Designation: D1405/D1405M – 08 (Reapproved 2013)

Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels[1]

This standard is issued under the fixed designation D1405/D1405M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the estimation of the net heat of combustion at constant pressure in SI units (megajoules per kilogram) or inch-pound units [Btu per pound].

1.2 This test method is purely empirical and 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 aniline-gravity product is justifiable only when the fuel belongs to a well-defined class for which a relation between heat of combustion and aniline-gravity product has been derived from accurate experimental measurements on representative samples of that class. Even in this case, the possibility that the estimates may be in error by large amounts for individual fuels should be recognized. The classes of fuels used to establish the correlation presented in this test method are represented by the following specifications:

Fuel	Specification
Aviation gasoline fuels: Grades 80, 82, 100/130, and 115/145	Specification D910 Specification D6227 DEF STAN 91–90 NATO Code F-18
Aviation turbine fuels: JP-4,Avtag/FSII	MIL-DTL-5624 DEF STAN 91–88 NATO Code F-40
JP-5,Avcat/FSII	MIL-DTL-5624 DEF STAN 91–86 NATO Code F-44
Jet A, Jet A-1, Avtur	Specification D1655 DEF STAN 91–91 NATO Code F-35

1.3 This test method is not applicable to pure hydrocarbons. It is not intended as a substitute for experimental measurements of heat of combustion.

1.4 The heat of combustion may also be determined in SI units by Test Method D4529. Test Method D4529 requires calculation of a single equation for all aviation fuels with a precision equivalent to that of this test method.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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]

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

D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

D611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents

D910 Specification for Aviation Gasolines

D941 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Lipkin Bicapillary Pycnometer (Withdrawn 1993)[3]

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)

[1] 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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This test method has been approved by the sponsoring committee and accepted by the Cooperating Societies in accordance with established procedures.

[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.

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

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
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
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
D6227 Specification for Unleaded Aviation Gasoline Containing a Non-hydrocarbon Component

2.2 *U.S. Military Standards:*[4]

MIL-DTL-5624 Aviation Turbine Fuels, Grades JP-4, JP-5, and JP-5/JP-8 ST
MIL-T-83133 Aviation Turbine Fuel, Grade JP-8

2.3 *Directorate of Standardization, Ministry of Defence:*[5]

DEF STAN 91–86 Aviation Turbine Fuel, High Flash Kerosene Type with Fuel System Icing Inhibitor
DEF STAN 91–88 Aviation Turbine Fuel, Wide Cut Type with Fuel System Icing Inhibitor
DEF STAN 91–90 Aviation Gasoline 80 and 100LL
DEF STAN 91–91 Aviation Turbine Fuel, Kerosene Type, Jet A-1

2.4 *NATO Codes:*[5]

F-18 Aviation Gasoline
F-35 Aviation Turbine Fuel, Jet A Type
F-40 Aviation Turbine Fuel, Grade JP-4
F-44 Aviation Turbine Fuel, Grade JP-5

3. Summary of Test Method

3.1 Correlations[6,7] have been established between the net heat of combustion and the product of the aniline point and API gravity. These relations, assuming the sample to be sulfur free, are given by the following equations:

3.1.1 Where the net heat of combustion is required in SI units (Note 2) (megajoules per kilogram):

Type Fuel	Equation	
Aviation gasoline, Grades 100–130 and 115–145	$Qp\,(\text{net}) = 41.9557 + 0.00020543\,(A \times G)$	(1)
JP-4	$Qp\,(\text{net}) = 41.8145 + 0.00024563\,(A \times G)$	(2)
JP-5	$Qp\,(\text{net}) = 41.6680 + 0.00024563\,(A \times G)$	(3)
Kerosine Jet A or A-1	$Qp\,(\text{net}) = 41.6796 + 0.00025407\,(A \times G)$	(4)

where:
Q_p (net) = net heat of combustion, MJ/kg, on a sulfur-free basis,
A = aniline point, °F, and
G = gravity, °API.

NOTE 2—In SI, the unit of heat of combustion has the dimensions J/kg, but for practical use a multiple is more convenient. The megajoule per kilogram (MJ/kg) is 10^6 J/kg and is customarily used for the representation of heats of combustion of petroleum fuels, particularly for mixtures such as those covered in this International Standard.

3.1.2 Where the net heat of combustion is required in inch-pound units or British Thermal Units [Btu per pound].

Type Fuel	Equation	
Aviation gasoline, Grades 100–130 and 115–145	$Qp\,(\text{net}) = 18\,037.7 + 0.0883\,(A \times G)$	(5)
JP-4	$Qp\,(\text{net}) = 17\,977 + 0.1056\,(A \times G)$	(6)
JP-5	$Qp\,(\text{net}) = 17\,914 + 0.1056\ \ (A \times G)$	(7)
Kerosine Jet A or A-1	$Qp\,(\text{net}) = 17\,919 + 0.10923\ \ (A \times G)$	(8)

where:
Q_p (net) = net heat of combustion, Btu/lb, on a sulfur-free basis,
A = aniline point, °F, and
G = gravity, °API.

3.2 To correct for the effect of the sulfur content of the sample on the net heat of combustion, apply the following equation:

3.2.1 Where the net heat of combustion is required in SI units (megajoules per kilogram):

$$Q' = Qp(\text{net}) \times [1 - 0.01(S)] + 0.1016(S) \quad (9)$$

where:

Q' = net heat of combustion, MJ/kg, of the sample containing S % sulfur,

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

[5] Available from Directorate of Standardization, Stan Ops I, Room 1138, Kentigern House, 65 Brown Street, Glasgow, G2 8EX, U.K.

[6] Cogliano, 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 of 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 Correlations with Other Properties," *Journal of Chemical and Engineering Data*, Vol 3, 1958, pp. 20–28.

[7] Armstrong, G. T., Fano, L., Jessup, R. S., Marantz, S., Mears, T. W., and Walker, J. A., "Net Heat of Combustion and Other Properties of Kerosene and Related Fuels," *Journal of Chemical and Engineering Data*, National Institute of Standards and Technology, Gaithersburg, MD. Vol 7, No. 1, January 1962, pp. 107–117.