as well as every minute during the test.

[b] The water flow rate and supply water temperature and inlet water temperature (if a recirculating loop is used) must be measured during the steady-state verification period at 1-minute intervals. After the steady-state verification period ends, flow rate, supply water temperature, and inlet water temperature (if measured) are not required to be measured during the standby loss test, as there is no flow occurring during the standby loss test.

4. *Determination of Storage Volume.* Determine the storage volume by subtracting the tare weight, measured while the system is dry and empty, from the weight of the system when filled with water and dividing the resulting net weight of water by the density of water at the measured water temperature. The volume of water contained in the water heater must be computed in gallons.

5. Fuel Input Rate

5.1. *Determination of Fuel Input Rate.* During the steady-state verification period and thermal efficiency test, as applicable, record the fuel consumption at 10-minute intervals. Calculate the fuel input rate for each 10-minute period using the equations in section 5.2 of this appendix. The measured fuel input rates for these 10-minute periods must not vary by more than ± 2 percent between any two readings. Determine the overall fuel input rate using the fuel consumption for the entire duration of the thermal efficiency test.

5.2. *Fuel Input Rate Calculation.* To calculate the fuel input rate, use the following equation:

$$Q = \frac{Q_s * C_s * H}{t}$$

Where:

Q = Fuel input rate, expressed in Btu/h

Q_s = Total fuel flow as metered, expressed in ft^3 for gas-fired equipment and lb for oil-fired equipment

C_s = Correction applied to the heating value of a gas H, when it is metered at temperature and/or pressure conditions other than the standard conditions for which the value of H is based. C_s=1 for oil-fired equipment.

H = Higher heating value of the fuel, expressed as Btu/ft^3 for gas-fired equipment and Btu/lb for oil-fired equipment.

t = Duration of measurement of fuel consumption

6. *Thermal Efficiency Test.* Before beginning the steady-state verification period, record the applicable parameters as specified in section 3.9.1 of this appendix. Begin drawing water from the unit by opening the main supply and outlet water valve, and adjust the water flow rate to achieve an outlet water temperature of 70 °F ± 2 °F above supply water temperature. The thermal efficiency test shall be deemed complete when there is a continuous, one-hour-long period where the steady-state conditions specified in section 6.1 of this appendix have been met, as confirmed by consecutive readings of the relevant parameters at 1-minute intervals (except for fuel input rate, which is determined at 10-minute intervals, as specified in section 5.1 of this appendix). During the one-hour-long period, the water heater must fire continuously at its full firing rate (*i.e.,* no modulation or cut-outs) and no settings can be changed on the unit being tested at any time. The first 30 minutes of the one-hour-period where the steady-state conditions in section 6.1 of this appendix are met is the steady-state verification period. The final 30 minutes of the one-hour-period where the steady-state conditions in section 6.1 of this appendix are met is the thermal efficiency test. The last reading of the steady-state verification period must be the first reading of the thermal efficiency test (*i.e.,* the thermal efficiency test starts immediately once the steady-state verification period ends).

6.1. *Steady-State Conditions.* The following conditions must be met at consecutive readings taken at 1-minute intervals (except for fuel input rate, for which measurements are taken at 10-minute intervals) to verify the water heater has achieved steady-state operation during the steady-state verification period and the thermal efficiency test.

6.1.1. The water flow rate must be maintained within ± 0.25 gallons per minute (gpm) of the initial reading at the start of the steady-state verification period.

6.1.2. Outlet water temperature must be maintained at 70 °F ± 2 °F above supply water temperature.

6.1.3. Fuel input rate must be maintained within ± 2 percent of the rated input certified by the manufacturer.

6.1.4. The supply water temperature (T_{SWT}) (or inlet water temperature (T_{IWT}) if a recirculating loop is used) must be maintained within ± 0.50 °F of the initial reading at the start of the steady-state verification period.

6.1.5. The rise between supply (or inlet if a recirculating loop is used) and outlet water temperatures must be maintained within ± 0.50 °F of its initial value taken at the start of the steady-state verification period for units with rated input less than 500,000 Btu/h, and maintained within ± 1.00 °F of its initial value for units with rated input greater than or equal to 500,000 Btu/h.

6.2. *Water Flow Measurement.* Measure the total weight of water heated during the 30-minute thermal efficiency test with either a scale or a water flow meter. With either method, the error of measurement of weight of water heated must not exceed 1 percent of the weight of the total draw.

6.3. *Thermal Efficiency Calculation.* Thermal efficiency must be calculated using data from the 30-minute thermal efficiency test. Calculate thermal efficiency, E_t, using the following equation:

$$E_t = \frac{K * W * (\theta_2 - \theta_1)}{(C_s * Q * H) + E_c}$$

Where:

K = 1.004 Btu/lb·°F, the nominal specific heat of water at 105 °F

W = Total weight of water heated, lb

θ_1 = Average supply water temperature, expressed in °F

θ_2 = Average outlet water temperature, expressed in °F

Q = Total fuel flow as metered, expressed in ft^3 (gas) or lb (oil)

C_s = Correction applied to the heating value of a gas H, when it is metered at temperature and/or pressure conditions other than the standard conditions for which the value of H is based. C_s=1 for oil-fired equipment.

H = Higher heating value of the fuel, expressed in Btu/ft^3 (gas) or Btu/lb (oil)

E_c = Electrical consumption of the water heater and, when used, the test set-up recirculating pump, expressed in Btu

7. *Standby Loss Test.* If the standby loss test is conducted immediately after a thermal efficiency test and no settings or conditions have been changed since the completion of the thermal efficiency test, then skip to section 7.2 or 7.3 of this appendix (as applicable). Otherwise, perform the steady-state verification in section 7.1 of this appendix. For thermostatically-activated instantaneous water heaters with an internal thermostat, use section 7.2 of this appendix to conduct the standby loss test, and for flow-activated and/or thermostatically-activated instantaneous water heaters with an external thermostat use section 7.3 of this appendix to conduct the standby loss test.

7.1. *Steady-State Verification Period.* For water heaters where the standby loss test is not conducted immediately following the thermal efficiency test, the steady-state verification period must be conducted before starting the standby loss test. Set the primary control in accordance with section 3.6 of this appendix, such that the primary control is always calling for heat and the water heater is firing continuously at the full firing rate (*i.e.,* no modulation or cut-outs). Begin drawing water from the unit by opening the main supply and the outlet water valve, and adjust the water flow rate to achieve an outlet water temperature of 70 °F ± 2 °F above supply water temperature. The steady-state verification period is complete when there is a continuous 30-minute period where the steady-state conditions specified in section 7.1.1 of this appendix are met, as confirmed by consecutive readings of the relevant parameters recorded at 1-minute intervals (except for fuel input rate, which is determined at 10-minute intervals, as specified in section 5.1 of this appendix).

7.1.1. *Steady-State Conditions.* The following conditions must be met at consecutive readings taken at 1-minute intervals (except for fuel input rate, for which measurements are taken at 10-minute intervals) to verify the water heater has achieved steady-state operation during the steady-state verification period prior to conducting the standby loss test.

