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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

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Contents

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 related products of synthetic or biological origin*.

This fourth edition cancels and replaces the third edition (ISO 5165:1998), which has been technically revised. It has been aligned with ASTM D613-15ae1.

The main changes compared to the previous edition are as follows:

— the Scope has been extended to paraffinic diesel from synthesis or hydrotreatment, in line with the outcome of the interlaboratory study organized by CEN/TC 19 in 2013[1];

— the possibility to use, as an alternative, the new digital (XCP) cetane panel has been added;

— the possibility to rate a sample with primary reference fuels (hexadecane and heptamethylnonane) has been added;

— a determinability limit has been introduced;

— a new procedure for measuring samples having cetane numbers expected to be greater than “T” secondary reference fuel has been introduced;

— cross-references to annexes that have been deleted in ASTM D613-15ae1 have been removed.

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)[1] confirmed that paraffinic diesel from synthesis or hydrotreatment, containing up to 7 % (*V*/*V*) 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, vegetable oils, etc. However, 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 because these are the historical units used in the manufacture of the equipment, and thus some references in this document include these 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 D613-15ae1, *Standard Test Method for Cetane Number of Diesel Fuel Oil*

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 top-dead-centre (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) and volumetrically proportioned mixture of these materials

Note 1 to entry: These PRFs now define the cetane number (CN) scale by the relationship given in the following formula:

$$CN = \%\,cetane + 0{,}15\left(\%\,HMN\right)$$

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 heptamethylnonane 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.

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 primary reference fuel (PRF), hexadecane with a minimum purity of 99,0 %, as determined by chromatographic analysis, shall be used as the designated 100 CN component.

5.4 Heptamethylnonane PRF, 2,2,4,4,6,8,8-heptamethylnonane with a minimum purity of 98 %, as determined by chromatographic analysis, shall be used as the designated 15 CN component.

WARNING — PRFs are combustible and vapour harmful.

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.

5.5 Secondary reference fuels (SRFs), volumetric blends of two diesel fuels having widely different CNs 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 (26 °F) above its cloud point as determined in accordance with ISO 3015. It should be held at this temperature for a period of at least 30 min and then the container should be thoroughly remixed.

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.

NOTE Blends of "T fuel" and "U fuel" that have been engine calibrated by the ASTM Diesel National Exchange Group can be, and typically are, used for routine testing. The calibration data are incorporated in blend tables that list the CNs assigned for various volume percentage blends of "T fuel" and "U fuel". "T fuel" is typically in the range of 73 CN to 75 CN and "U fuel" is typically in the range of 20 CN to 22 CN.

5.6 Check fuels, diesel fuel oils typical of the middle distillate type having a CN value determined by an interlaboratory comparison.

WARNING — Check fuels are combustible and the vapours harmful.

NOTE Low cetane check fuel will typically be in the range of 38 CN to 42 CN. High cetane check fuel will typically be in the range of 50 CN to 55 CN.

6 Apparatus

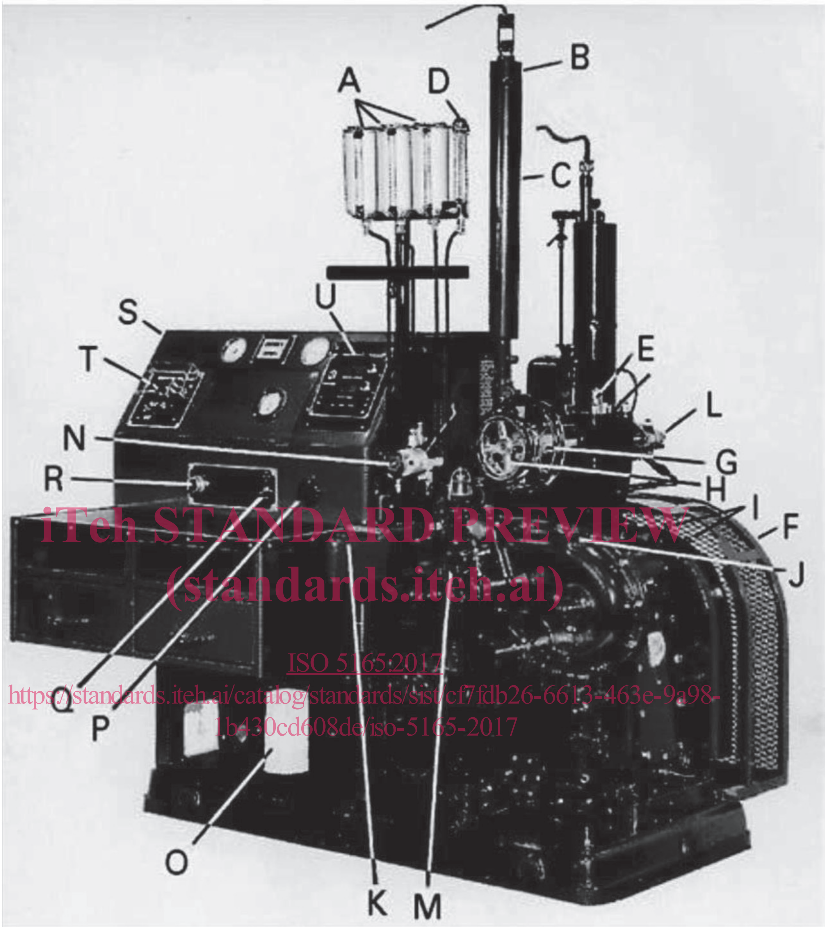
6.1 Test engine assembly.

As shown in Figure 1. It comprises a single cylinder engine consisting of a standard crankcase with fuel pump assembly, a cylinder with separate head assembly of the pre-combustion type (see Figure 2), thermal-siphon recirculating jacket coolant system, multiple fuel tank system with selector valving, injector assembly with specific injector nozzle, electrical controls and a suitable exhaust pipe. Figure 3 shows the software screen interface of the XCP digital panel. The engine shall be belt connected to a special electric power-absorption motor, which acts as a motor driver to start the engine and as a means to absorb power at constant speed when combustion is occurring (engine firing).

6.2 Instrumentation.

An electronic instrument to measure injection and ignition delay timing as well as conventional thermometry, gauges and general purpose meters.

NOTE Engine equipment and instrumentation are available from the single source manufacturer, CFR Engines Inc.1), N8 W22577 Johnson Drive, Pewaukee WI 53186, USA. CFR Engines Inc. also has authorized sales and service organizations in selected geographic areas.



Key

A	fuel tanks	L	injector assembly
B	air heater housing	M	fuel injection pump
C	air intake silencer	N	fuel selector valve
D	fuel flow-rate burette	O	oil filter
E	combustion pickup	P	crankcase oil heater control
F	safety guard	Q	air heater switch
G	variable compression plug (VCP) handwheel	R	engine start-stop panel
H	VCP locking handwheel	S	instrument panel
I	flywheel pickups	T	intake air temperature controller
J	oil filter cap	U	Dual Digital Cetane Meter
K	injection pump safety shutoff solenoid		

Figure 1 — Cetane method test engine assembly

1) This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

