ANSI/AHRI Standard 1500

2015 Standard for

Performance Rating of Commercial Space Heating Boilers

Approved American National Standard

ANSI

Approved by ANSI on 28 November 2014

AHRI Air-Conditioning, Heating, and Refrigeration Institute

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Note:
This standard supersedes AHRI Hydronics Institute Standard BTS-2000 Rev. 06.07.

INFORMATIVE NOTE

AHRI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program (See Section 2 for Scope of the Standard)

The certification program includes all gas- and oil-fired steam and hot water Heating Boilers with inputs ranging from 300,000 Btu/h to 2,500,000 Btu/h. Models within a model series, or individual boiler models, having inputs over 2,500,000 Btu/h may be included in the program at the Participant's option.

Certified Ratings

The following certification program ratings are verified by test:

All steam boilers, and hot water boilers from 300,000 Btu/h up to and including 2,500,000 Btu/h.

1. Thermal Efficiency, % (required)
2. Combustion Efficiency, % (optional)

Hot water boilers above 2,500,000 Btu/h.

1. Combustion Efficiency, % (required)
2. Thermal Efficiency, % (optional)

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PERFORMANCE RATING OF COMMERCIAL SPACE HEATING BOILERS

Section 1. Purpose

1.1 *Purpose*. The purpose of this standard is to establish for Commercial Space Heating Boilers: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; marking and nameplate data; and conformance conditions.

1.1.1 *Intent*. This standard is intended for the guidance of the industry, including manufacturers, designers, installers, contractors and users.

1.1.2 *Review and Amendment*. This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 *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:

2.1.1 A steam boiler designed to operate at or below a steam pressure of 15 psig; or

2.1.2 A hot water boiler designed to operate at or below a water pressure of 160 psig and a temperature of 250 °F; or

2.1.3 A boiler that is designed to be capable of supplying either steam or hot water, and designed to operate under the conditions in Sections 2.1.1 and 2.1.2 of this scope.

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

Section 3. Definitions

All terms in this document will follow the standard industry definitions in the *ASHRAE Terminology* website (https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology) unless otherwise defined in this section.

3.1 *Barometric Draft Regulator*. A balanced damper device attached to the vent connector to control draft (negative pressure).

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

3.2.1 *Atmospheric Boiler*. A Packaged Boiler with a gas Atmospheric Burner and that operates with a non-positive Vent static pressure.

3.2.2 *Condensing Boiler*. A Boiler which will, during the laboratory tests prescribed in this standard, condense part of the water vapor in the flue gases and which is equipped with a means of collecting and draining this condensate from the heat exchange section.

3.2.3 *Direct Vent Boiler*. A Boiler (indoor) with the means or instructions for all air for combustion to be derived directly from the outdoors.

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3.2.4 *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.

3.2.5 *Non-condensing Boiler.* A Boiler that is not a Condensing Boiler.

3.2.6 *Outdoor Boiler.* A Packaged Boiler with integral venting means, factory assembled, weather-proofed, and wired for use out of doors.

3.2.7 *Packaged Boiler.* A Boiler that is shipped complete with Burner and controls.

3.3 *Btu.* British Thermal Unit.

3.4 *Burner.* A device for the introduction of fuel and primary air into a Firebox at the desired velocities.

3.4.1 *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.

3.4.2 *Non-atmospheric Burner.* A Burner which supplies air for combustion at a pressure exceeding atmospheric pressure, or a Burner which depends on the draft induced by a fan incorporated in the Boiler, or a fan-powered Burner which depends on the natural draft developed by a chimney for proper operation, or a pulse combustion Burner.

3.5 *Choke Damper.* A Damper placed within the Vent Connector or vent pipe for regulating the flow of gases.

3.6 *Combustion Efficiency.* 100% less the losses due to (1) dry flue gas, (2) incomplete combustion, and (3) moisture formed by combustion of hydrogen.

3.7 *Condensate, Flue.* Liquid formed by the condensation of moisture in the flue gases.

3.8 *Condensate, Steam.* Liquid formed by the condensation of steam.

