Designation: D8183 − 22

Standard Test Method for Determination of Indicated Cetane Number (ICN) of Diesel Fuel Oils using a Constant Volume Combustion Chamber—Reference Fuels Calibration Method[1]

This standard is issued under the fixed designation D8183; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the quantitative determination of the indicated cetane number (ICN) of conventional diesel fuel oils, and diesel fuel oils containing cetane number improver additives; it is applicable to products typical of Specification D975, Grades No.1-D and 2-D diesel fuel oils, European standard EN 590, and Canadian standards CAN/CGSB-3.517 and CAN/CGSB-3.520. The test method is also applicable to biodiesel, blends of diesel fuel oils containing biodiesel material (for example, materials as specified in Specifications D975, D6751, D7467 and European standards EN 14214, EN 16734, and EN 16709), diesel fuels from non-petroleum origin, hydrocarbon oils, diesel fuel oil blending components, aviation turbine fuels, and polyoxymethylene dimethyl ether (OME).

1.2 This test method utilizes a constant volume combustion chamber (CVCC) with direct fuel injection into heated compressed air. The apparatus is calibrated using blends of reference fuels. ICN is determined directly from ignition delay using an instrument specific reference fuel calibration curve.

1.3 This test method and its precision cover the calibrated range of 35 ICN to 85 ICN, inclusive. The analyzer can measure ICN outside the calibrated range, but the precision has not been determined.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use. Some specific hazards statements are given in Section 7 on Hazards.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D613 Test Method for Cetane Number of Diesel Fuel Oil
D975 Specification for Diesel Fuel
D1193 Specification for Reagent Water
D3703 Test Method for Hydroperoxide Number of Aviation Turbine Fuels, Gasoline and Diesel Fuels
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
D6299 Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance
D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products, Liquid Fuels, and Lubricants
D6708 Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that Purport to Measure the Same Property of a Material
D6751 Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels
D7467 Specification for Diesel Fuel Oil, Biodiesel Blend (B6 to B20)

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.01 on Combustion Characteristics.

Current edition approved July 1, 2022. Published August 2022. Originally approved in 2018. Last previous edition approved in 2018 as D8183 – 18. DOI: 10.1520/D8183-22.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

2.2 *European Standards:*[3]

EN 590 Automotive fuels—Diesel—Requirements and test methods

EN 14214 Liquid petroleum products—Fatty acid methyl esters (FAME) for use in diesel engines and heating applications—Requirements and test methods

EN 16709 Automotive Fuels—High FAME diesel fuel (B20 and B30)—Requirements and test methods

EN 16734 Automotive Fuels—Automotive B10 Fuel—Requirements and test methods

2.3 *Energy Institute Standards:*[4]

IP 41 Ignition quality of diesel fuels—Cetane engine test method

IP 617 Determination of indicated cetane number (ICN) of fuels using a constant volume combustion chamber—Primary reference fuels calibration (PRFC) method

2.4 *Canadian Standards:*[5]

CAN/CGSB-3.517 Diesel Fuel—Specification

CAN/CGSB-3.520 Automotive Low-Sulphur Diesel Fuel Containing Low Levels of Biodiesel Esters (B1-B5)—Specification

2.5 *ISO Standards:*[6]

ISO 868 Plastics and ebonite—Determination of indentation hardness by means of a durometer (Shore hardness)

ISO Guide 35 Certification of reference materials—General statistical principles (Reference materials—Guidance for the characterization and the assessment of the homogeneity and stability of the material).

3. Terminology

3.1 *Definitions:*

3.1.1 *cetane number, n*—a measure of the ignition performance of a diesel fuel oil obtained by comparing it to reference fuels in a standardized engine test. **D4175**

3.1.1.1 *Discussion*—In the context of this test method, cetane number is measured and reported by Methods D613/IP 41.

3.1.2 *quality control (QC) sample, n*—for use in quality assurance programs to determine and monitor the precision and stability of a measurement system, a stable and homogeneous material having physical or chemical properties, or both, similar to those of typical samples tested by the analytical measurement system; the material is properly stored to ensure sample integrity, and is available in sufficient quantity for repeated, long term testing. **D6299**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *analyzer, n*—an integrated compression ignition apparatus to measure the ignition and combustion characteristics of diesel fuel oil.

