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Petroleum products — Determination of the ignition quality of diesel fuels — Cetane engine method

Produits pétroliers — Détermination de la qualité d'inflammabilité des carburants pour moteurs diesel — Méthode cétane

Reference number
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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.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 19, *Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fifth edition cancels and replaces the fourth edition (ISO 5165:2017), which has been technically revised. It is aligned with ASTM D613. The main changes to the previous edition are as follows:

— requirements for primary reference fuels (PRFs), secondary reference fuels (SRFs) and check fuels have been added;

— new low cetane primary reference fuel, pentamethylheptane (PMH), as an alternative to heptamethylnonane (HMN), have been added;

— new reporting requirements.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Petroleum products — Determination of the ignition quality of diesel fuels — Cetane engine method

WARNING — The use of this document can involve hazardous materials, operations and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of users of this document to take appropriate measures to ensure the safety and health of personnel prior to the application of the document.

1 Scope

This document establishes the rating of diesel fuel oil in terms of an arbitrary scale of cetane numbers (CNs) using a standard single cylinder, four-stroke cycle, variable compression ratio, indirect injected diesel engine. The CN provides a measure of the ignition characteristics of diesel fuel oil in compression ignition engines. The CN is determined at constant speed in a pre-combustion chamber-type compression ignition test engine. However, the relationship of test engine performance to full scale, variable speed and variable load engines is not completely understood.

This document is applicable for the entire scale range from 0 CN to 100 CN but typical testing is in the range of 30 CN to 65 CN. An interlaboratory study executed by CEN in 2013 (10 samples in the range 52,4 CN to 73,8 CN)[3] confirmed that paraffinic diesel from synthesis or hydrotreatment, containing up to a volume fraction of 7 % fatty acid methyl ester (FAME), can be tested by this test method and that the precision is comparable to conventional fuels.

This test can be used for unconventional fuels such as synthetics or vegetable oils. However, the precision for those fuels has not been established and the relationship to the performance of such materials in full-scale engines is not completely understood.

Samples with fluid properties that interfere with the gravity flow of fuel to the fuel pump or delivery through the injector nozzle are not suitable for rating by this method.

NOTE This document specifies operating conditions in SI units but engine measurements are specified in inch-pound units or Fahrenheit because these are the historical units used in the manufacture of the equipment, and thus some references in this document include these and other non-SI units in parenthesis.

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 3170, *Petroleum liquids — Manual sampling*

ISO 3171, *Petroleum liquids — Automatic pipeline sampling*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

ISO 4787, *Laboratory glassware — Volumetric instruments — Methods for testing of capacity and for use*

ASTM D613, *Standard Test Method for Cetane Number of Diesel Fuel Oil*

ASTM D3703, *Test Method for Hydroperoxide Number of Aviation Turbine Fuels, Gasoline and Diesel Fuels*

ASTM E832-81, *Standard Specification for Laboratory Filter Papers*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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/

3.1
cetane number
CN
measure of the ignition performance of a diesel fuel oil obtained by comparing it to reference fuels in a standardized engine test

Note 1 to entry: Ignition performance is understood to mean the *ignition delay* (3.3) of the fuel as determined when the standard test engine is operated under controlled conditions of fuel flow rate, *injection timing* (3.4) and *compression ratio* (3.2).

3.2
compression ratio
ratio of the volume of the combustion chamber including the pre-combustion chamber with the piston at bottom-dead-centre (b.d.c.) to the comparable volume with the piston at top-dead-centre (t.d.c.)

3.3
ignition delay
period of time between the start of fuel injection and the start of combustion, expressed in degrees of crank angle rotation

3.4
injection timing
injection advance
time in the combustion cycle at which fuel injection into the combustion chamber is initiated, expressed in degrees of crank angle

3.5
handwheel reading
arbitrary numerical value, related to *compression ratio* (3.2), obtained from a micrometer scale that indicates the position of the variable compression plug in the pre-combustion chamber of the engine

3.6
cetane meter
ignition delay meter
electronic instrument which displays *injection timing* (3.4) and *ignition delay* (3.3) derived from input pulses of multiple transducers (pickups)

Note 1 to entry: Three generations of apparatus have been approved for use as cetane meters. These are (with the year of introduction in parenthesis) the Mark II Ignition Delay Meter (1974), the Dual Digital Cetane Meter (1990) and the XCP Cetane Panel (2014).

