



Designation: D7668 – 23

Standard Test Method for Determination of Derived Cetane Number (DCN) of Diesel Fuel Oils—Ignition Delay and Combustion Delay Using a Constant Volume Combustion Chamber Method¹

This standard is issued under the fixed designation D7668; 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 derived cetane number of conventional diesel fuel oils, diesel fuel oils containing cetane number improver additives, and is applicable to products typical of Specification [D975](#), Grades No.1-D and 2-D regular, low and ultra-low-sulfur diesel fuel oils, European standard EN590, and Canadian standards CAN/CGSB-3.517, CAN/CGSB-3.520, and CAN/CGSB-3.522. The test method may be applied to the quantitative determination of the derived cetane number of biodiesel, blends of diesel fuel oils containing biodiesel material (for example, Specifications [D975](#), [D6751](#), and [D7467](#)), and diesel fuel oil blending components.

1.2 This test 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 sample. An equation converts the ignition delay and the combustion delay determined from the dynamic pressure curve to a derived cetane number (DCN).

1.3 This test method covers the ignition delay ranging from 1.9 ms to 25 ms and combustion delay ranging from 2.5 ms to 160 ms (30 DCN to 70 DCN). However, the precision stated only covers the range of DCN results from 38.45 to 64.35.

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.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standard-*

ization 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](#)
 - [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 Blendstock \(B100\) for Middle Distillate Fuels](#)
 - [D7467 Specification for Diesel Fuel Oil, Biodiesel Blend \(B6 to B20\)](#)
 - [E456 Terminology Relating to Quality and Statistics](#)
- ### 2.2 EN Standards:³
- [EN590 Automotive Fuels—Diesel—Requirements and Test Methods](#)

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.

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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.

³ Available from European Committee for Standardization. Central Secretariat: rue de Stassart, 36,B-1050 Brussels, Belgium.

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

2.3 Energy Institute Standards:⁴

IP41 Ignition Quality of Diesel Fuels—Cetane Engine Test Method

2.4 Canadian Standards:⁵

CAN/CGSB-3.517 Diesel fuel

CAN/CGSB-3.520 Diesel fuel containing low levels of biodiesel (B1–B5)

CAN/CGSB-3.522 Diesel fuel containing biodiesel (B6–B20)

2.5 DIN Standards:⁶

DIN 73372 Einspritzdüsen Grösse T und U

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this test method, refer to Terminology **D4175**.

3.1.2 *accepted reference value (ARV)*, *n*—a value that serves as an agreed-upon reference for comparison and that is derived as (1) a theoretical or established value, based on scientific principles, (2) an assigned value, based on experimental work of some national or international organization, such as the U.S. National Institute of Standards and Technology (NIST), or (3) a consensus value, based on collaborative experimental work under the auspices of a scientific or engineering group. **E456**

3.1.2.1 *Discussion*—In the context of this method, accepted reference value is understood to apply to the ignition delay and the combustion delay of specific reference materials determined under reproducibility conditions by collaborative experimental work.

3.1.3 *cetane number (CN)*, *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**

3.1.3.1 *Discussion*—In the context of this test method, cetane number is that defined by Test Method **D613/IP41**.

3.1.4 *check standard*, *n*—in QC testing, a material having an accepted reference value used to determine the accuracy of a measurement system.

3.1.4.1 *Discussion*—In the context of this test method, check standard refers to the calibration reference material.

3.1.5 *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 *calibration reference material*, *n*—a pure chemical or a specified mixture of pure chemicals having an assigned

ignition delay accepted reference value and an assigned combustion delay accepted reference value.

3.2.2 *chamber wall temperature*, *n*—temperature, in °C, of the combustion chamber wall.

3.2.3 *charge air*, *n*—compressed synthetic air at a specified pressure introduced into the combustion chamber at the beginning of each test cycle.

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

3.2.5 *combustion delay (CD)*, *n*—that period of time, in milliseconds (ms), between the start of fuel injection and mid-point of the combustion pressure curve.

3.2.5.1 *Discussion*—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 chamber static 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.

3.2.6 *derived cetane number (DCN)*, *n*—a number calculated using a conversion equation to determine a cetane number.

3.2.6.1 *Discussion*—The conversion equation relates a measured ignition delay or ignition delay and combustion delay from a combustion analyzer, to a cetane number.

3.2.7 *ignition delay (ID)*, *n*—that period of time, in milliseconds (ms), between the start of fuel injection and the start of combustion as determined using the specific combustion analyzer applicable for this test method.

3.2.7.1 *Discussion*—In the context of this test method, start of fuel injection is interpreted as the rise in the electronic signal that opens the injector; combustion is interpreted as the part of the pressure curve generated during the combustion cycle when significant (+0.02 MPa above the chamber static pressure) and sustained increase in rate-of-change in pressure, as measured by a pressure sensor in the combustion chamber.

3.2.8 *injection period*, *n*—the period of time, in microseconds (μs), that the fuel injector nozzle is open as determined by the length of the electronic signal, in microseconds, that opens the injector.

