INTERNATIONAL STANDARD ISO 3648

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Aviation fuels — Estimation of net heat of combustion

Carburants aviation — Estimation du pouvoir calorifique inférieur

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3648 was drawn up by Technical Committee ISO/TC 28, *Petroleum products*, and circulated to the Member Bodies in November 1974.

It has been approved by the Member Bodies of the following countries :

Australia	Germany	Spain
Austria	Iran	Sweden
Belgium	Israel	Turkey
Brazil	Mexico	United Kingdom
Bulgaria	Netherlands	U.S.A.
Canada	Portugal	Yugoslavia
Czechoslovakia	South Africa, Rep. of	

No Member Body expressed disapproval of the document.

This International Standard should be considered as an interim document, until new correlations can be established exclusively in SI units between the net heat of combustion and the product of the aniline point and density which will give results at least as reliable as the present method.

Aviation fuels – Estimation of net heat of combustion

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard specifies a method for the estimation of the net heat of combustion of aviation fuels, in megajoules per kilogram or British thermal units per pound. It is not applicable to pure hydrocarbons.

1.2 The method is purely empirical and is applicable only to liquid hydrocarbon fuels which conform to the requirements of specifications for aviation gasolines, or aircraft turbine and jet engine fuels of types Aviation turbine fuel, wide cut; Aviation turbine fuel, high flash; and Aviation turbine fuel, kerosine (see note 1). The method is intended for use as a guide in cases where an experimentally determined heat of combustion is not available and cannot be made conveniently, and where an estimate is considered satisfactory. It is not intended, for specifications and similar purposes, that estimated values of the net heat of combustion shall be used in place of experimentally determined values (see note 2).

NOTES

1 Internationally understood designations used by the air transport industry may be encountered, for example :

JP-4, Avtag and Jet B for Aviation turbine fuel, wide cut;

JP-5 and Avcat for Aviation turbine fuel, high flash;

Jet A, Jet A1 and Avtur for Aviation turbine fuel, kerosine.

2 The estimation of the net heat of combustion of hydrocarbon fuel from its aniline-gravity product is justifiable only when the fuel belongs to a well-defined type for which a relation between heat of combustion and aniline-gravity product has been derived from accurate experimental measurements on representative samples of that type. Even in this case, the possibility that the estimates may be in error by large amounts for individual fuels should be recognized.

2 REFERENCES

ISO/R 91, *Petroleum measurement tables.*

ISO 2192, *Petroleum products – Determination of sulphur – Lamp method.*

ISO 2977, *Petroleum products and hydrocarbon solvents – Determination of aniline and mixed aniline point.*

ISO 3675, *Crude petroleum and liquid petroleum products – Determination of density or relative density – Hydrometer method.*[1]

ISO 4260, *Petroleum products – Determination of sulphur content – Wickbold combustion method.*[1]

3 PRINCIPLE

3.1 Correlations have been established between the net heat of combustion and the product of the aniline point in degrees Fahrenheit and API gravity. These relations, assuming the sample to be sulphur-free, are given by the following equations :

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

Type of fuel	Equation	Equation No.
Aviation gasoline, Grades 100 and 115	$Q_{p(net)} = 41{,}955\,7 + 0{,}000\,205\,43\,(A \times G)$	(1)
Aviation turbine fuel, wide cut	$Q_{p(net)} = 41{,}814\,5 + 0{,}000\,245\,63\,(A \times G)$	(2)
Aviation turbine fuel, high flash	$Q_{p(net)} = 41{,}668\,0 + 0{,}000\,245\,63\,(A \times G)$	(3)
Aviation turbine fuel, kerosine	$Q_{p(net)} = 41{,}679\,6 + 0{,}000\,254\,07\,(A \times G)$	(4)

where

$Q_{p(net)}$ is the net heat of combustion, in megajoules per kilogram, on a sulphur-free basis;

A is the aniline point, in degrees Fahrenheit;

G is the API gravity, degrees.

1) At present at the stage of draft.

3.1.2 Where the net heat of combustion is required in U.K. non-metric or U.S. Customary Units (British thermal units per pound) :

Type of fuel	Equation	Equation No.
Aviation gasoline, Grades 100 and 115	$Q_{p(net)} = 18\ 037 + 0{,}088\ 32\ (A \times G)$	(6)
Aviation turbine fuel, wide cut	$Q_{p(net)} = 17\ 977 + 0{,}105\ 6\ (A \times G)$	(7)
Aviation turbine fuel, high flash	$Q_{p(net)} = 17\ 914 + 0{,}105\ 6\ (A \times G)$	(8)
Aviation turbine fuel, kerosine	$Q_{p(net)} = 17\ 919 + 0{,}109\ 23\ (A \times G)$	(9)

where

$Q_{p(net)}$ is the net heat of combustion, in British thermal units per pound, on a sulphur-free basis;

A is the aniline point, in degrees Fahrenheit;

G is the API gravity, degrees.