7.1.1.1. The water flow rate must be maintained within ± 0.25 gallons per minute (gpm) of the initial reading at the start of the steady-state verification period;

7.1.1.2. Fuel input rate must be maintained within ± 2 percent of the rated input certified by the manufacturer;

7.1.1.3. The supply water temperature (T_{SWT}) (or inlet water temperature (T_{IWT}) if a recirculating loop is used) must be maintained within ± 0.50 °F of the initial reading at the start of the steady-state verification period; and

7.1.1.4. The rise between the supply (or inlet if a recirculating loop is used) and outlet water temperatures must be maintained within ± 0.50 °F of its initial value taken at the start of the steady-state verification period for units with rated input less than 500,000 Btu/h, and maintained within ± 1.00 °F of its initial value for units with rated input greater than or equal to 500,000 Btu/h.

7.2. *Thermostatically-Activated Instantaneous Water Heaters with an Internal Thermostat.* For water heaters that will experience cut-in based on a temperature-activated control that is internal to the water heater, use the following steps to conduct the standby loss test.

7.2.1. Immediately after the thermal efficiency test or the steady-state verification period (as applicable), turn off the outlet water valve(s) (installed as per the provisions in section 2.2 of this appendix), and the water pump (if applicable) simultaneously and ensure that there is no flow of water through the water heater.

7.2.2. After the first cut-out following the end of the thermal efficiency test or steady-state verification period (as applicable), allow the water heater to remain in standby mode. Do not change any settings on the water heater at any point until measurements for the standby loss test are finished. Begin recording the applicable parameters specified in section 3.9.2 of this appendix.

7.2.3. At the second cut-out, record the time and ambient room temperature, and begin measuring the fuel and electricity consumption. Record the initial heat exchanger outlet water temperature (T_{OHX}) and initial ambient room temperature. For the remainder of the test, continue recording the applicable parameters specified in section 3.9.2 of this appendix.

7.2.4. Stop the test after the first cut-out that occurs after 24 hours, or at 48 hours, whichever comes first.

7.2.5. Immediately after conclusion of the standby loss test, record the total fuel flow and electrical energy consumption, the final ambient room temperature, the duration of the standby loss test, and if the test ends at 48 hours without a cut-out, the final heat exchanger outlet temperature, or if the test ends after a cut-out, the maximum heat exchanger outlet temperature that occurs after the cut-out. Calculate the average of the recorded values of the heat exchanger outlet water temperature and the ambient room temperature taken at each measurement interval, including the initial and final values.

7.2.6. *Standby Loss Calculation.* To calculate the standby loss, follow the steps below:

7.2.6.1. The standby loss expressed as a percentage (per hour) of the heat content of the stored water above room temperature must be calculated using the following equation:

$$S = \frac{E_c + (C_s)(Q_s)(H) - \left(\frac{k(V_a)(\Delta T_4)}{E_t/100}\right)}{k(V_a)(\Delta T_3)(t)} \times 100$$

Where:

ΔT_3 = Average value of the heat exchanger outlet water temperature (T_{OHX}) minus the average value of the ambient room temperature, expressed in °F

ΔT_4 = Final heat exchanger outlet water temperature (T_{OHX}) measured at the end of the test minus the initial heat exchanger outlet water temperature (T_{OHX}) measured at the start of the test, expressed in °F

K = 8.25 Btu/gallon·°F, the nominal specific heat of water

V_a = Volume of water contained in the water heater in gallons measured in accordance with section 4 of this appendix

E_t = Thermal efficiency of the water heater determined in accordance with section 6 of this appendix, expressed in %

E_c = Electrical energy consumed by the water heater during the duration of the test in Btu

T = Total duration of the test in hours

C_s = Correction applied to the heating value of a gas H, when it is metered at temperature and/or pressure conditions other than the standard conditions for which the value of H is based. C_s=1 for oil-fired equipment.

Q_s = Total fuel flow as metered, expressed in ft^3 (gas) or lb (oil)

H = Higher heating value of gas or oil, expressed in Btu/ft^3 (gas) or Btu/lb (oil)

S = Standby loss, the average hourly energy required to maintain the stored water temperature expressed as a percentage of the initial heat content of the stored water above room temperature

7.2.6.2. The standby loss expressed in Btu per hour must be calculated as follows:

SL (Btu per hour) = S (% per hour) × 8.25 (Btu/gal-°F) × Measured Volume (gal) × 70 (°F).

Where, SL refers to the standby loss of the water heater, defined as the amount of energy required to maintain the stored water temperature expressed in Btu per hour.

7.3. *Flow-Activated and Thermostatically-Activated Instantaneous Water Heaters with an External Thermostat.* For water heaters that are either flow-activated or thermostatically-activated with an external thermostat, use the following steps to conduct the standby loss test.

7.3.1. Immediately after the thermal efficiency test or the steady-state verification period (as applicable), de-energize the primary control to end the call for heating. If the main burners do not cut out, then turn off the fuel supply.

7.3.1.1. If the unit does not have an integral pump purge functionality, then turn off the outlet water valve and water pump at this time.

7.3.1.2. If the unit has an integral pump purge functionality, allow the pump purge operation to continue. After the pump purge operation is complete, immediately turn off the outlet water valve and water pump and continue recording the required parameters for the remainder of the test.

7.3.2. Recording Data

7.3.2.1. For units with pump purge functionality, record the initial heat exchanger outlet water temperature (T_{OHX}), and ambient room temperature when the main burner(s) cut-out or the fuel supply is turned off. After the pump purge operation is complete, record the time as t = 0 and the initial electricity meter reading. Continue to monitor and record the heat exchanger outlet water temperature (T_{OHX}) and time elapsed from the start of the test, and the electricity consumption as per the requirements in section 3.9.2 of this appendix.

7.3.2.2. For unit*s* not equipped with pump purge functionality, begin recording the measurements as per the requirements of section 3.9.2 of this appendix when the main burner(s) cut-out or the fuel supply is turned off. Specifically, record the time as t = 0, and record the initial heat exchanger outlet water temperature (T_{OHX}), ambient room temperature, and electricity meter readings. Continue to monitor and record the heat exchanger outlet water temperature (T_{OHX}) and the time elapsed from the start of the test as per the requirements in section 3.9.2 of this appendix.

7.3.3. *Stopping Criteria.* Stop the test when one of the following occurs:

7.3.3.1. The heat exchanger outlet water temperature (T_{OHX}) decreases by 35 °F from its value recorded immediately after the main burner(s) has cut-out, and the pump purge operation (if applicable) is complete; or

7.3.3.2. 24 hours have elapsed from the start of the test.

7.3.4. At the end of the test, record the final heat exchanger outlet water temperature (T_{OHX}), fuel consumed, electricity consumed from time t=0, and the time elapsed from the start of the test.

