

OPERATIONS MANUAL

COMMERCIAL WATER HEATERS CERTIFICATION PROGRAM



AHRI CWH OM – MAY 2023

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PREFACE

The following manual outlines the procedures and policies of the Performance Certification Program for Commercial Water Heaters (CWH) operated by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI). This manual is to be used in conjunction with the AHRI General Operations Manual (GOM) for AHRI Certification Programs. Where the AHRI General Operations Manual and this product-specific manual differ, this product-specific operations manual shall prevail.

The revision of this manual supersedes all previous revisions. The current edition of this manual, as well as the AHRI General Operations Manual, can be accessed through the AHRI website, www.ahrinet.org.

The CWH Certification Program by AHRI provides for independent verification of the Commercial Water Heater manufacturers' stated equipment performance. Safety criteria are not within the scope of this program.

Participation in the program is voluntary. Any manufacturer, regardless of AHRI membership, may obtain approval of Program Ratings and use of the AHRI CWH Certification Mark hereinafter referred to as the "Mark". The Mark is the Participant's public representation that the ratings of randomly selected units have been verified by an independent laboratory in accordance with test procedures prescribed by this operations manual. A Certification Agreement is executed between the manufacturer and AHRI specifying the conditions under which such Ratings and the Mark may be used. No manufacturer has the right to use Program Ratings or to state that their products have been tested in conformance with the procedures outlined in this Rating Procedure unless and until they have received written authority from AHRI to use the Mark as applied to the specific approved Program Ratings.

This Operations Manual has been prepared to assure that administration of the program is carried out in a uniform manner. It is an amplification of the Certification Agreement signed by licensees and AHRI. General information, procedural details, and copies of forms are included in this Operations Manual. Provisions of the Operations Manual may be amended as provided in the Certification Agreement.

This certification program complies with requirements of the ISO/IEC Standard 17065:2012, *General Requirements for Bodies Operating Product Certification Systems*.

Note:

This manual supersedes the Commercial Water Heater Operations Manual, January 2022.

CERTIFICATION OPERATIONS MANUAL FOR

COMMERCIAL WATER HEATERS

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1. Program Overview

1.1 Applicable Rating Standard. It is mandatory for program Participants to comply with Department of Energy (DOE) test procedures for Commercial Water Heaters as published in the latest edition of the Code of Federal Regulations, 10 CFR Part 431 Subpart G (Standard), including Appendices A, B, and C. A copy of the CFR is available for download from the U.S. Government Printing Office website, GPO Access, at <http://www.gpo.gov/fdsys/>.

1.2 Product Definitions. All terms in this document shall follow the AHRI General Operations Manual and the Standard definitions unless otherwise defined in this section.

1.2.1 Commercial Water Heater. A closed vessel, in which water is heated by the combustion of fuels or by electricity and is withdrawn for use external to the vessel, including the apparatus by which heat is generated and all controls and devices necessary to prevent water temperatures from exceeding 210°F [98.8°C].

1.2.1.1 Electric Storage Water Heaters. Electric Storage Water Heaters with energy input ratings greater than 12 kilowatts and less than 4,000 Btu/h per gallon of stored water.

1.2.1.2 Gas Storage Water Heaters. 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.

1.2.1.3 Gas Instantaneous Water Heaters. 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.

1.2.1.4 Oil Storage Water Heaters. Oil Storage Water Heaters with energy input greater than 105,000 Btu/h.

1.2.2 Hot Water Supply Boilers. A commercial boiler that has an input from 300,000 Btu/h up to 12,500,000 Btu/h of at least 4,000 Btu/h per gallon of stored water and having temperature and pressure controls necessary for heating potable water for purposes other than space heating and/or having intended uses which include heating potable water for purposes other than space heating. Such boiler shall conform to the safety and material requirements of the current ASME Boiler and Pressure Vessel Code, Section IV: Rules for Construction of Heating Boilers or ASME Boiler and Pressure Vessel Code, Section I: Rules for Construction of Power Boilers, or have an approved ASME code case.

1.3 Program Scope. This program applies to Production Models of Commercial Water Heaters and Hot Water Supply Boilers, as defined in Section 1.2, which have energy input ratings and capacities within the Standard.

1.3.1 Program Scope Exclusions.

- Residential-duty Commercial Water Heater. Any gas-fired storage, oil-fired storage, or electric instantaneous commercial water heater that meets the following conditions:
 - For models requiring electricity, uses single-phase external power supply;
 - Is not designed to provide outlet hot water at temperatures greater than 180°F; and
 - Is not one of the following:
 - Gas-fired Storage: Gas-fired Storage Water Heaters with a rated input greater than 105 kBtu/h or a rated storage volume greater than 120 gallons.
 - Oil-fired Storage: Oil-fired Storage Water Heaters with a rated input greater than 140 kBtu/h or a rated storage volume greater than 120 gallons.
 - Electric Instantaneous: Electric Instantaneous Water Heaters with a rated input greater than 58.6 kW or a rated storage volume greater than 2 gallons.
- Custom Water Heaters not listed in a printed or electronic catalog or advertising literature.
- Commercial Water Heaters designed for pressures above 160 psig, unless they are ASME “S” or “U” stamped in accordance with the ANSI/ASME Boiler and Pressure

Vessel Code, Section 1 or Section 8 or CSA B51, Boiler, Pressure Vessel and Pressure Piping Code.

- Commercial Water Heaters and Hot Water Supply Boilers over 500,000 Btu/h or over 130 gallons storage may be excluded from the program, at the Participant's option. If the excluded Water Heaters/Hot Water Supply Boilers appear on the same printed or electronic catalog and advertising literature as this certification programs included Commercial Water Heaters the literature shall clearly distinguish between certified and noncertified ratings.

1.4 Intended Market. The Intended Market for this certification program includes all products defined in Section 1.3 that are sold for use in the U.S. (including U.S. Territories) and Canada.

1.5 Basic Models and Basic Model Groups. A Participant's listings shall be grouped by Basic Model for Commercial Water Heaters and Hot Water Supply Boilers with storage capacities of 130 gallons or smaller, and 500,000 Btu/h or smaller. A Participant's listings shall be grouped by Basic Model Group for Commercial Water Heaters and Hot Water Supply Boilers with storage capacities larger than 130 gallons or larger than 500,000 Btu/h.

1.5.1 Basic Model. Models grouped by product families such that they do not have differing electrical, physical or functional characteristics that affect energy consumption.

1.5.2 Basic Model Group (BMG). Models grouped by product families such that they have a regular range of sizes of a similar type, design and construction, and have a common designation as catalogued.

2. Qualification Process

2.1 Original Equipment Manufacturer (OEM) Applicants. With the additions noted below, the OEM qualification process shall proceed according to the AHRI General Operations Manual, Section 4.

STEP 2.1.1 Certification Application Package. In addition to the Application for AHRI Certification and New Applicant License Fee Form – Sales Volume noted in the AHRI General Operations Manual, Section 4, STEP 4.1, Applicants shall submit following documentation to AHRI:

- Two test reports for each Basic Model or at least one test report for the largest and smallest models in each BMG with straight line interpolation of intermediate models (if not tested). The claimed Thermal Efficiency and/or Standby Loss shall meet the requirements of Section 3.9 and shall be supported by the test results provided in accordance with 10 CFR § 429.44 (1).
- If the Applicant chooses to conduct witness testing at its AHRI Approved Test Stand within a Facility (Facility), all required forms per Section 3.3.1 of this manual for Witness Testing Facility Approval shall also be submitted.
- An Applicant requesting AHRI to submit data to CEC shall submit third-party authorization, compliance forms and other necessary information.

Electronic forms shall be obtained from AHRI (available on www.ahrinet.org under the Product-Specific Certification Program).

STEP 2.1.2 Processing Application Package.

STEP 2.1.2.1 Performance Certification Agreement for Original Equipment Manufacturer (OEM Agreement). No further action required beyond that listed in Section 4, STEP 4.2 of the AHRI General Operations Manual.

STEP 2.1.2.2 Participation and Licensing Fee Invoice. Payment of the Participation and Licensing Fee is due within 30 calendar days of the invoice issue date. Testing shall not be conducted until the invoice is paid in full. No further action required beyond that listed in Section 4, STEP 4.2 of the AHRI General Operations Manual.

STEP 2.1.3 Selection and Acquisition of Test Samples.

STEP 2.1.3.1 Number of Qualification Tests. Each Applicant shall test a minimum of one (1) Commercial Water Heater.

STEP 2.1.3.1.1 Commercial Water Heaters and Hot Water Supply Boilers ≤ 130 gallons and $\leq 500,000$ Btu/h. Thirty percent (30%) of an Applicant's Basic Models shall be tested. Fractional models should be rounded to the nearest whole number using traditional rounding methods.

STEP 2.1.3.1.2 Commercial Water Heaters and Hot Water Supply Boilers > 130 gallons or $> 500,000$ Btu/h. Twenty percent (20%) of an Applicant's Basic Model Groups shall be tested. Fractional models should be rounded to the nearest whole number using traditional rounding methods.

STEP 2.1.3.2 Acquisition of Qualification Test Samples/Selection Criteria.

STEP 2.1.3.2.1 Commercial Water Heaters and Hot Water Supply Boilers ≤ 130 gallons and $\leq 500,000$ Btu/h. Within 60 calendar days of a request from AHRI, the Applicant shall have samples available for selection. Samples shall be acquired in accordance with Section 3 of this manual. The Applicant must supply the testing punch list in accordance with Section 3.7.

STEP 2.1.3.2.2 Commercial Water Heaters and Hot Water Supply Boilers > 130 gallons or $> 500,000$ Btu/h. Within 60 calendar days of a request from AHRI, the Applicant shall have samples available for selection. The testing shall be conducted at the Laboratory or Facility. If the testing is conducted at the Laboratory, the Applicant must supply the testing punch list in accordance with Section 3.7.

STEP 2.1.3.3 Witness Test Facility Approval and Sample Selection (for Commercial Water Heaters > 130 gallons or $> 500,000$ Btu/h and Hot Water Supply Boilers). If the Applicant has applied to conduct witness testing at its facility, the Independent Third-Party Laboratory contracted by AHRI (Laboratory) shall contact the Applicant to schedule a preliminary witness test facility inspection. Upon final approval of the Applicant's witness test facility and the approval of the Applicant's Selection Rating Software and/or paper catalogs, the Laboratory shall contact the Applicant to schedule initial qualification testing. Section 3 further explains the requirements and procedures for applying for and conducting witness testing.