3.2.2 *calibration and verification fluids, n*—volumetric blends of n-hexadecane and 1-methylnaphthalene, at 20 °C, define an ICN scale in specific volume ratios according to the relationship shown in Eq 1.

3.2.2.1 *Discussion*—Seven blends of n-hexadecane and 1-methylnaphthalene are used to create an analyzer specific calibration curve. A single blend is used to create a verification fluid.

3.2.3 *calibration curve, n*—plot of ID versus the ICN (see 3.2.6) of reference fuel blends obtained by making ignition delay measurements with calibration fluids for each analyzer.

3.2.3.1 *Discussion*—The calibration curve comprises seven calibration points covering the 35 ICN to 85 ICN range; see research report[7] for the format of the equation used.

3.2.3.2 *Discussion*—Calibration curves are different for each analyzer and can change each time calibration is carried out.

3.2.4 *combustion charge air, n*—compressed air at a specified pressure introduced into the combustion chamber.

3.2.5 *ignition delay (ID), n*—period of time, in milliseconds, between the start of fuel injection and the start of combustion.

3.2.5.1 *Discussion*—In the context of this standard, this period is represented by the mean of ID_0 and ID_{150}.

3.2.5.2 *ID_0, n*—the time in milliseconds (ms) between the start of fuel injection and the point where the relative pressure recovers to 0 kPa, as shown in Fig. A3.1.

3.2.5.3 *ID_{150}, n*—the time in milliseconds (ms) between the start of fuel injection and the point where the relative pressure reaches 150 kPa, as shown in Fig. A3.1.

3.2.5.4 *Discussion*—Start of fuel injection is interpreted as the rise in the electronic signal that opens the injector for the time given in Table 2; timings for ID_0 and ID_{150} commence at this start point.

3.2.5.5 *Discussion*—IDs are recorded but not reported as they are converted into ICN by an instrument specific calibration curve.

3.2.6 *indicated cetane number (ICN), n*—measure of the ignition performance of a diesel fuel obtained by comparing it to reference fuels that have been blended to a scale; where 0 and 100 are represented by 1-methylnaphthalene and n-hexadecane respectively, to create a calibration curve.

3.2.6.1 *Discussion*—It is in principle a number indicated from a calibration curve that has been generated on the analyszer under test using reference fuel blend calibration points. The calibration curve, ICN = function of ignition delay (ID); see research report[7] for the format of the equation used. The scale is defined by the relationship shown in Eq 1:

$$\text{indicated cetane number} = \%\ \text{n-hexadecane (volume fraction)} \quad (1)$$

for any blends of n-hexadecane and 1-MN.

3.2.7 *injection time, n*—the period of time, in microseconds (µs), that the fuel injector nozzle is open as determined by the

[3] Available from European Committee for Standardization (CEN), Rue de la Science 23, B-1040, Brussels, Belgium, http://www.cen.eu.

[4] Available from Energy Institute, 61 New Cavendish St., London, W1G 7AR, U.K., http://www.energyinst.org.

[5] Available from Canadian General Standards Board (CGSB), 11 Laurier St., Phase III, Place du Portage, Gatineau, Quebec K1A 0S5, Canada, http://www.tpsgc-pwgsc.gc.ca/ongc-cgsb.

[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[7] Research Report reference IP 617 (ILS): Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K., http://www.energyinst.org.uk.

length of the electronic signal (injection pulse), in microseconds, that opens the injector.

3.2.8 *reference fuels, n*—1-methylnaphthalene and n-hexadecane.

3.3 *Abbreviations:*

3.3.1 *ICN*—indicated cetane number

3.3.2 *ID*—ignition delay

3.3.3 *1–MN*—reference fuel 1-methylnaphthalene

3.3.4 *QC*—quality control

4. Summary of Test Method

4.1 A sub-sample of the sample under test is automatically drawn from a sample vial located in the auto-sampler carousel and heated during pressurization. At the start of a combustion cycle, a small specimen of the sub-sample is injected into a temperature and pressure controlled, constant volume combustion chamber, which has previously been charged with compressed air of a specified quality. Each injection, and its resulting combustion, causes a rapid pressure rise in the combustion chamber that is detected by the dynamic pressure sensor.