7.3.5. Standby Loss Calculation

7.3.5.1. Once the test is complete, use the following equation to calculate the standby loss as a percentage (per hour) of the heat content of the stored water above room temperature:

$$S = \frac{\frac{k(V_a)(\Delta T_1)}{E_t/100} + E_c}{k(V_a)(\Delta T_2)(t)} \times 100$$

Where,

ΔT_1 = Heat exchanger outlet water temperature (T_{OHX}) measured after the pump purge operation is complete (if the unit is integrated with pump purge functionality); or after the main burner(s) cut-out (if the unit is not equipped with pump purge functionality) minus heat exchanger outlet water temperature (T_{OHX}) measured at the end of the test, expressed in °F

ΔT_2 = Heat exchanger outlet water temperature (T_{OHX}) minus the ambient temperature, both measured after the main burner(s) cut-out, at the start of the test, expressed in °F

K = 8.25 Btu/gallon·°F, the nominal specific heat of water

V_a = Volume of water contained in the water heater in gallons measured in accordance with section 4 of this appendix

E_t = Thermal efficiency of the water heater determined in accordance with section 6 of this appendix, expressed in %

E_c = Electrical energy consumed by the water heater during the duration of the test in Btu

t = Total duration of the test in hours

S = Standby loss, the average hourly energy required to maintain the stored water temperature expressed as a percentage of the initial heat content of the stored water above room temperature

7.3.5.2. The standby loss expressed in terms of Btu per hour must be calculated as follows:

SL (Btu per hour) = S (% per hour) × 8.25 (Btu/gal-°F) × Measured Volume (gal) × 70 (°F)

Where, SL refers to the standby loss of the water heater, defined as the amount of energy required to maintain the stored water temperature expressed in Btu per hour.

16. Add appendix D to subpart G of part 431 to read as follows:

Appendix D to Subpart G of Part 431—Uniform Test Method for the Measurement of Standby Loss of Electric Instantaneous Water Heaters (Other Than Storage-Type Instantaneous Water Heaters)

Note: Prior to November 6, 2017, manufacturers must make any representations with respect to the energy use or efficiency of the subject commercial water heating equipment in accordance with the results of testing pursuant to this appendix or the procedures in 10 CFR 431.106 that were in place on January 1, 2016. On and after November 6, 2017, manufacturers must make any representations with respect to energy use or efficiency of electric instantaneous water heaters (other than storage-type instantaneous water heaters) in accordance with the results of testing pursuant to this appendix to demonstrate compliance with the energy conservation standards at 10 CFR 431.110.

1. General

Determine the standby loss (as applicable) in accordance with the following sections of this appendix.

2. Test Set-Up

2.1. Placement of Water Heater. A water heater for installation on combustible floors must be placed on a ¾-inch plywood platform supported by three 2 × 4-inch runners. If the water heater is for installation on noncombustible floors, suitable noncombustible material must be placed on the platform. When the use of the platform for a large water heater is not practical, the water heater may be placed on any suitable flooring. A wall-mounted water heater must be mounted on a simulated wall section.

2.2. Test Configuration. If the instantaneous water heater is not required to be tested using a recirculating loop, then set up the unit in accordance with Figure 2.1, 2.2, or 2.3 of this appendix (as applicable). If the unit is required to be tested using a recirculating loop, then set up the unit as per Figure 2.4 of this appendix.

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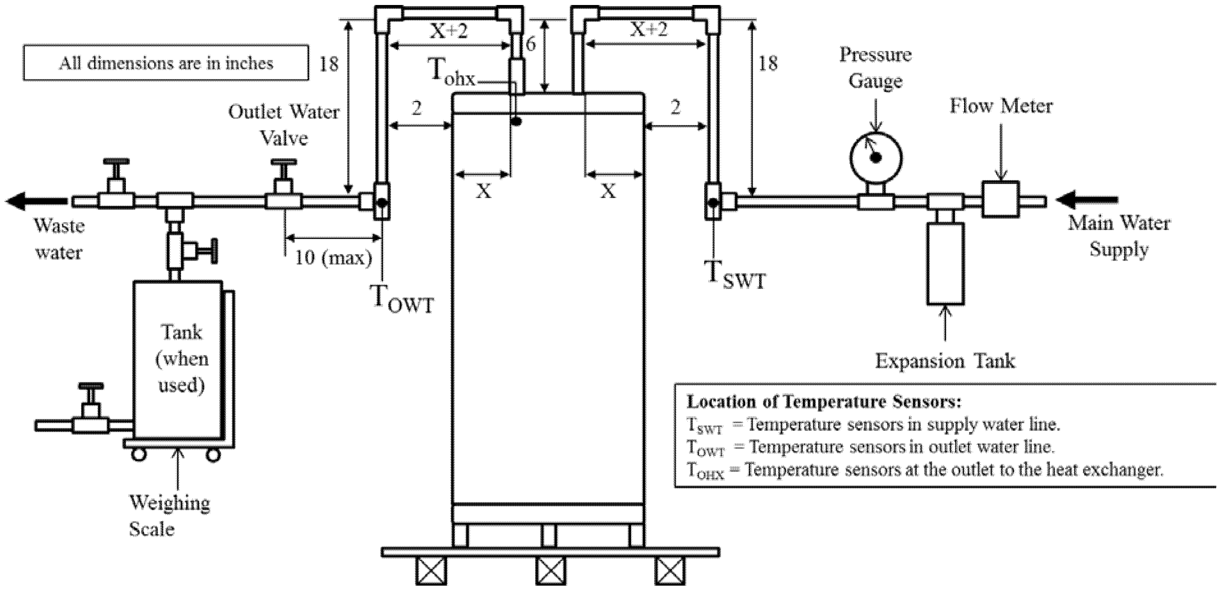

Figure 2.1. Set-up for standby loss test for electric instantaneous water heaters (other than storage-type instantaneous water heaters) equipped with vertical (top) connections not requiring a recirculating loop.