3.9 *Draft.* A pressure difference that causes gases or air to flow through a chimney, Vent or Boiler. Draft is the ambient pressure minus the pressure in the Vent or Firebox. Although draft represents a negative pressure, it is always expressed as a positive value.

3.10 *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 in the event of no draft, back draft, or stoppage beyond the Draft Hood, (2) prevent a back draft from entering the Firebox, and (3) neutralize the effect of stack action of the chimney or gas vent upon the operation of the Boiler.

3.11 *Draft Regulator.* See “Barometric Draft Regulator.”

3.12 *Efficiency, Combustion.* See "Combustion Efficiency".

3.13 *Efficiency, Thermal.* See "Thermal Efficiency".

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

3.15 *Firebox.* The space provided within the Boiler for combustion of the fuel.

3.16 *Flue, Boiler.* The passage(s) within a Boiler through which 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.

3.17 *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.

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3.18 *Flue Gas.* Products of combustion plus excess air in the Boiler Flue or heat exchanger.

3.19 *Flue Temperature.* The temperature of the Flue Gases, before dilution.

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

3.21 *Heating Value, Gas.* Amount of heat produced by the complete combustion of a unit quantity of fuel. This standard only uses the gross or higher heating value, which 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. The gas heating value is expressed in Btu/cubic foot at standard conditions of water vapor saturation, temperature of 60 °F and a pressure of 30" of mercury.

3.22 *Heating Value, Oil.* The higher heating value determined per ASTM D240-09 or ASTM D4809-09a and Section C3.2.1.1, Fuel Oil Analysis.

3.23 *Input Rating.* The maximum Btu/h or gph input located on the Boiler rating plate.

3.24 *Net Rating.* The recommended amount of installed radiation to be served by the Boiler, based on the normal allowance for piping and pickup losses.

3.25 *Oil.* Light oil refers to No. 2 oil, and heavy oil refers to Nos. 4, 5, and 6 oil, as defined in ASTM D396-14a.

3.26 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated Rating Conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. The term Published Rating 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.

3.26.1 *Standard Rating.* A rating based on tests performed at Standard Rating Conditions.

3.27 *Rating Conditions.* Any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur.

3.27.1 *Standard Rating Conditions.* Rating Conditions used as the basis of comparison for performance characteristics.

3.28 *Secondary Air.* Air for the purpose of aiding combustion, admitted beyond the Burner port or ports.

3.29 *"Shall" or "Should".* "Shall" or "should" shall be interpreted as follows:

3.29.1 *Shall.* Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.29.2 *Should.* "Should" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.30 *Superheat.* The temperature of steam in excess of its saturation temperature.

3.31 *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.

3.32 *Ultimate Carbon Dioxide (CO_2).* 11.9% CO_2 for natural gas, 15.6% CO_2 for No. 2 fuel oil, 15.8% CO_2 for No. 4 fuel oil, 16.3% CO_2 for No. 5 fuel oil, and 16.7% CO_2 for No. 6 fuel oil. These numbers are used in the

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standard to state the maximum percentage of carbon dioxide obtainable in the flue gas under stoichiometric combustion.

3.33 *Vent.* A passageway used to convey flue gasses from Boilers or their Vent Connectors to the outdoors.

3.34 *Vent Connector.* The pipe or duct that connects a Boiler to a Vent or chimney (sometimes called breaching).

3.35 *Vent Gases.* Products of combustion from Boilers, plus excess air and dilution air added to the Flue Gases after leaving the heat exchanger.

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.

4.1.1 *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 report the indoor boiler Thermal Efficiency and Outdoor Boilers shall report the outdoor boiler Thermal Efficiency.

5.2 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 1,000 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 1,000 Btu/h. Steam square feet (sq ft) shall be determined by dividing the rounded steam Net Rating by 240. It 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	1.333	1.150
1,255,000 to 1,839,000	$1.5462 - [(2.353 \cdot 10^{-7}) \cdot Q_{OUT}] + [(5.2086 \cdot 10^{-14}) \cdot {Q_{OUT}}^2]$	
1,840,000 to 1,939,000	$1.3268 - [(2 \cdot 10^{-8}) \cdot Q_{OUT}]$	
≥ 1,940,000	1.288	
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 also meet the requirements of Sections 5.3.2 and 5.3.3, and input rate as required to comply with Section C4.1.

