BSR/ASHRAE Standard 41.13-2023 (RA 202X)

Public Review Draft

Standard Methods for Fuel Higher Heating Value Measurement

First Public Review (February 2026)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

The appearance of any technical data or editorial material in this public review document does not constitute endorsement, warranty, or guaranty by ASHRAE of any product, service, process, procedure, or design, and ASHARE expressly disclaims such.

ASHRAE, 180 Technology Pkwy NW, Peachtree Corners, GA 30092

Insert Next Page

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus Standard developed under the auspices of ASHRAE. *Consensus* is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this Standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this Standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

ASHRAE obtains consensus through participation of its national and international members, associated societies, and public review.

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Senior Manager of Standards of ASHRAE should be contacted for

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

ASHRAE STANDARDS COMMITTEE 2025-2026

Adrienne Thomle, *Chair*
Jennifer A. Pille, *Vice Chair*
Anthony M. Abate
Omar A. Abdelaziz
Charles S. Barnaby
Hoy R. Bohanon
Coleman Brumley
Kelley P. Cramm
Abdel K. Darwich
Drake Erbe
Marcus Hassen
William M. Healy
Jaap Hogeling
Satish N. Iyengar
Phillip A. Johnson
Tatsuro Kobayashi
Paul A. Lindahl, Jr.
Kenneth A. Monroe
Philip J. Naughton
Kathleen Owen
Michael P. Patton
Karl L. Peterman
Justin M. Prosser
Christopher J. Seeton
Paolo M. Tronville
Douglas K. Tucker
Thomas E. Watson
David P. Yuill
Patrick C. Marks, *BOD ExO*
Devin Abellon, *CO*

Ryan Shanley, *Group Manager of Standards and Codes*

CONTENTS

BSR ~~ANSI~~/ASHRAE Standard 41.13-2023 RA 202X

Standard Methods for Fuel Higher Heating Value Measurement

NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

ASHRAE Standard 41.13 provides methods for determining the higher heating values needed for performance testing of fuel-burning heating, ventilating, air-conditioning, and refrigeration systems and components under laboratory and field conditions. This standard complies with ASHRAE's mandatory language requirements.

1. PURPOSE

This standard prescribes methods for determining fuel higher heating values.

Insert Foreword as shown on Next Page

2. SCOPE

This standard applies to determining fuel higher heating values for use in testing heating, ventilating, air-conditioning, and refrigeration systems and components under laboratory and field conditions.

3. DEFINITIONS

biodiesel: a liquid fuel derived from vegetable oils or animal fats as defined by ASTM D396 [1].

bio-derived gas: combustible gases produced from the microbial breakdown or thermal gasification of biomass (e.g., municipal waste, agricultural residues, and energy crops).

British thermal unit: the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at a specified temperature. (***Informative Note:*** As used in this standard, the Btu by default is based on the International Table definition (formally denoted as Btu_{IT} where necessary for clarity), but if a method of test standard or rating standard requires another reference temperature, then the specified reference temperature is provided in parentheses, e.g., Btu [60°F].)

heating value: the amount of heat released by the combustion of a known quantity of fuel.

higher heating value (HHV): a heating value that includes the latent heat of vaporization of water and is determined when water vapor formed from the combustion of fuel is cooled and condensed at standard conditions. Higher heating value is also referred to as "gross heating value."

lower heating value (LHV): a heating value that does not include the latent heat of vaporization of water and is determined when water vapor formed from the combustion of fuel remains in the vapor state. It is the difference between the higher heating value and the enthalpy of vaporization of water. Lower heating value is also referred to as "net heating value."

local conditions: the temperature, pressure, and moisture content of the fuel at the point where the HHV is of interest (e.g., the point where the fuel is burned or where custody transfer occurs).

manufactured gas: combustible gases traditionally produced from the gasification of coal, coke, and oil. These gases often contain a large fraction of hydrogen, carbon monoxide, and, sometimes, carbon dioxide.

refuse-derived fuels (RDF): fuels that are produced from combustible components that the industry calls "municipal solid waste." This waste, usually taken from industrial or commercial sites, is shred, dried, baled and then finally burned.

residual moisture: water present in a sample of solid fuel after it is air dried in accordance with the sample preparation procedure prescribed by the referenced HHV test method.