Qualification testing may be scheduled simultaneously with witness test facility inspection; however, should the witness test facility fail inspection the testing shall be delayed until the witness test facility is brought into compliance.

STEP 2.1.4 Qualification Testing. AHRI shall supply the Independent Third-party Laboratory Contracted by AHRI (Laboratory) with the Applicant's published ratings. The Laboratory shall conduct the testing of the samples in accordance with the Standard, against the published ratings.

STEP 2.1.4.1 Successful Completion of All Qualification Tests. If all qualification tests pass according to Section 3.8, proceed to STEP 2.1.5.

STEP 2.1.4.2 Qualification Test Failure. Refer to Section 4, STEP 4.4.2 of the AHRI GOM for details regarding the first sample qualification failure options.

STEP 2.1.4.3 Second Sample Qualification Test Failure. Refer to Section 4, STEP 4.4.3 of the AHRI GOM for details regarding the second sample qualification failure options.

STEP 2.1.5 Welcome to the Program. No further action required beyond that listed in Section 4, STEP 4.5 of the AHRI General Operations Manual.

2.2 Private Brand Marketer (PBM) Applicants. With the additions noted below, the PBM qualification process shall proceed according to the AHRI General Operations Manual, Section 5.

PBM Applicants are not required to undergo qualification testing. PBM product certification is contingent upon the certification of the associated OEM product.

STEP 2.2.1 Certification Application Package. In addition to the Application for AHRI Certification Form noted in the AHRI General Operations Manual, Section 4, STEP 1, Applicants shall submit the following documentation to AHRI: Certified product data sheets noting PBM/OEM equipment match-up.

STEP 2.2.2 Processing Application Package.

STEP 2.2.2.1 Performance Certification Agreement for Private Brand Marketer (PBM Agreement). No further action required beyond that listed in Section 5, STEP 5.2.1 of the AHRI General Operations Manual.

STEP 2.2.2.2 OEM Agreement on behalf of the PBM Applicant. No further action required beyond that listed in Section 5, STEP 5.2.2 of the AHRI General Operations Manual.

STEP 2.2.2.3 Licensing Fee Invoice. Payment of the Licensing Fee is due within 30 calendar days of the invoice issue date.

STEP 2.2.3 Welcome to the Program. No further action required beyond that listed in Section 5, STEP 5.3 of the AHRI General Operations Manual.

3. Equipment Selection and Testing

3.1 Annual Testing Requirement. Each program Participant shall test a minimum of one (1) Commercial Water Heater per year.

3.1.1 Testing Models Required for Commercial Water Heaters and Hot Water Supply Boilers ≤ 130 gallons and $\leq 500,000$ Btu/h. Thirty percent (30%) of a Participant's Basic Models shall be tested per year. Fractional models should be rounded to the nearest whole number using traditional rounding methods.

3.1.2 Testing Models Required for Commercial Water Heaters and Hot Water Supply Boilers > 130 gallons or $> 500,000$ Btu/h. Twenty percent (20%) of a Participant's Basic Model Groups shall be tested per year. Fractional models should be rounded to the nearest whole number using traditional rounding methods.

3.2 Location of Tests.

3.2.1 Commercial Water Heaters ≤ 130 gallons and $\leq 500,000$ Btu/h. Testing shall be performed at the Laboratory and the sample shall be installed in the test facility in accordance with the Participant's published installation instructions in printed or electronic format.

3.2.2 Commercial Water Heaters > 130 gallons or $> 500,000$ Btu/h and Hot Water Supply Boilers. Testing shall be performed at the Laboratory or at the Facility and the sample shall be installed in the test facility in accordance with the Participant's published installation instructions in printed or electronic format. The Facility shall be approved by AHRI prior to any test being conducted. Testing shall continue to be conducted at the Participant's Facility, contingent upon it remaining AHRI-approved, or until the Participant notifies AHRI, in writing, of its desire to change facilities. All tests, regardless of location, shall be conducted or witnessed by the Laboratory's Representative (Representative).

3.3 *Witness Testing Procedures and Operations.* The AHRI CWH Certification Program allows witness testing for Commercial Water Heaters >130 gallons or >500,000 Btu/h and for Hot Water Supply Boilers where Participant personnel, witnessed by the Representative, conducts testing at a Facility on the Participant's premises. Witness testing requirements are covered in the AHRI General Operations Manual, Section 9.9 and as specified below.

3.3.1 *Application for Witness Testing.* A Participant shall submit all of the following to AHRI:

- Form CWH-WT1, Application for Witness Testing;
- Form CWH-WT2, Personnel Experience Questionnaire;
- Form CWH-WT3, Facility and Equipment Questionnaire; and
- A complete list of all instruments and equipment being used to perform certification testing in accordance with the Standard and a copy of each calibration report showing date of last calibration.

Electronic copies of these forms are available from AHRI.

3.3.2 *Inspection of Witness Test Facility.* Following preliminary witness test facility approval based on submitted data, the Representative shall inspect the Participant's witness test facility to verify compliance to the data submitted and to the certification program. Testing may be scheduled simultaneously with the witness test facility inspection; however, should the facility fail inspection, the testing shall be delayed until the witness facility is brought to compliance.

3.3.2.1 *Non-Compliant Inspection Results.* If the results of the inspection indicate that a Facility is non-compliant with the certification program, all discrepancies shall be resolved and resubmitted to the AHRI, before approval may be granted to proceed with certified rating tests.

3.3.2.2 *Final Approval of Witness Test Facility.* Upon acceptable results of the inspection, AHRI shall notify the Participant of final Facility acceptance and approval to proceed with witness tests. AHRI shall provide the Participant with a certificate of approval.

3.3.3 *Scheduled Witness Test Facility Re-approval.* The Participant's Facility shall remain approved for no more than two (2) years. At this time, re-approval shall be required, including submittal of the documents outlined in Section 3.3.1 and inspection outlined in Section 3.3.2. Upon re-approval by AHRI, the Facility shall receive a new certificate of approval.

3.3.4 *Unscheduled Facility Re-approval.* Any changes that may affect a Facility's ability to function per the certification program requirements, shall be required to be re-approved by the Representative prior to the conducting of any witness testing. At this time, re-approval shall be required, including submittal of the documents outlined in Section 3.3.1 and the inspection outlined in Section 3.3.2.

3.3.5 *Witness Test Operations at a Facility.*

3.3.5.1 *Advance Set-Up of Sample in the AHRI-Approved Test Facility.* A Participant may set up the test sample in the Facility prior to the arrival of the Representative. Prior to witness test commencement, the Representative shall verify that the sample is the model selected by AHRI for witness testing and that the sample has been set up in the Facility in accordance with the Participant's installation instructions and the Standard.

3.3.5.2 *Duty Assignments of Representative.* Sample testing, data acquisition, and generation of test data shall be performed by the Participant personnel and assisted and witnessed by the Representative. Participant or Facility personnel shall be on-hand to assist the Representative as requested and are permitted to be present but are not permitted to tamper or adjust samples during witness tests, unless specifically requested by the Representative responsible for the witness test.

Verification of instrument application (in accordance with the procedures defined in the Standard) and verification of calibrations shall be performed by the Representative.

3.3.5.3 Sample Start-Up and Operation. Start-up and operation of the sample shall be in accordance with the installation and operation instructions shipped with the sample.

3.4 Selection of Test Samples. AHRI shall perform a Build-To-Specifications Test Sample Selection based on data contained in the Directory. AHRI shall inform the Participant, in writing, of the sample(s) selected for test.

3.5 Method of Acquiring Test Samples. Upon notification of selection by AHRI, the selected samples shall be made available accompanied by the Participant's published installation instructions in printed or electronic format. One (1) sample of each selected model shall be available; therefore, a Random Sample Selection is not required. The sample(s) can be shipped directly to the laboratory.

3.6 Sample Acquisition Timeframe.

3.6.1 For Commercial Water Heaters and Hot Water Supply Boilers ≤ 130 gallons and $\leq 500,000$ Btu/h. Upon notification of selections by AHRI, the Participant shall have 60 calendar days to ship the units to the Laboratory (accompanied by the Participant's published installation instructions in printed or electronic format). (Refer to Section 9 of the AHRI General Operations Manual.)

3.6.2 For Commercial Water Heaters and Hot Water Supply Boilers > 130 gallons or $> 500,000$ Btu/h. Upon notification of selections by AHRI, the Participant shall have 90 calendar days to ship the units to the Laboratory (accompanied by the Participant's published installation instructions in printed or electronic format), or conduct witness testing at the Facility. (Refer to Section 9 of the AHRI General Operations Manual.)

Where requested models are not readily available, AHRI shall work with the Participant to find alternate representative models or time to allow for the manufacture of requested models. Where a requested model or acceptable alternate model is not available, the Participant shall work with AHRI to provide access for testing on next production. If a requested model or acceptable alternate is not produced and available for test within two (2) years from the date of request or five (5) years from the date the model entered the program or previous verification test, whichever is longer, the manufacturer shall discontinue the BMG.

3.7 Testing Punch List. The Participant shall complete and provide a Punch List, for all tests conducted at the Laboratory, (refer to the AHRI website) in electronic format to the Laboratory prior to sample arrival at the Laboratory. The Participant may choose to furnish a single Punch List for multiple tests.

The Punch List shall not contradict the installation and operations manual provided by the Participant, nor shall it contradict the guidelines provided in Appendix A of this operations manual. If there is a discrepancy between notes written on the Punch List, Installation and Operations Manual, products specific operations manual, Standard, and/or the Directory, AHRI shall determine which document takes precedence.

3.8 Inoperable Samples. In addition to the requirements for Inoperable Samples in the General Operations Manual, samples received at the Laboratory which produce more than 400 ppm air-free CO (sample taken at steady state following the procedure described in ANSI Z21.10.3) at normal input shall be deemed Inoperable Samples.

3.9 Certified Data. Within the program, tests shall be conducted to verify the following certified data:

- Thermal Efficiency. Required on all Gas and Oil Commercial Water Heaters and Hot Water Supply Boilers.

For annual testing, the Thermal Efficiency test results shall be greater than or equal to 95.0% of the rated value.

For qualification testing, the Thermal Efficiency test results shall be greater than or equal to 98.0% of the rated value.