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 no greater than, the maximum CO_2 level that is within the specified range and that also meets the requirements of Sections 5.3.2 and 5.3.3, and input rate as required to comply with Section C4.1.

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 no less than, the minimum O_2 level that is within the specified range and that also meets the requirements of Sections 5.3.2 and 5.3.3, and input rate as required to comply with Section C4.1.

5.3.1.1.4 *No Specified CO_2 or O_2 Level or Range*. If there is no CO_2 or O_2 level or range specified in the manufacturer's instructions shipped with the boiler, the burner system shall be adjusted to within ±0.2% of the CO_2 level closest to 8% that also meets the requirements of Sections 5.3.2 and 5.3.3, and input rate as required to comply with Section C4.1.

5.3.1.2 *Atmospheric Burners*. Adjust the input rate as required to comply with Section C4.1.

5.3.2 *Smoke*. The smoke readings shall not exceed #1 for light oil or #4 for heavy oil during any test (see Section C2.5.4).

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.

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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 *Non-condensing Boilers*. The inlet temperature (Figure C9, point A) shall be 35°F to 80°F, and the outlet temperature (Figure C9, 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 *Condensing Boilers*. For condensing boilers, the outlet temperature (Figure C9, point C) shall be 180°F ± 2°F and the inlet temperature (Figure C9, point A) shall be 80°F ± 5°F at all times during the test.

5.3.5.3 *Optional Recirculating Loop*. For Boilers that require a greater flow rate to prevent boiling, a recirculating line shall be installed as shown in Figure C9. The temperature rise through the boiler itself (between points B and C in Figure C9) shall not be less than 20°F. The temperature rise from inlet (Figure C9, Point A) to the outlet (Figure C9, Point C) shall meet the requirements of Section 5.3.5.1 or 5.3.5.2 as applicable.

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 between 30 and 100 °F at any time during the test at each data collection point required by Section C5.

5.3.9 *Ambient Humidity*. The relative humidity of the room for Condensing Boilers shall not exceed 80 percent when recorded at the interval defined by Section C5.

Section 6. Minimum Data Requirements for Published Ratings

6.1 *Minimum Data Requirements for Published Ratings.* As a minimum, Published Ratings shall include all Standard Ratings as specified in Section 5.1. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with ANSI/AHRI Standard 1500." Claims to ratings outside the scope of this standard shall not imply or claim compliance with ANSI/AHRI Standard 1500.

Section 7. Marking and Nameplate Data

7.1 *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

8.1 *Conformance.* 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

A1 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.

A1.1 *ASHRAE Handbook Fundamentals*, 2013, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.2 *ASHRAE Terminology*, https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology, 2015, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.3 ASME PTC-19.11 – 2008, *Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle*, ASME, Two Park Avenue, New York, NY 10016-5990, U.S.A.

A1.4 ASTM Standard D240 - 09, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter*, ASTM International, 2009, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

A1.5 ASTM Standard D396 – 14a, *Standard Specification for Fuel Oils*, ASTM International, 2013, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

A1.6 ASTM Standard D2156 – 09, *Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels*, ASTM International, 2013, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

A1.7 ASTM Standard D4809 – 09a, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)*, ASTM International, 2009, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

A1.8 ASTM Standard D5291 – 10, *Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants*, ASTM International, 2010, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, U.S.A.

APPENDIX B. REFERENCES - INFORMATIVE

B1 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.

B1.1 *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.

B1.2 *Thermodynamic Properties of Steam*, Keenan and Keyes, 1969.

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APPENDIX C. METHODS OF TESTING FOR RATING COMMERCIAL SPACE HEATING BOILERS – NORMATIVE

C1 *Instruments*. Instruments which meet the minimum requirements shown in Table C1 shall be used.

