SLOVENSKI PREDSTANDARD

oSIST prEN 15195:2005

maj 2005

Liquid petroleum products - Determination of ignition delay and derived cetane number (DCN) of middle distillate fuels by combustion in a constant volume chamber

ICS 75.160.20

Referenčna številka
oSIST prEN 15195:2005(en)

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 15195

March 2005

ICS

English version

Liquid petroleum products - Determination of ignition delay and derived cetane number (DCN) of middle distillate fuels by combustion in a constant volume chamber

Produits pétroliers liquides - Détermination du délai d'inflammation et de l'indice de cétane dérivé (ICD) des distillats moyens par combustion dans une enceinte à volume constant

Flüssige Mineralöl-Erzeugnisse - Bestimmung des Zündverzugs und der abgeleiteten Cetanzahl (ACZ) von Kraftstoffen aus Mitteldestillaten in einer Verbrennungskammer mit konstantem Volumen

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. prEN 15195:2005: E

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Foreword

This document (prEN 15195:2005) has been prepared by Technical Committee CEN/TC 19 “Petroleum products, lubricants and related products”, the secretariat of which is held by NEN.

This document is currently submitted to the CEN Enquiry.

Introduction

This document is derived from joint standardization work in the Energy Institute and ASTM International. It is based on IP 498/05 published by the Energy Institute.

The described method is an alternative quantitative determination of ignition delay and derived cetane number of middle distillate fuels intended for use in compression ignition engines. Correlation studies between this method and EN ISO 5165:1998 has been done and results of this are incorporated in this European Standard.

For the moment the basics of one type of apparatus are described[1]. 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] The injection pump in the currently described apparatus is covered by a patent.

1 Scope

This document specifies a method of test for the quantitative determination of ignition delay of middle distillate fuels intended for use in compression ignition engines. The method utilizes a constant volume combustion chamber designed for operation by compression ignition, and employing direct injection of fuel into compressed air that is controlled to a specified pressure and temperature. An equation is given to calculate the derived cetane number (DCN) from the ignition delay measurement.

This standard is applicable to fuels from petroleum and non-petroleum origin, although users are warned that the relationship between ignition characteristics and engine performance in unconventional fuels is not yet fully understood. The test is applicable over the range of 3,3 ms to 6,4 ms ignition delay.

NOTE 1 Ignition delay values of 3,3 ms to 6,4 ms correspond to derived cetane numbers (DCN) of 61 to 34 respectively.

NOTE 2 For the purpose of this European Standard, the expression "% (*V/V*)" is used to represent the volume fraction and "% (*m/m*)" mass fraction

WARNING — The use of this 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.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN ISO 3170, *Petroleum liquids — Manual sampling (ISO 3170:2004)*

EN ISO 3171, *Petroleum liquids — Automatic pipeline sampling (ISO 3171:1988)*

EN ISO 5165, *Diesel fuels — Determination of the ignition quality — Cetane method (ISO 5165:1998)*

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

ISO 4010, *Diesel engines — Calibrating nozzle, delay pintle type*

3 Terms and definitions

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

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

NOTE Hexadecane (cetane), heptamethylnonane (HMN) and volumetrically proportioned mixtures of these materials define the cetane number (CN) scale by the relationship: CN = cetane (%*V/V*) + 0,15 HMN (%*V/V*).

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

NOTE In the context of this standard, this period is determined by movement and pressure sensors in the instrument.

3.3
derived cetane number
DCN
calculated value, derived from the ignition delay in combustion of the tested fuel kept in a constant volume chamber, giving a reasonably close approximation of the cetane number

3.4
primary reference fuels
hexadecane (cetane) (100) and heptamethyl-nonane (HMN) (15) and volumetrically proportioned mixtures of these
NOTE derived from EN ISO 5165

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

NOTE The value may be that derived from scientific principles, that assigned by an accredited organization, or a consensus value based on collaborative experimental work under the auspices of a scientific or engineering group.

3.6
quality control 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 analyzer.

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

4 Symbols and abbreviations

T_i injector coolant temperature

Ti_{min} minimum injector coolant temperature

Ti_{max} maximum injector coolant temperature

Ta_{min} minimum combustion chamber air temperature

Ta_{max} maximum combustion chamber air temperature

Tps_{min} minimum combustion chamber pressure sensor temperature

Tps_{max} maximum combustion chamber pressure sensor temperature

5 Principle

A test portion of the material under test is injected into a charge of compressed air in a constant volume combustion chamber. Sensors detect the start of injection and the start of combustion for each single-shot cycle. A complete test sequence consists of 15 preliminary combustion cycles to ensure apparatus equilibrium and 32 subsequent test cycles to obtain ignition delay values. The average ignition delay (ID) of these 32 cycles is inserted into an equation to obtain the derived cetane number (DCN). 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.

