SLOVENSKI STANDARD
SIST EN 16715:2015

01-oktober-2015

Tekoči naftni proizvodi - Ugotavljanje zakasnitve vžiga in izpeljanega cetanskega števila (DCN) v srednje destilatnih gorivih - Določevanje zakasnitve vžiga in sežiga z uporabo komore s konstantno prostornino z direktnim injiciranjem goriva

Liquid petroleum products - Determination of ignition delay and derived cetane number (DCN) of middle distillate fuels - Ignition delay and combustion delay determination using a constant volume combustion chamber with direct fuel injection

Flüssige Mineralölerzeugnisse - Bestimmung des Zündverzugs und der abgeleiteten Cetanzahl (ACZ) von Kraftstoffen aus Mitteldestillaten - Bestimmung des Zündverzugs und des Verbrennungsverzugs in einer Verbrennungskammer mit konstantem Volumen und direkter Kraftstoffeinspritzung

Produits pétroliers liquides - Détermination due délai d'inflammation et de l'indice de cétane dérivé (ICD) des distillatsmoyens - Détermination due délai d'inflammation et de combustion par utiliser in une une chambre à volume constant avec injection direct de gazole

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EUROPEAN STANDARD
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English Version

Liquid petroleum products - Determination of ignition delay and derived cetane number (DCN) of middle distillate fuels - Ignition delay and combustion delay determination using a constant volume combustion chamber with direct fuel injection

Produits pétroliers liquides - Détermination du délai d'inflammation et de l'indice de cétane dérivé (ICD) des distillats moyens - Détermination du délai d'inflammation et de combustion en utilisant une chambre à volume constant avec injection directe de gazole

Flüssige Mineralölerzeugnisse - Bestimmung des Zündverzugs und der abgeleiteten Cetanzahl (ACZ) von Kraftstoffen aus Mitteldestillaten - Bestimmung des Zündverzugs und des Verbrennungsverzugs in einer Verbrennungskammer mit konstantem Volumen und direkter Kraftstoffeinspritzung

This European Standard was approved by CEN on 20 June 2015.

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European foreword

This document (EN 16715:2015) has been prepared by Technical Committee CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2016 and conflicting national standards shall be withdrawn at the latest by February 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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Introduction

This European Standard is derived from joint standardization work within the Energy Institute and ASTM International. It is based on and technically equivalent with ASTM D7668 [1].

The described method is an alternative quantitative determination of the cetane number of middle distillate fuels intended for use in compression ignition engines. A correlation study between this method and EN ISO 5165:1998 [2] has been done and the results of this are incorporated in this European Standard. Research Report RR: D02-1771 [3].

The basis of this method is the derived cetane number (DCN) correlation equation as given in Clause 12. The on-going validation of the equation is monitored and evaluated through the existing American and European fuel exchange programs. The validation data will be reviewed by CEN/TC 19 with a frequency of at least every two years. As a result of the review, CEN/TC 19 may make the decision to, if necessary, modify the existing equation/correlation or develop a new one. As part of this review, the sample types will be examined, and if certain types are underrepresented, further steps may be taken to evaluate how they perform.

The ignition delay (ID) and combustion delay (CD) values and the DCN value determined by this test method can provide a measure of the ignition characteristics of diesel fuel oil used in compression ignition engines. This test is for use by engine manufacturers, petroleum refiners and marketers, and in commerce as a specification aid to relate or match fuels and engines. This test is also applicable to non-conventional diesel fuels.

For the moment the basics of one type of apparatus are described. Once more correlation data on different types of derived cetane number testing equipment is available, CEN/TC 19 will consider revising this European Standard.

1 Scope

This European Standard specifies a test method for the quantitative determination of ignition and combustion delays of middle distillate fuels intended for use in compression ignition engines. The method utilizes a constant volume combustion chamber with direct fuel injection into heated, compressed synthetic air. A dynamic pressure wave is produced from the combustion of the product under test. An equation is given to calculate the derived cetane number (DCN) from the ignition and combustion delays determined from the dynamic pressure curve.

This European Standard is applicable to middle distillate fuels, fatty acid methyl esters (FAME) and blends of diesel fuels and FAME. The method is also applicable to middle distillate fuels of non-petroleum origin, oil-sands based fuels, blends of fuel containing biodiesel material, diesel fuel oils containing cetane number improver additives and low-sulfur diesel fuel oils. However, users applying this standard especially to unconventional distillate fuels are warned that the relationship between derived cetane number and combustion behaviour in real engines is not yet fully understood.

This European Standard covers the ignition delay range from 2,47 ms to 4,09 ms and combustion delay from 3,71 ms to 6,74 ms (67 DCN to 39 DCN).