4.2 The complete test sequence comprises a cleaning stage and multiple combustion cycles (see Section 13, A3.1.5, and A3.1.5.1) to obtain ignition delay (ID) values. The ICN result is determined using the mean of the combustion cycles' IDs, and the reference fuel calibration curve.

4.3 Each analyzer is calibrated with seven fluids created from blends of reference fuels, with known ICNs calculated from the ICN scale; test results outside the calibration range are determined by extrapolating the calibration curve, but are subject to increased uncertainty.

5. Significance and Use

5.1 The ICN value determined by this test method provides a measure of the ignition characteristics of diesel fuel oil used in compression ignition engines.

5.2 This test can be used by engine manufacturers, petroleum refiners, fuel producers and in commerce as a specification aid to relate or match fuels and engines.

5.3 The relationship of diesel fuel ICN determinations to the full scale, variable speed, variable load diesel engine is not completely understood.

5.4 This test can be applied to non-conventional diesel fuels.

5.5 This test determines ICN; it requires a sample of approximately 40 mL and a test time of approximately 25 min.

5.6 This test method is based on the Energy Institute Test Method IP 617.

6. Interferences

6.1 Effects of UV light. Minimize exposure of sample fuels, reference fuels, calibration and verification fluids, and QC samples to sunlight or fluorescent lamp UV emissions to minimize induced chemical reactions that can affect the ignition delay measurements.

6.1.1 Exposure of these fuels and materials to UV wavelengths shorter than 550 nm for a short period of time can significantly affect ignition delay measurements.

NOTE 1—The formation of peroxide and free radicals can affect ignition delay. These formations are minimized when the fuel sample is stored in the dark in a cold room at a temperature of less than 10 °C and covered by a blanket of inert gas.

6.2 A limited study (see Appendix X1) demonstrated that an unusually high purity (99 %) reference fuel (1- MN) used for calibration can result in a positive relative bias of 0.3 ICN at a level of 50 ICN.

7. Apparatus

7.1 *Automatic Auto-sampling Analyzer*[8]—The apparatus as shown in Fig. A2.1 and outlined in 7.1.1, 7.1.2, 7.1.3, and 7.1.4, is described in more detail in Annex A2. For the installation and set-up procedures, and for a detailed system description, refer to the manufacturer's instructions.

7.1.1 *Electronics,* comprising power supplies (including an integral uninterruptable power supply) for the programmable logic controllers, data acquisition units,and associated interfaces.

7.1.2 *Combustion Chamber Assembly,* comprising the heated constant volume combustion chamber, cooled dynamic pressure sensor as well as regulating and shut-off valves, and temperature and pressure sensors.

7.1.2.1 *Combustion Chamber,* a stainless steel combustion chamber of capacity 0.390 L ± 0.010 L.

7.1.3 *Common Rail Injection System,* comprising a cooled piezoelectric injector, high pressure piston pump, heated piping, and temperature and pressure sensors.

7.1.4 *Auto Sampler/Carousel,* providing space for up to 36 sample vials and cleaning fluid.

7.2 *Sample Vials,* 40 mL (nominal) headspace vials with screw caps and silicone/PTFE septa or natural rubber/PTFE septa, approximately 1.3 mm thick, Shore A hardness of approximately 45 (see ISO 868). The PTFE side of the septum shall be on the inside of the vial.

7.2.1 The vials shall be amber or brown glass to help protect against the effects of UV light.

7.3 *Syringe Filter,* disposable, 25 mm to 28 mm diameter with a nominal pore size of 0.45 µm or less, PTFE filter media, to be attached onto a syringe (7.4).

7.4 *Syringe,* disposable, ≥20 mL plastic, suitable for use with a syringe filter (7.3).

7.5 *Recirculating Cooler,* capable of recirculating coolant to the injector assembly and the dynamic pressure sensor and maintaining a bath temperature of 65 °C ± 5 °C.

7.6 *Computer,* for inputting and outputting data, printing functions and interfacing with the analyzer and networks.

[8] The sole source of supply of the analyzer described in this method known to the committee at this time is Stanhope-Seta, London Street, Chertsey, Surrey KT16 8AP UK. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.