- Standby Loss. Required on all Commercial Water Heaters and Hot Water Supply Boilers having rated storage capacities equal to or greater than 10 gallons. Products meeting the following criteria may be tested for Standby Loss at the Applicant/Participant's option:
 - Instantaneous Gas and Oil-Fired Water Heaters and Hot Water Supply Boilers with less than 10 gallons of water.
 - Water Heaters having more than 140 gallons of storage capacity provided that the tank surface is thermally insulated to R-12.5 or more, a standing pilot light is not used, and Gas or Oil-fired heaters utilize fan assisted combustion.

For annual testing and qualification testing, the Standby Loss test results shall be less than or equal to 110.0% of the rated value.

3.9.1 Rounding to Determine Compliance. The required number of significant digits, per the Applicable Rating Standard, shall be used for calculations. The result of the Thermal Efficiency test, as applicable, shall be rounded to the nearest whole number using traditional rounding to determine compliance. If reported in Btu/h, the result of the Standby Loss test shall be rounded to the nearest whole number using traditional rounding to determine compliance, and two decimal places if reported using %/hour.

When determining compliance using the results of more than two samples, the mean of the applicable test results shall be determined before rounding.

3.10 Test Failures.

3.10.1 Options Following First Sample Failure

3.10.1.1 Commercial Water Heaters and Hot Water Supply Boilers ≤ 130 gallons and $\leq 500,000$ Btu/h. When the Participant is notified of a first sample certified rating failure, the Participant has seven (7) calendar days to select one (1) of the following options (effective starting with tests in the 2019 program year):

- Re-rate the Basic Model and its derivatives proportionate to the failed test results;
- Test second sample of the same model (sample shall be available within the timeframe and procedure allotted in Section 3.6.1 following notification of decision to AHRI via Manufacturer's Decision Form [MDF]); or
- Obsolete the Basic Model and its derivatives.

3.10.1.2 Commercial Water Heaters and Hot Water Supply Boilers > 130 gallons or $> 500,000$ Btu/h. When the Participant is notified of a first sample certified rating failure, the Participant has seven (7) calendar days to select one (1) of the following options (effective starting with tests in the 2019 program year):

- Re-rate the BMG, proportionately lower, based on the test sample's failed results;
- Test second sample of the same model (sample shall be available within the timeframe and procedure allotted in Section 3.6.2 following notification of decision to AHRI via Manufacturer's Decision Form [MDF]); or
- Obsolete the affected model and either obsolete or rerate all models that are part of a BMG.

3.10.2 Options Following Second Sample Failure

3.10.2.1 Commercial Water Heaters and Hot Water Supply Boilers ≤130 gallons and ≤500,000 Btu/h. When the Participant is notified of a second-sample certified rating failure, the Participant has seven (7) calendar days to select one of the following options (effective starting with tests in the 2019 program year):

- Re-rate the Basic Model. The re-rating of the affected model shall be no better than the mean results of the tested samples;
- Request testing of up to 2 additional samples selected by AHRI. Where possible, these samples should be selected from different production runs, and shall be completed within six (6) months of AHRI's approval of additional sample request.
 - If the mean result of all tested samples is compliant, no further action is required.
 - If, at the conclusion of additional sample testing, the ratings are not verified, the Participant shall select to either obsolete or re-rate within seven (7) calendar days of notification of additional sample testing failure; or
- Obsolete the Basic Model.

3.10.2.2 Commercial Water Heaters and Hot Water Supply Boilers >130 gallons or >500,000 Btu/h. When the Participant is notified of a second-sample certified rating failure, the Participant has seven (7) calendar days to select one of the following options (effective starting with tests in the 2019 program year):

- Re-rate the Basic Model, or all models that are part of a BMG, no better than the mean results of the tested samples.
- Obsolete the affected model and either obsolete or rerate all models that are part of a BMG. The re-rating of the affected model shall be no better than the mean results of the tested samples

3.11 Clarification of Test Procedures. The AHRI CWH Test Procedure Guideline shall be used to help standardize running of the test procedures in the Standard. Such guidelines shall not revise or modify the test procedure but shall seek to provide uniformity in interpretation of terms, measurements, and application of procedures.

3.11.1 Compliance with Testing Guidelines. For consistent and repeatable results, the Laboratory shall test samples in accordance with Appendix A.

3.12 Re-rating, Production Stopped, or Obsolete a Basic Model or BMG.

3.12.1 Voluntarily Changed Rating or Changing Status to Production Stopped for a Model.

- The Participant may voluntarily change a model's status to Production Stopped or lower the rating (decrease Thermal Efficiency or increase Standby Loss) for any existing model at any time prior to AHRI's selection for compliance testing of that model or any of its associated models.
- The Participant may increase the rating (increase Thermal Efficiency or decrease Standby Loss) if supporting data is submitted following the requirements of Section 3.13. The increased rating shall not be included in the program until any questions concerning the re-rating are answered to the satisfaction of the AHRI. Models with increased ratings shall be subject to increased review and selection for verification testing.

3.13 Requirement for Adding New Basic Model or BMG to the Directory. To add a new Basic Model or BMG, Participants shall submit the following documentation to AHRI:

- Two test reports for each Basic Model; or
- At least one test report for the largest and smallest models in each BMG with straight line interpolation of intermediate models (if not tested).

The claimed Thermal Efficiency and/or Standby Loss shall meet the requirements of Section 3.9 and shall be supported by the test results provided in accordance with 10 CFR § 429.44 (1).

A Participant requesting AHRI to submit data to CEC shall submit third-party authorization, compliance forms and other necessary information.

4. Challenge Tests

The Challenge Test process shall proceed according to the AHRI General Operations Manual, Section 10.

5. AHRI Directory of Certified Product Performance

All certified products shall be listed in the Directory, www.ahridirectory.org. Certification shall not be implied nor claimed for any product not listed in the Directory. Except as noted below, the Participant shall follow the steps outlined in Section 11 of the AHRI General Operations Manual.

5.1 Publication of Ratings in Certified Directory. The following information pertaining to each model certified shall be published in the Directory:

- AHRI Certified Reference Number
- Model Status
- Brand Name
- Series Name
- Model Number(s) or Designation(s)
- Energy Source
- Heater Type
- Hot Water Supply Boiler
- Thermal Efficiency, %
- Standby Loss (% per hour or Btu/h per federal requirements) or Insulation R value (optional for Commercial Water Heaters with storage \geq 140 gallons without standing pilot or with fan assisted combustion)
- Rated Volume (gallons)
- Measured Volume (gallons) for electric only
- Input Rate (MBtu/h or kW)

Additional data may be shown for products sold in areas requiring further product information or ratings.

6. Assessment and Payment of Certification Fees

Refer to Section 12 of the AHRI General Operations Manual.

7. Issuance of Violations and/or Termination

Refer to Section 14 of the AHRI General Operations Manual.

8. Program Hierarchy, Complaints, and the Appeals Process

Refer to Section 15 of the AHRI General Operations Manual

9. Proper Use of the AHRI Certification Mark and Claims to Certification

Refer to Section 8 of the AHRI General Operations Manual.

9.1 Advertising with Residential Water Heater Metrics. Pursuant to the February 8, 2019 Department Of Energy (DOE) Enforcement Policy Statement for Water Heater Efficiency Representations, manufacturers will not receive a program violation for a model advertised in the AHRI Directory as a Commercial Water Heater that is also advertised in the market with metrics in accordance with 10 CFR Part 430 Subpart B Appendix E provided that the following criteria are met:


- Should be able to provide test reports in accordance with 10 CFR Part 430 Subpart B Appendix E.
- The model does not fall within the scope of the DOE Enforcement Policy for Circulating Water Heaters effective September 5, 2019 and ending December 31, 2021.
- The model does not fall within the scope of the DOE Enforcement Policy for Certain Consumer Water Heaters effective October 1, 2019 and ending December 31, 2021.
- AHRI Certification and AHRI Certification Mark only apply to the model as a Commercial Water Heater. All product literature clearly differentiates between AHRI Certified and non-certified metrics, and program Ratings and other data shall be placed into a table meeting the specified format found in the examples below or equivalent.


Example 1a: Commercial Water Heater Performance Data Shown With Standby Loss And Optional First Hour Rating And Uniform Energy Factor In The Same Table

Model Number	Rated Volume, Gal	Input Rate, Btu/h	AHRI CERTIFIED™		Ratings Not Certified by AHRI	
			Thermal Efficiency, %	Standby Loss Btu/h	UEF	First Hour Rating, Gal
WH080199	80	199,000	82	1200	0.6	250

Example 1b: Commercial Water Heater Performance Data Shown Without Standby Loss And Optional First Hour Rating And Uniform Energy Factor In The Same Table

Model Number	Input Rate, Btu/h	AHRI CERTIFIED™		Ratings Not Certified by AHRI	
		Thermal Efficiency, %	UEF	Max GPM	
WH250	250,000	95	0.92	7.0	

Example 2a: Commercial Water Heater Performance Data Shown With Standby Loss And Optional First Hour Rating And Uniform Energy Factor In Two Tables				
Model Number	Rated Volume, Gal	Input Rate, Btu/h		
			Thermal Efficiency, %	Standby Loss Btu/h
WH080199	80	199,000	82	1200
Model Number	Rated Volume, Gal	Input Rate, Btu/h	Ratings Not Certified by AHRI	
			UEF	First Hour Rating, Gal
WH080199	80	199,000	0.6	250

Example 2b: Commercial Water Heater Performance Data Shown Without Standby Loss And Optional First Hour Rating And Uniform Energy Factor In Two Tables				
Model Number	Input Rate, Btu/h			
		Thermal Efficiency, %		
WH250	250,000	95		
Model Number	Input Rate, Btu/h	Ratings Not Certified by AHRI		
		UEF	Max GPM	
WH250	250,000	0.92	7.0	

APPENDIX A. GUIDELINE FOR TESTING ELECTRIC, GAS, AND OIL-FIRED COMMERCIAL WATER HEATERS

Note: This document is an adjunct to the Department of Energy (DOE) test method for determining the energy efficiency of commercial water heaters as in the test procedure incorporated by reference in 10 CFR Part 431 Subpart G. It is used by the AHRI Commercial Water Heater Certification Program as a guideline providing clarification on how testing is conducted by the contracted third-party laboratory. None of the details contained in this document are counter to or inconsistent with the DOE test method.