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

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

$$Q' = Q_{p(net)}\ \text{MJ/kg} \times (1 - 0{,}01\ S) + 0{,}101\ 6\ S \qquad \ldots (5)$$

where

Q' is the net heat of combustion, in megajoules per kilogram, of the sample containing S % sulphur;

S is the sulphur content of the sample, as a percentage by mass;

0,101 6 is a constant based on the thermochemical data on sulphur compounds.

3.2.2 Where the net heat of combustion is required in U.K. non-metric or U.S. Customary Units (British thermal units per pound) :

$$Q' = Q_{p(net)}\ \text{Btu/lb} \times (1 - 0{,}01\ S) + 43{,}7\ S \qquad \ldots (10)$$

where

Q' is the net heat of combustion, in British thermal units per pound, of the sample containing S % sulphur;

S is the sulphur content of the sample, as a percentage by mass;

43,7 is a constant based on the thermochemical data on sulphur compounds.

3.3 The empirical linear equations (1), (2), (3), (4) and (6), (7), (8), (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 Aviation turbine fuel, wide cut; Aviation turbine fuel, high flash; and to specifications for Aviation turbine fuels, kerosine.

4 PROCEDURE

4.1 Determine the aniline point of the sample, A', in degrees Celsius to the nearest 0,1 °C as specified in ISO 2977. Obtain the aniline point, A, in degrees Fahrenheit to the nearest 0,2 °F from table 2 referred to in ISO/R 91 or from the relation

$$A = 1{,}8\ A' + 32$$

4.2 Determine the API gravity of the sample, G, to the nearest 0,1 °API as specified in ISO 3675 (sub-clause 8.3 or annex).

4.3 Determine the sulphur content of the sample, S, to the nearest 0,02 % (m/m) sulphur as specified in ISO 2192 or ISO 4260, depending upon the volatility of the sample.

5 EXPRESSION OF RESULTS

5.1 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.

5.2 From tables 1, 2, 3, 4 or 5, 6, 7, 8, make a linear interpolation between rows, bracketing the aniline-gravity products, and within columns, bracketing the sulphur content of the sample. The tables used shall be those applicable to the type of product being tested; that is tables 1 or 5 shall be used for Aviation gasolines; tables 2 or 6 shall be used for Aviation turbine fuel, wide cut; tables 3 or 7 shall be used for Aviation turbine fuel, high flash; and tables 4 or 8 shall be used for Aviation turbine fuels, kerosine.

5.3 From the values obtained in accordance with 5.2, make a linear interpolation for the sulphur content within the row for the calculated aniline-gravity product.

Example :

Sample : Aviation turbine fuel, wide cut

Determined values :

Aniline point	$A = 137$ °F
Gravity	$G = 54{,}8$ °API
Sulphur content	$S = 0{,}10$ % (m/m)

Calculated value : $A \times G = 7\ 508$

By interpolation from table 2

A × *G*	0 % sulphur	0,1 % sulphur	0,2 % sulphur
7 400	43,63		43,57
7 508*	43,66**	43,63***	43,59**
7 600	43,68		43,61

or table 6

A × *G*	0 % sulphur	0,1 % sulphur	0,2 % sulphur
7 400	18 758		18 729
7 508*	18 769**	18 755***	18 740**
7 600	18 779		18 750

* Value calculated from determined values.

** First step : Interpolation between rows in columns bracketing the sulphur content.

*** Second step : Interpolation within a row between columns.

Estimated net heat of combustion : 43,63 MJ/kg
18 755 Btu/lb

6 PRECISION

The precision of the method, as obtained by statistical examination of inter-laboratory test results, is as follows :

6.1 Repeatability

The difference between two test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material, 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 :

0,012 MJ/kg (see note in 6.2)
5 Btu/lb

6.2 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, in the normal and correct operation of the test method, exceed the following value only in one case in twenty :

0,035 MJ/kg (see note)
15 Btu/lb

NOTE — These values and all other values involved have been calculated using the following equation :

1 Btu/lb = 0,002 326 MJ/kg

7 TEST REPORT

Report the result in megajoules per kilogram or British thermal units per pound as the estimated net heat of combustion, and make reference to this International Standard.

