



Designation: D4868 – 17

Standard Test Method for Estimation of Net and Gross Heat of Combustion of Hydrocarbon Burner and Diesel Fuels¹

This standard is issued under the fixed designation D4868; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the estimation of the gross and net heat of combustion in SI units, megajoules per kilogram, of hydrocarbon fuels and blendstocks from the fuel density and sulfur, water, and ash contents.

1.1.1 This test method is not applicable to fuels containing non-hydrocarbons such as alcohols (for example, ethanol, methanol), ethers (for example, MTBE), or esters (for example, biodiesel).

NOTE 1—The equation for estimation of net and gross heat of combustion used in this method was originally published as NBS Miscellaneous Publication No. 97.

1.2 This test method is especially useful for estimating, using a minimum number of tests, the heat of combustion of burner and diesel fuels (which do not contain non-hydrocarbon components) for which it is not usually critical to obtain very precise heat determinations.

NOTE 2—More accurate estimation methods are available for aviation fuels (Test Methods D1405, D4529, and D3338). However, those estimation methods require additional tests to those required in this test method.

1.3 This test method is purely empirical (Note 1). It was derived using liquid hydrocarbon fuels produced by normal refining processes from conventional crude oil that conform to the requirements of specifications for petroleum fuels as described in Note 3. This test method is valid for those fuels in the density range from 750 kg/m³ to 1000 kg/m³ and those that do not contain an unusually high aromatic content. High aromatic content fuels will not normally meet some fuel specification criteria.

NOTE 3—The estimation of the heat of combustion of a hydrocarbon fuel from its density and sulfur, water, and ash content is justifiable only when the fuel belongs to well-defined classes for which a relationship between these quantities have been derived from accurate experimental measurements on representative samples of these classes. Even in these classes, the possibility that the estimate can be in error for individual fuels should be recognized. This test method has been tested for a limited

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.05 on Properties of Fuels, Petroleum Coke and Carbon Material.

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number of fuels from oil sand bitumen and shale oil origin and has been found to be valid. The classes of fuels used to establish the correlation presented in this test method are represented by the following applications:

Fuel (not applicable to any fuels containing non-hydrocarbon components)	Specification
Fuel Oils Grades No. 1, 2, 4 (light), 4, 5 (light), 5 (heavy), and 6	D396
Diesel Grades No. 1-D, 2-D, and 4-D	D975
Aviation Turbine Jet A and Jet A-1	D1655
Jet B	D6615
Gas Turbine Grades No. 0-GT, 1-GT, 2-GT, 3-GT, and 4-GT	D2880
Kerosene Grades No. 1-K and 2-K	D3699

1.4 This test method is not applicable to pure hydrocarbon compounds. It is not intended as a substitute for highly accurate experimental measurements of heat of combustion (Note 4).

NOTE 4—The procedures for the experimental determination of the gross and net heats of combustion are described in Test Methods D240 and D4809.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation

D129 Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

D240 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter

D396 Specification for Fuel Oils

D482 Test Method for Ash from Petroleum Products

D975 Specification for Diesel Fuel Oils

D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D1405 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

D1480 Test Method for Density and Relative Density (Specific Gravity) of Viscous Materials by Bingham Pycnometer

D1481 Test Method for Density and Relative Density (Specific Gravity) of Viscous Materials by Lipkin Bicapillary Pycnometer

D1552 Test Method for Sulfur in Petroleum Products by High Temperature Combustion and Infrared (IR) Detection or Thermal Conductivity Detection (TCD)

D1655 Specification for Aviation Turbine Fuels

D1744 Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent (Withdrawn 2016)³

D1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)

D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry

D2880 Specification for Gas Turbine Fuel Oils

D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

D3699 Specification for Kerosine

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry

D4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

D4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)

D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence

D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration

D6615 Specification for Jet B Wide-Cut Aviation Turbine Fuel

D7039 Test Method for Sulfur in Gasoline, Diesel Fuel, Jet Fuel, Kerosine, Biodiesel, Biodiesel Blends, and Gasoline-Ethanol Blends by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry

2.2 *NIST Publication:*

NBS Miscellaneous Publication No. 97 Thermal Properties of Petroleum Products⁴

3. Summary of Test Method

3.1 The density and sulfur, water, and ash content of the sample are determined by experimental test methods. The heat of combustion is calculated using the values obtained by these test methods based on reported correlations.