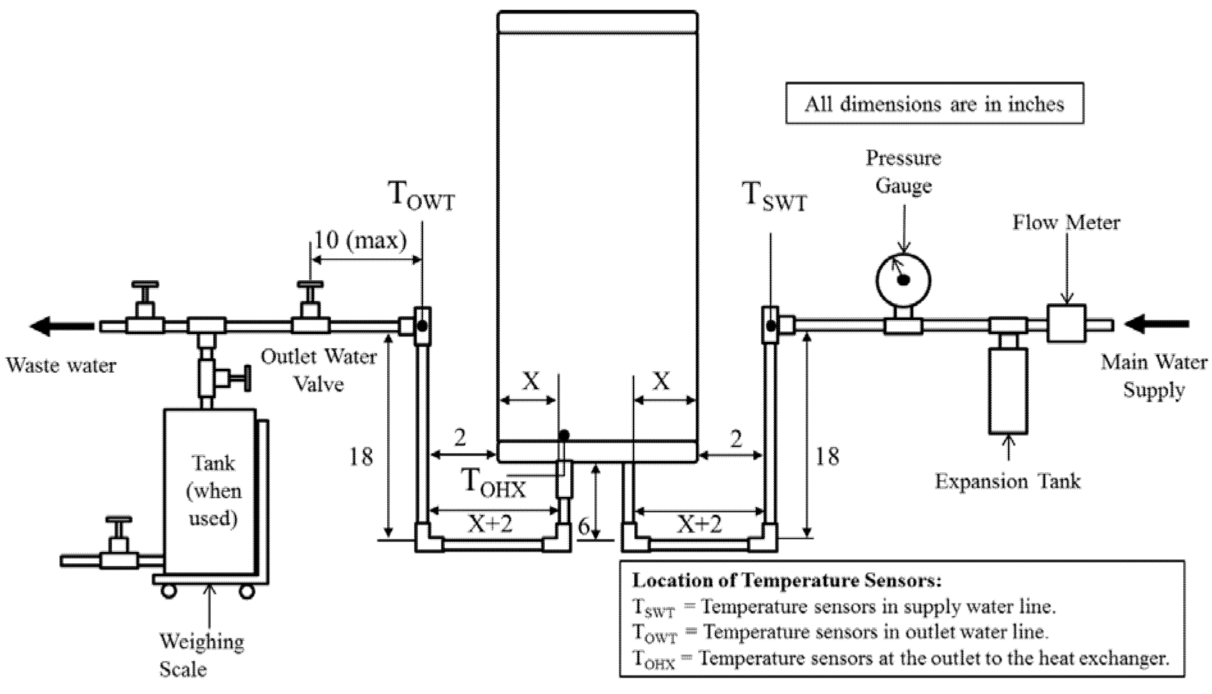

Figure 2.2. Set-up for standby loss test for electric instantaneous water heaters (other than storage-type instantaneous water heaters) equipped with vertical (bottom) connections not requiring a recirculating loop.

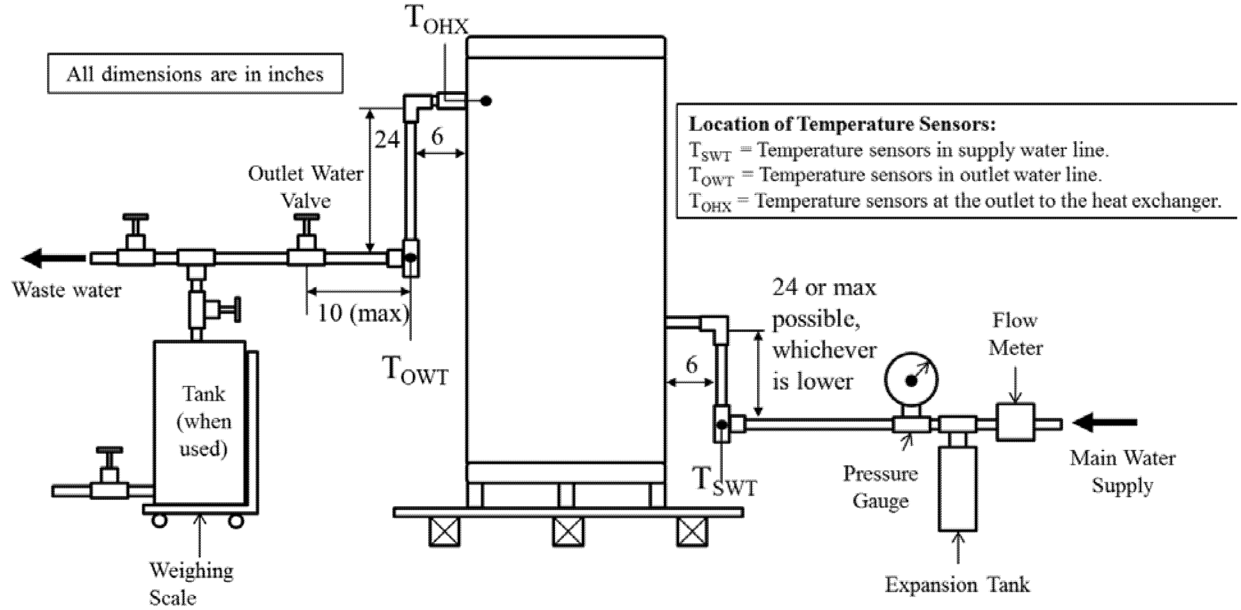

Figure 2.3. Set-up for standby loss test for electric instantaneous water heaters (other than storage-type instantaneous water heaters) equipped with horizontal connections not requiring a recirculating loop.

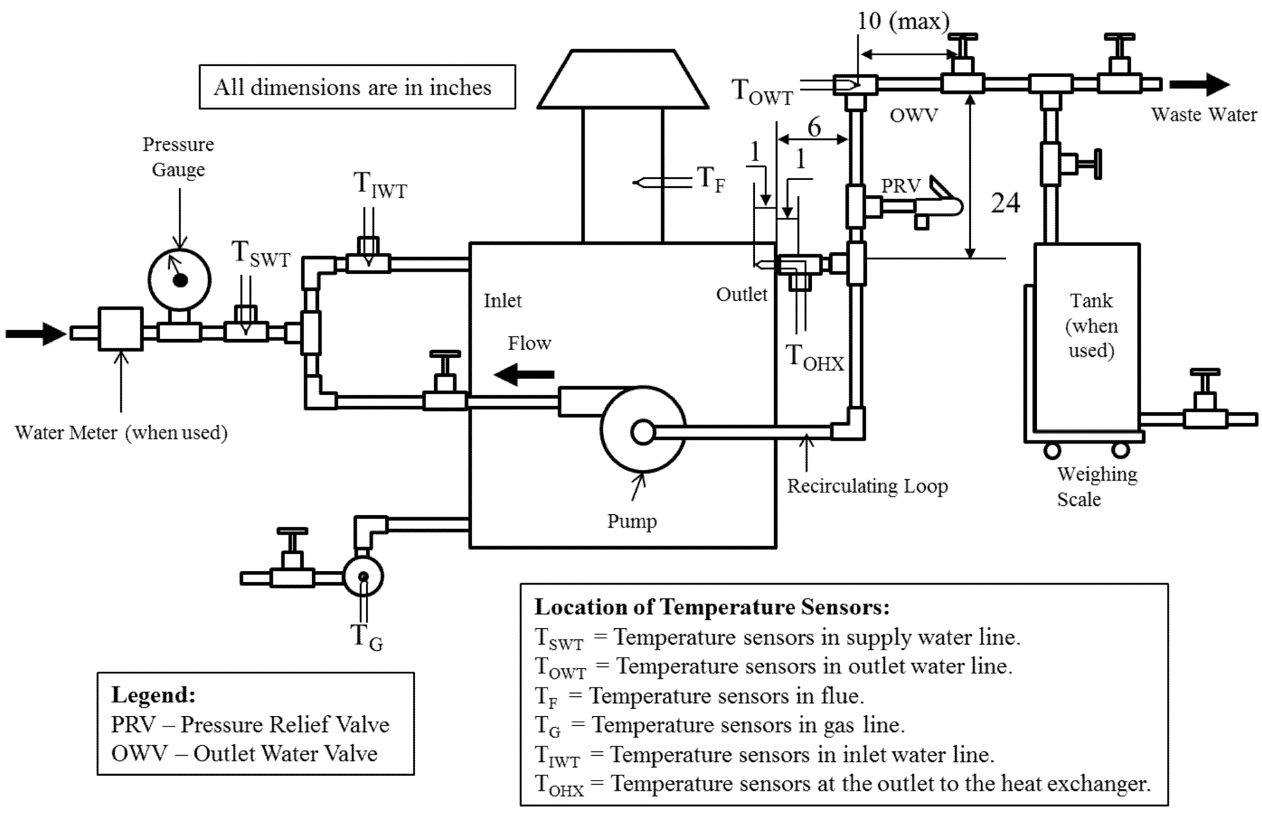

Figure 2.4. Set-up for standby loss test for electric instantaneous water heaters (other than storage-type instantaneous water heaters) requiring a recirculating loop for testing.