3.7
injector nozzle opening pressure
fuel pressure that overcomes the resistance of the spring which normally holds the injector nozzle pintle closed, and thus forces the pintle to lift and release an injection spray from the nozzle

3.8
reference pickup
transducers or optical sensors mounted over the flywheel of the engine, triggered by a flywheel pointer, used to establish a t.d.c. reference and a time base for calibration of the *cetane meter* (3.6)

3.9
injector pickup
transducer to detect motion of the injector pintle, thereby indicating the beginning of injection

3.10
combustion pickup
pressure transducer exposed to cylinder pressure to indicate the start of combustion

3.11
primary reference fuel
PRF
hexadecane (*n*-cetane), heptamethylnonane (HMN), pentamethylheptane (PMH) and volumetrically proportioned binary mixture of *n*-cetane with either HMN or PMH

Note 1 to entry: These PRFs now define the CN scale by the relationships given in Formulae (1) and (2).

$$CN = P_r + 0,15\ P_{HMN} \quad (1)$$

$$CN = P_r + 0,163 P_{PMH} \quad (2)$$

where

P_r is the percentage n-cetane in the binary mixture;

P_{HMN} is the percentage of HMN in the binary mixture;

P_{PMH} is the percentage of PMH in the binary mixture.

Note 2 to entry: Alphamethylnaphthalene (1-methylnaphthalene), in its pure form, was originally defined as 0 and *n*-cetane (hexadecane) as 100 for the CN scale. With blends of the two chemicals being used for the intervening values, alphamethylnapthalene was subsequently replaced in 1962 by HMN as the low reference material, with an assigned value of 15, as it was more readily available and experience had shown that it had better storage stability. Pentamethylheptane, a second low cetane ingredient as an alternative to HMN with an assigned value of 16,3, was introduced in 2018 to utilize a material of higher purity and better availability.

3.12
secondary reference fuel
SRF
volumetrically proportioned blend of two selected, numbered and paired hydrocarbon mixtures designated “T fuel” (high CN) and “U fuel” (low CN) where each numbered paired set of “T fuel” and “U fuel” is rated by the ASTM Diesel National Exchange Group (NEG) in various combinations by comparison to *primary reference fuel* (3.11) blends

3.13
check fuel
diesel fuel oil having a *cetane number* (3.1) value determined by an interlaboratory comparison which provides a guide for an individual laboratory to check the cetane rating performance of a specific engine unit

4 Principle

The CN of a diesel fuel oil is determined by comparing its combustion characteristics in a test engine with those for blends of reference fuels of known CN under standard operating conditions. This is accomplished using the bracketing handwheel procedure, which varies the compression ratio (handwheel reading) for the sample and each of two bracketing reference fuels to obtain a specific ignition delay permitting the interpolation of CN in terms of handwheel reading.

5 Reagents and reference materials

5.1 Cylinder jacket coolant, water conforming to grade 3 of ISO 3696.

Water shall be used in the cylinder jacket for laboratory locations where the resultant boiling temperature is 100 °C ± 2 °C (212 °F ± 3 °F). Water with commercial glycol-based antifreeze added in a sufficient quantity to meet the boiling temperature requirement shall be used when the laboratory altitude dictates. A commercial multi-functional water-treatment material should be used in the coolant to minimize corrosion and mineral scale that can alter heat transfer and rating results.

5.2 Engine crankcase lubricating oil, an SAE 30 viscosity grade oil[2] meeting current American Petroleum Institute (API) service classification or compatible previous API service classification for engines shall be used. It shall contain a detergent additive and have a kinematic viscosity of 9,3 mm^2/s to 12,5 mm^2/s at 100 °C (212 °F) and a viscosity index of not less than 85. Oils containing viscosity index improvers shall not be used. Multi-graded lubricating oils shall not be used.

The suggested oil change interval is 50 engine-running hours.

5.3 Cetane PRF, hexadecane meeting the specifications in Table 1 shall be used as the designated 100 CN component.

IMPORTANT — Store and use PRFs at temperatures of 20 °C or higher to avoid solidification of hexadecane, which has a melting point of 18 °C.

5.4 Heptamethylnonane PRF, 2,2,4,4,6,8,8-heptamethylnonane meeting the specifications in Table 1 shall be used as the designated 15 CN component.

5.5 Pentamethylheptane PRF, 2,2,4,6,6-pentamethylheptane meeting the specifications in Table 1 shall be used as the designated 16,3 CN component.

WARNING — PRFs are combustible and the vapours are harmful.

Table 1 — Specifications for primary reference fuels

Property	Hexadecane	Heptamethylnonane	Pentamethylheptane	Test method
Purity g/kg, minimum	990	980	995	Gas Chromatography
Hydroperoxide number, mg/kg as O, maximum	5,0	5,0	5,0	ASTM D3703

5.6 SRFs, volumetric blends of two diesel fuels meeting the specifications in Table 2 that have been round-robin engine calibrated by a recognized exchange testing group.

Storage and use of “T fuel” and “U fuel” should be at temperatures above 0 °C (32 °F) to avoid potential solidification, particularly of “T fuel”. Before a container that has been stored at low temperature is placed in service, it should be warmed to a temperature of at least 14 °C (57 °F) above its cloud point. It should be held at this temperature for a period of at least 30 min and then the container should be thoroughly remixed.

NOTE 1 Cloud point is normally determined in accordance with ISO 3015.

SRF blends are rated in numbered pairs and are not interchangeable with SRF blends from other batches.

WARNING — SRFs are combustible and the vapours harmful.