4. CLASSIFICATIONS

4.1 Fuel Type Classification. Fuels that are within the scope of this standard are classified according to physical state: gaseous, liquid, and solid.

4.2 HHV Test Methods and Example Fuels. Table 1 includes a list of fuels used for heating, ventilation, air-conditioning, and refrigeration (HVAC) applications, along with the corresponding HHV test methods referenced by this standard. This standard applies to all fuels that fall within the scope of these HHV test methods.

5. REQUIREMENTS

5.1 Requirements Plan. The requirements plan shall be one of the following documents:

a. A document provided by the person or the organization that authorized the tests and calculations to be performed.

(This foreword is not a part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard.)

This is a reaffirmation of Standard 41.13-2023. This standard was prepared under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). It may be used, in whole or in part, by an association or government agency with due credit to ASHRAE. Adherence is strictly on a voluntary basis and merely in the interests of obtaining uniform guidelines throughout the industry. This version of the reaffirmation has no changes.

Table 1 Summary of Test Methods to Determine HHV

State at Standard Conditions[a]	HHV Test Method	Technique Description	Examples of Covered Fuels
Gaseous	ASTM D3588, *Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels* [2]	Gas chromatograph	Natural Gas
			Commercial propane
			Manufactured gas
			Bio-derived gas
	ASTM D1826, *Standard Test Method for Calorific (Heating) Value of Gases in Natural Gas Range by Continuous Recording Calorimeter* [3]	Continuous calorimeter	Natural gas
Liquid	ASTM D240, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeters* [4]	Calorimeter	Kerosene
			#2–#6 fuel oil
			Biodiesel blends
Solid	ASTM E711, *Standard Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter* [5]	Calorimeter	Wood
			Refuse-derived fuel (RDF)
	ASTM D5865/D5865M, *Standard Test Method for Gross Calorific Value of Coal and Coke* [6]	Calorimeter	Coal
			Coke

a. Standard conditions are defined in Section 5.3.

b. A method-of-test standard.
c. A rating standard.
d. A regulation or code.
e. Any combination of items (a) through (d).

5.1.1 The requirements plan shall specify the following:

a. Fuel name or composition.
b. Fuel state (solid, liquid, or gas) at the standard conditions specified in Section 5.3.
c. For liquid fuels, HHV shall be reported on mass basis, volumetric basis, or both.
d. If specified in the requirements plan, the method for determining measurement uncertainty.

5.2 Values to be Determined and Reported if Required in Section 5.1.

5.2.1 Gaseous Fuels. Fuel higher heating value, kJ/m^3 (Btu/ft^3) or MJ/m^3 (Btu/ft^3), at the standard conditions specified in Section 5.3.1.

5.2.2 Liquid Fuels. Fuel higher heating value, MJ/kg (Btu/lb_m) or MJ/L (Btu/gal) at the standard conditions specified in Section 5.3.2.

5.2.3 Solid Fuels. Fuel higher heating value, MJ/kg (Btu/lb_m) at the standard conditions specified in Section 5.3.3.

5.3 Standard Conditions for Fuel Higher Heating Values

5.3.1 5.3.1 Gas. Gaseous fuel higher heating values are based on these standard conditions: 15.6°C/288.8 K, (60.0°F/519.7°R), dry, and absolute pressure of 101.6 kPa (30.00 in. Hg) where 1 Btu_{IT} = 1.055056 kJ.

5.3.2 Liquid. Liquid fuel higher heating values reported on a volumetric basis are based on a temperature of 15.6°C (60.0°F) in the following units: MJ/L (Btu/gal), where 1 Btu_{IT} = 1.055056 kJ.