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2.2.1. If the instantaneous water heater does not have any external piping, install an outlet water valve within 10 inches of the piping length of the water heater jacket or enclosure. If the instantaneous water heater includes external piping assembled at the manufacturer's premises prior to shipment, install water valves in the outlet piping within 5 inches of the end of the piping supplied with the unit.

2.2.2. If the water heater is not able to achieve an outlet water temperature of 70 °F ± 2 °F above the supply water temperature at a constant maximum electricity input rate, a recirculating loop with pump as shown in Figure 2.4 of this appendix must be used.

2.2.2.1. If a recirculating loop with a pump is used, then ensure that the inlet water temperature (labeled as T_{IWT} in Figure 2.4 of this appendix) is greater than or equal to 70 °F and less than or equal to 120 °F at all times during the steady-state verification period.

2.3. Installation of Temperature Sensors

2.3.1. Without Recirculating Loop

2.3.1.1. *Vertical Connections.* Use Figure 2.1 (for top connections) and 2.2 (for bottom connections) of this appendix.

2.3.1.2. *Horizontal Connections.* Use Figure 2.3 of this appendix.

2.3.2. *With Recirculating Loop.* Set up the recirculating loop as shown in Figure 2.4 of this appendix.

2.3.3. For water heaters with multiple outlet water connections leaving the water heater jacket that are required to be operated to achieve the rated input, temperature sensors must be installed for each outlet water connection leaving the water heater jacket or enclosure that is used during testing, in accordance with sections 2.3.1 and 2.3.2 of this appendix.

2.4. *Piping Insulation.* Insulate all the water piping external to the water heater jacket or enclosure, including piping that is installed by the manufacturer or shipped with the unit, for at least 4 ft of piping length from the connection at the appliance with material having an R-value not less than 4 °F·ft^2·h/Btu. Ensure that the insulation does not contact any appliance surface except at the location where the pipe connections penetrate the appliance jacket or enclosure.

2.5. *Temperature and Pressure Relief Valve Insulation.* If the manufacturer has not provided a temperature and pressure relief valve, one shall be installed and insulated as specified in section 2.4 of this appendix. The temperature and pressure relief valve must be installed in the outlet water piping between the unit being tested and the outlet water valve.

2.6. *Energy Consumption.* Install equipment that determines, within ± 1 percent, the quantity of electricity consumed by factory-supplied water heater components, and of the test loop recirculating pump, if used.

3. Test Conditions

3.1. Water Supply

3.1.1. *Water Supply Pressure.* The pressure of the water supply must be maintained between 40 psi and the maximum pressure specified by the manufacturer of the unit being tested. The accuracy of the pressure-measuring devices must be ± 1.0 psi.

3.1.2. *Water Supply Temperature.* During the steady-state verification period, the temperature of the supply water (T_{SWT}) must be maintained at 70 °F ± 2 °F.

.2. *Electrical Supply.* Maintain the electrical supply voltage to within ± 5 percent of the voltage specified on the water heater nameplate. If a voltage range is specified on the nameplate, maintain the voltage to within ± 5 percent of the center of the voltage range specified on the nameplate.

3.3. *Ambient Room Temperature.* Maintain the ambient room temperature at 75°F ± 10 °F at all times during the steady-state verification period and the standby loss test. Measure the ambient room temperature at 1-minute intervals during these periods. Measure the ambient room temperature at the vertical mid-point of the water heater and approximately 2 feet from the water heater jacket or enclosure. Shield the sensor against radiation. Calculate the average ambient room temperature for the standby loss test. During the standby loss test, the ambient room temperature must not vary more than ± 5.0 °F at any reading from the average ambient room temperature.

3.4. *Maximum Air Draft.* During the steady-state verification period and the standby loss test, the water heater must be located in an area protected from drafts of more than 50 ft/min. Prior to beginning steady-state verification before the standby loss test, measure the air draft within three feet of the jacket or enclosure of the water heater to ensure this condition is met. Ensure that no other changes that would increase the air draft are made to the test set-up or conditions during the conduct of the test.

3.5. Primary Control

3.5.1. *Thermostatically-Activated Water Heaters with an Internal Thermostat.* Before starting the steady-state verification prior to the standby loss test, the thermostat setting must be obtained. Set the thermostat to ensure:

3.5.1.1. With supply water temperature as per section 3.1.2 of this appendix (*i.e.,* 70 °F ± 2 °F) the water flow rate can be varied so that the outlet water temperature is constant at 70 °F ± 2 °F above the supply water temperature, while the heating element is operating at the rated input.

3.5.1.2. After the water supply is turned off and the thermostat reduces the electricity supply to the heating element to a minimum, the maximum heat exchanger outlet water temperature (T_{OHX}) is 140 °F ± 5 °F.

3.5.1.3. If the water heater includes a built-in safety mechanism that prevents it from achieving a heat exchanger outlet water temperature of 140 °F ± 5 °F, adjust the thermostat to its maximum setting.

3.5.2. *Flow-Activated Instantaneous Water Heaters and Thermostatically-Activated Instantaneous Water Heaters with an External Thermostat.* Before starting the steady-state verification prior to the standby loss test energize the primary control such that it is always calling for heating and the heating element is operating at the rated input. Maintain the supply water temperature as per section 3.1.2 of this appendix (*i.e.,* 70 °F ± 2 °F). Set the control so that the outlet water temperature (T_{OWT}) is 140 °F ± 5 °F. If the water heater includes a built-in safety mechanism that prevents it from achieving a heat exchanger outlet water temperature of 140 °F ± 5 °F, adjust the control to its maximum setting.

3.6. For Units With Multiple Outlet Water Connections

3.6.1. For each connection leaving the water heater that is required for the unit to achieve the rated input, the outlet water temperature must not differ from that of any other outlet water connection by more than 2 °F during the steady-state verification period prior to the standby loss test.

3.6.2. Determine the outlet water temperature representative for the entire unit at every required measurement interval by calculating the average of the outlet water temperatures measured at each connection leaving the water heater jacket or enclosure that is used during testing. Use the outlet water temperature representative for the entire unit in all calculations for the standby loss test.

3.7. *Data Collection Intervals.* During the standby loss test, follow the data recording intervals specified in Table 3.1 of this appendix. Also, the electricity consumption over the course of the entire test must be measured and used in calculation of standby loss.

3.7.1. *Steady-State Verification Period.* Follow the data recording intervals specified in Table 3.1 of this appendix.