NOTE 1 The combustion analyser can measure shorter or longer ignition and combustion delays, but precision is not known.

NOTE 2 There is no information about how DCNs outside the 67 to 39 range compare to EN ISO 5165.

NOTE 3 For the purpose of this European Standard, the expression "% (*V/V*)" is used to represent the volume fraction (φ), and "% (*m/m*)" the mass fraction (ω).

WARNING — The use of this standard can 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 users of this standard to take appropriate measures to ensure the safety and health of personnel prior to application of the standard, and fulfil statutory and regulatory requirements for this purpose.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 3170, *Petroleum liquids - Manual sampling (ISO 3170)*

EN ISO 3171, *Petroleum liquids - Automatic pipeline sampling (ISO 3171)*

EN ISO 3696, *Water for analytical laboratory use - Specification and test methods (ISO 3696)*

ISO 1998-2, *Petroleum industry - Terminology - Part 2: Properties and tests*

IP 537, *Determination of the purity of Derived Cetane Number reference materials - Gas chromatography method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1998-2 and the following apply.

3.1
cetane number
CN
measure of the ignition performance of a diesel fuel in a standardized engine test on a scale defined by reference fuels

Note 1 to entry: It is expressed as the percentage by volume of hexadecane (cetane) in a reference blend having the same ignition delay as the fuel for analysis. The higher the cetane number, the shorter the ignition delay.

3.2
ignition delay
ID
period of time, in milliseconds (ms), between the start of fuel injection and the start of combustion

Note 1 to entry: In the context of this test method, the start of fuel injection is interpreted as the rise in the electronic signal that opens the injector and the combustion start is interpreted as the first increase of the chamber pressure during the combustion cycle, as measured by a pressure sensor in the combustion chamber.

3.3
combustion delay
CD
period of time, in milliseconds (ms), between the start of fuel injection and mid-point of the combustion pressure curve

Note 1 to entry: In the context of this test method, the start of fuel injection is interpreted as the rise in the electronic signal that opens the injector and the combustion pressure curve mid-point is interpreted as the part of the pressure curve midway between the initial chamber pressure and the maximum pressure generated during the combustion cycle, as measured by a pressure sensor in the combustion chamber. The combustion delay CD measures the time between the injection of the sample and phase of combustion controlled by the diffusive mixing of the air and fuel.

3.4
derived cetane number
DCN
number calculated by using an equation that correlates a combustion analyser's ignition and combustion delays to the cetane number

3.5
accepted reference value
ARV
value agreed upon as a reference for comparison

Note 1 to entry: The value is derived as (1) a theoretical or established value, based in scientific principles, (2) an assigned value, based on experimental work of some national or international organization, or (3) a consensus value, based on collaborative experimental work under the auspices of a scientific or engineering group.

3.6
quality control sample
QC sample
stable and homogenous material(s) similar in nature to the materials under test, properly stored to ensure integrity, and available in sufficient quantity for repeated long-term testing

3.7
calibration reference fluid
stable and homogenous fluid used to calibrate the performance of the combustion analyser

3.8
verification reference fluid
stable and homogenous fluid used to verify the performance of the combustion analyser

4 Principle

A test portion of the material under test is injected into a temperature and pressure controlled, constant volume combustion chamber, which has previously been charged with synthetic air of a specified quality. Each injection produces a compression ignition combustion cycle detected using a pressure sensor. The ignition delay and combustion delay are measured from the rise of the electronic signal that activates the injector solenoid to two specific points along the combustion pressure wave produced by the combustion cycle.

A complete sequence comprises 5 preliminary injection cycles and 15 subsequent injection cycles used for the sample analysis. The ID and CD measurements for the last 15 injection cycles are statistically reviewed and the outlying ID's and CD's are eliminated using Peirce's Criterion [4]. The remaining ID's and CD's are averaged to produce the ID and CD results. An equation is given to calculate the derived cetane number (DCN) from the ignition and combustion delays determined from the dynamic pressure curve. The DCN obtained by this procedure is an estimate of the cetane number (CN) obtained from the conventional large-scale engine test EN ISO 5165 [2].

5 Reagents and materials

5.1 Calibration reference fluid, 40:60 mixture by weight of hexadecane and 2,2,4,4,6,8,8-heptamethylnonane, respectively, measured with an accuracy of 0,01 percent. For peroxide-free material the assigned ID_{ARV} is 2,96 ms and the assigned CD_{ARV} is 4,90 ms.

5.1.1 Hexadecane, minimum purity of 99,0 % (*m/m*).

5.1.2 2,2,4,4,6,8,8-Heptamethylnonane, minimum purity of 98,0 % (*m/m*).

