



Designation: D 1405 – 95a

An American National Standard



Designation: 193/80

Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels¹

This standard is issued under the fixed designation D 1405; 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 is also a standard of the Institute of Petroleum issued under the fixed designation IP 193. The final number indicates the year of last revision.

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

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 metric (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.

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 values stated in acceptable metric units are to be regarded as the standard.

1.5 The heat of combustion may also be determined in SI units by Test Method D 4529. Test Method D 4529 requires calculation of a single equation for all aviation fuels with a precision equivalent to that of this test method.

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:

D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)²

D 240 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Colorimeter²

D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)²

D 611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents²

D 910 Specification for Aviation Gasolines²

D 941 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Lipkin Bicapillary Pycnometer³

D 1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer²

D 1250 Guide for Petroleum Measurement Tables²

D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)²

D 1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method²

D 1655 Specification for Aviation Turbine Fuels²

D 2382 Test Method for Heat of Combustion of Hydrocarbon Fuels by Bomb Calorimeter (High-Precision Method)³

D 2622 Test Method for Sulfur in Petroleum Products by X-Ray Spectrometry⁴

D 3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry⁴

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter⁴

D 4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels⁴

D 4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Intermediate Precision Method)⁵

¹ This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.05 on Petroleum, Coke, and Carbon Materials.

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In the IP, this test method is under the jurisdiction of the Standardization Committee.

In 1964, this test method was adopted as standard with editorial revisions.

² *Annual Book of ASTM Standards*, Vol 05.01.

³ Discontinued; See 1993 *Annual Book of ASTM Standards*, Vol 05.01.

⁴ *Annual Book of ASTM Standards*, Vol 05.02.

⁵ *Annual Book of ASTM Standards*, Vol 05.03.

2.2 U.S. Military Standards:⁶

MIL-G-5572 Aviation Gasoline

MIL-T-5624 Aviation Turbine Fuel, Grades JP-4 and JP-5

MIL-T-83133 Aviation Turbine Fuel, Grade JP-8

2.3 Department of Energy Research and Development:⁷

DERD 2453 Aviation Turbine Fuel, Kerosene

DERD 2454 Aviation Turbine Fuel, Wide-Cut with AIA

DERD 2485 Aviation Gasoline

DERD 2486 Turbine Fuel, Wide-Cut

DERD 2494 Aviation Turbine Fuel, Kerosene

NOTE 1—The following are typical fuel designations: Nato Codes⁸
F-18 Aviation Gasoline, F-34 Aviation Turbine Fuel, Grade JP-8,
F-35 Aviation Turbine Fuel, JET A Type, F-40 Aviation Turbine Fuel,
Grade JP-4, and F-44 Aviation Turbine Fuel, Grade JP-5.

3. Summary of Test Method

3.1 Correlations^{8,9} 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 ^A	
Aviation gasoline, Grades 100–130 and 115–145	$Q_p(\text{net}) = 41.9557 + 0.00020543 (A \times G)$	(1)
JP-4	$Q_p(\text{net}) = 41.8145 + 0.00024563 (A \times G)$	(2)
JP-5	$Q_p(\text{net}) = 41.6680 + 0.00024563 (A \times G)$	(3)
Kerosine Jet A or A-1	$Q_p(\text{net}) = 41.6796 + 0.00025407 (A \times G)$	(4)

^Awhere:

$Q_p(\text{net})$ = 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 ^A	
Aviation gasoline, Grades 100–130 and 115–145	$Q_p(\text{net}) = 18\,037.7 + 0.0883 (A \times G)$	(5)

⁶ Available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

⁷ Available from Ministry of Defence, 154 St. Giles Court, London WC2H 8LD England.

⁸ 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.

⁹ 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.

JP-4	$Q_p(\text{net}) = 17\,977 + 0.1056 (A \times G)$	(6)
JP-5	$Q_p(\text{net}) = 17\,914 + 0.1056 (A \times G)$	(7)
Kerosine Jet A or A-1	$Q_p(\text{net}) = 17\,919 + 0.10923 (A \times G)$	(8)

^Awhere:

$Q_p(\text{net})$ = 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):

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

where:

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

S = sulfur content of the sample, mass, %, and

0.1016 = a constant based on the thermo-chemical data on sulfur compounds.

3.2.2 Where the net heat of combustion is required in inch-pound units or British Thermal Units (Btu per pound):

$$Q' = Q_p(\text{net}) \times [1 - 0.01(S)] + 43.7(S) \quad (10)$$

where:

Q' = net heat of combustion, Btu/lb, of the sample containing S % sulfur,

S = sulfur content of the sample, mass %, and

43.7 = a constant based on the thermochemical data on sulfur compounds.

3.3 The empirical linear equations 1–4 and 6–9 for the estimated net heat of combustion were derived by the method of least squares from accurate data on fuels, most of which conformed at least approximately to specifications for aviation gasolines, or aircraft turbine and jet engine fuels of Types JP-4 and JP-5 and to Specification D 1655, Jet A and A-1.

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 3—The procedure for the experimental determination of the net heat of combustion is described in Test Methods D 240, D 2382, and D 4809.

NOTE 4—The estimation of the net heat of combustion of a hydrocarbon fuel from its 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 fuels used to establish the correlation presented in this method are defined by the following specifications:



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