TABLE 3.1—DATA TO BE RECORDED BEFORE AND DURING THE STEADY-STATE VERIFICATION PERIOD

Item recorded	Before steady-state verification period	Every 1 minute [a]	Every 10 minutes
Air draft, ft/min	X		
Time, minutes/seconds		X	
Electricity Consumed, Btu			X
Supply water temperature (T_{SWT}), °F		X	
Inlet water temperature (T_{IWT}), °F		X [b]	
Outlet water temperature (T_{OWT}), °F		X	
Ambient room temperature, °F		X	
Water flow rate, (gpm)		X	

Notes:
[a] These measurements are to be recorded at the start and end, as well as every minute of the steady-state verification period.
[b] Only measured when a recirculating loop is used.

3.7.2. *Standby Loss Test.* Follow the data recording intervals specified in Table 3.2 of this appendix. Additionally, the electricity consumption over the course of the entire test must be measured and used in calculation of standby loss.

TABLE 3.2—DATA TO BE RECORDED BEFORE AND DURING THE STANDBY LOSS TEST

Item recorded	Before test	Every 1 minute [a]
Air draft, ft/min	X	
Time, minutes/seconds		X
Heat exchanger outlet water temperature, °F (T_{OHX})		X
Ambient room temperature, °F		X

Note:
[a] These measurements are to be recorded at the start and end of the test, as well as every minute during the test.

4. *Determination of Storage Volume.* Determine the storage volume by subtracting the tare weight—measured while the system is dry and empty—from the weight of the system when filled with water and dividing the resulting net weight of water by the density of water at the measured water temperature. The volume of water contained in the water heater must be computed in gallons.

5. *Standby Loss Test.* Perform the steady-state verification period in accordance with section 5.1 of this appendix. For thermostatically-activated instantaneous water heaters with an internal thermostat, use section 5.2 of this appendix to conduct the standby loss test, and for flow-activated and/or thermostatically-activated instantaneous water heaters with an external thermostat (including remote thermostatically activated and/or flow-activated instantaneous water heaters), use section 5.3 of this appendix to conduct the standby loss test.

Set the primary control in accordance with section 3.5 of this appendix, such that the primary control is always calling for heat and the water heater is operating at its full rated input. Begin drawing water from the unit by opening the main supply and the outlet water valve, and adjust the water flow rate to achieve an outlet water temperature of 70 °F ± 2 °F above supply water temperature. At this time, begin recording the parameters specified in section 3.7.1 of this appendix. The steady-state verification period is complete when there is a continuous 30-minute period where the steady-state conditions specified in section 5.1 of this appendix are met, as confirmed by consecutive readings of the relevant parameters recorded at 1-minute intervals (except for electric power input rate, which is determined at 10-minute intervals, as specified in section 3.7.1 of this appendix).

5.1. *Steady-State Conditions.* The following conditions must be met at consecutive readings taken at 1-minute intervals (except for electricity input rate, for which measurements are taken at 10-minute intervals) to verify the water heater has achieved steady-state operation prior to conducting the standby loss test.

5.1.1. The water flow rate must be maintained within ± 0.25 gallons per minute (gpm) of the initial reading at the start of the steady-state verification period;

5.1.2. Electric power input rate must be maintained within 2 percent of the rated input certified by the manufacturer.

5.1.3. The supply water temperature (or inlet water temperature if a recirculating loop is used) must be maintained within ± 0.50 °F of the initial reading at the start of the steady-state verification period; and

5.1.4. The rise between the supply (or inlet if a recirculating loop is used) and outlet water temperatures is maintained within ± 0.50 °F of its initial value taken at the start of the steady-state verification period for units with rated input less than 500,000 Btu/h, and maintained within ± 1.00 °F of its initial value for units with rated input greater than or equal to 500,000 Btu/h.

5.2. *Thermostatically-Activated Instantaneous Water Heaters with an Internal Thermostat.* For water heaters that will experience cut-in based on a temperature-activated control that is internal to the water heater, use the following steps to conduct the standby loss test.

5.2.1. Immediately after the steady-state verification period, turn off the outlet water valve(s) (installed as per the provisions in section 2.2 of this appendix), and the water pump (if applicable) simultaneously and ensure that there is no flow of water through the water heater.

5.2.2. After the first cut-out following the steady-state verification period, allow the water heater to remain in standby mode. Do not change any settings on the water heater at any point until measurements for the standby loss test are finished. Begin recording the applicable parameters specified in section 3.7.2 of this appendix.

5.2.3. At the second cut-out, record the time and ambient room temperature, and begin measuring the electricity consumption. Record the initial heat exchanger outlet water temperature (T_{OHX}) and initial ambient room temperature. For the remainder of the test, continue recording the applicable parameters specified in section 3.7.2 of this appendix.

5.2.4. Stop the test after the first cut-out that occurs after 24 hours, or at 48 hours, whichever comes first.

5.2.5. Immediately after conclusion of the standby loss test, record the total electrical energy consumption, the final ambient room temperature, the duration of the standby loss test, and if the test ends at 48 hours without a cut-out, the final heat exchanger outlet temperature, or if the test ends after a cut-out, the maximum heat exchanger outlet temperature that occurs after the cut-out. Calculate the average of the recorded values of the heat exchanger outlet water temperature and of the ambient air temperatures taken at each measurement interval, including the initial and final values.

5.2.6. *Standby Loss Calculation.* Calculate the standby loss, expressed as a percentage (per hour) of the heat content of the stored water above room temperature, using the following equation:

$$S = \frac{E_c - \left(\frac{k(V_a)(\Delta T_4)}{E_t/100}\right)}{k(V_a)(\Delta T_3)(t)} \times 100$$

Where,

ΔT_3 = Average value of the heat exchanger outlet water temperature (T_{OHX}) minus the average value of the ambient room temperature, expressed in °F

ΔT_4 = Final heat exchanger outlet water temperature (T_{OHX}) measured at the end of the test minus the initial heat exchanger outlet water temperature (T_{OHX}) measured at the start of the test, expressed in °F

k = 8.25 Btu/gallon·°F, the nominal specific heat of water

V_a = Volume of water contained in the water heater in gallons measured in accordance with section 4 of this appendix

E_t = Thermal efficiency = 98 percent for electric water heaters with immersed heating elements

E_c = Electrical energy consumed by the water heater during the duration of the test in Btu

t = Total duration of the test in hours

S = Standby loss, the average hourly energy required to maintain the stored water temperature expressed as a percentage of the initial heat content of the stored water above room temperature

5.3. *Flow-Activated and Thermostatically-Activated Instantaneous Water Heaters with an External Thermostat.* For water heaters that are either flow-activated or thermostatically-activated with an external thermostat, use the following steps to conduct the standby loss test:

5.3.1. Immediately after the steady-state verification period, de-energize the primary control to end the call for heating. If the heating elements do not cut out, then turn off the electricity supply to the heating elements. After the heating elements have cut-out, or the electricity supply to the heating elements is turned off, begin recording the measurements as per the requirements in section 3.7.2 of this appendix.

5.3.1.1. If the unit does not have an integral pump purge functionality, then turn off the outlet water valve and water pump immediately after the main burners cut-out.

5.3.1.2. If the unit has an integral pump purge functionality, allow the pump purge operation to continue. After the pump purge operation is complete, immediately turn off the outlet water valve and water pump and continue recording the required parameters for the remainder of the test.