3.2.9 *operation period*, *n*—the time, not to exceed 12 h, between successive calibration or QC testing, or both, of the combustion analyzer by a single operator.

3.3 Abbreviations:

3.3.1 *ARV*—accepted reference value

3.3.2 *CD*—combustion delay

3.3.3 *CN*—cetane number

3.3.4 *DCN*—derived cetane number

3.3.5 *ID*—ignition delay

3.3.6 *QC*—quality control

⁴ Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K., <http://www.energyinst.org.uk>.

⁵ Available from the Canadian General Standards Board, Sales Centre, Gatineau, Canada, K1A1G6. www.ongc-cgsb.ca.

⁶ Available from Beuth Verlag GmbH (DIN—DIN Deutsches Institut für Normung e.V.), Burggrafenstrasse 6, 10787, Berlin, Germany, <http://www.en.din.de>.

4. Summary of Test Method

4.1 A small specimen of sample is injected into a heated, temperature-controlled, constant volume chamber, which has previously been charged with compressed 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.⁷ The remaining ID's and CD's are averaged to produce the two independent results. An equation converts the average ID result and the average CD result into a DCN.

5. Significance and Use

5.1 The ID and CD values and the DCN 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 and marketers, and in commerce as a specification aid to relate or match fuels and engines.

5.3 The relationship of diesel fuel oil DCN determinations to the performance of full-scale, variable-speed, variable-load diesel engines is not completely understood.

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

5.5 This test determines ignition characteristics and requires a sample of approximately 370 mL and a test time of approximately 30 min using a fit-for-use instrument.

6. Interferences

6.1 **Warning**—Minimize exposure of sample fuels, calibration reference materials, QC samples, and check standards to sunlight or fluorescent lamp UV emissions to minimize induced chemical reactions that can affect the delay measurements.⁸

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 radicals can affect ignition delay measurement. These formations are minimized when the sample or material is stored in the dark in a cold room at a temperature of less than 10 °C and covered by a blanket of nitrogen.

⁷ Ross, Stephen, "Peirce's Criterion for the Elimination of Suspect Experimental Data," *Journal of Engineering Technology*, Fall 2003.

⁸ Supporting data, "Sunlight and Air Exposure Effects on Octane Number or Cetane Number of Petroleum Product Samples," have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1502.

7. Apparatus

7.1 *General*—This test method uses an integrated automated analytical measurement system⁹ comprised of:

7.1.1 *Combustion Chamber*—A cylindrical chamber having a volume of 0.473 L ± 005 L, with external heating elements, heat shield, and electrically actuated intake and exhaust valves. There is an opening at one end of the chamber to accommodate insertion of the fuel injection nozzle assembly and there are openings at the other end of the chamber to insert air, remove exhaust, and attach a pressure sensor.

7.1.2 *Fuel Injection System*—A high pressure sample, generated using a hydraulic pump and pressure multiplier, is delivered to a commercial electronic diesel fuel injector. A sample reservoir supplies the pressure multiplier with sample to ensure proper and repeatable injection of calibration, QC material, and test specimens into the combustion chamber. The system includes:

7.1.2.1 *Fuel Sample Reservoir*—A metal reservoir having a nominal volume of 200 mL.

7.1.2.2 *Hydraulic Pump*—Capable of producing fuel pressures up to 19 MPa.

7.1.2.3 *Pressure Multiplier*—10:1 ratio.

7.1.2.4 *Fuel Injector*—A solenoid-based common rail diesel fuel injector from Bosch with the part number 0445110181 (**Annex A6**).

7.1.2.5 *Safety Burst Disk*—Relieves the high pressure if the sample pressure exceeds 180 MPa. The burst disk is attached to the high pressure sample system manifold block opposite the injector.

7.1.2.6 *Flush Valve*—High pressure air actuated valve used to exchange samples.

7.1.3 *Coolant System*—A closed loop circulating coolant system to control the temperature of the combustion injector nozzle and dynamic pressure sensor. The system includes an auxiliary heat exchanger with built-in circulating pump and flow control valves.

7.1.4 *Instrument Sensors*—Sensors used to measure and either indicate the value of a variable or transmit the condition for control or data acquisition purposes such as:

7.1.4.1 *Combustion Chamber Static Pressure Sensor*—A calibrated sensor installed to correct the temperature offset of dynamic pressure sensor.

7.1.4.2 *Combustion Chamber Dynamic Pressure Sensor*—A calibrated sensor installed to measure the pressure within the combustion chamber.

7.1.4.3 *Sample Pressure Sensor*—A calibrated sensor installed to measure the pressure of the sample injected into the combustion chamber.

7.1.4.4 *Nitrogen Pressure Sensor*—A sensor installed to measure the inlet pressure from the nitrogen regulator.

7.1.4.5 *Combustion Chamber Inner Wall Temperature Sensor*—Type K thermocouple with a stainless steel sheath.

⁹ The sole source of supply of the analyzer described in this method known to the committee at this time is PAC LP, 8824 Fallbrook Drive, Houston, TX 77064. 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.