C1.1 *Calibration*. Instruments shall be calibrated to a recognized standard at regular intervals.

Table C1. Instruments

Property Measured	Item Measured	Informative Note: Example of Instrument Type	Minimum Resolution	Minimum Accuracy	Informative Note: Approximate Range of Readings
Temperature	Room Air	Thermometer, Thermocouple, RTD	1°F	±1°F	30 - 100°F
	Test Air	Thermometer, Thermocouple, RTD	1°F	±1°F	30 - 100°F
	Inlet Water	Thermometer or RTD	0.2°F	±0.2°F	40 - 125°F
	Outlet Water	Thermometer or RTD	0.2°F	±0.2°F	130 - 220°F
	Flue Gas	Thermocouple Grid	2°F	±2°F	80 - 650°F
	Gas	Thermometer or RTD	0.5°F	±0.5°F	30 - 100°F
Pressure	Atmospheric	Barometer	0.05 in Hg	±0.05 in Hg	28 - 31 in Hg
	Steam	Manometer, Bourdon Tube Gage	Greater of 0.1 in H_2O or 10% of observed value	Greater of ±0.1 in H_2O or ±10% of observed value	0 – 30 psi
	Firebox	Draft Gage	Greater of 0.02 in H_2O or 10% of observed value	Greater of ±0.02 in H_2O or ±10% of observed value	As needed
	Vent	Draft Gage	0.01 in H_2O	±0.01 in H_2O	0 - 0.5 in H_2O
	Flue/Vent Connector	Draft Gage	0.01 in H_2O	±0.01 in H_2O	0 - 0.5 in H_2O
	Fuel Gas	Manometer	≤14 in H_2O: 0.1 in H_2O >14 in H_2O: 0.01 psi	≤14 in H_2O: ±0.1 in H_2O >14 in H_2O: ±0.05 psi	0 - 14 in H_2O 0.5 - 15 psi

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Table C1. Instruments (continued)

Property Measured	Item Measured	Informative Note: Example of Instrument Type	Minimum Resolution	Minimum Accuracy	Informative Note: Approximate Range of Readings
Weight or Flow	Oil	Scale, Burette or Flow Meter	0.25% of hourly rate	±0.25% of hourly rate	Sized for Rated Flow
	Gas	Volume Meter	Greater of 1 ft^3 or 0.25% of hourly rate	±1% of hourly rate	Sized for Rated Flow
	Water or Steam Condensate	Scale or Water Meter	Greater of 0.5 lb or 0.25% of hourly rate	Greater of ±0.5 lb or ±0.25% of hourly rate	Sized for Rated Flow
	Flue Condensate	Scale	Greater of 0.05 lb or 0.5% of measured weight	Greater of ±0.05 lb or ±0.5% of measured weight	As Needed
	Separator Moisture	Scale	0.1 lb	±0.1 lb	As Needed
Time	Test Period	Stopwatch	1 second/h	±1 second/h	0 - 3 h
Gas Chemistry	Carbon Dioxide	CO_2 Tester or Meter	0.1% CO_2	±0.1% CO_2	0 - 15% CO_2
	Carbon Monoxide	CO Tester or Meter	1 ppm	Greater of ±10 ppm or ±5% of reading	0 – 500 ppm CO
	Oxygen	O_2 Tester or Meter	0.1% O_2	±0.1% O_2	0 - 20% O_2
Gas Optics	Smoke	Smoke Spot Bacharach	1 Smoke Spot	±½ Smoke Spot	0 – 7
Heating Value	Natural Gas	Calorimeter or Gas Chromatograph	2 Btu/ft^3	± 1% of reading	970 – 1100 Btu/ft^3
	Oil	See Section C3.2.1.1	See Section C3.2.1.1	± 1% of reading	18500 – 20500 Btu/lb (#2 oil)
Humidity	Relative Humidity	Psychrometer	5%	± 5% of full scale	10 – 90%

C2 *Apparatus.*

C2.1 *Test Room or Area.* The test location shall be of sufficient size to permit easy access to all parts of the test unit and instrumentation, as well as to maintain relatively stable ambient conditions. Adequate electrical, water and drainage facilities are required. A chimney, or vent with induced draft fan, as well as provisions for supplying sufficient air for combustion are required.

