ANSI/AHRI Standard 1500-2024 (I-P)

Performance Rating of Commercial Space Heating Boilers

Approved American National Standard
ANSI

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Note:

This standard supersedes ANSI/AHRI Standard 1500-2015.

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Intent

This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors, and users.

Review and Amendment

This standard is subject to review and amendment as technology advances.

2024 Edition

This edition of AHRI Standard 1500, *Performance Rating of Commercial Space Heating Boilers*, was prepared by Hydronic Systems Standards Technical Committee. The standard was approved by the Heating Standards Subcommittee on 13 May 2024 and was approved as an American National Standard (ANS) on 3 June 2024.

Origin and Development of AHRI Standard 1500

The initial publication was ANSI/AHRI Standard 1500-2015, *Performance Rating of Commercial Space Heating Boilers*

Summary of Changes

AHRI Standard 1500-2024 (I-P) contains the following update(s) to the previous edition:

- Changes to definitions.
- Clarification of certain burner adjustment requirements for non-atmospheric boilers
- Removed humidity measurement requirement for non-condensing boilers
- Changed required measurement intervals for various metrics
- Added annual calibration requirement for all instrumentation
- Revised the inlet water temperature to align with 10 CFR 431 Subpart E Appendix A
- Revised calculations for determining steam output, including addition of superheat calculation coverage

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Committee Personnel

Hydronic Systems Standards Technical Committee

Company/Organization	Participant	Voting Role
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Bosch Thermotechnology Corp	Stephen Barnard	Primary Voter
	Dan Moffroid	Alternate Voter
Cleaver Brooks	John Sutphen	Primary Voter
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Weil-McLain, a brand of WM Technologies, LLC	Mark Swanson	Primary Voter
Panos Fykas		AHRI Staff Liaison

Hydronic Systems Standards Technical Committee Scope:

The Hydronic Systems Standards Technical Committee is responsible for the development and maintenance of AHRI standards and guidelines pertaining to boilers, indirect water heaters, and other hydronic system components.

Out of scope for this STC are water heaters and pool heaters not specifically part of a hydronic system.

This STC reports to the Heating Standards Subcommittee.

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Bradford White Corp.	Bryan Ahee	Primary Voter
Crown Boiler Co., LLC	Paul Sohler	Primary Voter
Gas-Fired Products, Inc.	Martin Brice	Primary Voter
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Heating Standards Subcommittee Scope:

The scope of the Heating Standards Subcommittee is standards and guidelines related to the end products that are part of the AHRI Heating Industry Sector. (The definition of and list of products associated with each sector are found on the AHRI website

This list represents the membership at the time the Standards Technical Committee and Standards Subcommittee were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. Membership on these committees shall not in and of itself constitute an endorsement by the committee members or their employers of any document developed by the committee on which the member serves.

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	Jared Ledford	Olson Plumbing and Heating	Primary Voter
General Interest	Jim Kendzel	American Supply Association	Primary Voter
	Timothy Matthews	Lee Company	Primary Voter
	Aniruddh Roy	Energy Solutions	Primary Voter
Product Manufacturer	Paul Haydock	Carrier Corporation	Primary Voter
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PERFORMANCE RATING OF COMMERCIAL SPACE HEATING BOILERS

Section 1. Purpose

This standard establishes definitions, test requirements, rating requirements, minimum data requirements for *published ratings*, marking and nameplate data, and conformance conditions for commercial space *heating boilers*.

Section 2. Scope

This standard applies to gas and oil-fired steam and hot water *packaged boilers*, as defined in Section 3, that have an *input rating* equal to or greater than 300,000 Btu/h, that are

1) A steam *boiler* designed to operate at or below a steam pressure of 15 psig; or
2) A hot water *boiler* designed to operate at or below a water pressure of 160 psig and a temperature of 250°F or
3) A *boiler* that is designed to be capable of supplying either steam or hot water and designed to operate under the conditions described in this scope.

Products covered under this standard are for use in heating or space conditioning applications, utilize any means of natural or mechanical draft configurations, and can be intended for installation in either indoor or outdoor environments.

