Designation: D 1405 – ~~95a~~01

An American National Standard

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

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.~~ reapproval.

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.

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 D 910 Specification D 6227 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 D 1655 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 combusiton.

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.*

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

Current edition approved ~~Dec.~~ Jan. 10, ~~1995.~~ 2001. Published ~~February 1996.~~ March 2001. Originally published as D 1405 – 56. Last previous edition ~~D 1405 – 95. In the IP, this test method is under the jurisdiction of the Standardization Committee.~~ D 1405 – 95a.

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

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 Colorimeter[2]

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 Solvents[2]

D 910 Specification for Aviation Gasolines[2]

D 941 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Lipkin Bicapillary Pycnometer[3]

D 1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer[2]

D 1250 Guide for Petroleum Measurement Tables[2]

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 Method[2]

D 1655 Specification for Aviation Turbine Fuels[2]

D 2386~~22~~ Test Method for ~~Heat of Combustion of Hydrocarbon Fuels~~ Sulfur in Petroleum Products by ~~Bomb Calorimeter (High-Precision Method)~~[3] X-Ray Spectrometry[2]

D ~~2622 Test~~ 3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum ~~Products~~ Hydrocarbons by ~~X-Ray Spectrometry~~ Oxidative Microcoulometry[2]

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[4]

D ~~3120 Test~~ 4294 Test Method for ~~Trace Quantities of~~ Sulfur in ~~Light Liquid~~ Petroleum ~~Hydrocarbons~~ and Petroleum Products by ~~Oxidative Microcoulometry~~ Energy-Dispersive X-ray Fluorescence Spectrometry[4]

~~D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[4]~~

~~D 4529 Test~~ 4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels[4]

D 4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter ~~(Intermediate Precision~~ (Precision Method)[4]

D 5453 Test Method for determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence[5]

D 6227 Specification for Grade 82 Unleaded Aviation Gasoline[5]

2.2 *U.S. Military Standards:*[6]

~~MIL-G-5572 Aviation Gasoline~~

~~MIL-T-5624 Aviation~~

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 ~~*Department*~~*Directorate* ~~*of Energy Research and Development:*~~ *Standardization, Ministry of Defence:*[7]

~~DERD 2453 Aviation~~

DEF STAN 91–86 Aviation Turbine Fuel, High Flash Kerosene Type with Fuel System Icing Inhibitor

DE~~RD 2454~~F STAN 91–88 Aviation Turbine Fuel, Wide~~-~~ Cut Type with ~~AIA~~

~~DERD 2485 Aviation Gasoline~~

~~DERD 2486 Turbine Fuel, Wide-Cut~~

~~DERD 2494 Aviation~~ Fuel System Icing Inhibitor

DEF STAN 91–90 Aviation Gasoline 80 and 100LL

DEF STAN 91–91 Aviation Turbine Fuel, ~~Kerosene~~

[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.

[6] Available from ~~Naval Publications and Forms Center, 5801 Tabor Ave.,~~ Department of Defense Single Stock Point, 700 Robbins Avenue, Building 4D, Philadelphia, PA 191~~2~~11–5098.

[7] Available from ~~Ministry~~ Directorate of ~~Defence, 154 St. Giles Court, London WC2H 8LD England.~~ Standardization, Stan Ops I, Room 1138, Kentigern House, 65 Brown Street, Glasgow, G2 8EX, U.K.

~~NOTE 1—The following are typical fuel designations: Nato Codes[8] F-18 Aviation Gasoline, F-34 Aviation~~ Kerosene Type, Jet A-1

2.4 *NATO Codes:*[7]

F-18 Aviation Gasoline

F-35 Aviation Turbine Fuel, ~~Grade JP-8, F-35 Aviation Turbine Fuel, JET~~ 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[8,10] 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):

[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.

Type Fuel	Equation[A]	
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)

[A]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[A]	
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)

[A]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,
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):

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

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,~~ D 240 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~~

[10] 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.

