



Designation: D 5293 – 04

An American National Standard

Standard Test Method for Apparent Viscosity of Engine Oils Between –5 and –35°C Using the Cold-Cranking Simulator¹

This standard is issued under the fixed designation D 5293; 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 laboratory determination of apparent viscosity of engine oils by cold cranking simulator (CCS) at temperatures between –5 and –35°C at shear stresses of approximately 50 000 to 100 000 Pa and shear rates of approximately 10^5 to 10^4 s^{–1} and viscosities of approximately 500 to 25 000 mPa·s. The range of an instrument is dependent on the instrument model and software version installed. These results are related to engine-cranking characteristics of engine oils.

1.2 A special procedure is provided in **Annex A1** for highly viscoelastic oils.

1.3 Procedures are provided for both manual and automated determination of the apparent viscosity of engine oils using the cold-cranking simulator.

1.4 A special manual procedure is provided in **Annex A1** for highly viscoelastic oils.

1.5 The values stated in SI units are to be regarded as the standard.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific warning statements are given in **7.1**, **7.2**, **7.3**, and **Section 8**.

2. Referenced Documents

2.1 ASTM Standards:²

D 2602 Test Method for Apparent Viscosity of Engine Oils at Low Temperature Using the Cold-Cranking Simulator³

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.07 on Flow Properties.

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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³ Withdrawn.

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products

3. Terminology

3.1 Definitions:

3.1.1 *Newtonian oil or fluid, n*—one that exhibits a constant viscosity at all shear rates.

3.1.2 *non-Newtonian oil or fluid, n*—one that exhibits a viscosity that varies with changing shear stress or shear rate.

3.1.3 *viscosity, η, n*—the property of a fluid that determines its internal resistance to flow under stress, expressed by:

$$\eta = \tau/\dot{\gamma} \quad (1)$$

where:

τ = the stress per unit area, and

$\dot{\gamma}$ = the rate of shear.

3.1.3.1 *Discussion*—It is sometimes called the coefficient of dynamic viscosity. This coefficient is thus a measure of the resistance to flow of the liquid. In the SI, the unit of viscosity is the pascal-second; for practical use, a submultiple (millipascal-second) is more convenient and is customarily used. The millipascal second is 1 cP.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *apparent viscosity, n*—the viscosity obtained by use of this test method.

3.2.1.1 *Discussion*—Since many engine oils are non-Newtonian at low temperature, apparent viscosity can vary with shear rate.

3.2.2 *calibration oils, n*—oils with known viscosity and viscosity/temperature functionality that are used to define the calibration relationship between viscosity and cold-cranking simulator rotor speed.

3.2.3 *test oil, n*—any oil for which the apparent viscosity is to be determined by use of this test method.

3.2.4 *viscoelastic oil, n*—a non-Newtonian oil or fluid that climbs up the rotor shaft during rotation.

4. Summary of Test Method

4.1 An electric motor drives a rotor that is closely fitted inside a stator. The space between the rotor and stator is filled with oil. Test temperature is measured near the stator inner wall

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



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FIG. 1 Cold Cranking Simulator

and maintained by regulated flow of refrigerated coolant through the stator. The speed of the rotor is calibrated as a function of viscosity. Test oil viscosity is determined from this calibration and the measured rotor speed.

5. Significance and Use

5.1 The CCS apparent viscosity of automotive engine oils correlates with low temperature engine cranking. CCS apparent viscosity is not suitable for predicting low temperature flow to the engine oil pump and oil distribution system. Engine cranking data were measured by the Coordinating Research Council (CRC) L-49⁴ test with reference oils that had viscosities between 600 and 8400 mPa·s (cP) at -17.8°C and between 2000 and 20 000 mPa·s (cP) at -28.9°C . The detailed relation between this engine cranking data and CCS apparent viscosities is in Appendixes X1 and X2 of the 1967 T edition of Test Method D 2602⁵ and CRC Report 409.⁴ Because the CRC L-49 test is much less precise and standardized than the CCS procedures, CCS apparent viscosity need not accurately predict the engine cranking behavior of an oil in a specific engine. However, the correlation of CCS apparent viscosity with average L-49 engine cranking results is satisfactory.

