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## Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels<sup>1</sup>

This standard is issued under the fixed designation D4529; 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 net heat of combustion at constant pressure in metric (SI) units, megajoules per kilogram.

1.2 This test method is purely empirical, and it is applicable only to liquid hydrocarbon fuels derived by normal refining processes from conventional crude oil which conform to the requirements of specifications for aviation gasolines or aircraft turbine and jet engine fuels of limited boiling ranges and compositions as described in **Note 1**.

NOTE 1—The estimation of the net heat of combustion of a hydrocarbon fuel from its aniline point temperature and density is justifiable only when the fuel belongs to a well-defined class for which a relationship between these quantities has been derived from accurate experimental measurements on representative samples of that class. Even in this class, the possibility that the estimates can be in error by large amounts for individual fuels should be recognized. The JP-8 fuel, although not experimentally tested, has properties similar to JP-5 and Jet A fuels and can be considered in the same class. The classes of fuels used to establish the correlation presented in this test method are represented by the following applications:

Fuel	Specification
Aviation gasoline fuels: Grades 80, UL82, UL87, 90, 91, UL91, 94, UL94, 100/100LL/100VLL	Specification <b>D910</b> Specification <b>D6227</b> Specification <b>D7547</b> Specification <b>D7592</b>
Aviation turbine fuels: Jet B, JP-4	Specification <b>D6615</b> MIL-DTL-5624
JP-5	MIL-DTL-5624
JP-8	MIL-DTL-83133
Jet A, Jet A-1	Specification <b>D1655</b> Specification <b>D7223</b> Specification <b>D7566</b>

1.3 The net heat of combustion can also be estimated by Test Methods **D1405** or **D3338**. Test Method **D1405** requires

calculation of one of four equations dependent on the fuel type with the precision equivalent to that of this test method, whereas Test Method **D3338** requires calculation of a single equation for aviation fuel with a precision equivalent to that test method.

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

1.5 *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>

- D129** Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)
- D240** Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter
- D611** Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents
- D910** Specification for Leaded Aviation Gasolines
- D941** Test Method for Density and Relative Density (Specific Gravity) of Liquids by Lipkin Bicapillary Pycnometer (Withdrawn 1993)<sup>3</sup>
- D1217** Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer
- D1250** Guide for Use of the Petroleum Measurement Tables
- 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

<sup>1</sup> 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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<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.

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

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

- D1655** Specification for Aviation Turbine Fuels
- D2622** Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
- D3120** Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
- D3338** Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
- 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
- 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
- D6227** Specification for Unleaded Aviation Gasoline Containing a Non-hydrocarbon Component
- 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
- D7223** Specification for Aviation Certification Turbine Fuel
- D7547** Specification for Hydrocarbon Unleaded Aviation Gasoline
- D7566** Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons
- D7592** Specification for Specification for Grade 94 Unleaded Aviation Gasoline Certification and Test Fuel (Withdrawn 2016)<sup>3</sup>
- 2.2 *U.S. Military Standards*:<sup>4</sup>
- MIL-DTL-5624** Turbine Fuel, Aviation, Grades JP-4 and JP-5
- MIL-DTL-83133** Aviation Turbine Fuel, Kerosene Types, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37)

### 3. Summary of Test Method

3.1 The aniline point, density, and sulfur content of the sample are determined by experimental test methods and the net heat of combustion is calculated using the values obtained by these test methods based on reported correlations.<sup>5,6,7</sup>

### 4. Significance and Use

4.1 This test method is intended for use as a guide 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 measurements of heat of combustion (**Note 2**).

**NOTE 2**—The procedures for the experimental determination of the gross and net heats of combustion are described in Test Methods **D240** and **D4809**.

4.2 The net heat of combustion is a factor in the performance of all aviation fuels. Because the exhaust of aircraft engines contains uncondensed water vapors, the energy released by fuel in vaporizing water cannot be recovered and must be subtracted from gross heat of combustion determinations to calculate net heat of combustion. For high performance weight-limited aircraft, the net heat of combustion per unit mass and the mass of fuel loaded determine the total safe range. The proper operation of the aircraft engine also requires a certain minimum net energy of combustion per unit volume of fuel delivered.

4.3 Because the heat of combustion of hydrocarbon fuel-mixtures are slowly varying functions of the physical properties of the mixtures, the heat of combustion of the mixtures can often be estimated with adequate accuracy from simple field tests of density and aniline point temperature, without the elaborate apparatus needed for calorimetry.

4.4 The empirical quadratic equation for the net heat of combustion of a sulfur-free fuel was derived by the method of least squares from accurate measurements on fuels, most of which conformed to specifications for fuels found in **Note 1** and were chosen to cover a range of values of properties. Those fuels not meeting specifications were chosen to extend the range of densities and aniline-point temperatures above and below the specification limits to avoid end effects. The sulfur correction was found by a simultaneous least-squares regression analysis of sulfur-containing fuels among those tested.

### 5. Procedure

5.1 Determine the aniline point temperature of the sample to the nearest 0.05 °C as described in Test Methods **D611**.

5.2 Determine the density at 15 °C of the sample to the nearest 0.5 kg/m<sup>3</sup> as described in Test Methods **D941**, **D1217**, **D1298**, **D4052**, or Guide **D1250**.

5.3 Determine the sulfur content of the sample to the nearest 0.02 % by mass sulfur as described in Test Methods **D129**, **D1266**, **D2622**, **D3120**, **D4294**, **D5453**, or **D7039**.

### 6. Calculation

6.1 Calculate the net heat of combustion using either Procedure A or B.

<sup>4</sup> Available for electronic download at ASSIST Quick Search (<http://quicksearch.dla.mil>). The ASSIST Quick Search website is the official US Department of Defense depository for public releasable specifications, standards and handbooks.

<sup>5</sup> Armstrong, G. T., Fano, L., Jessup, R. S., Maraatz, S., Mears, T. W., and Walker, J. A., "Net Heat of Combustion and Other Properties of Kerosine and Related Fuels," *Journal of Chemical and Engineering Data*, National Institute for Standards and Technology, Washington, DC, Vol 7, No. 1, January 1962, pp. 107–117.

<sup>6</sup> Coglianze, J. A., and Jessup, R. S., "Relation Between Net Heat of Combustion and Aniline-Gravity Product of Aircraft Fuels," *ASTM Bulletin*, ASTBA, No. 201, October 1954, p. 55 (TP 217); also the National Institute for Standards and Technology findings as reported by Armstrong, G. T., Jessup, R. S., and Mears, T. W., "Net Heat of Combustion of Aviation Gasoline and its Correlation with Other Properties," *Journal of Chemical and Engineering Data*, Vol 3, 1958, pp. 20–28.

<sup>7</sup> Nuttall, R. L., and Armstrong, G. T., "Estimation of Net Enthalpies of Some Aviation Fuels Expressed in the International System of Units (SI)," NIST Technical Note 937, April 1977.