6 Reagents and materials

6.1 Water, unless otherwise specified, meeting the requirements for grade 3 of ISO 3696.

6.2 Coolant system fluid, 50:50 volumetric mixture of commercial grade ethylene glycol-type radiator antifreeze with water (6.1).

NOTE This mixture meets the boiling point requirements and gives adequate protection of the coolant system against corrosion and mineral scale that can alter heat transfer and rating results. See the manufacturer's manual for the correct ethylene glycol-type antifreeze quality.

6.3 Calibration reference fluid, heptane of a purity of minimum 99,5 % (*m/m*) to be used as the designated 3,78 ms ignition delay accepted reference value material

NOTE If the initial purity is not known and during a long-time stored reference fluid, it is advised to check the purity in accordance with IP PM-CY/04 [1].

6.4 Verification reference fluid, methylcyclohexane of a purity of minimum 99,0 % (*m/m*) to be used as the designated 10,4 ms ignition delay accepted reference value material

NOTE If the initial purity is not known and during a long-time stored reference fluid, it is advised to check the purity in accordance with IP PM-CY/04 [1].

6.5 Quality control sample

6.6 Combustion charge air, of oxygen content 20,9 % (*V/V*) ± 1,0 % (*V/V*), and containing less than 0,003 % (*V/V*) hydro-carbons and less than 0,025 % (*V/V*) water.

NOTE The effects of air quality deviations are still under investigation. The limiting values are based on current practice.

6.7 Actuating air, oil free compressed air containing less than 0,1 % (*V/V*) water supplied at a minimum sustained pressure of 1,5 MPa.

