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Petroleum products — Estimation of net specific energy of aviation turbine fuels using hydrogen content data

Produits pétroliers — Estimation de l'énergie spécifique inférieure des carburéacteurs à partir de la teneur en hydrogène

Reference number
ISO 15911:2000(E)

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15911 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*.

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Petroleum products — Estimation of net specific energy of aviation turbine fuels using hydrogen content data

WARNING — The use of this International Standard may involve hazardous material, operations and equipment. This International Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1 Scope

This International Standard describes a procedure for the estimation of the net specific energy of aviation turbine fuels using hydrogen content data. It is not applicable to pure hydrocarbons.

The 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 aircraft turbine and jet engine fuels of limited boiling ranges and compositions.

NOTE 1 The method is intended for use as a guide in cases where an experimental determination of net specific energy is not available and cannot be made conveniently, and where an estimate is considered satisfactory for specifications and similar purposes. It is not intended that estimated values of the net specific energy be used in place of experimentally determined values.

NOTE 2 The estimation of the net specific energy of hydrocarbon fuel from its sulfur content, hydrogen content and density is justifiable only when the fuel belongs to a well-defined class for which a relationship between net specific energy and sulfur content, hydrogen content and density has been derived from accurate experimental measurements on representative samples of this class. Even in this class, the possibility that the estimates can be in error by large amounts for individual fuels must be recognized.

NOTE 3 The fuels used to establish the correlation presented in this International Standard are defined in annex A.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 91-1:1992, *Petroleum measurement tables — Part 1: Tables based on reference temperatures of 15 °C and 60 °F.*

ISO 3675:1998, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method.*

ISO 4260:1987, *Petroleum products and hydrocarbons — Determination of sulfur content — Wickbold combustion method.*

ISO 8754:1992, *Petroleum products — Determination of sulfur content — Energy-dispersive X-ray fluorescence method.*

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ISO 12185:1996, *Crude petroleum and petroleum products — Determination of density — Oscillating U-tube method.*

IP 338/98, *Determination of hydrogen content of aviation turbine fuels — Low resolution nuclear magnetic resonance spectrometry method.*

ASTM D 3701-98, *Standard test method for hydrogen content of aviation turbine fuels by low resolution nuclear magnetic resonance spectroscopy.*

3 Term and definition

For the purposes of this International Standard, the following term and definition applies.

3.1
net specific energy
amount of heat liberated when a unit mass or volume of fuel is burnt in air saturated with water vapour under constant pressure, and the products of combustion are cooled to a specified temperature

NOTE 1 The net specific energy is the gross specific energy less the latent heat of the water produced during combustion.

NOTE 2 The terms "calorific value" and "heat of combustion" are synonymous with specific energy.

4 Principle

The hydrogen content, sulfur content and density of the sample are determined by experimental test methods and the net specific energy is calculated from these test data using known correlations.

5 Procedure

5.1 Determine the mass fraction of hydrogen in the sample to the nearest 0,01 % (*m/m*) in accordance with the procedure described in IP 338 or ASTM D 3701.

NOTE For the purposes of this International Standard, the expression "% (*m/m*)" is used to represent the mass fraction of a material.

5.2 Determine the density of the sample at 15 °C, to the nearest 0,5 kg/m^3, in accordance with the procedure described in ISO 3675 or ISO 12185, using the corrections given in ISO 91-1 if appropriate.

5.3 Determine the mass fraction of sulfur in the sample, to the nearest 0,02 % (*m/m*), in accordance with the procedure described in ISO 4260 or ISO 8754.

6 Calculation

6.1 Calculate the net specific energy at constant pressure on a mass basis, e_p in megajoules per kilogram, by inserting the measured values of mass fraction of hydrogen, mass fraction of sulfur and density in equation (1).

$$e_p = 37{,}288\,9 + 0{,}556\,173\omega_{\mathrm{H}} - 0{,}326\,6\omega_{\mathrm{S}} - 0{,}002\,300\,3\rho \qquad (1)$$

where

ω_{H} is the mass fraction of hydrogen, expressed as a percentage by mass;

ω_{S} is the mass fraction of sulfur, expressed as a percentage by mass;

ρ is the density at 15 °C, expressed in kilograms per cubic metre.