5.3.2. Recording Data

5.3.2.1. For units with pump purge functionality, record the initial heat exchanger outlet water temperature (T_{OHX}), and ambient room temperature when the main heating element(s) cut-out or the electricity supply to the heating element(s) is turned off. After the pump purge operation is complete, record the time as t = 0 and the initial electricity meter reading. Continue to monitor and record the heat exchanger outlet water temperature (T_{OHX}) and time elapsed from the start of the test as per the requirements in section 3.7.2 of this appendix.

5.3.2.2. For units not equipped with pump purge functionality, begin recording the measurements as per the requirements of section 3.7.2 of this appendix when the main heating element(s) cut-out or the electricity supply to the heating element(s) is turned off. Specifically, record the time as t = 0, and record the initial heat exchanger outlet water temperature (T_{OHX}), ambient room temperature, and electricity meter readings. Continue to monitor and record the heat exchanger outlet water temperature (T_{OHX}) and the time elapsed from the start of the test as per the requirements in section 3.7.2 of this appendix.

5.3.3. *Stopping Criteria.* Stop the test when one of the following occurs:

5.3.3.1. The heat exchanger outlet water temperature (T_{OHX}) decreases by 35 °F from its value recorded after the main heating element(s) have cut-out, and the pump purge operation (if applicable) is complete; or

5.3.3.2. 24 hours have elapsed from the start of the test.

5.3.4. At the end of the test, record the final heat exchanger outlet water temperature (T_{OHX}), electricity consumed from time t = 0, and the time elapsed from the start of the test.

5.3.5. *Standby Loss Calculation.* Calculate the standby loss, expressed as a percentage (per hour) of the heat content of the stored water above room temperature, using the following equation:

$$S = \frac{\frac{k(V_a)(\Delta T_1)}{E_t/100} + E_c}{k(V_a)(\Delta T_2)(t)} \times 100$$

Where,

ΔT_1 = Heat exchanger outlet water temperature (T_{OHX}) measured after the pump purge operation is complete (if the unit is integrated with pump purge functionality); or after the main heating element(s) cut-out (if the unit is not equipped with pump purge functionality) minus heat exchanger outlet water temperature (T_{OHX}) measured at the end of the test, expressed in °F

ΔT_2 = Heat exchanger outlet water temperature (T_{OHX}) minus the ambient room temperature, both measured after the main heating element(s) cut-out at the start of the test, expressed in °F

k = 8.25 Btu/gallon·°F, the nominal specific heat of water

V_a = Volume of water contained in the water heater in gallons measured in accordance with section 4 of this appendix

E_t = Thermal efficiency = 98 percent for electric water heaters with immersed heating elements

E_c = Electrical energy consumed by the water heater during the duration of the test in Btu

t = Total duration of the test in hours

S = Standby loss, the average hourly energy required to maintain the stored water temperature expressed as a percentage of the initial heat content of the stored water above room temperature

17. Add appendix E to subpart G of part 431 to read as follows:

Appendix E to Subpart G of Part 431—Uniform Test Method for the Measurement of Energy Efficiency of Commercial Heat Pump Water Heaters

Note: On and after November 6, 2017, manufacturers must make any representations with respect to energy use or efficiency of commercial heat pump water heaters in accordance with the results of testing pursuant to this appendix.

1. General. Determine the COP_h for commercial heat pump water heaters (CHPWHs) using the test procedure set forth below. Certain sections below reference ANSI/ASHRAE 118.1–2012 (incorporated by reference; see § 431.105). Where the instructions contained below differ from those contained in ANSI/ASHRAE 118.1–2012, the sections in this appendix control.

2. Definitions and Symbols. The definitions and symbols are as listed in section 3 of ANSI/ASHRAE 118.1–2012.

3. Instrumentation. The instruments required for the test are as described in section 6 of ANSI/ASHRAE 118.1–2012 (except sections 6.3, 6.4, and 6.6).

4. Test Set-Up. Follow the provisions described in this section to install the CHPWH for testing. Use the test set-up and installation instructions set forth for Type IV and Type V equipment (as applicable), defined in sections 4.4 and 4.5 of ANSI/ASHRAE 118.1–2012 and in accordance with the sections below:

4.1. Test set-up and installation instructions.

4.1.1. For air-source CHPWHs, set up the unit for testing as per section 7.1 and Figure 5a of ANSI/ASHRAE 118.1–2012 for CHPWHs without an integral storage tank, and as per Figure 6 in section 7.7.1 of ANSI/ASHRAE 118.1–2012 for CHPWHs with an integral storage tank.

4.1.2. For direct geo-exchange CHPWHs, set up the unit for testing as per section 7.1 and Figure 5b of ASNI/ASHRAE 118.1–2012 for CHPWHs without an integral storage tank, and as per Figure 7 in section 7.7.2 of ANSI/ASHRAE 118.1–2012 for CHPWHs with an integral storage tank.

4.1.3. For indoor water-source, ground-source closed-loop, and ground water-source CHPWHs, set up the unit for testing as per section 7.1 and Figure 5c of ANSI/ASHRAE 118.1–2012 for CHPWHs without an integral storage tank, and as per Figure 8 in section 7.7.3 of ANSI/ASHRAE 118.1–2012 for CHPWHs with an integral storage tank.

4.2. Use the water piping instructions described in section 7.2 of ANSI/ASHRAE 118.1–2012 and the special instructions described in section 7.7.6 of ANSI/ASHRAE 118.1–2012. Insulate all the pipes used for connections with material having a thermal resistance of not less than 4 h·°F·ft²/Btu for a total piping length of not less than 4 feet from the water heater connection ports.

4.3. Install the thermocouples, including the room thermocouples, as per the instructions in sections 7.3.1, 7.3.2, and 7.3.3 (as applicable) of ANSI/ASHRAE 118.1–2012.

4.4. Section 7.6 of ANSI/ASHRAE 118.1–2012 must be used if the manufacturer neither submits nor specifies a water pump applicable for the unit for laboratory testing.

4.5. Install the temperature sensors at the locations specified in Figure 5a, 5b, 5c, 6, 7, or 8 of ANSI/ASHRAE 118.1–2012, as applicable as per section 4.1 of this appendix. The sensor shall be installed in such a manner that the sensing portion of the device is positioned within the water flow and as close as possible to the center line of the pipe. Follow the instructions provided in sections 7.7.7.1 and 7.7.7.2 of ANSI/ASHRAE 118.1–2012 to install the temperature and flow-sensing instruments.

4.6. Use the following evaporator side rating conditions as applicable for each category of CHPWHs. These conditions are also mentioned in Table 5.1 of this appendix:

4.6.1. For air-source CHPWHs, maintain the evaporator air entering dry-bulb temperature at 80.6 °F ± 1 °F and wet-bulb temperature at 71.2 °F ± 1 °F throughout the conduct of the test.

4.6.2. For direct geo-exchange CHPWHs, maintain the evaporator refrigerant temperature at 32 °F ± 1 °F.

4.6.3. For indoor water-source CHPWHs, maintain the evaporator entering water temperature at 68 °F ± 1 °F.

4.6.4. For ground water-source CHPWHs, maintain the evaporator entering water temperature at 50 °F ± 1 °F.

4.6.5. For ground-source closed-loop CHPWHs, maintain the evaporator entering water temperature at 32 °F ± 1 °F.

4.6.5.1. For ground-source closed-loop CHPWHs, the evaporator water must be mixed with 15-percent methanol by-weight to allow the solution to achieve the rating conditions required in section 4.6.5.