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in this section.

3.1 Expression of Provisions

Terms that provide clear distinctions between requirements, recommendations, permissions, options, and capabilities.

3.1.1 "Can" or "cannot"

Express an option or capability.

3.1.2 "May"

Signifies a permission expressed by the document.

3.1.3 "Must"

Indication of unavoidable situations and does not mean that an external constraint referred to is a requirement of the document.

3.1.4 "Shall" or "shall not"

Indication of mandatory requirements to strictly conform to the standard and where deviation is not permitted.

3.1.5 "Should" or "should not"

Indication of recommendations rather than requirements. In the negative form, a recommendation is the expression of potential choices or courses of action that is not preferred but not prohibited.

3.2 Standard Specific Definitions

3.2.1 Boiler

A closed direct fired pressure vessel intended for use in heating water or generating steam to be used external to itself.

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3.2.1.1 Atmospheric Boiler

A *packaged boiler* with a gas *atmospheric burner* and that operates with a non-positive *vent* static pressure.

3.2.1.2 Condensing Boiler

A *boiler* that condenses part of the water vapor in the *flue gases* during the laboratory tests prescribed in this standard, and that is equipped with a means of collecting and draining this condensate from the heat exchange section.

3.2.1.3 Direct Vent Boiler

A *boiler* (indoor) with the means or instructions for all air for combustion to be derived directly from the outdoors

3.2.1.4 Heating Boiler

A *boiler* designed to supply low-pressure steam or hot water for space heating applications. A low-pressure steam *boiler* operates at or below 15 psig steam pressure; a low-pressure hot water *boiler* operates at or below 160 psig water pressure and 250°F water temperature.

3.2.1.5 Non-condensing Boiler

A *boiler* that is not a *condensing boiler*.

3.2.1.6 Outdoor Boiler

A *packaged boiler* with integral venting means, factory assembled, weather-proofed, and wired for use out of doors.

3.2.1.7 Packaged Boiler

A *boiler* that is shipped complete with Burner and controls.

3.2.2 Boiler Flue

The passage(s) within a *boiler* where combustion products pass from the *firebox* of the *boiler* to the *draft hood* inlet opening on a *boiler* equipped with a *draft hood* or to the outlet of the *boiler* on a *boiler* not equipped with a *draft hood*.

3.2.3 British Thermal Unit (Btu)

A unit of heat. The amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

3.2.4 Burner

A device for the introduction of fuel and primary air into a *firebox* at specific velocities.

3.2.4.1 Atmospheric Burner

A *burner* for the final conveyance of a mixture of gas and air at atmospheric pressure, to the combustion zone. Air at atmospheric pressure is injected into the *burner* by a jet of gas.

3.2.4.2 Non-atmospheric Burner

A *burner* that supplies air for combustion at a pressure exceeding atmospheric pressure, or a *burner* that depends on the *draft* induced by a fan incorporated in the *boiler*, or a fan-powered *burner* that depends on the natural *draft* developed by a chimney for proper operation, or a pulse combustion *burner*.

3.2.5 Choke Damper

A damper placed within the *vent connector* or *vent* pipe for regulating the flow of gases.

3.2.6 Condensate

3.2.6.1 Flue Condensate

Liquid formed by the condensation of moisture in the *flue gases*.

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3.2.6.2 Steam Condensate

Liquid formed by the condensation of steam.

3.2.7 Draft

A pressure difference that causes gases or air to flow through a chimney, *vent*, or *boiler* and is the ambient pressure minus the pressure in the *vent* or *firebox*. Represents a negative pressure and is always expressed as a positive value.

3.2.8 Draft Hood

A non-adjustable device, either built into or external to the *boiler*, that is designed to:

1) provide for the exhaust of the products of combustion if *draft*, back *draft*, or stoppage beyond the *draft hood* are not present
2) prevent a back *draft* from entering the *firebox*
3) neutralize the effect of stack action of the chimney or gas *vent* upon the operation of the *boiler*

3.2.9 Draft Regulator

A balanced damper device attached to the vent connector to control draft (negative pressure).

Can be called “barometric draft regulator”.

