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Petroleum products — Calculation of cetane index of middle-distillate fuels by the four variable equation

Produits pétroliers — Calcul de l'indice de cétane des distillats moyens par équation à quatre variables

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*.

This third edition cancels and replaces the second edition (ISO 4264:2007), which has been technically revised.

The main changes from the previous edition are as follows:

— this edition includes a statement on the existence of sample specific bias;

— the second procedure to establish the cetane index using nomography is moved into an informative annex;

— ISO 3924 is added as an alternative to test method ISO 3405.

Petroleum products — Calculation of cetane index of middle-distillate fuels by the four variable equation

WARNING — Use of this document can involve hazardous materials, operations and equipment. This document does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this document to take appropriate measures to ensure the safety and health of personnel prior to application of the document and to determine the applicability of any other restrictions for this purpose.

1 Scope

This document specifies a procedure for the calculation of the cetane index of middle-distillate fuels from petroleum-derived sources. The calculated value is termed the “cetane index by four-variable equation”. Throughout the remaining text of this document, the term “cetane index” implies cetane index by four-variable equation.

This document is applicable to fuels containing non-petroleum derivatives from tar sand and oil shale. It is not applicable to pure hydrocarbons, nor to distillate fuels derived from coal. Cetane index calculations do not take into account the effects from additives used to enhance the Cetane number.

NOTE 1 This document was originally developed using a matrix of fuels, some of which contain non-petroleum derivatives from tar sands and oil shale.

NOTE 2 The cetane index is not an alternative way to express the cetane number; it is a supplementary tool, to be used with due regard for its limitations.

NOTE 3 The cetane index is used to estimate the cetane number of diesel fuel when a test engine is not available to determine this property directly, or when insufficient sample is available for an engine rating.

The most suitable range of fuel properties for application of this document is as follows:

Fuel property	**Range**
Cetane number	32,5 to 56,5
Density at 15 °C, kg/m^3	805,0 to 895,0
10 % (V/V) distillation recovery temperature, °C	171 to 259
50 % (V/V) distillation recovery temperature, °C	212 to 308
90 % (V/V) distillation recovery temperature, °C	251 to 363

Within the range of cetane number (32,5 to 56,5), the expected error of the prediction via the cetane index equation will be less than ±2 cetane numbers for 65 % of the distillate fuels examined. Errors can be greater for fuels whose properties fall outside this range of application.

As a consequence of sample-specific biases observed, the expected error can be greater even when the fuel’s properties fall inside the recommended range of application. Therefore, users can assess the required degree of prediction agreement to determine the fitness-for-use of the prediction.

NOTE 4 Sample specific biases were observed for distillate fuels containing FAME (fatty acid methyl ester).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 91, *Petroleum and related products — Temperature and pressure volume correction factors (petroleum measurement tables) and standard reference*

ISO 3405, *Petroleum products — Determination of distillation characteristics at atmospheric pressure*

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

ISO 3924, *Petroleum products — Determination of boiling range distribution — Gas chromatography method*

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

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Principle

The density at 15 °C and the temperatures at which 10 % (*V*/*V*), 50 % (*V*/*V*) and 90 % (*V*/*V*) are recovered (distillation recovery temperatures) are determined by standard test methods and the cetane index is calculated from these test data using known correlations.

5 Procedure

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

5.2 Determine the temperatures, to the nearest 1 °C, at which 10 % (*V*/*V*), 50 % (*V*/*V*) and 90 % (*V*/*V*) of the sample is recovered during distillation, corrected to standard barometric pressure, by the procedure described in ISO 3405.

5.3 Test method ISO 3924 may be used as an alternative to test method ISO 3405 to determine the 10 %, 50 % and 90 % recovery temperatures of the fuel.

5.4 If test method ISO 3924 is used, convert the ISO 3924 data to estimated ISO 3405 data, following instructions of the former document on the calculation of equivalent data, and use the estimated ISO 3405 data in place of actual ISO 3405 data in the calculations.

6 Calculation

6.1 Calculate the cetane index using the following procedure:

Insert the measured values (see 5.1 and 5.2) in Formula (1) below and calculate the cetane index, *CI*:

$$CI = 45{,}2 + 0{,}089\,2T_{10N} + (0{,}131 + 0{,}901B)T_{50N} + (0{,}0523 - 0{,}42B)T_{90N} + \ldots$$
$$\ldots + 0{,}000\,49\left(T_{10N}^2 - T_{90N}^2\right) + 107B + 60B^2 \quad (1)$$

where

T_{10N} = $T_{10} - 215$;

T_{50N} = $T_{50} - 260$;

T_{90N} = $T_{90} - 310$;

T_{10} is the 10 % (*V*/*V*) distillation recovery temperature, in degrees Celsius;

T_{50} is the 50 % (*V*/*V*) distillation recovery temperature, in degrees Celsius;

T_{90} is the 90 % (*V*/*V*) distillation recovery temperature, in degrees Celsius;

B = $[\exp(-0{,}003\,5D_N)] - 1$;

D_N = $D - 850$;

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

6.2 The cetane index may also be derived by using nomography (see Annex A). However, in case of dispute, the procedure as given in 6.1 is to be applied.

7 Expression of results

Report the result to the nearest 0,1 as the cetane index by four-variable equation.

8 Precision

8.1 The calculation of the cetane index from measured density at 15 °C and measured 10 % (*V*/*V*), 50 % (*V*/*V*) and 90 % (*V*/*V*) distillation recovery temperatures is exact.

8.2 The precision of the cetane index equation is dependent on the precision of the original density and distillation recovery temperature determinations which enter into the calculation. The precision of these determinations is stated in ISO 3675, ISO 12185 and ISO 3405.

9 Test report

The test report shall contain at least the following information:

a) a reference to this document;

b) the type and 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.

Annex A
(informative)

Calculated cetane index by means of nomographs

A.1 General

The calculated cetane index by four variable equation is computed using the formula given in 6.1. The calculated cetane index by four variable equation can also be easily determined by means of the nomographs appearing in Figures A.1 to A.3.

A.2 Procedure

A.2.1 Step 1

Use the nomographs in Figures A.1, A.2 and A.3 to derive the cetane index as follows:

a) insert the density and 50 % (*V/V*) distillation recovery temperature values in Figure A.1 to estimate the fuel cetane index;

b) insert the density and 90 % (*V/V*) distillation recovery temperature values in Figure A.2 to determine a correction factor for deviations in these parameters from average values;

c) insert the 10 % (*V/V*) and 90 % (*V/V*) distillation recovery temperature values in Figure A.3 to determine a second correction factor for deviations in these parameters from average values;

d) sum the correction factors from Figures A.2 and A.3 with the estimated cetane index from Figure A.1 to give the final cetane index.

A.2.2 Step 2

A.2.2.1 General

The method of using the nomography is indicated by the example shown below for a fuel of cetane number 46,8.

A.2.2.2 Measured fuel properties

Density at 15 °C, kg/m^3	860,0
10 % (*V/V*) distillation recovery temperature, °C	220
50 % (*V/V*) distillation recovery temperature, °C	290
90 % (*V/V*) distillation recovery temperature, °C	340