Section A1. Purpose

A1.1 *Purpose.* The purpose of this guideline is to provide details on the specific instrumentation, test setup, and testing procedures used to measure water heater efficiency. This document has been drafted as an adjunct to the Department of Energy (DOE) test method for determining the energy efficiency of commercial water heaters as incorporated by reference in 10 CFR Part 431 Subpart G.

A1.1.1 *Intent.* This guideline is intended for the guidance of the industry, including manufacturers and third-party laboratories.

A1.1.2 *Review and Amendment.* This guideline is subject to review and amendment as technology advances.

Section A2. Scope

A2.1 *Scope.* These guidelines apply to Commercial Water Heaters and Hot Water Supply Boilers, as defined in Section 1.2.

A2.2 *Exclusions.* These guidelines do not apply to the rating and testing of any other type of systems providing potable hot water.

Section A3. Definitions

A3.1 *Thermal Efficiency.* As defined in 10 CFR Part 431.102.

A3.2 *Standby Loss.* As defined in 10 CFR Part 431.102.

A3.3 *Storage Vessel Capacity.* As determined according to ANSI Z21.10.3-2011/CSA 4.3.

Section A4. Test Guidelines

A4.1 *Test Preparation.*

A4.1.1 *Documentation.*

A4.1.1.1 *Reference Standard.* The following standard shall be referenced:
10 CFR Part 431 Subpart G and ANSI Z21.10.3-2011/CSA 4.3-2011.

A4.1.1.2 Operator shall initiate a new test file and assign a new test number for each test unit.

A4.1.2 *Instrumentation.* At a minimum, all instruments shall meet the accuracies listed in Table A1.

A4.1.2.1 When a water flow meter is used, the flow shall be measured on the inlet side of the water heater. Where water mass is used in calculations the density of the water shall be determined based on the temperature of the water where the water flow or weight is measured.

A4.1.3 *Calibration.* Instruments shall be calibrated at a minimum of every 12 months (refer to Table A2). Instrument calibration records shall be maintained and instruments shall be labeled with an identification number matching its calibration record. Operator shall ensure that calibrations are current and, if applicable, instruments are zeroed out prior to test. Instruments shall be calibrated by an ISO 17025 certified laboratory unless:

A4.1.3.1 When using external calibration services:

A4.1.3.1.1 Traceability of measurements is assured by the use of calibration services for laboratories that can demonstrate competence, measurement capability and traceability; and

A4.1.3.1.2 Calibration certificates issued by these laboratories contain the measurement results for the ranges being used.

A4.1.3.2 When equipment is internally calibrated:

A4.1.3.2.1 Laboratory established traceability of its own measurement standards and measuring instruments to the International System of Units (SI) by means of an unbroken chain of calibrations or comparisons linking them to the relevant primary standards of the SI units of measurement; and

A4.1.3.2.2 The link to units achieved by reference to national measurement standards (i.e. measurement standards and instruments directly traceable to the National Institute of Standards and Technology (NIST) or other nationally recognized organization such as A2LA, UKAS, SCC, IAS, etc.).

A4.1.4 *Thermocouples* submerged in water shall be of the sheathed, ungrounded type. For the thermocouple tree, beaded-type thermocouple wires may be used instead of probes when:

- Using the outlet fitting, its diameter is insufficient to pass the six probe assembly without restricting the water flow; or
- There is a top center outlet with no anode, requiring an offset in the TC's in order to clear the elements; or
- There are side relief openings where the TC's require a 90-degree bend, which would destroy probes; or
- Encountering other circumstances after the testing agency and the manufacturer have consulted and agreed it is necessary.

Table A1. Minimum Instrument Accuracies			
Measurement	Units	Source	Minimum
Electric Power	watt-hour	transducer	± 0.25% of RDG
Water Flow Rate	gpm or lbm/min	flow meter	± 0.25% of RDG
W_f	lbm	scale	± 0.5% of RDG
Barometric Pressure	in Hg	barometer	± 0.05 in Hg
Volume of Gas	cu-ft	gas meter	1%
HHV	Btu/cu-ft	Calorimeter or spectrometer	± 0.5% of RDG
P_2	psig	pressure gauge or transducer	± 1 psi
P_{gas}	in H ₂ O	manometer	±0.1 inch of water column
Water I/O Temperature	°F	TC or RTD	± 0.2°F
Tank Temperature	°F	TC or RTD	± 0.5°F
Ambient Temperature	°F	TC or RTD	± 0.2°F
Gas Temperature	°F	TC or RTD	± 0.5°F
Time	hr		0.000139 hr
Voltage	volts	transducer	1.0 volt
Current	amp	amp transducer	0.1 amp

Table A2. Instruments Calibration Timetable	
Equipment	Calibration Cycle
Natural Gas Calorimeter	Every year
Gas Chromatograph	Quarterly
Water Flow Meter	Every year
Manometer	Every year
Temperature Readout	Every year
Stopwatch	Every year
Scale	Every year
Pressure Transducer	Every year
U-Tube Manometer	Every year
T/C Assembly	Every year
Pressure Transducer	Every year
Pressure gauge	Every year
Digital Multimeter	Every year
CO / CO ₂ Analyzer	Verified daily if used, calibrated annually

A4.2 *Test Set-up.***A4.2.1** *Test Unit Preparation and Storage Vessel Capacity.*

A4.2.1.1 Operator shall place the unit in a conditioned space for at least 24 hours. The conditioned space must be maintained at $75^{\circ}\text{F} \pm 10^{\circ}\text{F}$.

A4.2.1.2 The operator shall place the unit on a test platform as specified in ANSI Z21.10.3-2011 E.1 and install valves, plugs and water connections required for the storage capacity test.

A4.2.1.3 The water heater shall be connected to a compressed air supply and a drain hose shall be connected to the water heater's drain valve.

A4.2.1.4 The water heater's drain valve shall be opened and the compressed air supply shall be turned on.

A4.2.1.4.1 Tip the water heater towards its drain valve while the air supply is turned on to allow all water that may be inside the tank to be drained off. After all water is removed, remove the drain hose and compressed air supply line.

A4.2.1.5 Test unit shall be weighed with valves, plugs and connections attached and dry weight recorded ($W_{\text{TANK, DRY}}$).

A4.2.1.6 Water heater shall be filled with water at a minimum pressure of 40 psi but not in excess of the water heater's rated maximum allowable working pressure and checked for leaks.

A4.2.1.6.1 Air shall be purged from the water heater during this process, including any other time the water heater is filled, transferred to a different test station, or disconnected from the water supply. A top spud location shall be used to purge any air from the water heater.

A4.2.1.7 Temperature of the inlet water shall be noted, and density of water at that temperature shall be used to calculate the volume.

A4.2.1.8 The filled water heater shall be weighed ($W_{\text{TANK, FULL}}$). The weight of the water in the water heater (W) shall be recorded in the test report.

A4.2.2 *Thermocouple Placement Procedure for Water Heaters with Tanks (optional for units with less than 10 gallons or more than 140 gallons of storage capacity)*

A4.2.2.1 Install a clear 0.25 in. inner diameter (ID) tube on tank drain cock with provision to control the flow of and collect water drained from the water heater. Draw the tube up the side of the water heater jacket and secure the end of the tube.

A4.2.2.2 Fill water heater with water.

A4.2.2.3 Open drain cock between the tank and clear tube and allow water level to stabilize in tube. Ensure the water heater is filled with no entrapped air. CAUTION: Do not allow the insulation to become wet, the water heater will be considered damaged and must be replaced with a new unit.

A4.2.2.4 Place tank top mark "T" on the water heater jacket at level of full water heater.

A4.2.2.5 Using the weight of the water in the tank (W), drain $W/12 \pm 0.5$ lb. of water.

A4.2.2.6 Allow the water level in the tube to stabilize. Mark water level in tube on the water heater jacket. Measure and record distance from mark indicating tank top (T) to indicate 1/12 capacity. This value is P6.

A4.2.2.7 Remove $W/6 \pm 0.5$ lb. of water for each successive thermocouple. After each draw, allow the water level in the tube to stabilize, and mark the water level in the tube on water heater jacket.

A4.2.2.8 Measure and record distance from previous thermocouple mark to successive thermocouple mark until all 6 thermocouple locations have been identified.

A4.2.2.9 Using thermocouple placements determined in A4.2.2.6 through A4.2.2.7, and taking into account placement of the thermocouple tree fitting, set thermocouples in tree within ± 0.25 " of the measured thermocouple positions.

A4.2.3 *Thermocouple Placement Procedure for Instantaneous Water Heaters. (optional for units with less than 10 gallons or more than 140 gallons of storage capacity)*

A4.2.3.1 Install piping on the unit per ANSI Z21.10.3-2011 test procedure document, as detailed in Figures A1, A2, A3, and A4.

A4.2.4 *Test Unit Set-up.*

A4.2.4.1 The operator shall install fittings, heat traps, and insulation (if provided) on pipes, relief valves, and water connections. Any other supplied components with the water heater must be installed per the manufacturer's installation instructions. This includes, but is not limited to the following: blowers, burners, controls, etc.

A4.2.4.2 Operator shall install insulation with a minimum R-Value of $8^{\circ}\text{F}\cdot\text{ft}^2\cdot\text{hr} / \text{BTU}$ on inlet and outlet thermocouples and any additional fittings that were added by the operator. All insulation must be tightly secured to minimize heat loss potential.

A4.2.4.3 For gas-fired water heaters only, install the minimum length venting, per the manufacturer's instructions.

A4.2.4.4 For oil-fired water heaters only, install the minimum length venting, per the manufacturer's instructions. Then, adjust the vent length according to 10 CFR Part 431 Subpart G to achieve the proper chimney/stack draft.

A4.2.4.5 For heat pump water heaters, a minimum of one (1) humidity sensor shall be located 18" away from the water heater air inlet. If there is more than one humidity sensor, the sensors shall be spaced evenly around the circumference of the water heater. Vertically, the sensor(s) must be located half way between the top and bottom of the heat pump portion of the water heater and shielded from direct airflow out of the heat pump. The sensor(s) must monitor the surrounding area's humidity for all testing conducted.

A4.2.4.6 At least one picture must be taken of the water heater, including its venting, piping, etc. This picture must be saved with the test file and be provided, upon request.

A4.2.4.7 All air movement should be less than 50 ft/min prior to starting and during the standby loss test.

A4.3 *Test Procedure*

A4.3.1 *Electric Storage Water Heaters: Standby Loss Test.*

Notice: Section A4.3, Test Set-up shall be followed prior to proceeding to this section.