3.2.10 Efficiency

3.2.10.1 Combustion Efficiency

100% less the losses due to dry flue gas, incomplete combustion, and moisture formed by combustion of hydrogen.

3.2.10.2 Thermal Efficiency

The ratio of the heat absorbed by the water or the water and steam to the higher heating value in the fuel burned.

3.2.11 Feedwater

The water that is heated, cooled, or blended as needed and supplied to the *boiler* test fixture.

3.2.12 Firebox

The space provided within the *boiler* for combustion of the fuel.

3.2.13 Flue Collar

That portion of a *boiler* designed for attachment of a *draft hood*, *vent connector*, or continuous open passageway to the outdoors for the purpose of removing *flue* or *vent gasses*.

3.2.14 Flue Gas

Products of combustion plus excess air in the *boiler flue* or heat exchanger.

3.2.15 Flue Temperature

The temperature of the *flue gases*, before dilution.

3.2.16 Gross Output

The output determined from thermal efficiency test data, in terms of *Btu*/h, under the conditions and limitations stipulated by this standard.

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3.2.17 Heating Value

3.2.17.1 Gas Heating Value

Amount of heat produced by the complete combustion of a unit quantity of fuel expressed in *Btu*/cubic foot at standard conditions of water vapor saturation, temperature of 60°F and a pressure of 30 in of mercury. This standard only uses the gross or higher heating value, that is obtained when all the products of combustion are cooled to the temperature existing before combustion, the water vapor formed during combustion is condensed, and all the necessary corrections to standard conditions have been made in accordance with Appendix E.

3.2.17.2 Oil Heating Value

The higher heating value determined per ASTM D240-09 or ASTM D4809-09a and Section C.3.2.2, Fuel Oil Analysis.

3.2.18 Input Rating

The maximum *Btu*/h or gph input located on the *boiler* rating plate.

3.2.19 Net Rating

The amount of installed radiation to be served by the *boiler*, based on the allowance for piping and pickup losses.

3.2.20 Oil Types

3.2.20.1 Heavy Oil

Nos. 4, 5, and 6 oil, as defined in ASTM D396-14a.

3.2.20.2 Light Oil

No. 2 oil as defined in ASTM D396-14a.

3.2.21 Published Rating

A statement of the assigned values of those performance characteristics, under stated *rating conditions*, where a unit can be chosen to fit the application. These values apply to all units of the same nominal size and type (identification) produced by the same manufacturer. This includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated *rating conditions*.

3.2.21.1 Rating Conditions

Any set of operating conditions where a single level of performance results and causes only that level of performance to occur.

3.2.21.2 Standard Rating

A rating based on tests performed at *standard rating conditions*.

3.2.21.3 Standard Rating Conditions

Rating conditions used as the basis of comparison for performance characteristics.

3.2.22 Superheat

The temperature of steam above the saturation temperature.

3.2.23 Vent

A passageway used to convey *flue gases* from *boilers* or their *vent connectors* to the outdoors.

3.2.24 Vent Connector

The pipe or duct that connects a *boiler* to a *vent* or chimney.

3.2.25 Vent Gases

Products of combustion from *boilers*, plus excess air and dilution air added to the *flue gases* after leaving the heat exchanger.

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Section 4. Test Requirements

4.1 Test Requirements.

Published ratings shall be verified by tests conducted in accordance with the test method described in Appendix C and at the *rating conditions* in Section 5.

4.2 Equipment.

Boilers shall be tested using all components as recommended by the manufacturer.

Section 5. Rating Requirements

5.1 Standard Ratings

Standard ratings shall be established at the *standard rating conditions* specified in Section 5.3.

Combustion efficiency is a required *standard rating* for hot water *boilers* with an *input rating* greater than 2,500,000 *Btu*/h.

Thermal efficiency is a required *standard rating* for all steam *boilers* and for hot water *boilers* with an *input rating* less than or equal to 2,500,000 *Btu*/h. Indoor *boilers* shall record the indoor *boiler thermal efficiency* and *outdoor boilers* shall record the *outdoor boiler thermal efficiency*.