4. Significance and Use

4.1 This test method is intended for use in cases where an experimental determination of heat of combustion is not available and cannot be made conveniently, and where an estimate is considered satisfactory. It is not intended as a substitute for experimental measurement of heat of combustion.

5. Procedure

5.1 Determine the density to the nearest 0.1 kg/m³ as described in Test Methods **D1298**, **D1480**, **D1481** or **D4052**.

5.2 Determine the sulfur content of the sample to the nearest 0.01 % by mass sulfur as described in Test Methods **D129**, **D1266**, **D1552**, **D2622**, **D4294**, **D5453**, or **D7039**.

5.3 Determine the water content of the sample to the nearest 0.05 % by mass water as described in Test Methods **D95**, **D1744**, **D1796**, or **D6304**.

5.4 Determine the ash content of the sample to two significant figures as described in Test Method **D482**.

6. Calculation

6.1 Calculate the gross heat of combustion of the fuel corrected for the sulfur, water and ash content in accordance with the following equation:

$$Q_v (\text{gross}) = (51.916 - 8.792 d^2 \times 10^{-6}) (1 - [x + y + s]) + 9.420s \quad (1)$$

where:

Q_v = gross heat of combustion at constant volume, MJ/kg,
 d = density at 15 °C, kg/m³,
 x = mass fraction of water (% divided by 100),
 y = mass fraction of ash (% divided by 100), and
 s = mass fraction of sulfur (% divided by 100).

6.2 Calculate the net heat of combustion of the fuel corrected for the sulfur, water and ash content in accordance with the following equation:

$$Q_p (\text{net}) = (46.423 - 8.792 d^2 \times 10^{-6} + 3.170d \times 10^{-3}) (1 - [x + y + s]) + 9.420s - 2.449x \quad (2)$$

where:

Q_p = net heat of combustion at constant pressure, MJ/kg,

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available by download from National Institute of Standards and Technology (NIST), https://library.nist.gov/uhtbin/cgiisirs/x/SIRSI/0/57/60/61/X?user_id=WEBSERVER

7. Report

7.1 Report the result as the estimated gross or net heat of combustion in MJ/kg to the nearest 0.01.

8. Precision and Bias

8.1 *Precision*—The precision⁵ of the estimated values will be dependent upon the accuracy of the determined density and sulfur, water and ash contents. The following precision is the aggregate precision of the measurements used to calculate the heat content by (Eq 1) and (Eq 2) and does not indicate the precision of the heat content of an individual sample. That precision is estimated in Note 4. When using data on the density, sulfur, water and ash content of a fuel determined by Test Methods D4052, D4294, D1796, and D482, respectively, the following criteria shall be used for judging the acceptability of estimated heat of combustion results.

8.1.1 *Repeatability*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test material

would, in the long run, in the normal and correct operation of the test method exceed the following value only in one case in twenty:

Repeatability 0.05 MJ/kg

8.1.2 *Reproducibility*—The difference between two single and independent results, obtained by different operators working in different laboratories on identical test material would, in the long run, and in the normal and correct operation of the test method, exceed the following value only in one case in twenty:

Reproducibility 0.15 MJ/kg

8.2 *Bias*—Bias cannot be determined for the procedure in Test Method D4868 since the data used to determine the correlation cannot be compared with accepted reference materials.

NOTE 5—The correlation equations were tested using 199 present day fuels. The data is included in ASTM Research Report RR:D02-1233. About 95 % of the calculated data were within 0.35 MJ/kg of measured heats of combustion.

9. Keywords

9.1 burner fuels; diesel fuels; gross heat of combustion; heat energy; heat of combustion; heating tests; hydrocarbon fuels; net heat of combustion

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1233. Contact ASTM Customer Service at service@astm.org.

SUMMARY OF CHANGES

Subcommittee D02.05 has identified the location of selected changes to this standard since the last issue (D4868 – 00 (2010)) that may impact the use of this standard. (Approved Jan. 1, 2017.)

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| (1) Revised the title of the standard. | (3) Revised subsections 5.1, 5.2, and 5.3. |
| (2) Revised Section 1, Scope, and Section 2, Referenced Documents. | (4) Revised Eq 1 and Eq 2. |

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