~~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:~~

~~Fuel~~	~~Specification~~
~~Aircraft engine fuels:~~	
~~— Grades 100 to 130 and 115 to 145~~	~~MIL-G-5572~~ ~~Specification D 910~~ ~~D. Eng. RD 2485~~
~~Aircraft turbine and jet engine fuels:~~	
~~— JP-4~~	~~MIL-T-5624~~ ~~D. Eng. RD 2486~~
~~— JP-5~~	~~MIL-T-5624~~ ~~D. Eng. RD 2488~~
~~— Jet A and Jet A-1~~	~~Specification D 1655~~

5. Procedure

5.1 Determine the aniline points of the sample to the nearest 0.05 C (0.1 F) as described in Test Method D 611.

5.2 Determine the API gravity of the sample to the nearest 0.1° API as described in Test Method D 287. Alternatively, determine the relative density by Test Methods D 941, D 1217, and D 4052 and correct the result to API gravity by Guide 1250.

TABLE 1 Values of Q′ for Aviation Gasolines Calculated from Eq 1 and Eq 9

Aniline-Gravity Product	Net Heat of Combustion, MJ/kg				
	0% Sulfur	0.1% Sulfur	0.2% Sulfur	0.3% Sulfur	0.4% Sulfur
4 000	42.777	42.745	42.712	42.680	42.647
4 200	42.819	42.786	42.753	42.721	42.688
4 400	42.860	42.827	42.794	42.761	42.729
4 600	42.901	42.868	42.835	42.802	42.770
4 800	42.942	42.909	42.876	42.843	42.811
5 000	42.983	42.950	42.917	42.884	42.852
5 200	43.024	42.991	42.958	42.925	42.892
5 400	43.065	43.032	42.999	42.966	42.933
5 600	43.106	43.073	43.040	43.007	42.974
5 800	43.147	43.114	43.081	43.048	43.015
6 000	43.188	43.155	43.122	43.089	43.056
6 200	43.229	43.196	43.163	43.130	43.097
6 400	43.270	43.237	43.204	43.171	43.138
6 600	43.312	43.278	43.245	43.212	43.179
6 800	43.353	43.319	43.286	43.253	43.220
7 000	43.394	43.360	43.327	43.294	43.261
7 200	43.435	43.402	43.368	43.335	43.302
7 400	43.476	43.443	43.409	43.376	43.343
7 600	43.517	43.484	43.450	43.417	43.384
7 800	43.558	43.525	43.491	43.458	43.424
8 000	43.599	43.566	43.532	43.499	43.465
8 200	43.640	43.607	43.573	43.540	43.506
8 400	43.681	43.648	43.614	43.581	43.547
8 600	43.722	43.689	43.655	43.622	43.588
8 800	43.763	43.730	43.696	43.663	43.629
9 000	43.805	43.771	43.737	43.704	43.670
9 200	43.846	43.812	43.778	43.745	43.711
9 400	43.887	43.853	43.819	43.786	43.752
9 600	43.928	43.894	43.860	43.827	43.793
9 800	43.969	43.935	43.901	43.867	43.834
10 000	44.010	43.976	43.942	43.908	43.875
10 200	44.051	44.017	43.983	43.949	43.916
10 400	44.092	44.058	44.024	43.990	43.956
10 600	44.133	44.099	44.065	44.031	43.997
10 800	44.174	44.140	44.106	44.072	44.038
11 000	44.215	44.181	44.147	44.113	44.079
11 200	44.257	44.222	44.188	44.154	44.120
11 400	44.298	44.263	44.229	44.195	44.161
11 600	44.339	44.305	44.270	44.236	44.202
11 800	44.380	44.346	44.311	44.277	44.243
12 000	44.421	44.387	44.352	44.318	44.284

5.3 Determine the sulfur content of the sample to the nearest 0.02 % sulfur as described in Test Methods D 129, ~~Test Method~~ D 1266, ~~Test Method~~ D 2622, D 3120, D 4294, or ~~Test Method D 3120~~ D 5453 depending upon the volatility of the sample.