IMPORTANT — Hydrocarbons can form peroxides and other free radicals forming contaminants that can influence the ID and CD. Experience has found some 40:60 blends of hexadecane and 2,2,4,4,6,8,8-heptamethylnonane meeting the purity specification can contain peroxides and other free radically form contaminants. Typically, the peroxides and other free radically formed contaminants can be removed from the 40:60 mixture of hexadecane and 2,2,4,4,6,8,8-heptamethylnonane by subjecting the blend to activated 4 Å molecular sieves.

5.2 Verification reference fluid, methylcyclohexane (MCH) of a purity of minimum 99,0 % (*m/m*) to be used as the designated 11,0 ms ignition delay (ID_{ARV}) and the designated 17,0 ms combustion delay (CD_{ARV}) assigned accepted reference value material.

If the initial purity is not known the purity shall be checked in accordance with IP 537.

Even if the verification reference fluid meets the purity specification, it may not meet the Ignition and Combustion delay requirements (see Table 2). It is recommended to either pass the suspect MCH through a filter column to remove peroxide based impurities or to test a bottle of MCH that has been shown to meet the ID and CD requirements. It is recommended that each bottle of MCH is tested prior to its use as a verification reference fluid to confirm it is of acceptable quality.

5.3 Quality control sample, stable and homogenous distillate fuel, similar in nature to the materials under test (see 3.6).

5.4 Combustion charge air, a compressed synthetic air mixture containing (20,0 ± 0,5) % (V/V) oxygen with the balance nitrogen, less than 0,003 % (V/V) hydrocarbons, and less than 0,025 % (V/V) water. It is recommended that a quality control test be performed after an air cylinder has been changed.

NOTE Oxygen content of combustion charge air can vary between batches (cylinders). Significant variation will lead to changes in ignition and combustion delay (higher oxygen content leads to shorter ignition and combustion delays).

5.5 Heptane, (n-Heptane) with a minimum purity of 99,5 % (*m/m*).

5.6 Water, unless otherwise specified, meeting the requirements of grade 3 of EN ISO 3696.

5.7 Coolant system fluid, 50:50 volumetric mixture of commercial grade ethylene glycol-type radiator antifreeze with water (5.6).

5.8 Compressed nitrogen, of minimum purity 99,9 % (*V/V*), capable of delivering a pressure of (0,6 to 1,0) MPa to the instrument.

6 Apparatus

6.1 Combustion analyser

The apparatus is described in more detail in Annex A. For the installation and set-up procedures, and for detailed system description, refer to the manufacturer's manual.

The system described in this standard comprises a temperature and pressure controlled combustion chamber (6.1.1) with fluid cooling of designated areas, chamber inlet and exhaust valves and associated piping, an electronically controlled fuel injection system, a fuel delivery system, a recirculating coolant system, solenoids, sensors, controls and connection fittings for the compressed gas utilities. Figure 1 gives a schematic outline of the analyser.

6.1.1 Combustion chamber, a steel combustion chamber of capacity 0,473 l ± 0,005 l. Annex A gives further details.

6.1.2 Filter medium, a removable polytetrafluoroethylene filter with a 5 µm pore size is placed downstream from the sample vessel to filter particulate matter from the test portion.