C2.2 *Vent Connection.*

C2.2.1 *Test Vent for Boilers with Non-Atmospheric Gas or Oil Burners Meeting the Following Criteria: 1) With Negative Vent Pressure, or 2) With Positive Vent Pressure and that are Not Direct Vent Boilers, as Defined in Section 3.*

Note: If the boiler has positive vent pressure and is a Direct Vent Boiler, see Section C2.2.2.

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All vent pipe connections shall be carefully sealed before the insulation is applied. A minimum of R-7 foil-faced insulation suitable for the temperature shall be applied as shown in Figure C1. The plane of the thermocouple grid and flue gas sampling points shall be located at the points shown in Figure C1. If dilution air is introduced into the flue gasses before the plane of the thermocouple and flue gas sampling points in the vent, utilize an alternate plane of thermocouple grid and flue gas sampling point located downstream from the heat exchanger and upstream from the point of dilution air introduction. (See Figure C1).

A barometric damper shall not be installed if the boiler has positive vent pressure.

C2.2.1.1 *Horizontal Discharge*. When the vent gases discharge horizontally, attach an elbow, sized to fit, directly to the flue collar or, if a sizing adapter is specified by the manufacturer's instructions shipped with the boiler, the elbow shall be sized to fit the adapter. Adding pipe between the flue collar and the elbow is allowed, if it is necessary for the test vent to clear obstructing boiler parts. Attach a vertical length of vent pipe, 3 pipe diameters long to the elbow. Additional vent length may be used if the installation complies with Section 5.3.4.

C2.2.1.1.1 *Additional Requirements for Horizontal Discharge with Negative Vent Pressure*. If a draft regulator is used, it shall be attached to the end of this vertical vent pipe, following the draft regulator manufacturer's instructions. If additional vent height or a mechanical draft inducer is needed to obtain the minimum draft specified in the manufacturer's installation instructions shipped with the boiler, it shall be attached to the end of the vertical vent pipe or to the draft regulator, if used.

C2.2.1.2 *Vertical Discharge*. When the vent gases discharge vertically, attach an elbow, sized to fit, directly to the flue collar or, if a sizing adapter is specified by the manufacturer's instructions shipped with the boiler, the elbow shall be sized to fit the adapter. Adding pipe between the flue collar and the first elbow is allowed, if it is necessary for the test vent to clear obstructing boiler parts. Attach a horizontal length of vent pipe 3 pipe diameters long to the elbow. Attach a second elbow, oriented up, to the end of the horizontal length of vent pipe. Additional vent length may be used if the installation complies with Section 5.3.4.

C2.2.1.2.1 *Additional Requirements for Vertical Discharge with Negative Vent Pressure*. If a draft regulator is used, it shall be attached to the vertical outlet of the second elbow, following the draft regulator manufacturer's instructions. If additional vent height or a mechanical draft inducer is needed to obtain the minimum draft specified in the manufacturer's installation instructions shipped with the boiler, it shall be attached to the vertical outlet of the second elbow or to the draft regulator, if used.

C2.2.2 *Test Vent for Boilers with Gas or Oil Non-Atmospheric Burners and with Positive Vent Pressure and that are Direct Vent Boilers, as Defined in Section 3.*

Note: If the boiler has positive vent pressure and is not a Direct Vent Boiler, see Section C2.2.1.

The test vent shall be the minimum length and type specified by the manufacturer's instructions shipped with the boiler and shall be attached to the flue collar. If the minimum vent length is not specified in the manufacturer's instructions shipped with the boiler, a 5 ft. vent pipe shall be attached. The vent diameter shall be sized to connect directly to the test boiler flue collar, unless a different size vent is required by the manufacturer's instructions shipped with the Boiler. A barometric damper shall not be installed (see Figure C4).