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6.2 Calculate the net specific energy at constant pressure on a volume basis, e_{pV}, in megajoules per cubic metre, by means of equation (2).

$$e_{pV} = e_p \times \rho \quad (2)$$

7 Expression of results

Report the result, to the nearest 0,01 MJ/kg or 10 MJ/m^3, as the net specific energy on a mass or volume basis respectively.

This International Standard was originally derived for fuels on a mass basis only. To enable reporting on an equivalent volume basis, calculations show that, for the range of fuel densities for which this International Standard applies, results should be reported on a volume basis to the nearest 10 MJ/m^3.

8 Precision

8.1 General

The precision of this International Standard, as obtained by statistical examination of interlaboratory test results when using the data from IP 338, ASTM D 3701, ISO 3675 and ISO 4260, is given in 8.2 and 8.3.

8.2 Repeatability, r

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 in only one case in 20:

r = 0,05 MJ/kg on a mass basis

8.3 Reproducibility, R

The difference between two single and independent test 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 in only one case in 20:

R = 0,06 MJ/kg on a mass basis

NOTE 1 The precision for this International Standard was derived for fuels on a mass basis only. As a guide, an estimate of precision on a volume basis has been calculated for a fuel with a density of 810,0 kg/m^3 as follows:

Repeatability: 40 MJ/m^3

Reproducibility: 50 MJ/m^3

These values have been rounded off to the nearest 10 MJ/m^3.

NOTE 2 Use of fuel property data obtained with greater or lesser precision than that of the test methods indicated will have a similar trend in the precision of the predicted specific energy.

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9 Test report

The test report shall contain at least the following information:

a) a reference to this International Standard;

b) the type and complete identification of the product tested;

c) the result of the test (see clause 7);

d) any deviation, by agreement or otherwise, from the procedure specified;

e) the date of the test.

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Annex A
(informative)

Correlation fuels

A.1 The fuels used to establish the correlation presented in this International Standard are defined by the specifications given in Table A.1.

Table A.1 — Fuel specifications

Fuel	Specification (see the bibliography)
AVTUR, Jet A-1	Def Stan 91-91 (DERD 2494) [2-5] ASTM D 1655 [1]
Jet A	ASTM D 1655 [1]
AVCAT/FSII	Def Stan 91-86 (DERD 2452) [6]
AVTUR/FSII	Def Stan 91-87 (DERD 2453) [7]
JP-4, JP-5, JP-5 ST, JP-8 ST	MIL-T-5624 [8]

A.2 The precision of this International Standard was derived using the range of test fuels which can be characterized by the following properties:

a) mass fraction of hydrogen: 13,00 % (*m/m*) to 14,14 % (*m/m*);

b) mass fraction of sulfur: 0,01 % (*m/m*) to 0,33 % (*m/m*);

c) density at 15 °C: 789,0 kg/m^3 to 830,5 kg/m^3.

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Bibliography

[1] ASTM D 1655-97, *Standard specification for aviation turbine fuels.*

[2] Def Stan 91-91/Issue 2 (DERD 2494): 8 May 1996, *Turbine fuel, aviation kerosine type, Jet A-1. NATO code: F-35. Joint Service Designation: AVTUR.*

[3] Def Stan 91-91/Issue 2 – Amendment 1: 14 May 1996.

[4] Def Stan 91-91/Issue 2 – Amendment 2: 6 August 1997.

[5] Def Stan 91-91/Issue 2 – Amendment 3: 11 September 1998.

[6] Def Stan 91-86/Issue 2 (DERD 2452): 23 May 1997, *Turbine fuel, Aviation: high flash type, containing fuel system icing inhibitor. NATO code: F-44. Joint Service Designation: AVCAT/FSII.*

[7] Def Stan 91-87/Issue 2 (DERD 2453): 23 May 1997, *Turbine fuel, aviation: kerosine type, containing fuel system icing inhibitor. NATO code: F-34. Joint Service Designation: AVTUR/FSII.*

[8] MIL-T-5624R: 3 Mar 1995, *Turbine fuel, aviation, grades JP-4, JP-5 and JP-5/JP-8 ST.*

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