A4.3.1.1 Install electrical connections.

A4.3.1.2 Install inlet and outlet thermocouples, as noted in Figures A1, A2, A3, and A4. Any combination of inlet and outlet configurations may be used from these figures based on the orientation of the water heater connections.

A4.3.1.3 Fill the water heater and test it for leaks at a minimum pressure of 40 psi but not in excess of the water heater's rated maximum allowable working pressure. Isolate the water heater from the expansion tank by closing a ball valve between the two. The pressure inside the tank must be monitored to see if it changes over a period of 10 minutes. The starting and ending pressures shall be recorded.

A4.3.1.4 Turn the power on and set the water heater thermostat(s) for approximately 140°F. Allow the test unit to soak-in for a minimum period of 24 hours after the average tank temperature has reached a temperature of 140°F ± 5°F. At no time shall the unit be disconnected from its energy supply for more than 1 hour. Manufacturers may elect to skip the soak-in period.

A4.3.1.5 After the soak-in period, turn the power off, and disconnect the electrical connections if transferring between a warm-up station and test station. At the test station, connect the ambient, tank, inlet and outlet thermocouples, current sensors, and power cord. Seal any gaps in water heater jacket due to sensor leads to minimize heat loss. At no time shall the unit be disconnected from its energy supply for more than 1 hour.

A4.3.1.6 Ensure the water supply temperature meets the requirements in Z21.10.3-2011 Exhibit G.

A4.3.1.7 Confirm the thermostat(s) are set to 140°F; adjust if necessary using the test procedure noted below. Draw water from the tank until the appropriate thermostat cut-in.

A4.3.1.7.1 For electric water heaters only, monitor tank temperatures located above upper element(s) and force the upper element(s) to cut-out when the temperatures are 140°F ± 5°F.

A4.3.1.7.2 For electric water heaters only, monitor tank temperatures and force the middle and lower element(s) to cut-out when average tank temperature is 140°F ± 5°F.

A4.3.1.7.3 Ensure the average tank temperature is 140°F ± 5°F. If the average tank temperature is not 140°F ± 5°F, initiate a water draw until lower element(s) cut-in and repeat the thermostat setting procedure above.

A4.3.1.8 Ensure the electrical supply voltage is within ±5 percent of the voltage specified on the water heater nameplate.

A4.3.1.9 Initiate the Standby Loss Test and data acquisition system after lower element(s) cut-out. Conduct the test as detailed in ANSI Z21.10.3-2011, as well as in 10 CFR Part 431 Subpart G.

A4.3.1.10 Compile data and print report.

A4.3.1.11 Validate the test results.

A4.3.2 *Gas-Fired Storage Water Heaters: Thermal Efficiency Test.*

Note: Section A4.2, Test Set-up shall be followed prior to proceeding to this section.

A4.3.2.1 Install the gas line and the manifold pressure line.

A4.3.2.2 Connect the gas meter.

- A4.3.2.3** Inlet and outlet thermocouples shall be located as indicated in Figures A1, A2, A3, and A4.
- A4.3.2.4** Fill the water heater and test it for leaks at a minimum pressure of 40 psi but not in excess of the water heater's rated maximum allowable working pressure. Isolate the water heater from the expansion tank by closing a ball valve between the two. The pressure inside the tank must be monitored to see if it changes over a period of 10 minutes. The starting and ending pressures shall be recorded.
- A4.3.2.5** Light the pilot, if applicable. Otherwise, turn on the water heater.
- A4.3.2.6** Adjust the water heater set point to allow the burner to fire.
- A4.3.2.7** Check the entire gas train for leaks using a liquid leak detector or combustible gas detector.
- A4.3.2.8** Burners shall be adjusted according to the requirements in ANSI Z21.10.3-2011 Section 2.3.3.
- A4.3.2.8.1** If adjusting the manifold pressure does not achieve the rated input, the operator shall re-orifice the unit using an alternate orifice supplied by the manufacturer. [Note: Manufacturers are to supply test facility with a selection of orifices for use at the test facility. When a test unit is re-orificed, the test facility will notify the manufacturer of the alternate orifice used, and the manufacturer shall re-supply the test facility with a replacement orifice.]
- A4.3.2.8.2** The operator shall check the entire gas train for leaks after re-orificing the water heater. Any leaks discovered shall be fixed.
- A4.3.2.8.3** Combustion must only be checked when the water heater is very clearly operating abnormally (e.g. CO alarms are going off, producing smoke (when it is not supposed to), flames are shooting out of the vent, etc.).
- A4.3.2.9** Set the water heater thermostat for approximately 140°F. Allow the test unit to soak-in for a minimum period of 24 hours after the average tank temperature has reached a temperature of 140°F ± 5°F. At no time shall the unit be disconnected from its energy supply for more than 1 hour. Manufacturers may elect to skip the soak-in period.
- A4.3.2.10** After soak-in period, turn off fuel supply, disconnect fuel supply and electric connections if transferring between a warm-up and test station. At no time shall the unit be disconnected from its energy supply for more than 1 hour.
- A4.3.2.11** Install the unit in a test station, connect the gas meter, manifold pressure line, and manifold pressure transducer. Connect the ambient, tank, inlet and outlet thermocouples, any current sensors, and power cords.
- A4.3.2.12** Ensure the water supply temperature meets the requirements in Z21.10.3-2011 Exhibit G.
- A4.3.2.13** Set the water heater thermostat to 150°F or higher to ensure that the water heater does not modulate or cycle off during the efficiency test.
- A4.3.2.14** The data acquisition system shall be initiated and the flow rate shall be adjusted to achieve an outlet temperature according to the requirements in Z21.10.3-2011 Exhibit G. Flow control may be either manually or automatically controlled. Except as noted below, data points shall be recorded at least every 60 seconds. The test shall be deemed complete when there is a

continuous, one-hour-long period meeting the requirements of the test procedure incorporated by reference in 10 CFR Part 431 Subpart G and the following conditions:

A4.3.2.14.1 Water flow rate variation is no greater than ± 0.25 gpm.

A4.3.2.14.2 Measured gas higher heating value variation is no greater than $\pm 5\%$. Gas higher heating value shall be taken at a minimum every 30 minutes (minimum of 3 data points).

A4.3.2.14.4 The inlet supply water temperature is within $\pm 0.50^\circ\text{F}$ of its initial reading for the duration of the one-hour-long period.

A4.3.2.14.3 For units with input rates $< 500,000$ Btu/h, the rise between inlet and outlet water temperatures is within $\pm 0.50^\circ\text{F}$ of its initial value for the duration of the one-hour-long period. For units with input rates $\geq 500,000$ Btu/h, the rise between inlet and outlet water temperatures is within $\pm 1.00^\circ\text{F}$ of its initial value for the duration of the one-hour-long period.

A4.3.2.15 Use the final 30 minutes of the test period described in A4.3.2.14 to calculate the result of the Thermal Efficiency Test.

A4.3.2.16 Compile data and print report. Include a data log of the measurements during the 60-minute period described in A4.3.2.14.

A4.3.2.17 Validate the test results.

A4.3.3 *Gas-Fired Storage Water Heaters: Standby Loss Test.*

Note: Section A4.2, Test Set-up must be followed prior to proceeding to this section.

A4.3.3.1 After the water heater has finished a Thermal Efficiency Test, close the valve on the water heater outlet.

A4.3.3.2 Adjust the water heater thermostat such that the topmost thermocouple achieves the temperature conditions in accordance with 10 CFR Part 431 Subpart G.

A4.3.3.3 Initiate the Standby Loss Test and data acquisition system after burner cut-out. Conduct the test as detailed in the test procedure incorporated by reference in ANSI Z21.10.3-2011, as well as 10 CFR Part 431 Subpart G.

A4.3.3.4 Compile data and print report.

A4.3.3.5 Validate the test results.

A4.3.4 *Oil-Fired Storage Water Heaters: Thermal Efficiency Test.*

Notice: Section 4.2, Test Set-up shall be followed prior to proceeding to this section.

A4.3.4.1 Install the fuel line quick connect fitting.

A4.3.4.2 Install a pressure gauge.

A4.3.4.3 Install the electrical sensing leads.

A4.3.4.4 Connect the fuel supply line.

A4.3.4.5 Fill the water heater and test it for leaks at a minimum pressure of 40 psi. Isolate the water heater from the expansion tank by closing a ball valve between the two. The pressure inside the tank must be monitored to see if it changes over a period of 10 minutes. The starting and ending pressures shall be recorded.

A4.3.4.6 Turn the water heater on and check the entire fuel train for leaks by confirming that the fuel stream contains no bubbles while priming the oil pump.

A4.3.4.7 Using the pressure gage, verify the pump is operating within the manufacturer's specifications and adjust as necessary.

A4.3.4.8 After the burner has been on for 15 minutes, check the input rate. It must be within $\pm 2\%$ of the rated value, calculated per Section A4.4.

A4.3.4.9 Adjust the burner for minimum stack, or over fire draft, as outlined in the manufacturer's instructions.

A4.3.4.10 Without exceeding a #1 smoke, the CO₂ level shall be adjusted, as outlined in the manufacturer's instructions. If no CO₂ is provided, the testing laboratory shall request a CO₂ level from the manufacturer.

A4.3.4.11 Set the water heater thermostat for approximately 140°F. Allow the test unit to soak-in for a minimum period of 24 hours after the average tank temperature has reached a temperature of 140°F \pm 5°F. At no time shall the unit be disconnected from its energy supply for more than 1 hour.

A4.3.4.12 After soak-in period, turn off fuel supply, disconnect fuel supply and electric connections if transferring between a warm-up and test station. At no time shall the unit be disconnected from its energy supply for more than 1 hour.

A4.3.4.13 Install the unit in a test station, connect the fuel supply, the ambient, tank, inlet and outlet thermocouples, any current sensors, and power cords.

A4.3.4.14 Ensure the water supply temperature is 70°F \pm 2°F.

A4.3.4.15 Set the water heater thermostat to 150°F or higher to ensure that the water heater does not modulate or cycle off during the efficiency test.