6. Calculation

6.1 Calculate the product of the aniline point in degrees Fahrenheit and the gravity in degrees API; round off the value obtained to the nearest integer.

6.2 From Tables 1-8, make a linear interpolation between rows bracketing the aniline-gravity products and within columns bracketing the sulfur content of the sample. Use the table applicable to the type of product being tested. Thus, use Table 1 or Table 5 for Aviation Gasolines, Table 2 or Table 6 for JP-4 jet-type fuels; Table 3 or Table 7 for JP-5 jet type fuels, and Table 4 or Table 8 for kerosene-type aviation turbine fuels (Specification D 1655, Jet A or A-1).

6.3 From the values obtained in 6.2, make a linear interpolation for the sulfur content within the row for the calculated aniline gravity constant.

6.3.1 *Example:*

Sample: JP-4 Fuel

6.3.1.1 *Determined Values:*

Aniline point, A = 137°F

Gravity, G = 54.8° API

Sulfur content = 0.10 mass %

6.3.1.2 *Calculated Value:*

A × G product = 7508

TABLE 2 Values of Q' for JP-4 Fuels Calculated from Eq 2 and Eq 9

Aniline-Gravity Product	Net Heat of Combustion, MJ/kg					
	0% Sulfur	0.2% Sulfur	0.4% Sulfur	0.6% Sulfur	0.8% Sulfur	1.0% Sulfur
5 200	43.092	43.026	42.960	42.894	42.828	42.762
5 400	43.141	43.075	43.009	42.943	42.877	42.811
5 600	43.190	43.124	43.058	42.992	42.926	42.860
5 800	43.239	43.173	43.107	43.041	42.975	42.908
6 000	43.288	43.222	43.156	43.090	43.023	42.957
6 200	43.337	43.271	43.205	43.138	43.072	43.006
6 400	43.387	43.320	43.254	43.187	43.121	43.054
6 600	43.436	43.369	43.303	43.236	43.169	43.103
6 800	43.485	43.418	43.351	43.285	43.218	43.152
7 000	43.534	43.467	43.400	43.334	43.267	43.200
7 200	43.583	43.516	43.449	43.383	43.316	43.249
7 400	43.632	43.565	43.498	43.431	43.364	43.297
7 600	43.681	43.614	43.547	43.480	43.413	43.346
7 800	43.730	43.663	43.596	43.529	43.462	43.395
8 000	43.780	43.712	43.645	43.578	43.511	43.443

TABLE 3 Values of Q′ for JP-5 Fuels Calculated from Eq 3 and Eq 9

Analine-Gravity Product	Net Heat of Combustion, MJ/kg					
	0% Sulfur	0.2% Sulfur	0.4% Sulfur	0.6% Sulfur	0.8% Sulfur	1.0% Sulfur
4 200	42.700	42.635	42.569	42.504	42.439	42.374
4 400	42.749	42.684	42.618	42.553	42.488	42.423
4 600	42.798	42.733	42.667	42.602	42.537	42.472
4 800	42.847	42.782	42.716	42.651	42.586	42.520
5 000	42.896	42.831	42.765	42.700	42.634	42.569
5 200	42.945	42.880	42.814	42.749	42.683	42.617
5 400	42.994	42.929	42.863	42.797	42.732	42.666
5 600	43.044	42.978	42.912	42.846	42.780	42.715
5 800	43.093	43.027	42.961	42.895	42.829	42.763
6 000	43.142	43.076	43.010	42.944	42.878	42.812
6 200	43.191	43.125	43.059	42.993	42.927	42.861
6 400	43.240	43.174	43.108	43.042	42.975	42.909
6 600	43.289	43.223	43.157	43.090	43.024	42.958
6 800	43.338	43.272	43.206	43.139	43.073	43.007
7 000	43.387	43.321	43.255	43.188	43.122	43.055

TABLE 4 Values of Q′ for Aviation Turbine Fuels Jet A and A-1 Calculated from Eq 4 and Eq 9