5.2 Verification of Standard Ratings

All *standard ratings* shall be verified by tests in accordance with Section 5.

5.2.1 Values of Standard Ratings

Combustion efficiency shall be expressed to the nearest tenths of a percent.

Thermal efficiency shall be expressed to the nearest tenths of a percent.

5.2.2 Values of Optional Standard Ratings

Gross output shall be expressed to the nearest 1000 *Btu*/h.

Net ratings are determined by dividing the *gross output* by the piping and pickup factor listed in Table 1 and rounding out to the nearest 1000 *Btu*/h. Steam square feet (sq ft) shall be determined by dividing the rounded steam *net rating* by 240. The *net rating* shall be catalogued to either the nearest sq ft or the nearest 5 sq ft.

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Table 1 Net Rating Calculation

***Gross Output, Btu*/h**	**Steam Factor[1]**	**Water Factor**
≤ 1,255,000	1333	1150
1,255,000 to 1,839,000	$1546\ 2 - [(2{,}353 \cdot 10^{-7}) \cdot Q_{OUT}] + [(5{,}208\ 6 \cdot 10^{-14}) \cdot {Q_{OUT}}^2]$	
1,840,000 to 1,939,000	$1326\ 8 - [(2 \cdot 10^{-8}) \cdot Q_{OUT}]$	
≥ 1,940,000	1288	

Notes:
1. Round calculated steam factors to three decimal places.

5.3 Standard Rating Conditions

The conditions of test for *standard ratings* shall be established at the *standard rating conditions* specified in this section.

5.3.1 CO_2 or O_2 in Flue Gas

5.3.1.1 Oil and Non-atmospheric Gas Burners.

5.3.1.1.1 Specified CO_2 or O_2 Level

If the CO_2 or O_2 level is specified in the manufacturer's instructions shipped with the *boiler*, the *burner* system shall be adjusted to within ± 0.1% of the specified level. The setup shall meet the requirements of Section 5.3.2 and Section 5.3.3, and the *input rate* shall comply with Section C.4.1.

5.3.1.1.2 Specified CO_2 Range

If a CO_2 range is specified in the manufacturer's instructions shipped with the *boiler*, the *burner* system shall be adjusted to within 0.2% of, but not greater than, the maximum CO_2 level that is within the specified range and that meets the requirements of Section 5.3.2 and Section 5.3.3, and the input rate shall comply with Section C.4.1.

5.3.1.1.3 Specified O_2 Range

If an O_2 range is specified in the manufacturer's instructions shipped with the *boiler*, the *burner* system shall be adjusted to within 0.2% of, but not less than, the minimum O_2 level that is within the specified range and that meets the requirements of Section 5.3.2 and Section 5.3.3, and the input rate shall comply with Section C.4.1

5.3.1.1.4 Unspecified CO_2 or O_2 Level or Range

If no CO_2 or O_2 level or range is specified in the manufacturer's instructions shipped with the *boiler*, the *burner* system shall be adjusted to within ± 0.2% of the following default CO_2 level based on the fuel:

Natural Gas: 8.0%

#2 Oil: 11.0%

#4 Oil: 11.1%

#5 Oil: 11.5%

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#6 Oil: 11.8%

If the requirements of Section 5.3.2, Section 5.3.3, or input rate adjustment cannot be met at the default CO_2, the burner system shall be adjusted as close as possible to the default CO_2, while simultaneously meeting all other requirements.

5.3.1.2 Atmospheric Burners

The input rate shall be adjusted to comply with Section C.4.1.

5.3.2 Smoke

The smoke readings shall not exceed #1 for *light oil* or #4 for *heavy oil* during any test (see Section C.2.5.4).

5.3.3 CO in Flue Gas

The *burner* shall not produce CO to exceed 400 ppm (air free basis), for natural gas or propane fired units.

5.3.4 Vent Pressure for Boilers with Positive Vent Pressure and Non-atmospheric Burner

If a minimum positive *vent* pressure is specified in the manufacturer's instructions shipped with the *boiler*, that pressure, within the greater of ± 0.02 inches of water or 10% of the specified *vent* pressure shall be established before testing and data collection begins.