7 Sampling

7.1 Unless otherwise specified, obtain samples in accordance with the procedures given in EN ISO 3170 or EN ISO 3171.

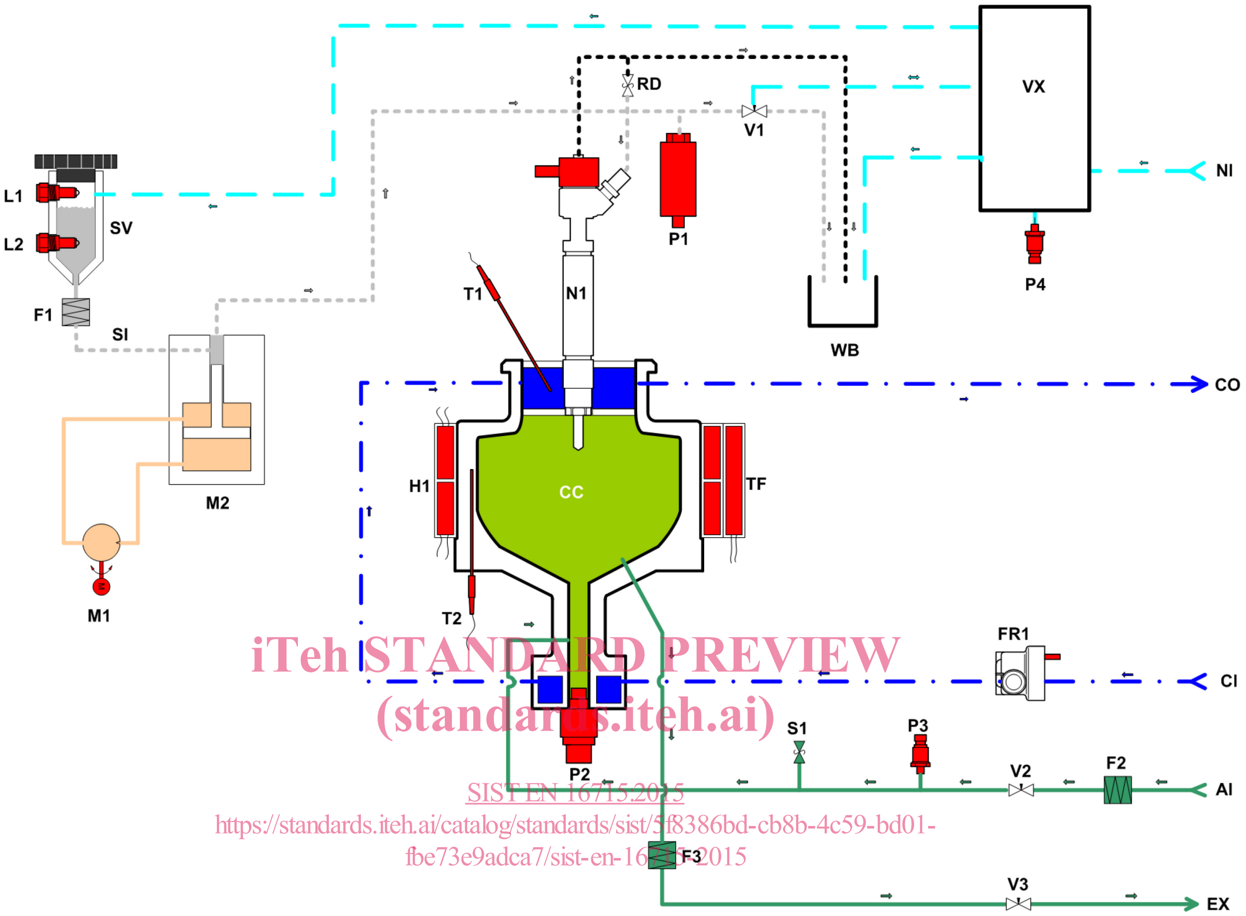
7.2 To minimize exposure to UV emissions that can induce chemical reactions, which may affect ignition and combustion delays measurement, collect and store samples in sample containers that are either constructed of materials that minimize light reaching the sample such as a dark brown bottle, metal can or containers that shall be wrapped or boxed in light-proof containers immediately after filling. If the fuel is not to be analysed within 24 h, retain in a dark, cool environment, and preferably under an inert gas.

NOTE 1 Exposure of petroleum fuels to UV wavelengths of less than 550 nm for even a short period of time has been shown to affect ignition delay [5].

NOTE 2 The formation of peroxides and radicals, which affect the ignition delay and the combustion delay, is minimized when the sample is stored in the dark, under a nitrogen blanket in a cool environment.

7.3 Condition the diesel fuel oil sample before opening the storage container, so that it is at room temperature, typically 18 °C to 32 °C.

7.4 Inspect the sample for wax precipitation. If precipitants are present, bring the test sample to a temperature of at least 14 °C above the expected cloud point of the material being tested, taking care not to lose any lower boiling range components. Agitate the sample to return precipitants back in to the solution, ensuring the sample is homogeneous before proceeding.



Key

Digital signals	**Analogue signals**
L1: upper level sensor	T1: coolant temperature
L2: lower level sensor	T2: inner wall temperature
TF: thermal fuse	P1: fuel pressure
M1: hydraulic pump	P2: chamber dynamic pressure
N1: injector	P3: chamber static pressure
V1: flush valve	P4: nitrogen pressure
V2: air inlet valve	FR1: coolant flow rate
V3: exhaust valve	
Vx: nitrogen circuit valves	
Analyser lines	**Analyser parts (no signal registration)**
AI: Air inlet	CC: Combustion chamber
CI: Coolant input	F1, F2, F3: Filter
CO: Coolant output	M2: Multiplier
EX: Air exhaust	RD: Rupture disk
NI: Nitrogen input	S1: Safety valve
SI: Sample inlet	SV: Sample vessel
	WB: Sample waste drain
	H1: Clam shell heater

Figure 1 — Schematic overview of combustion analyser