TABLE 1 – **Values of *Q'* for Aviation gasolines, calculated from equations (1) and (5)**

Aniline-gravity product	**Net heat of combustion, MJ/kg**				
	0 % sulphur	**0,1 % sulphur**	**0,2 % sulphur**	**0,3 % sulphur**	**0,4 % sulphur**
4 000	42,78	42,74	42,71	42,68	42,65
4 200	42,82	42,79	42,75	42,72	42,69
4 400	42,86	42,83	42,79	42,76	42,73
4 600	42,90	42,87	42,84	42,80	42,77
4 800	42,94	42,91	42,88	42,84	42,81
5 000	42,98	42,95	42,92	42,88	42,85
5 200	43,02	42,99	42,96	42,93	42,89
5 400	43,07	43,03	43,00	42,97	42,93
5 600	43,11	43,07	43,04	43,01	42,97
5 800	43,15	43,11	43,08	43,05	43,02
6 000	43,19	43,16	43,12	43,09	43,06
6 200	43,23	43,20	43,16	43,13	43,10
6 400	43,27	43,24	43,20	43,17	43,14
6 600	43,31	43,28	43,25	43,21	43,18
6 800	43,35	43,32	43,29	43,25	43,22
7 000	43,39	43,36	43,33	43,29	43,26
7 200	43,43	43,40	43,37	43,33	43,30
7 400	43,48	43,44	43,41	43,38	43,34
7 600	43,52	43,48	43,45	43,42	43,38
7 800	43,56	43,52	43,49	43,46	43,42
8 000	43,60	43,57	43,53	43,50	43,47
8 200	43,64	43,61	43,57	43,54	43,51
8 400	43,68	43,65	43,61	43,58	43,55
8 600	43,72	43,69	43,66	43,62	43,59
8 800	43,76	43,73	43,70	43,66	43,63
9 000	43,80	43,77	43,74	43,70	43,67
9 200	43,85	43,81	43,78	43,74	43,71
9 400	43,89	43,85	43,82	43,79	43,75
9 600	43,93	43,89	43,86	43,83	43,79
9 800	43,97	43,94	43,90	43,87	43,83
10 000	44,01	43,98	43,94	43,91	43,87
10 200	44,05	44,02	43,98	43,95	43,92
10 400	44,09	44,06	44,02	43,99	43,96
10 600	44,13	44,10	44,07	44,03	44,00
10 800	44,17	44,14	44,11	44,07	44,04
11 000	44,22	44,18	44,15	44,11	44,08
11 200	44,26	44,22	44,19	44,15	44,12
11 400	44,30	44,26	44,23	44,20	44,16
11 600	44,34	44,30	44,27	44,24	44,20
11 800	44,38	44,35	44,31	44,28	44,24

TABLE 2 – **Values of *Q'* for Aviation turbine fuel, wide cut, calculated from equations (2) and (5)**

Aniline-gravity product	**Net heat of combustion, MJ/kg**					
	0 % sulphur	**0,2 % sulphur**	**0,4 % sulphur**	**0,6 % sulphur**	**0,8 % sulphur**	**1,0 % sulphur**
5 200	43,09	43,03	42,96	42,89	42,83	42,76
5 400	43,14	43,07	43,01	42,94	42,88	42,81
5 600	43,19	43,12	43,06	42,99	42,93	42,86
5 800	43,24	43,17	43,11	43,04	42,97	42,91
6 000	43,29	43,22	43,16	43,09	43,02	42,96
6 200	43,34	43,27	43,20	43,14	43,07	43,01
6 400	43,39	43,32	43,25	43,19	43,12	43,05
6 600	43,44	43,37	43,30	43,24	43,17	43,10
6 800	43,48	43,42	43,35	43,28	43,22	43,15
7 000	43,53	43,47	43,40	43,33	43,27	43,20
7 200	43,58	43,52	43,45	43,38	43,32	43,25
7 400	43,63	43,57	43,50	43,43	43,36	43,30
7 600	43,68	43,61	43,55	43,48	43,41	43,35
7 800	43,73	43,66	43,60	43,53	43,46	43,39
8 000	43,78	43,71	43,65	43,58	43,51	43,44

TABLE 3 – **Values of *Q'* for Aviation turbine fuels, high flash, calculated from equations (3) and (5)**

Aniline-gravity product	**Net heat of combustion, MJ/kg**					
	0 % sulphur	**0,2 % sulphur**	**0,4 % sulphur**	**0,6 % sulphur**	**0,8 % sulphur**	**1,0 % sulphur**
4 200	42,70	42,63	42,57	42,50	42,44	42,37
4 400	42,75	42,68	42,62	42,55	42,49	42,42
4 600	42,80	42,73	42,67	42,60	42,54	42,47
4 800	42,85	42,78	42,72	42,65	42,59	42,52
5 000	42,90	42,83	42,77	42,70	42,63	42,57
5 200	42,95	42,88	42,81	42,75	42,68	42,62
5 400	42,99	42,93	42,86	42,80	42,73	42,67
5 600	43,04	42,98	42,91	42,85	42,78	42,71
5 800	43,09	43,03	42,96	42,90	42,83	42,76
6 000	43,14	43,08	43,01	42,94	42,88	42,81
6 200	43,19	43,12	43,06	42,99	42,93	42,86
6 400	43,24	43,17	43,11	43,04	42,98	42,91
6 600	43,29	43,22	43,16	43,09	43,02	42,96
6 800	43,34	43,27	43,21	43,14	43,07	43,01
7 000	43,39	43,32	43,25	43,19	43,12	43,06