5.3.3 Solid. This standard treats the HHV of solid fuels as independent of ambient temperature and pressure where (a) 1 Btu_{IT} = 1.055056 kJ for wood and refuse-derived fuels and (b) Btu_{IT} is converted to kJ at the specified reference temperature for coal and coke.

5.4 Methods for Correcting Fuel Higher Heating Values to Local Conditions at a Precision Level of Four Significant Digits

5.4.1 Gaseous Fuels. Apply Equation 1 to convert the HHV for a gaseous fuel at the standard conditions defined in Section 5.3.1 to local conditions.

$$HHV_2 = HHV_{sc} \times \frac{(P_b + P_2 - P_{wvl})}{P_s - P_{wvs}} \times \frac{T_s}{T_2} \times \frac{1}{Z} \quad (1)$$

where

HHV_2 = HHV at local conditions, MJ/m^3(Btu/ft^3)
HHV_{sc} = HHV at standard conditions as defined in Section 5.3.1, MJ/m^3 (Btu/ft^3)
P_b = local barometric pressure, kPa (in. Hg)
P_s = standard absolute pressure as defined in Section 5.3.1, kPa (in. Hg)
P_{wvl} = partial pressure of water in fuel under local conditions, kPa, (in. Hg)
P_{wvs} = partial pressure of water in fuel under standard conditions, kPa (in. Hg). (Because 5.3.1 defines standard conditions as dry, P_{wvs} is = 0 kPa [0 in. Hg].)
P_2 = local gas pressure relative to atmosphere, kPa (in. Hg)
T_s = standard absolute temperature as defined in Section 5.3.1, K (°R)
T_2 = local absolute temperature of gas, K(°R)
Z = compressibility factor defined as follows:
For ideal gases, $Z = 1.0$.
For real gases, Z shall be calculated using ASTM D3588[2].

Informative Notes:

1. For saturated gas, the partial pressure of water is equal to the vapor pressure of water at the temperature of the gas.
2. Commercial natural gas is generally delivered to the end user with negligible water content, making it possible to treat P_{wvl} and P_{wvs} as zero. A notable exception is when certain types of calorimeters and gas meters are used, which saturate the gas as part of the measurement process. For this reason, it is usually possible to treat commercial natural gas as either completely dry or saturated.
3. Barometric pressure reported by weather forecasters and airports is generally not local but corrected to sea level. Use of such readings will yield erroneous results if the local elevation is significantly different from the source elevation.

5.4.2 Liquid Fuels. The HHV method in Section 7.2 determines liquid fuel HHV in units of energy per unit mass. To determine HHV on a volumetric basis, determine the density of the fuel using ASTM D4052 [7] at the standard temperature 15.6°C (60.0°F) as stated in Section 5.3.2. Volumetric HHV is then determined using Equation 2.

$$HHV_v = HHV_m \times \rho \quad (2)$$

where

HHV_v = HHV on a volumetric basis, MJ/L (Btu/gal)
HHV_m = HHV on a mass basis, MJ/kg (Btu/lb$_m$)
ρ = density, kg/L (lb$_m$/gal), at standard temperature of 15.6°C (60.0°F) as stated in Section 5.3.2

5.4.3 Solid Fuels. The HHV methods in Section 7.3 determine solid fuel HHV in units of energy per unit mass, where the unit mass includes residual moisture contained in the fuel. The residual moisture content of the fuel shall be measured and reported using the test method referenced Section 7.3. Apply Equation 3 to calculate the moisture content at local conditions.

$$HHV_2 = HHV_{sc}\left[\frac{(100 - MC_2)}{100 - MC_{sc}}\right] \quad (3)$$

where

HHV_2 = HHV at local conditions, MJ/kg (Btu/lb$_m$)
HHV_{sc} = HHV at the residual moisture reported with the HHV, on a mass basis, MJ/kg (Btu/lb$_m$)
MC_2 = moisture content at local conditions by mass, %
MC_{sc} = residual moisture content reported with the HHV by mass, %

Informative Note: The total moisture content of solid fuels may change significantly from the value measured when the HHV was determined during subsequent storage and transport of the fuel. It is therefore important to measure the moisture content and correct the HHV, in accordance with the equation above, at the time and place of use or custody transfer.)