4.7. The CHPWH being tested must be installed as per the instructions specified in sections 4.1 to 4.6 (as applicable) of this appendix. For all other installation requirements, use section 7.7.4 of ANSI/ASHRAE 118.1–2012 to resolve any issues related to installation (other than what is specified in this test procedure) of the equipment for testing. Do not make any alterations to the equipment except as specified in this appendix for installation, testing, and the attachment of required test apparatus and instruments.

4.8. Use Table 3 of ANSI/ASHRAE 118.1–2012 for measurement tolerances of various parameters.

4.9. If the CHPWH is equipped with a thermostat that is used to control the throttling valve of the equipment, then use the provisions in section 7.7.7.3 of ANSI/ASHRAE 118.1–2012 to set up the thermostat.

4.10. For CHPWHs equipped with an integral storage tank, supplemental heat inputs such as electric resistance elements must be disabled as per section 7.7.8 of ANSI/ASHRAE 118.1–2012.

4.11. Install instruments to measure the electricity supply to the equipment as specified in section 7.5 of ANSI/ASHRAE 118.1–2012.

5. Test Procedure

Test all CHPWHs that are not equipped with an integral storage tank as per the provisions described in ANSI/ASHRAE 118.1–2012 for ''Type IV'' equipment as defined in section 4.4 of ANSI/ASHRAE 118.1–2012. Test all CHPWHs that are equipped with an integral storage tank as per the provisions described in ANSI/ASHRAE 118.1–2012 for ''Type V'' equipment as defined in section 4.5 of ANSI/ASHRAE 118.1–2012. Tests for all CHPWHs must follow the steps described below.

5.1. Supply the CHPWH unit with electricity at the voltage specified by the manufacturer. Follow the provisions in section 8.2.1 of ANSI/ASHRAE 118.1–2012 to maintain the electricity supply at the required level.

5.1.1. For models with multiple voltages specified by the manufacturer, use the minimum voltage specified by the manufacturer to conduct the test. Maintain the voltage as per the limits specified in section 8.2.1 of ANSI/ASHRAE 118.1–2012. The test may be repeated at other voltages at the manufacturer's discretion.

5.2. Set the condenser supply water temperature and outlet water temperature per the following provisions and as set forth in Table 5.1 of this section:

TABLE 5.1—EVAPORATOR AND CONDENSER SIDE RATING CONDITIONS

Category of CHPWH	Evaporator side rating conditions	Condenser side rating conditions
Air-source commercial heat pump water heater.	Evaporator entering air conditions: Dry bulb: 80.6 °F ± 1 °F .... Wet bulb: 71.2 °F ± 1 °F	Entering water temperature: 70 °F ± 1 °F. Vary water flow rate (if needed) to achieve the outlet water temperature as specified in section 8.7.2 of ANSI/ASHRAE 118.1–2012. If the required outlet water temperature as specified in section 8.7.2 of ANSI/ASHRAE 118.1–2012 is not met even after varying the flow rate, then change the condenser entering water temperature to 110 °F ± 1 °F. Vary flow rate to achieve the conditions in section 8.7.2 of ANSI/ASHRAE 118.1–2012.
Direct geo-exchange commercial heat pump water heater.	Evaporator refrigerant temperature: 32 °F ± 1 °F.	Entering water temperature: 110 °F ± 1 °F.
Indoor water-source commercial heat pump water heater.	Evaporator entering water temperature: 68 °F ± 1 °F.	Entering water temperature: 110 °F ± 1 °F.
Ground water-source commercial heat pump water heater.	Evaporator entering water temperature: 50 °F ± 1 °F.	Entering water temperature: 110 °F ± 1 °F.
Ground-source closed-loop commercial heat pump water heater.	Evaporator entering water temperature: 32 °F ± 1 °F.	Entering water temperature: 110 °F ± 1 °F.

5.2.1. For air-source CHPWHs:

5.2.1.1. Set the supply water temperature to 70 °F ± 1 °F. The water pressure must not exceed the maximum working pressure rating for the equipment under test.

5.2.1.2. Use the provisions in section 8.7.1 of ANSI/ASHRAE 118.1–2012 to set the tank thermostat for CHPWHs equipped with an integral storage tank.

5.2.1.3. Initiate operation at the rated pump flow rate and measure the outlet water temperature. If the outlet water temperature is maintained at 120 °F ± 5 °F with no variation in excess of 2 °F over a three-minute period, as required by section 8.7.2 of ANSI/ASHRAE 118.1–2012, skip to section 5.3 of this appendix.

5.2.1.4. If the outlet water temperature condition as specified in section 8.7.2 of ANSI/ASHRAE 118.1–2012 is not achieved, adjust the water flow rate over the range of the pump's capacity. If, after varying the water flow rate, the outlet water temperature is maintained at 120 °F ± 5 °F with no variation in excess of 2 °F over a three-minute period, as required by section 8.7.2 of ANSI/ASHRAE 118.1–2012, skip to section 5.3 of this appendix.

5.2.1.5. If, after adjusting the water flow rate within the range that is achievable by the pump, the outlet water temperature condition as specified in section 8.7.2 of ANSI/ASHRAE 118.1–2012 is still not achieved, then change the supply water temperature to 110 °F ± 1 °F and repeat the instructions from sections 5.2.1.2 and 5.2.1.4 of this appendix.

5.2.1. 6. If the outlet water temperature condition cannot be met, then a test procedure waiver is necessary to specify an alternative set of test conditions.

5.2.2. For direct geo-exchange, indoor water-source, ground-source closed-loop, and ground water-source CHPWHs use the following steps:

5.2.2.1. Set the condenser supply water temperature to 110 °F ± 1 °F. The water pressure must not exceed the maximum working pressure rating for the equipment under test.

5.2.2.2. Use the provisions in section 8.7.1 of ANSI/ASHRAE 118.1–2012 to set the tank thermostat for CHPWHs equipped with an integral storage tank.

5.2.2.3. Follow the steps specified in section 8.7.2 of ANSI/ASHRAE 118.1–2012 to obtain an outlet water temperature of 120 °F ± 5 °F with no variation in excess of 2 °F over a three-minute period.

5.3. Conduct the test as per section 9.1.1, ''Full Input Rating,'' of ANSI/ASHRAE 118.1–2012. The flow rate, ''FR,'' referred to in section 9.1.1 of ANSI/ASHRAE 118.1–2012 is the flow rate of water through the CHPWH expressed in gallons per minute obtained after following the steps in section 5.2 of this appendix. Use the evaporator side rating conditions specified in section 4.6 of this appendix to conduct the test as per section 9.1.1 of ANSI/ASHRAE 118.1–2012.

5.4. Calculate the COP_h of the CHPWH according to section 10.3.1 of the ANSI/ASHRAE 118.1–2012 for the ''Full Capacity Test Method.'' For all calculations, time differences must be expressed in minutes.

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