Aniline-Gravity Product	Net Heat of Combustion, MJ/kg				
	0% Sulfur	0.1% Sulfur	0.2% Sulfur	0.3% Sulfur	0.4% Sulfur
4 200	42.747	42.714	42.682	42.649	42.616
4 400	42.798	42.765	42.732	42.700	42.667
4 600	42.848	42.816	42.783	42.750	42.718
4 800	42.899	42.866	42.834	42.801	42.768
5 000	42.950	42.917	42.884	42.852	42.819
5 200	43.001	42.968	42.935	42.902	42.869
5 400	43.052	43.019	42.986	42.953	42.920
5 600	43.102	43.069	43.037	43.004	42.971
5 800	43.153	43.120	43.087	43.054	43.021
6 000	43.204	43.171	43.138	43.105	43.072
6 200	43.255	43.222	43.189	43.156	43.122
6 400	43.306	43.273	43.239	43.206	43.173
6 600	43.356	43.323	43.290	43.257	43.224
6 800	43.407	43.374	43.341	43.308	43.274
7 000	43.458	43.425	43.391	43.358	43.325
7 200	43.509	43.476	43.442	43.409	43.376
7 400	43.560	43.526	43.493	43.460	43.426
7 600	43.611	43.577	43.544	43.510	43.477
7 800	43.661	43.628	43.594	43.561	43.527
8 000	43.712	43.679	43.645	43.612	43.578
8 200	43.763	43.729	43.696	43.662	43.629
8 400	43.814	43.780	43.746	43.713	43.679
8 600	43.865	43.831	43.797	43.763	43.730
8 800	43.915	43.882	43.848	43.814	43.780
9 000	43.966	43.932	43.899	43.865	43.831
9 200	44.017	43.983	43.949	43.915	43.882
9 400	44.068	44.034	44.000	43.966	43.932
9 600	44.119	44.085	44.051	44.017	43.983
9 800	44.169	44.135	44.101	44.067	44.033
10 000	44.220	44.186	44.152	44.118	44.084

By interpolation from Table 2:

A × G	0 % Sulfur	0.1 % Sulfur	0.2 % Sulfur
7400	43.632		43.565
7508[A]	43.659[B]	43.625[C]	43.592[B]
7600	43.681		43.614

By interpolation from Table 6:

A × G	0.0 % Sulfur	0.1 % Sulfur	0.2 % Sulfur
7400	18 758		18 729
7508[A]	18 769[B]	18 755[C]	18 740[B]
7600	18 779		18 750

[A] Value calculated from determined values.
[B] First step interpolation between rows in columns bracketing the sulfur content.