5.3.5 Water Temperatures for Hot Water Boilers

5.3.5.1 Inlet Temperature

The inlet temperature (Figure 9, point A) shall be 80°F ± 5°F, and the outlet temperature (Figure 9, point C) shall be 180°F ± 2°F. A higher outlet water temperature shall be used when specified by a manufacturer.

5.3.5.2 Optional Recirculating Loop

For *boilers* that require a greater flow rate to prevent boiling, a recirculating line shall be installed as shown in Figure 9. Maintain the inlet temperature at point B of Figure 9 at 140°F ± 5°F during the warm-up period and test period. The temperature rise through the *boiler* (between points B and C in Figure 9) shall not be less than 20°F. The temperature rise from inlet (Figure 9 Point A) to the outlet (Figure 9, Point C) shall meet the requirements of Section 5.3.5.1.

5.3.6 Steam Pressure

Tests shall be made at atmospheric pressure or at the pressure required to comply with Section 5.3.7, not exceeding 15 psi gauge. If necessary, pressure shall be developed by throttling with a valve beyond the separator.

5.3.7 Moisture in Steam

During a *thermal efficiency* test, the moisture in the steam shall not exceed 2% of the water fed to the *boiler* during the test.

5.3.8 Air Temperature

The room ambient temperature shall be measured at each data collection point required by Section C.5. During a *non-condensing boiler* test, room ambient temperature shall be maintained between 65°F and 100°F at any time during the test. For a *condensing boiler* test, the room ambient temperature shall be maintained between 65°F and 85°F at any time during the test.

5.3.9 Ambient Humidity

The relative humidity of the room for *condensing boilers* shall be maintained below 80% when recorded at the interval defined by Section C.5.

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Section 6. Minimum Data Requirements for Published Ratings

As a minimum, *published ratings* shall include all *standard ratings*. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 1500 (I-P)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 1500 (I-P)". *Application ratings* within the scope of the standard shall include a statement of the conditions under which the ratings apply.

Section 7. Marking and Nameplate Data

As a minimum, the nameplate shall display the manufacturer's name, model designation, and maximum *Btu*/h or gph input (*input rating*).

Section 8. Conformance Conditions

While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's Purpose (Section 1) and Scope (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

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APPENDIX A. REFERENCES – NORMATIVE

Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of the standard.

A.1. ASHRAE Handbook Fundamentals, 2021, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, USA.

A.2. ASHRAE Terminology. ASHRAE. Accessed January 14, 2022. https://www.ashrae.org/technical-resources/free-resources/ashrae-terminology.

A.3. ASME PTC-19.11 – 2008 (R2018), *Steam and Water Sampling*, Conditioning, and Analysis in the Power Cycle, 2018, ASME, Two Park Avenue, New York, NY 10016-5990, USA.

A.4. ASTM Standard D240 - 09, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter,* 2014, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

A.5. ASTM Standard D396 – 14a, *Standard Specification for Fuel Oils*, 2014, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

A.6. ASTM Standard D2156 – 09, *Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels*, 2018, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

A.7. ASTM Standard D4809 – 09a, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method),* 2012, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

A.8. ASTM Standard D5291 – 10, *Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants*, 2021, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

A.9. Lemmon, Eric W., Bell, Ian H., Huber, Marcia L, and McLinden, Mark O., *Thermophysical Properties of Fluid Systems*. Gaithersburg: National Institute of Standards and Technology, 2021. NIST Chemistry WebBook. DOI: https://doi.org/10.18434/T4D303**.** https://webbook.nist.gov/chemistry/.

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APPENDIX B. REFERENCES - INFORMATIVE

Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

B.1. *Empirical Specific Heat Equations Based Upon Spectroscopic Data*, Sweigert and Beardsley, State Engineering Experiment Station of the Georgia School of Technology, Volume I, No. 3, June 1938.

B.2. Keenan, Joseph H. *Steam Tables: Thermodynamic Properties of Water Including Vapor, Liquid, and Solid Phases.* New York, NY: J. Wiley and Sons, 1969.

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