A4.3.4.16 The data acquisition system shall be initiated and the flow rate shall be adjusted to achieve an outlet temperature of 70°F above the supply temperature \pm 2°F. Flow control may be either manually or automatically controlled. Except as noted below, data points shall be recorded at least every 60 seconds. The test shall be deemed complete when there is a continuous, one-hour-long period meeting the requirements of the test procedure incorporated by reference in 10 CFR Part 431 Subpart G and the following conditions:

A4.3.4.16.1 Water flow rate variation is no greater than ± 0.25 gpm.

A4.3.4.16.3 The inlet supply water temperature is within ± 0.50 °F of its initial reading for the duration of the one-hour-long period.

A4.3.4.16.4 For units with input rates < 500,000 Btu/h, the rise between inlet 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 input rates \geq 500,000 Btu/h, the rise between inlet and outlet water temperatures is within ± 1.00 °F of its initial value for the duration of the one-hour-long period.

A4.3.4.17 Use the final 30 minutes of the test period described in A4.3.4.16 to calculate the result of the Thermal Efficiency Test.

A4.3.4.18 Compile data and print report. Include a data log of the measurements during the 60-minute period described in A4.3.4.16.

A4.3.4.19 Validate the test results.

A4.3.5 *Oil-Fired Storage Water Heaters: Standby Loss Test.*

Note: Section A4.2, *Test Set-up*, must be followed prior to proceeding to this section.

A4.3.5.1 After the water heater has finished a Thermal Efficiency Test, close the valve on the water heater outlet.

A4.3.5.2 Adjust the water heater thermostat such that the topmost thermocouple achieves the temperature conditions in accordance with 10 CFR Part 431 Subpart G.

A4.3.5.3 Initiate the Standby Loss Test and data acquisition system after burner cut-out. Conduct the test as detailed in the test procedure incorporated by reference in ANSI Z21.10.3-2011, as well as 10 CFR Part 431 Subpart G.

A4.3.5.4 Compile data and print report.

A4.3.5.5 Validate the test results.

A4.3.6 *Gas-Fired Instantaneous Water Heaters: Thermal Efficiency*

Notice: Section 4.2, *Test Set-up*, shall be followed prior to proceeding to this section.

A4.3.6.1 Install the gas line and the manifold pressure line.

A4.3.6.2 Connect the gas meter.

A4.3.6.3 Inlet and outlet thermocouples shall be located as indicated in Figures A1, A2, A3, and A4. Any combination of inlet and outlet configurations may be used from these figures based on the orientation of the water heater connections.

A4.3.6.4 Fill the water heater and test for leaks at a minimum pressure of 40 psi but not in excess of the water heater's rated maximum allowable working pressure. Isolate the water heater from the expansion tank by closing a ball valve between the two. The pressure inside the tank must be monitored to see if it changes over a period of 10 minutes. The starting and ending pressures shall be recorded.

A4.3.6.5 Turn on the water heater.

A4.3.6.6 Allow water to flow through the unit to allow the burner to fire at its maximum input rate.

A4.3.6.7 Check the entire gas train for leaks using a liquid leak detector or combustible gas detector.

A4.3.6.8 Burners shall be adjusted according to the requirements in ANSI Z21.10.3-2011 "Test pressures and burner adjustments".

A4.3.6.8.1 If adjusting the manifold pressure does not achieve the rated input or it cannot be adjusted, the operator shall re-orifice the unit using (an) alternate orifice(s) supplied by the manufacturer.

Note: Manufacturers are to supply test facility with a selection of orifices for use at the test facility. When a test unit is re-orificed, the test facility will notify the manufacturer of the alternate orifice(s) used, and manufacturer shall re-supply the test facility with a replacement orifice(s).

A4.3.6.8.2 The operator shall check the entire gas train for leaks after re-orificing the water heater. Any leaks discovered shall be fixed.

A4.3.6.8.3 Combustion shall only be checked when the water heater is very clearly operating abnormally (e.g. CO alarms are going off, producing smoke when it is not supposed to, flames are shooting out of the vent, etc.). If the manufacturer indicates a CO₂% for proper set-up, the unit should be operating at the intended level $\pm 0.1\%$ of the CO₂ specified by the manufacturer. If the CO₂ level or range is specified in the manufacturer's instructions provided with the water heater, the burner system shall be adjusted to within $\pm 0.1\%$ the specified level or to within 0.2% but no greater than the maximum level within the specified range.

If there is no CO₂ level or range specified in the manufacturer's instructions shipped with the water heater, the burner system shall be adjusted to within $\pm 0.2\%$ of the CO₂ level closest to 8%.

A4.3.6.9.4 Set the water heater thermostat to ensure that the water heater does not modulate or cycle off during the efficiency test, and supplies outlet water temperature according to the requirements in Z21.10.3-2011 Exhibit G.

A4.3.6.9.5 Install the unit in a test station, connect the gas meter, manifold pressure line, and manifold pressure transducer. Connect the ambient, tank, inlet and outlet thermocouples, any current sensors, and power cords.

A4.3.6.9.6 Ensure the water supply temperature meets the requirements in Z21.10.3-2011 Exhibit G.

A4.3.6.9.7 Set the water heater thermostat to 150°F or higher to ensure that the water heater does not modulate or cycle off during the efficiency test.

A4.3.6.9.8 The data acquisition system shall be initiated and the flow rate shall be adjusted to achieve an outlet temperature of 70°F above the supply temperature $\pm 2^\circ\text{F}$. Flow control may be either manually or automatically controlled. Except as noted below, data points shall be recorded at least every 60 seconds. The test shall be deemed complete when there is a continuous, one-hour-long period meeting the requirements of the test procedure incorporated by reference in 10 CFR Part 431 Subpart G and the following conditions:

A4.3.6.9.8.1 Water flow rate variation is no greater than ± 0.25 gpm.

A4.3.6.9.8.2 Measured gas higher heating value variation is no greater than $\pm 5\%$. Gas higher heating value shall be taken at a minimum every 30 minutes (minimum of 3 data points).

A4.3.6.9.8.3 The inlet supply water temperature is within $\pm 0.50^\circ\text{F}$ of its initial reading for the duration of the one-hour-long period.

A4.3.6.9.8.4 For units with input rates < 500,000 Btu/h, the rise between inlet and outlet water temperatures is within $\pm 0.50^\circ\text{F}$ of its initial value for the duration of the one-hour-long period. For units with input rates $\geq 500,000$ Btu/h, the rise between inlet and outlet water temperatures is within $\pm 1.00^\circ\text{F}$ of its initial value for the duration of the one-hour-long period.

A4.3.6.9.9 Manifold pressure shall be monitored throughout the test to detect improper gas valve operation or leaks.

A4.3.6.9.10 Use the final 30 minutes of the test period described in **A4.3.6.9.8** to calculate the result of the Thermal Efficiency Test. A bypass loop may be required, consult the manufacturer.

A4.3.6.9.11 Compile data and print report. Include a data log of the measurements during the 60-minute period described in **A4.3.6.9.8**.

A4.3.6.9.12 Validate the test results.

A4.4 Calculation Methods.

A4.4.1 Heat Input, Q_{IN} ,

Heat Input, Q_{IN} , in Btu/h for oil-fired water heaters

$$Q_{IN} = \frac{W_F \times HHV}{t_T}$$

where:

W_F = weight of fuel, lb.

HHV = higher heating value, Btu/lb.

t_T = test duration, hr

Heat Input, Q_{IN} , in Btu/h for gas-fired water heaters

$$Q_{IN} = \frac{W_V \times C_S \times HHV}{t_T}$$

where:

W_V = metered volume of gas, ft^3

C_S = correction factor to be applied if the gas, as metered, is not at standard temperature and pressure.

HHV = higher heating value, Btu/ ft^3

t_T = test duration, hr

Correction factor, C_S , applied to the heating value, HHV, for a fuel gas when it is metered at temperature and/or pressure conditions other than the standard conditions on which the value of HHV is based.

Dry gas utilizing a dry test meter:

Inch Pounds:

$$C_S = \frac{P_g(459.7 + T_{std})}{P_s(459.7 + T_g)}$$

International System of Units (metric):
$$C_S = \frac{P_g(273.15 + T_{std})}{P_S(273.15 + T_g)}$$

Saturated gas utilizing a wet test meter:

Inch Pounds:
$$C_S = \frac{(P_g - P_{ww})(459.7 + T_{std})}{(P_S - P_{wvs})(459.7 + T_g)}$$

International System of Units (metric):
$$C_S = \frac{(P_g - P_{ww})(275.15 + T_{std})}{(P_S - P_{wvs})(275.15 + T_g)}$$

where:

P_g = absolute pressure of gas being metered (barometric pressure plus gas pressure in meter, inHg (kPa))

P_S = standard absolute pressure, inHg (kPa)

T_g = temperature of gas in meter, °F (°C)

T_{std} = standard temperature, °F (°C)

P_{ww} = water vapor pressure at T_g , inHg (kPa)

P_{wvs} = water vapor pressure at T_{std} , inHg (kPa)

NOTE: For water vapor pressures, see *ASHRAE Handbook - 2013 Fundamentals*, Chapter 6, Table 3.

If the value of HHV is based on a dry condition and the gas is metered with a wet test meter, its value must also be reduced by a correction factor, C_f , of:

$$C_f = \frac{P_S - P_{wvs}}{P_S}$$

Conversely, if the value is based upon a saturated condition and the gas is metered dry, its value must be increased by a factor of:

$$C_f = \frac{P_S}{P_S - P_{wvs}}$$

A4.4.2 Weight of Water in the Water Heater, W

$$W = W_{TANK,FULL} - W_{TANK,DRY}$$

where:

W is the weight of water in the water heater,

$W_{TANK,DRY}$ is the dry weight of the Test unit with valves, plugs and connections attached, and

$W_{TANK,FULL}$ is the weight of the Test unit with valves, plugs and connections attached when full of water.

Section A5 REFERENCES - NORMATIVE

None.

Section A6 REFERENCES - INFORMATIVE

A1.1 ANSI Z21.10.3-2011/CSA 4.3-2011 - Gas Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous. CSA Group, 8501 East Pleasant Valley Road, Cleveland, Ohio 44131-5575.