TABLE 5 Values of Q′ for Aviation Gasolines Calculated from Eq 5 and Eq 10

Aniline-Gravity Product	Net Heat of Combustion, Btu/lb				
	0% Sulfur	0.1% Sulfur	0.2% Sulfur	0.3% Sulfur	0.4% Sulfur
4 000	18 391	18 377	18 363	18 349	18 335
4 200	18 409	18 395	18 381	18 367	18 352
4 400	18 426	18 412	18 398	18 384	18 370
4 600	18 444	18 430	18 416	18 402	18 388
4 800	18 462	18 448	18 433	18 419	18 405
5 000	18 479	18 465	18 451	18 437	18 423
5 200	18 497	18 483	18 469	18 455	18 440
5 400	18 515	18 500	18 486	18 472	18 458
5 600	18 532	18 518	18 504	18 490	18 476
5 800	18 550	18 536	18 522	18 507	18 493
6 000	18 568	18 553	18 539	18 525	18 511
6 200	18 585	18 571	18 557	18 543	18 528
6 400	18 603	18 589	18 574	18 560	18 546
6 600	18 621	18 606	18 592	18 578	18 564
6 800	18 638	18 624	18 610	18 595	18 581
7 000	18 656	18 642	18 627	18 613	18 599
7 200	18 674	18 659	18 645	18 631	18 616
7 400	18 691	18 677	18 663	18 648	18 634
7 600	18 709	18 695	18 680	18 666	18 652
7 800	18 727	18 712	18 698	18 684	18 669
8 000	18 744	18 730	18 716	18 701	18 687
8 200	18 762	18 748	18 733	18 719	18 704
8 400	18 780	18 765	18 751	18 736	18 722
8 600	18 797	18 783	18 768	18 754	18 740
8 800	18 815	18 800	18 786	18 772	18 757
9 000	18 833	18 818	18 804	18 789	18 775
9 200	18 850	18 836	18 821	18 807	18 792
9 400	18 868	18 853	18 839	18 824	18 810
9 600	18 886	18 871	18 857	18 842	18 828
9 800	18 903	18 889	18 874	18 860	18 845
10 000	18 921	18 906	18 892	18 877	18 863
10 200	18 939	18 924	18 909	18 895	18 880
10 400	18 956	18 942	18 927	18 912	18 898
10 600	18 974	18 959	18 945	18 930	18 915
10 800	18 992	18 977	18 962	18 948	18 933
11 000	19 009	18 995	18 980	18 965	18 951
11 200	19 027	19 012	18 998	18 983	18 968
11 400	19 045	19 030	19 015	19 001	18 986
11 600	19 062	19 048	19 033	19 018	19 003
11 800	19 080	19 065	19 050	19 036	19 021
12 000	19 098	19 083	19 068	19 053	19 039

TABLE 6 Values of Q' for JP-4 Fuels Calculated from Eq 6 and Eq 10

Aniline-Gravity Product	Net Heat of Combustion, Btu/lb					
	0% Sulfur	0.2% Sulfur	0.4% Sulfur	0.6% Sulfur	0.8% Sulfur	1.0% Sulfur
5 200	18 526	18 498	18 469	18 441	18 413	18 384
5 400	18 547	18 519	18 490	18 462	18 434	18 405
5 600	18 568	18 540	18 511	18 483	18 454	18 426
5 800	18 589	18 561	18 532	18 504	18 475	18 447
6 000	18 611	18 583	18 554	18 526	18 497	18 469
6 200	18 632	18 603	18 575	18 547	18 518	18 489
6 400	18 653	18 624	18 596	18 568	18 539	18 510
6 600	18 674	18 645	18 617	18 588	18 560	18 531
6 800	18 695	18 666	18 638	18 609	18 580	18 552
7 000	18 716	18 687	18 659	18 630	18 601	18 573
7 200	18 737	18 708	18 680	18 651	18 622	18 593
7 400	18 758	18 729	18 700	18 672	18 643	18 614
7 600	18 779	18 750	18 721	18 693	18 664	18 635
7 800	18 800	18 771	18 742	18 714	18 685	18 656
8 000	18 821	18 792	18 763	18 735	18 706	18 677

[C] Second step interpolation within a row between columns.

6.3.1.3 *Estimated Net Heat of Combustion:*

43.625 MJ/kg

18 755 Btu/lb

TABLE 7 Values of Q′ for JP-5 Fuels Calculated from Eq 7 and Eq 10

Aniline-Gravity Product	Net Heat of Combustion, Btu/lb					
	0% Sulfur	0.2% Sulfur	0.4% Sulfur	0.6% Sulfur	0.8% Sulfur	1.0% Sulfur
4 200	18 358	18 330	18 302	18 274	18 246	18 218
4 400	18 379	18 351	18 323	18 295	18 267	18 239
4 600	18 400	18 372	18 344	18 316	18 288	18 260
4 800	18 421	18 393	18 365	18 337	18 309	18 280
5 000	18 442	18 414	18 386	18 358	18 329	18 301
5 200	18 463	18 435	18 407	18 378	18 350	18 322
5 400	18 484	18 456	18 428	18 399	18 371	18 343
5 600	18 505	18 477	18 448	18 420	18 392	18 364
5 800	18 526	18 498	18 469	18 441	18 413	18 384
6 000	18 548	18 520	18 491	18 463	18 435	18 406
6 200	18 569	18 541	18 512	18 484	18 455	18 427
6 400	18 590	18 562	18 533	18 505	18 476	18 448
6 600	18 611	18 583	18 554	18 526	18 498	18 469
6 800	18 632	18 604	18 575	18 547	18 519	18 490
7 000	18 653	18 625	18 596	18 568	18 540	18 511

