INTERNATIONAL STANDARD

**ISO 3648**

Second edition
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# Aviation fuels — Estimation of net specific energy

*Carburants aviation — Estimation de l'énergie massique*

Reference number
ISO 3648:1994(E)

# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

International Standard ISO 3648 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*.

This second edition cancels and replaces the first edition (ISO 3648:1976), which has been technically revised.



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# Aviation fuels — Estimation of net specific energy

**WARNING — The use of the International Standard may involve hazardous materials, operations and equipment. This standard does not purport to address all of the safety problems 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.**

## 1 Scope

**1.1** This International Standard describes a procedure for the estimation of the net specific energy of aviation fuels from their aniline point, density and sulfur content. 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 aviation gasolines, or aircraft turbine and jet engine fuels of limited boiling ranges and compositions.

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

— 100/130, 100LL and 115/145 for aviation gasolines;

— Jet A, JetA-1, Avtur and JP-8 for aviation turbine fuels, kerosine type;

— Avcat, and JP-5 for aviation turbine fuels, high flash;

— Jet B, Avtag and JP-4 for aviation turbine fuels, wide cut.

**1.2** 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. It is not intended, for specific specifications and similar purposes, that estimated values of the net specific energy shall be used in place of experimentally determined values.

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

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO 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 degrees F.*

ISO 2977:1989, *Petroleum products and hydrocarbon solvents — Determination of aniline point and mixed aniline point.*

ISO 3675:1993, *Crude petroleum and liquid petroleum products — Laboratory determination of density or relative 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.*

ISO 12185:—[1], *Petroleum products — Determination of density — Digital density meter method.*

## 3 Definition

For the purposes of this International Standard, the following 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.

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

NOTE 3 The terms "calorific value" and "heat of combustion" are synonymous with specific energy.

## 4 Principle

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

## 5 Procedure

**5.1** Determine the aniline point of the sample, to the nearest 0,05 °C, in accordance with ISO 2977.

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

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

## 6 Calculation

**6.1** Calculate the net specific energy at constant pressure on a sulfur-free basis using the procedure in either 6.1.1 or 6.1.2.

**6.1.1** Insert the measured values in equation (1) below and calculate the net specific energy at constant pressure on a sulfur-free basis ($e_p$).

$$e_p = 22{,}959\,6 - 0{,}012\,658\,7\,A + 26\,640{,}9/D + 32{,}622\,A/D - \left(6{,}690\,3 \times 10^{-5}\right)A^2 - \left(9{,}217\,76 \times 10^{6}\right)/D^2 \quad \ldots (1)$$

where

$A$ is the aniline point, in degrees Celsius;

$D$ is the density at 15 °C, in kilograms per cubic metre;

$e_p$ is the net specific energy at constant pressure on a sulfur-free basis, in megajoules per kilogram.

**6.1.2** Interpolate the measured values into table 1, using linear interpolation between both the rows representing density, and the columns representing aniline point, to obtain the net specific energy in megajoules per kilogram.

**6.2** Calculate the net specific energy corrected for sulfur content by means of equation (2):

$$e'_p = e_p - 0{,}116\,3\,S \quad \ldots (2)$$

where

$e'_p$ is the net specific energy corrected for sulfur content, in megajoules per kilogram;

$e_p$ is the net specific energy at constant pressure, calculated as in 6.1, in megajoules per kilogram;

$S$ is the sulfur content, in percentage by mass.

1) To be published.