6. INSTRUMENTS

6.1 Instrumentation Requirements for All Measurements

6.1.1 Instruments and data acquisition systems shall be selected to meet the requirements specified in the corresponding test method referenced in Section 7.

6.1.2 Measurements from the instruments shall be traceable to primary or secondary standards calibrated by the National Institute of Standards and Technology (NIST) or to the Bureau International des Poids et Mesures (BIPM) if a National Metrology Institute (NMI) other than NIST is used. Instruments shall be recalibrated on regular intervals that do not exceed the intervals prescribed by the instrument manufacturer and calibration records shall be maintained. Instruments shall be installed in accordance with the instrument manufacturer's requirements or the manufacturer's accuracy does not apply.

7. METHODS FOR DETERMINING FUEL HIGHER HEATING VALUES

The fuel higher heating values determined by using the methods in this section are at the standard conditions that are defined in Section 5.3. To correct the resulting fuel higher heating values at standard conditions to local conditions, apply the correction methods that are specified in Section 5.4.

7.1 Gaseous Fuels

7.1.1 The higher heating value (HHV) of gaseous fuels shall be measured in accordance with ASTM D3588 [2]. The resulting HHV shall then be corrected to the standard pressure shown in Section 5.3.1 using the following equation:

$$\mathrm{HHV}_{sc} = \mathrm{HHV}_{3588} \times \frac{14.738}{14.696}$$

where

HHV_{sc} = HHV at standard conditions defined in Section 5.3.1, MJ/m^3 **(**Btu/ft^3)

HHV_{3588} = HHV determined using ASTM D3588[2], MJ/m^3 **(**Btu/ft^3)

14.735 = standard absolute pressure defined in 5.3.1 (psia).

14.696 = base absolute pressure defined in Section 1.1 of ASTM D3588 [2] (psia)

7.1.2 Measurement of the HHV of ideal natural gas using ASTM D1826 [3] shall be permitted in place of ASTM D3588 [2]. The HHV obtained using ASTM D1826 [3] is based on the standard pressure in Section 5.3.1, and Equation 4 shall not be used.

7.2 7.2 Liquid Fuels. The HHV of liquid fuels shall be measured in accordance with ASTM D240 [4]. Where HHV is to be reported on a volumetric basis, density shall be measured in accordance with ASTM D4052 [7] and the volumetric HHV at the conditions specified in Section 5.3.2 calculated in accordance with Section 5.4.2.

7.3 Solid Fuels

7.3.1 Wood and Refuse-Derived Fuels

7.3.1.1 Higher Heating Value. The higher heating value of wood and refuse derived fuels shall be measured and reported in accordance with ASTM E711 [5].

7.3.1.2 Moisture. The residual moisture content of wood and refuse derived fuels shall be measured in accordance with ASTM E790 [8] and reported with the HHV.

7.3.2 Coal

7.3.2.1 Higher Heating Value. The higher heating value shall be measured in accordance with ASTM D5865/D5865M [6].

7.3.2.2 Moisture. The residual moisture content of coal shall be measured in accordance with ASTM D3173/D3173M [9].

8. RESULTS

The following information shall be reported:

8.1 Fuel name or composition.

8.2 Date of analysis.

8.3 Name of person responsible for the analysis.

8.4 Name and location of laboratory performing the analysis.

8.5 Test method or methods used.

8.6 Fuel higher heating value:

a. For a gaseous fuel, report the higher heating value, kJ/m^3 (Btu/ft^3) or MJ/m^3 (Btu/ft^3), at the standard conditions specified in Section 5.3.1
b. For a liquid fuel, report the higher heating value, MJ/kg (Btu/lbm) or MJ/L (Btu/gal), at the standard conditions specified in Section 5.3.2
c. For a solid fuel, report the fuel higher heating value, MJ/kg (Btu/lbm), at the standard conditions specified in Section 5.3.3 and residual moisture content.