A1.3 ASHRAE Fundamentals 2013

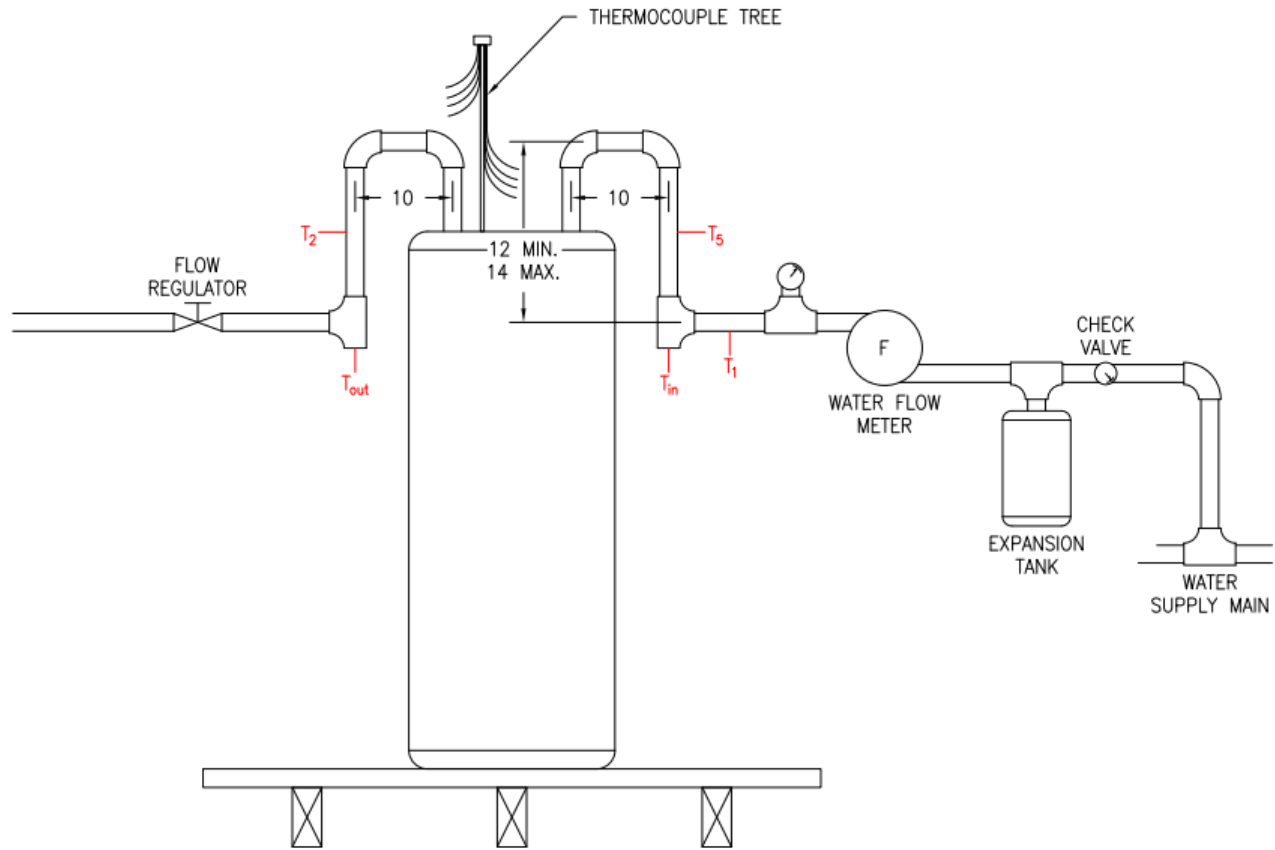
A1.4 ASHRAEwiki, Terminology. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc, Web. 07 June 2013 <http://wiki.ashrae.org/>.

A1.5 ASME Int. Steam Tables Published in 2000 ASME Steam Tables are formulated under IAPWS-IF97

A1.6 ISO/IEC 17025:2005 - General requirements for the competence of testing and calibration laboratories. International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

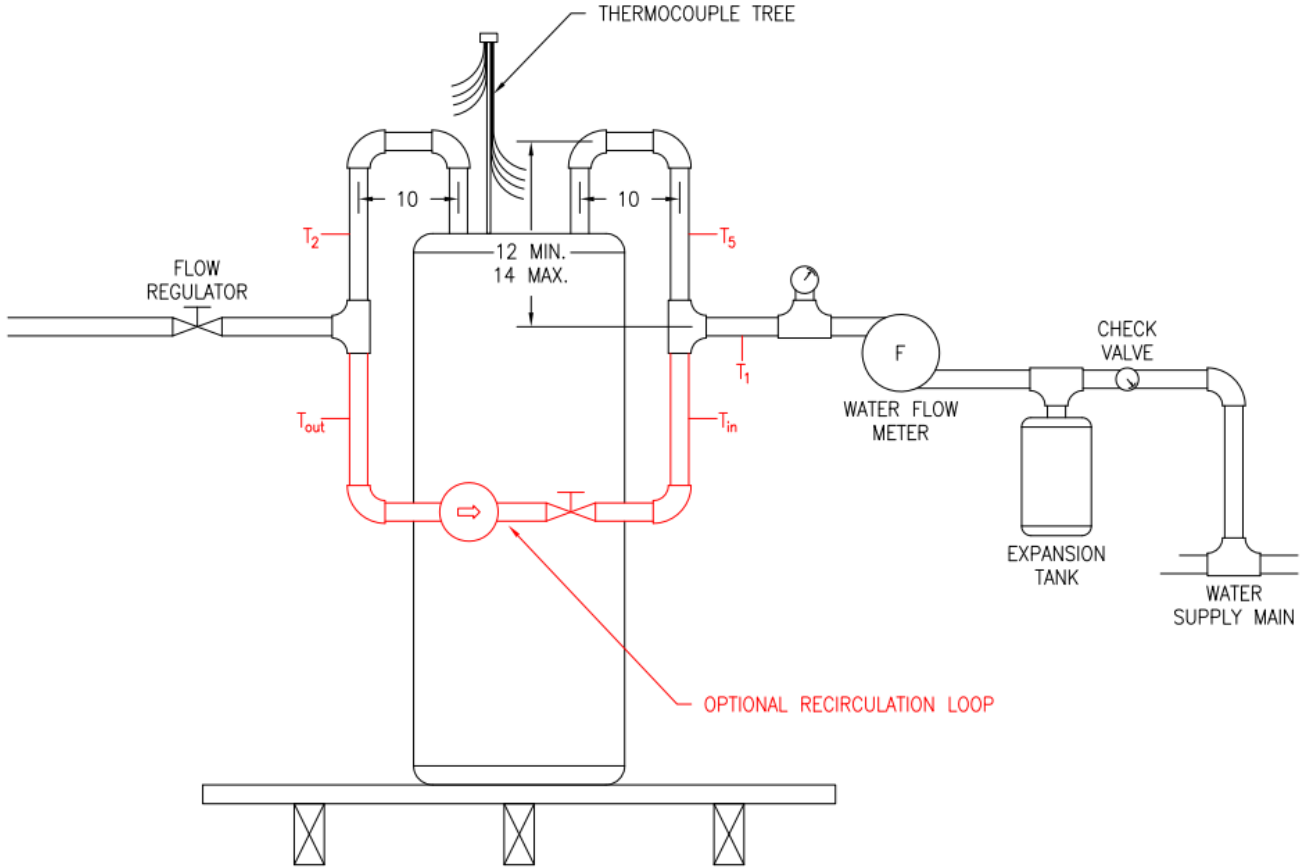
A1.7 U.S. Department of Energy (DOE) § 431.106 Subpart G of 10 CFR Part 431 - Uniform Test Method for Measuring the Energy Efficiency of Commercial Water Heaters and Hot Water Supply Boilers (Other Than Commercial Heat Pump Water Heaters), *Federal Register*, 77 FR 28996, May 16, 2012.

A.7 FIGURES



The thermocouple tree must be installed in the top anode location provided that the thermocouples do not interfere with the heating elements. If there is no top anode location, the thermocouple tree must be installed in the top outlet fitting if one exists. The top fitting that is used must not involve removing the T&P relief valve. The thermocouple tree must not be placed in the center of the water heater to avoid interfering with the heating elements.

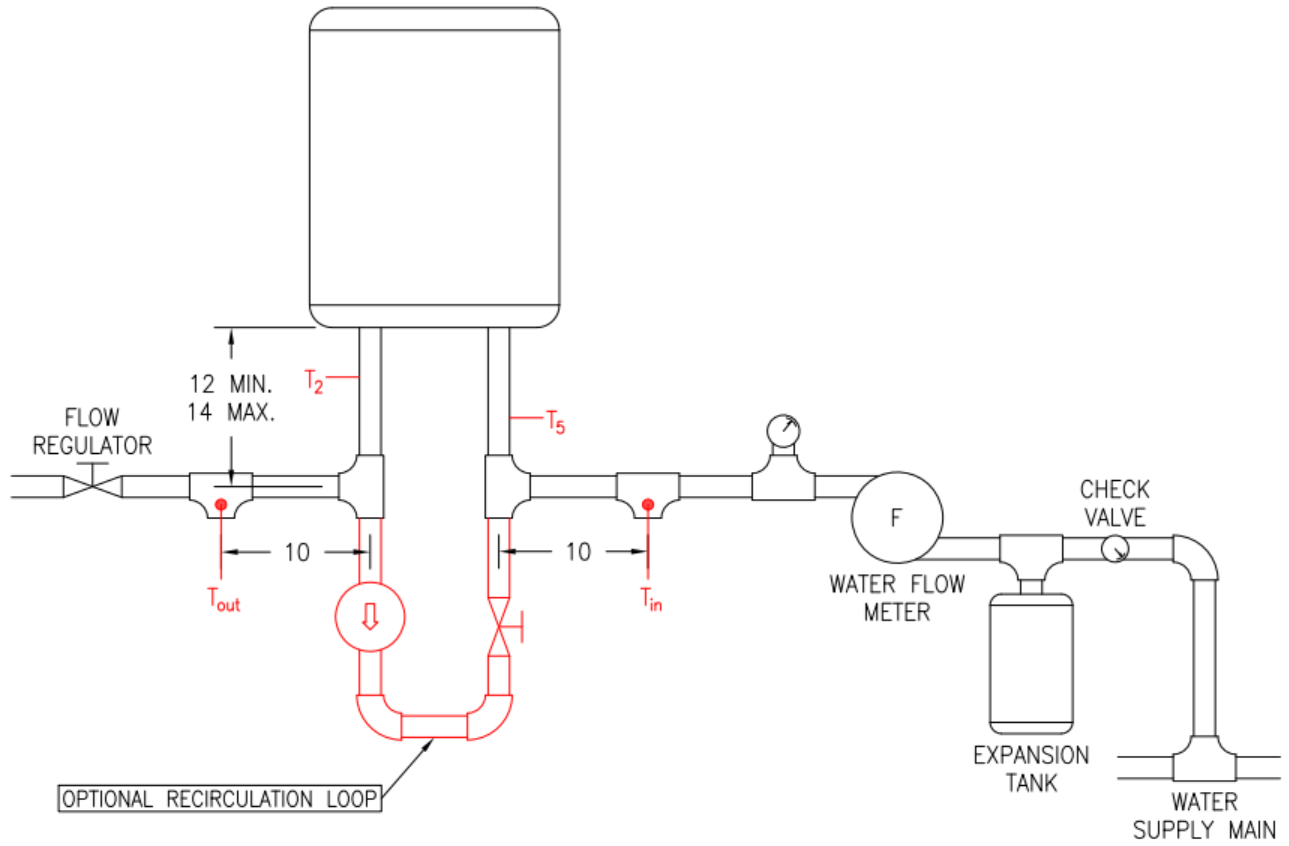
*accommodations can be made to the horizontal dimension for water heaters with larger diameters
Figure A1: Top Piping Connections