All vent pipe connections shall be carefully sealed before the insulation is applied. A minimum of R-7 foil-faced insulation suitable for the temperature shall be applied as shown in Figure C4. The plane of the thermocouple grid and flue gas sampling points shall be located in the vent at the

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points shown in Figure C4 for boilers with preheat or boilers without preheat. The alternate plane of thermocouple grid and flue gas sampling shall be used if dilution air is introduced into the flue gasses before the plane of the thermocouple and flue gas sampling points in the vent. This alternate plane of thermocouple grid and sampling point shall be located downstream from the heat exchanger and upstream from the point that dilution air is introduced. Vent insulation is not required, if the plane of the thermocouple grid and flue gas sampling is located at a point before the flue gasses enter the vent (see Figure C4).

C2.2.3 *Atmospheric Boilers*. The boiler Vent Connector or Draft Hood flue collar shall be connected to an uninsulated sheet-metal vent sized to fit the Vent Connector or Flue Collar or, if a sizing adapter is specified by the manufacturer's instructions shipped with the boiler, it shall be sized to fit the adapter. If elbows are used, they shall be of the 90-degree (1.57 rad) and four-piece sheet-metal type. The vent pipe shall have a reasonably smooth inner contour. The vent pipe shall be arranged as follows:

C2.2.3.1 *For Boilers with a Maximum Input Rating of 400,000 Btu/h or Less*. When the Vent Gases discharge horizontally, a 2 ft. section of horizontal vent pipe, an elbow and a vertical section of vent pipe shall be attached to the Draft Hood or external draft diverter outlet, or in the absence of an external draft control device, to the Vent Connector. The height of the vertical section shall be 5 ft. as measured from the highest point of the vent connector or, if there is an external draft control device, from the draft control device outlet. When Vent Gases discharge vertically, an elbow shall first be attached directly to the vent connector or, if there is an external draft control device, directly to the draft control device outlet (see Figure C2).

C2.2.3.2 *For Boilers with a Maximum Input Rating Over 400,000 Btu/h*. When the Vent Gases discharge horizontally, an elbow and 5 ft. of vertical Vent pipe, measured from the end of the elbow, shall be attached to the Draft Hood or external draft diverter outlet, or in the absence of an external draft control device, to the Vent Connector. When Vent Gases discharge vertically, 4 ft. of vertical pipe, measured from point of attachment, shall be attached to the Draft Hood or external draft diverter outlet, or in the absence of an external draft control device to the Vent Connector (see Figure C3).

C2.2.4 *Additional Requirements for Condensing Boilers*. The vent pipe installation shall not allow Flue Condensate formed in the Vent pipe to flow back into the unit. An initial downward slope from the unit's exit, an offset with a drip leg, annular collection rings, or drain holes shall be included in the vent pipe installation without disturbing normal Flue Gas flow. Additional precautions shall be taken to facilitate uninterrupted flow of Flue Condensate during the test. Flue Condensate collection-containers shall be a smooth, non-porous material such as glass or polished stainless steel, so removal of interior deposits can be easily made. The collection-container shall have a vent opening to the atmosphere.

C2.2.5 *Additional Requirements for Outdoor Boilers*. If the manufacturer provides more than one outdoor venting arrangement, the Boiler shall be tested with the arrangement having the least draft loss.

C2.3 *Steam Piping (Thermal Efficiency Test)*. A typical set-up is shown diagrammatically in Figures C5 through C8. Connect to the boiler risers as specified in the manufacturer's instructions shipped with the boiler. If not specified, the risers shall be taken full size from regular steam outlet tapings and combined into a header. The risers shall be connected by piping of adequate size to either an effective separator or a throttling steam calorimeter in the outlet piping.

If a separator is used, this piping shall pitch downward to the separator, and from the separator downward to the condenser or exhaust outlet. A vented water seal shall be placed in the drain from the separator.

The separator or throttling steam calorimeter and the piping connecting it to the boiler shall be well insulated. Provision shall be made for temperature measurement in the outlet piping if output due to

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