8.7 The reference temperature that is used to determine the conversion from Btu to kJ if the fuel is coal or coke.

8.8 Measurement uncertainty if the method for determining measurement uncertainty is specified in the requirements plan.

9. REFERENCES

1. ASTM. 2021. ANSI/ASTM D396, *Standard Specification for Fuel Oils*. West Conshohocken, PA: American Society for Testing and Materials. (See Note 1.)
2. ASTM. 2020. ASTM D3588, *Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels*. West Conshohocken, PA: American Society for Testing and Materials. (See Note 2.)
3. ASTM. 2017. ASTM D1826-94 (2017), *Standard Test Method for Calorific (Heating) Value of Gases in Natural Gas Range by Continuous Recording Calorimeter*. West Conshohocken, PA: American Society for Testing and Materials. (See Note 3.)
4. ASTM. 2019. ASTM D240, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeters.* West Conshohocken, PA: American Society for Testing and Materials. (See Note 4.)
5. ASTM. 2004. ASTM E711-87 (2004), *Standard Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter.* West Conshohocken, PA: American Society for Testing and Materials. (See Note 5.)
6. ASTM. 2019. ASTM D5865/D5865M, *Standard Test Method for Gross Calorific Value of Coal and Coke*. West Conshohocken, PA: American Society for Testing and Materials. (See Note 6.)
7. ASTM. 2018. ASTM D4052-18a, *Standard Test Method for Density, Relative Density, or API Gravity of Liquids by Digital Density Meter.*West Conshohocken, PA: American Society for Testing and Materials. (See Note 7.)
8. ASTM. 2021. ASTM E790, *Standard Test Method for Residual Moisture in Refuse-Derived Fuel Analysis Samples*. West Conshohocken, PA: American Society for Testing and Materials. (See Note 8.)
9. ASTM. 2017. ASTM D3173/D3173M-17a, *Standard Test Method for Moisture in the Analysis Sample of Coal and Coke.* West Conshohocken, PA: American Society for Testing and Materials. (See Note 9.)
10. NIST. 2008. NIST Special Publication 811, *The NIST Guide for the Use of the International System of Units*, Appendix B8. Gaithersburg, MD: National Institute of Standards and Technology.

Informative Notes:

1. This reference is only required if the fuel is an oil.
2. This reference is only required if the fuel is a gas and the gas chromatograph technique is applied.
3. This reference is only required if the fuel is a gas and the continuous calorimeter technique is applied.
4. This reference is only required if the fuel is a liquid.
5. This reference is only required if the fuel is wood or a refuse-derived fuel.
6. This reference is only required if the fuel is coal or coke.
7. This reference is only required if the fuel is a liquid.
8. This reference is only required if the fuel is wood or a refuse-derived fuel.
9. This reference is only required if the fuel is coal or coke.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ASHRAE · 180 Technology Parkway · Peachtree Corners, GA 30092 · www.ashrae.org

About ASHRAE

Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

To stay current with this and other ASHRAE Standards and Guidelines, visit www.ashrae.org/standards, and connect on LinkedIn, Facebook, Twitter, and YouTube.

Visit the ASHRAE Bookstore

ASHRAE offers its Standards and Guidelines in print, as immediately downloadable PDFs, and via ASHRAE Digital Collections, which provides online access with automatic updates as well as historical versions of publications. Selected Standards and Guidelines are also offered in redline versions that indicate the changes made between the active Standard or Guideline and its previous edition. For more information, visit the Standards and Guidelines section of the ASHRAE Bookstore at www.ashrae.org/bookstore.

IMPORTANT NOTICES ABOUT THIS STANDARD

To ensure that you have all of the approved addenda, errata, and interpretations for this Standard, visit www.ashrae.org/standards to download them free of charge.

Addenda, errata, and interpretations for ASHRAE Standards and Guidelines are no longer distributed with copies of the Standards and Guidelines. ASHRAE provides these addenda, errata, and interpretations only in electronic form to promote more sustainable use of resources.

Product code: 86724 5/23