NOTE: KEEP T_{in} and T_{out} AS CLOSE TO THE TEE AS POSSIBLE

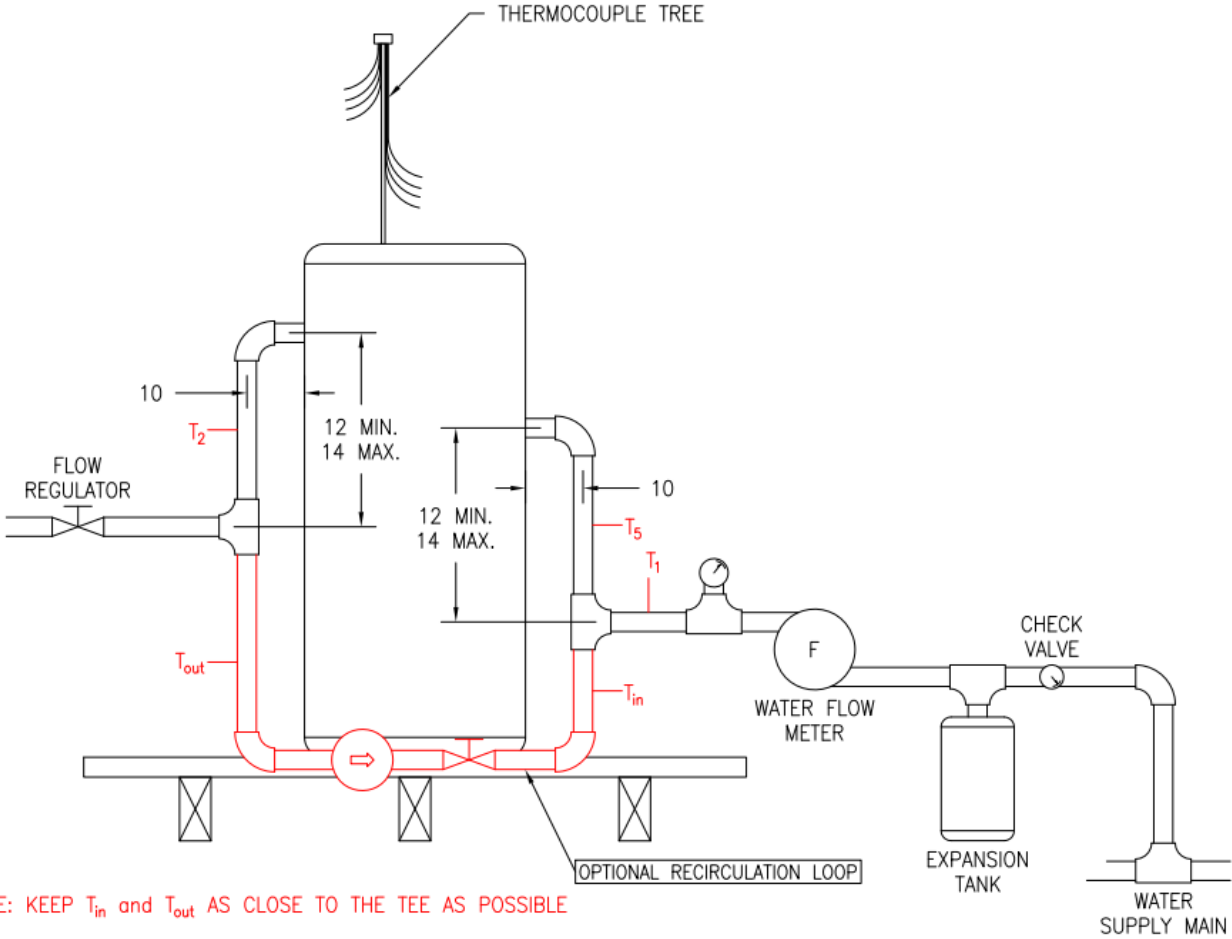
The thermocouple tree must be installed in the top anode location provided that the thermocouples do not interfere with the heating elements. If there is no top anode location, the thermocouple tree must be installed in the top outlet fitting if one exists. The top fitting that is used must not involve removing the T&P relief valve. The thermocouple tree must not be placed in the center of the water heater to avoid interfering with the heating elements.

*accommodations can be made to the horizontal dimension for water heaters with larger diameters
Figure A2: Top Piping Connections With Optional Recirculation Loop



*ACCOMMODATIONS CAN BE MADE TO THE HORIZONTAL DIMENSION FOR WATER HEATERS WITH LARGER DIAMETERS

*accommodations can be made to the horizontal dimension for water heaters with larger diameters
Figure A3: Bottom Piping Connections



The thermocouple tree must be installed in the top anode location provided that the thermocouples do not interfere with the heating elements. If there is no top anode location, the thermocouple tree must be installed in the top outlet fitting if one exists. The top fitting that is used must not involve removing the T&P relief valve. The thermocouple tree must not be placed in the center of the water heater to avoid interfering with the heating elements.

Figure A4: Side Piping Connections

A.8. STANDARD WEIGHTS, MEASURES AND CONVERSIONS - INFORMATIVE

For conversion purposes, one may use either the ASME Int. Steam Tables Published in 2000 ASME Steam Tables are formulated under IAPWS-IF97 or the curve fit present below:

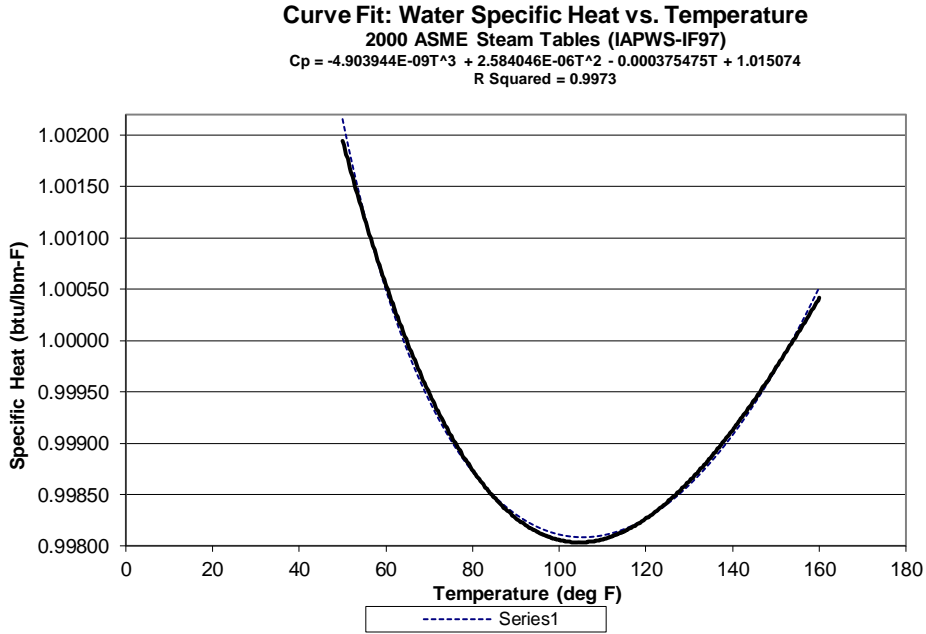


Figure A5: Curve Fit – Water Specific Heat vs. Temperature

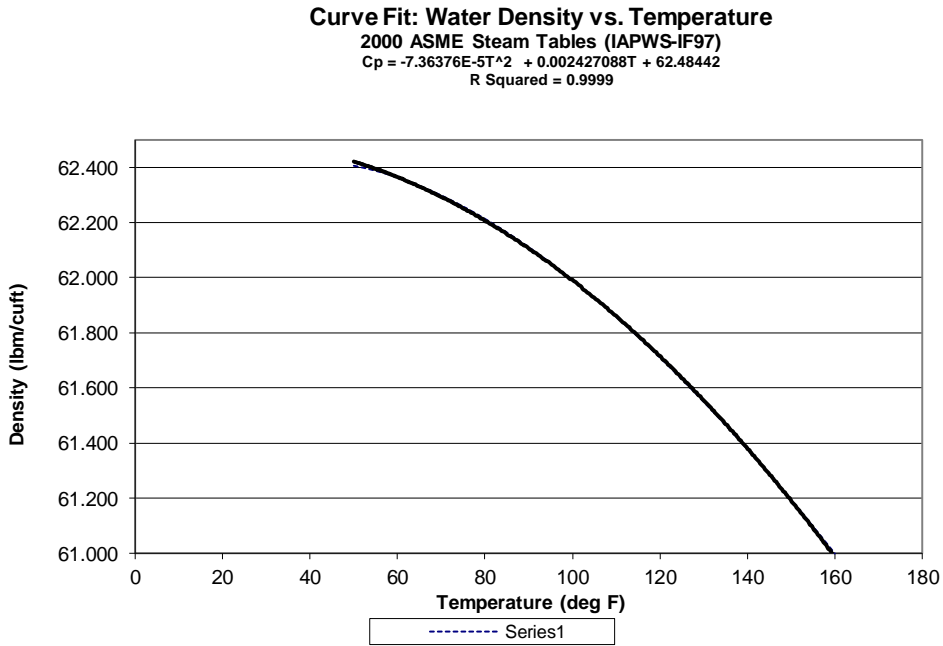


Figure A6: Curve Fit – Water Density vs. Temperature