6.8 Compressed nitrogen, of minimum purity 99,9 % (*V/V*).

7 Apparatus

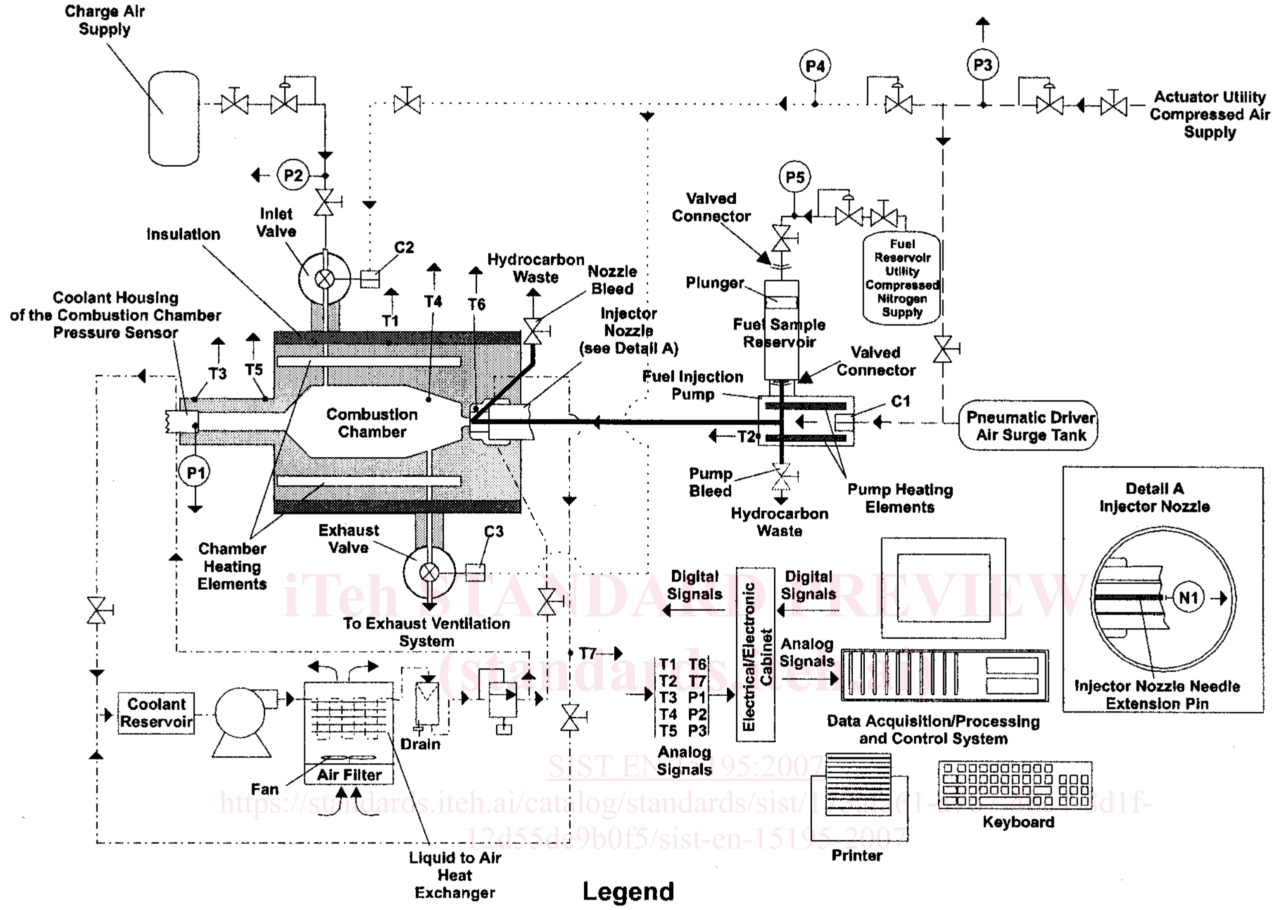
7.1 Combustion analyzer

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 standard system consists of a heated combustion chamber (7.1.1) with fluid cooling of designated areas, external chamber inlet and exhaust valves and associated piping, a pneumatically-driven fuel injection pump, a constant pressure 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 analyzer.

7.1.1 Combustion chamber, steel combustion chamber of capacity 0,213 l ± 0,002 l, further detailed in Annex A.

7.2 Filter medium, with a nominal pore size 3 µm to 5 µm, made of glass fibre, polytetrafluorethylene (PTFE) or nylon, of a size appropriate to the apparatus being used for sample filtration (see 8.4).



Legend

P1: Combustion Chamber Pressure
P2: Charge Air Pressure
P3: Injection Actuator Air Pressure
P4: Inlet/Exhaust Valve Actuator Air Pressure (Gauge)
P5: Sample Fuel Reservoir Pressure (Gauge)
T1: Combustion Chamber Outer Surface Temperature
T2: Fuel Injection Pump Temperature
T3: Combustion Chamber Pressure Sensor Temperature
T4: Charge Air Temperature
T5: (used for diagnostic functions)
T6: Injector Nozzle Coolant Passage Temperature
T7: Coolant Return Temperature
N1: Injector Nozzle Needle Motion Sensor
C1: Digital Signal - Fuel Injection Actuator
C2: Digital Signal - Inlet Valve Actuator
C3: Digital Signal - Exhaust Valve Actuator

-·-·-·- : Charge Air Line
······· : Inlet/Exhaust Valve Actuator Air Line
——— : Fuel Reservoir Utility Nitrogen Line
— — — : Fuel Injection Pump Driver Air Line
-··-··- : Coolant System Line
▬▬▬ : High Pressure Fuel Line

Figure 1 — Schematic overview of combustion analyser

8 Sampling

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

8.2 Collect and store samples in an opaque container to minimize exposure to UV emissions which can induce chemical reactions which may affect ignition delay measurements. If the sample is not to be analyzed within 24 h, retain in a dark, cool/cold 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 [2].

NOTE 2 The formation of peroxides and radicals, which affect the ignition delay, is minimized when the sample is stored in the dark, under a nitrogen blanket and in a cold (below 10 °C) environment.

8.3 Bring the laboratory sample to 18 °C to 32 °C before testing.

8.4 Filter the laboratory sample through the filter medium (7.2) at ambient temperature, without vacuum. Use a folding filter or syringe filter set-up. Immediately collect the filtered sample in an opaque container.

9 Apparatus assembly and installation

Annexes A and B give more details on the apparatus assembly and installation. The apparatus requires placement on a level floor with facilities for the hook-up of all utilities and engineering and technical support. The user shall ensure compliance with all local and national codes. The apparatus requires an environment with a temperature of 18 °C to 32 °C. The exhaust gases shall be directed into a low suction pressure fume extraction system.

NOTE The heat exchange of the coolant system and the injection pump operate satisfactorily at 18 °C to 32 °C.

CAUTION 1 — The apparatus requires high-pressure compressed air at high flow for intermittent short periods of time.

CAUTION 2 — The noise level without a noise reduction system is approximately 86 dB, measured at 1,5 m distance, and approximately 77 dB with noise reduction. Local regulations may apply to high noise levels, but ear protectors should be worn when equipment is in operation.

10 Preparation of apparatus

10.1 System start-up and warm-up

10.1.1 For more details, refer to the manufacturer's manual.

10.1.2 Switch on power to the combustion analyzer and the coolant pump.

10.1.3 Warm up the system.

10.1.4 Pressure the nitrogen and actuating air to the pressures given in the manufacturer's manual.

10.1.5 Check the coolant temperature. Follow diagnostic procedures given in the manufacturer's manual when the specified temperatures and tolerances are not met.

10.2 Standard operating conditions

10.2.1 Set the fuel injection pump temperature to 35 °C ± 3 °C.

10.2.2 Set the combustion charge air pressure to 2,137 MPa ± 0,007 MPa.

10.2.3 Check the sealing of the combustion chamber by measuring the pressure drop during a charge test in accordance with the manufacturer's manual. Follow the diagnostic procedures given in the manual when the pressure drop is higher than specified.

NOTE A high pressure drop indicates unsatisfactory sealing of the combustion chamber.