TABLE 8 Values of Q′ for Aviation Turbine Fuels Jet A and A-1 (Specification D 1655) Calculated from Eq 8 and Eq 10

Aniline-Gravity Product	Net Heat of Combustion, Btu/lb				
	0% Sulfur	0.05% Sulfur	0.10% Sulfur	0.15% Sulfur	0.20% Sulfur
4 200	18 378	18 371	18 364	18 357	18 350
4 400	18 400	18 393	18 386	18 379	18 372
4 600	18 421	18 414	18 407	18 400	18 393
4 800	18 443	18 436	18 429	18 422	18 415
5 000	18 465	18 458	18 451	18 444	18 437
5 200	18 487	18 480	18 473	18 466	18 459
5 400	18 509	18 502	18 495	18 488	18 481
5 600	18 531	18 524	18 517	18 509	18 502
5 800	18 553	18 545	18 538	18 531	18 524
6 000	18 574	18 567	18 560	18 553	18 546
6 200	18 596	18 589	18 582	18 575	18 568
6 400	18 618	18 611	18 604	18 597	18 590
6 600	18 640	18 633	18 626	18 619	18 611
6 800	18 662	18 655	18 647	18 640	18 633
7 000	18 684	18 676	18 669	18 662	18 655
7 200	18 705	18 698	18 691	18 684	18 677
7 400	18 727	18 720	18 713	18 706	18 699
7 600	18 749	18 742	18 735	18 728	18 720
7 800	18 771	18 764	18 757	18 749	18 742
8 000	18 793	18 786	18 778	18 771	18 764
8 200	18 815	18 807	18 800	18 793	18 786
8 400	18 837	18 829	18 822	18 815	18 808
8 600	18 858	18 851	18 844	18 837	18 829
8 800	18 880	18 873	18 866	18 858	18 851
9 000	18 902	18 895	18 888	18 880	18 873
9 200	18 924	18 917	18 909	18 902	18 895
9 400	18 946	18 938	18 931	18 924	18 917
9 600	18 968	18 960	18 953	18 946	18 938
9 800	18 989	18 982	18 975	18 968	18 960
10 000	19 011	19 004	18 997	18 989	18 982

7. Report

7.1 Report the result in megajoule per kilogram to the nearest 0.001 or British thermal units per pound to the nearest integer as estimated Net Heat of Combustion, D1405.

8. Precision and Bias

8.1 *Repeatability*—The difference between successive test results obtained by the same operator with the apparatus under constant operating conditions on identical test material (using a second set of measured values for the aniline point temperature, the relative density, and the sulfur content determined by Test Methods D 611, D 1298, and D 129, respectively) 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 = 0.012 MJ/kg~~ (11)

Repeatability = 0.012 MJ/kg or 5 BTU/lb (11)

8.2 *Reproducibility*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material (using the aniline point temperature, the relative density, and the sulfur content determined by Test Methods D 611, D 1298, and D 129, respectively) would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

~~Reproducibility = 0.035 MJ/kg~~ (12)

Reproducibility = 0.035 MJ/kg or 15 BTU/lb (12)

NOTE ~~5~~4—Use of fuel property data obtained with greater or lesser precision than that of the methods indicated will have a like trend on the precision of the predicted heat of combustion.

8.3 *Bias*—No general statement is made on bias for the standard, since the data used to determine the correlation cannot be compared with accepted reference materials.

9. Keywords

9.1 aviation fuel; gross heat of combustion; heat energy; heat of combustion; heating tests; net heat of combustion