5.2 The correlation between CCS and apparent viscosity and engine cranking was confirmed at temperatures between -1 and -40°C by work on 17 commercial engine oils (SAE grades 5W, 10W, 15W, and 20W). Both synthetic and mineral oil based products were evaluated. See ASTM STP 621.⁶

5.3 A correlation was established in a low temperature engine performance study between light duty engine startability and CCS measured apparent viscosity. This study used ten 1990's engines at temperatures ranging from -5 down to -40°C with six commercial engine oils (SAE 0W, 5W, 10W, 15W, 20W, and 25W).⁷

6. Apparatus

6.1 Two types of apparatus are available for use in this test method: the manual cold-cranking simulator (see 6.2) and the automated CCS (see 6.3 and 6.4).

6.2 *Manual CCS*⁸, consisting of a direct current (dc) electric motor that drives a rotor inside a stator; a rotor speed sensor or tachometer that measures rotor speed; a dc ammeter and fine current-control adjust dial; a stator temperature control system that maintains temperature within $\pm 0.05^{\circ}\text{C}$ of set point; and a coolant circulator compatible with the temperature control system. See Fig. 1.

6.3 *Automated CCS*⁸, consisting of the CCS described in 6.2, with computer, computer interface, and test sample injection pump. The methanol circulator (see 6.6.1) is not used because the test sample injection displaces the previous test sample. See Fig. 2.

6.4 *Automatic Automated CCS*⁸—The CCS described in 6.3 with the addition of an automated sample table allowing up to 30 test samples to be run sequentially under computer control without operator attention. See Fig. 3.

NOTE 1—In some CCS instruments, the refrigeration may be achieved using solid state thermoelectric modules.

6.5 *Calibrated Thermistor*—Sensor for insertion in a well near the inside surface of the stator to indicate the test temperature.

⁴ CRC Report No. 409 "Evaluation of Laboratory Viscometers for Predicting Cranking Characteristics of Engine Oils at -0°F and -20°F ," April 1968 available from the Coordinating Research Council, Inc., 219 Perimeter Center Parkway, Atlanta, GA 30346.

⁵ Supporting data (Appendixes X1 and X2) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1402.

⁶ Stewart, R. M., "Engine Pumpability and Crankability Tests on Commercial "W" Grade Engine Oils Compared to Bench Test Results," *ASTM STP 621* ASTM 1967, 1968. 1969 *Annual Book of ASTM Standards*, Part 17 (Also published as SAE Paper 780369 in SAE Publication SP-429.).

⁷ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1442.

⁸ The sole source of supply of the apparatus known to the committee at this time is Cannon Instrument Co., P.O. Box 16, State College, PA 16804. 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 committee¹, which you may attend.

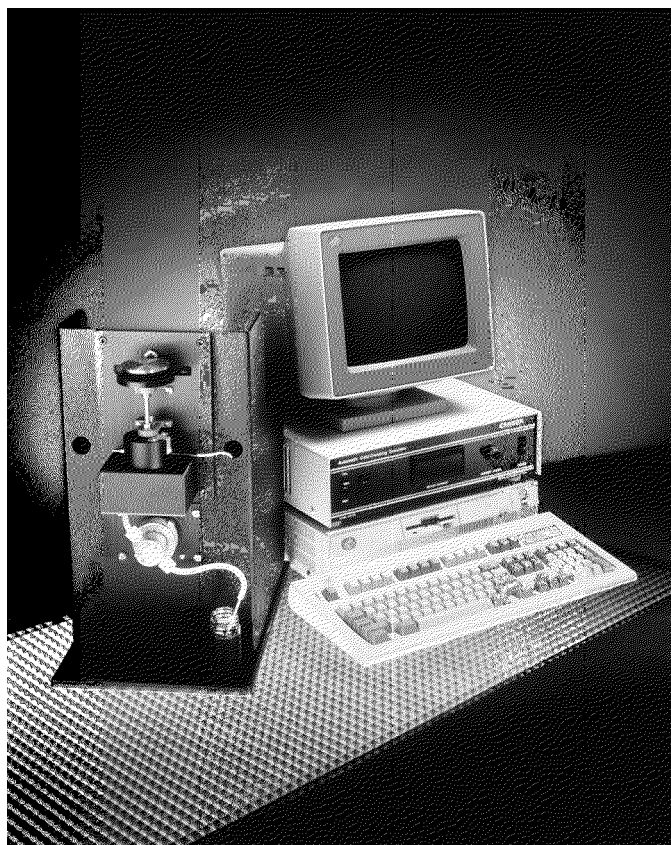


FIG. 2 Automated Cold-Cranking Simulator



FIG. 3 Automatic Automated Cold-Cranking Simulator