



# Standard Test Method for Estimation of Net and Gross Heat of Combustion of Burner and Diesel Fuels<sup>1</sup>

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 ( $\epsilon$ ) 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 petroleum fuels from the fuel density, sulfur, water, and ash content.

NOTE 1—The equation for estimation of net and gross heat of combustion used in this method were originally published by the [NIST 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 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 is applicable only to liquid hydrocarbon fuels derived 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 to 1000 kg/m<sup>3</sup> and those that do not contain an unusually high aromatic content. High aromatic content fuels will not normally meet 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 may be in error by large amounts for individual fuels should be recognized. This test method has been tested for a limited 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:

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee [D02](#) on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee [D02.05](#) on Properties of Fuels, Petroleum Coke and Carbon Material.

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Fuel	Specification
Fuel Oils Grades 1, 2, 4 (light), 4, 5 (light), 5 (heavy), and 6	<a href="#">D396</a>
Diesel Grades 1-D, 2-D, and 4-d	<a href="#">D975</a>
Aviation Turbine Jet A, Jet A-1, and Jet B	<a href="#">D1655</a>
Gas Turbine Grades 0-GT, 1-GT, 2-GT, 3-GT and 4-GT	<a href="#">D2880</a>
Kerosine Grades 1-K and 2-K	<a href="#">D3699</a>

1.4 This test method is not applicable to pure hydrocarbons. It is not intended as a substitute for 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:<sup>2</sup>

- [D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation](#)
- [D129 Test Method for Sulfur in Petroleum Products \(General Bomb Method\)](#)
- [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 \(Lamp Method\)](#)

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- D1298** Test Method for Density, Relative Density (Specific Gravity), 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 (High-Temperature Method)
- D1655** Specification for Aviation Turbine Fuels
- D1744** Standard Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent<sup>3</sup>
- 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 Kerosene
- 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
- 2.2 *NIST Standard*:<sup>4</sup>
- NIST Publication No. 97** Thermal Properties of Petroleum Products

### 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/m<sup>3</sup> as described in Practice **D1298**, and Test Methods **D1480**, **D1481** or **D4052**.

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

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

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/m<sup>3</sup>,
- $x$  = 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,

### 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 precision<sup>5</sup> 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

<sup>3</sup> Withdrawn. The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 3460, Gaithersburg, MD 20899-3460.

<sup>5</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1233.

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 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; net heat of combustion

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