**Table 1 — Net specific energy**

| Density at 15 °C, kg/m³ | Net specific energy, MJ/kg | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aniline point, °C | | | | | | |
| | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| 650,0 | 42,852 2 | 43,194 1 | 43,522 5 | 43,837 6 | 44,139 3 | 44,427 6 | 44,702 6 |
| 660,0 | 42,872 1 | 43,206 4 | 43,527 2 | 43,834 7 | 44,128 8 | 44,409 5 | 44,676 8 |
| 670,0 | 42,881 9 | 43,208 7 | 43,522 2 | 43,822 3 | 44,109 0 | 44,382 4 | 44,642 3 |
| 680,0 | 42,882 3 | 43,202 0 | 43,508 3 | 43,801 3 | 44,080 8 | 44,347 0 | 44,599 8 |
| 690,0 | 42,874 3 | 43,187 0 | 43,486 4 | 43,772 3 | 44,044 9 | 44,304 2 | 44,550 0 |
| 700,0 | 42,858 4 | 43,164 4 | 43,457 0 | 43,736 2 | 44,002 1 | 44,254 5 | 44,493 6 |
| 710,0 | 42,835 4 | 43,134 8 | 43,420 9 | 43,693 5 | 43,952 8 | 44,198 7 | 44,431 3 |
| 720,0 | 42,805 9 | 43,099 0 | 43,378 6 | 43,644 9 | 43,897 3 | 44,137 3 | 44,363 5 |
| 730,0 | 42,770 4 | 43,057 3 | 43,330 7 | 43,590 8 | 43,837 5 | 44,070 8 | 44,290 8 |
| 740,0 | 42,729 5 | 43,010 3 | 43,277 8 | 43,531 8 | 43,772 5 | 43,999 7 | 44,213 6 |
| 750,0 | 42,683 7 | 42,958 6 | 43,220 1 | 43,468 3 | 43,703 1 | 43,924 5 | 44,132 5 |
| 760,0 | 42,633 2 | 42,902 4 | 43,158 2 | 43,400 7 | 43,629 7 | 43,845 4 | 44,047 7 |
| 770,0 | 42,578 7 | 42,842 3 | 43,092 5 | 43,329 4 | 43,552 9 | 43,763 0 | 43,959 7 |
| 780,0 | 42,520 3 | 42,778 5 | 43,023 3 | 43,257 4 | 43,472 8 | 43,677 5 | 43,868 7 |
| 790,0 | 42,458 5 | 42,711 4 | 42,950 9 | 43,177 1 | 43,389 8 | 43,589 2 | 43,775 2 |
| 800,0 | 42,393 6 | 42,641 3 | 42,875 7 | 43,096 7 | 43,304 3 | 43,498 5 | 43,679 3 |
| 810,0 | 42,325 8 | 42,568 5 | 42,797 8 | 43,013 8 | 43,216 3 | 43,405 5 | 43,581 3 |
| 820,0 | 42,255 5 | 42,493 3 | 42,717 7 | 42,928 7 | 43,126 4 | 43,310 6 | 43,481 5 |
| 830,0 | 42,182 8 | 42,415 8 | 42,635 4 | 42,841 7 | 43,034 5 | 43,214 0 | 43,380 1 |
| 840,0 | 42,108 0 | 42,336 3 | 43,551 3 | 42,752 8 | 42,941 0 | 43,115 8 | 43,277 2 |
| 850,0 | 42,031 3 | 42,255 1 | 42,465 5 | 42,662 4 | 42,846 0 | 43,016 3 | 43,173 1 |
| 860,0 | 41,952 9 | 42,172 2 | 42,378 1 | 42,570 7 | 42,749 8 | 42,915 6 | 43,065 0 |
| 870,0 | 41,873 0 | 42,087 9 | 42,289 5 | 42,477 7 | 42,652 4 | 42,813 8 | 42,961 9 |
| 880,0 | 41,791 7 | 42,002 4 | 42,199 7 | 42,383 6 | 42,554 1 | 42,711 2 | 42,855 0 |
| 890,0 | 41,709 2 | 41,915 7 | 42,108 5 | 42,288 6 | 42,454 9 | 42,607 9 | 42,747 5 |

**6.3** Calculate the volumetric net specific energy by means of the equation:

$$e_{pv} = e_p D \quad \ldots (3)$$

or

$$e'_{pv} = e'_p D \quad \ldots (4)$$

where

$e_{pv}$ is the volumetric net specific energy on a sulfur-free basis, in megajoules per cubic metre;

$e'_{pv}$ is the volumetric net specific energy corrected for sulfur content, in megajoules per cubic metre;

$e_p$ and $D$ are as defined in 6.1.1;

$e'_p$ is as defined in 6.2.

## 7 Expression of results

Report the result, to the nearest 0,001 MJ/kg or 1 MJ/m³, as the net specific energy on a mass or volume basis respectively.

## 8 Precision

The precision of this International Standard, as obtained by statistical examination of interlaboratory test results when using the data from ISO 2977, ISO 3675, and ISO 4260 is given in 8.1 and 8.2 below.

**8.1 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 values only in one case in twenty:

0,012 MJ/kg

**8.2 Reproducibility.** The difference between two single and independent results obtained by different operators working in different laboratories on nominally identical test material, 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:

0,035 MJ/kg

NOTE 4 Use of fuel data obtained with greater or lesser precision than that of the test methods indicated will have a like trend in the precision of the predicted specific energy.

## 9 Test report

The test report shall contain at least the following information:

a) a reference to this International Standard;

b) all details necessary for 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 in this International Standard;

e) the date of the test.

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**Descriptors:** petroleum products, automotive fuels, aviation fuels, tests, determination, calorific value.

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