



Designation: D5001 – 23

Standard Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)¹

This standard is issued under the fixed designation D5001; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers assessment of the wear aspects of the boundary lubrication properties of aviation turbine fuels on rubbing steel surfaces.

1.1.1 This test method incorporates two procedures, one using a semi-automated instrument and the second a fully automated instrument. Either of the two instruments may be used to carry out the test.

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

1.3 *This standard does not purport to address 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.*

1.4 *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

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination

D6708 Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that

Purport to Measure the Same Property of a Material

2.2 *American Iron and Steel Institute Standard:*³
AISI E-52100 Chromium Alloy Steel

2.3 *ISO Standard:*⁴
ISO 3290-1 Rolling bearings -- Balls -- Part 1: Steel balls

2.4 *Society of Automotive Engineers Standard:*⁵
SAE 8720 Steel

3. Terminology

3.1 *Definitions:*

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lubricity, n*—qualitative term describing the ability of a fluid to minimize friction between, and damage to, surfaces in relative motion under load.

3.2.1.1 *Discussion*—In this test method, the lubricity of a fluid is defined in terms of a wear scar, in millimeters, produced on a loaded stationary ball from contact with a fluid-wetted rotating cylindrical test ring operating under closely defined and controlled conditions.

3.2.2 *wear scar, n*—in the liquid fuels industry, average diameter of a worn and abraded area, measured in two specified directions, produced on a test ball under defined conditions.

3.2.2.1 *Discussion*—The wear scar generated by Test Method D5001 is often referred to as the BOCLE wear scar.

3.3 *Abbreviations:*

3.3.1 **BOCLE**—Ball On Cylinder Lubricity Evaluator

3.3.2 **HRC**—Rockwell Hardness “C” scale.

3.3.3 **WSD**—Wear Scar Diameter

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.J0.04** on Additives and Electrical 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 Available from American Iron and Steel Institute (AISI), 1140 Connecticut Ave., NW, Suite 705, Washington, DC 20036, <http://www.steel.org>.

⁴ Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, <http://www.iso.ch>.

⁵ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

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

4. Summary of Test Method

4.1 The fluid under test is placed in a test reservoir in which atmospheric air is maintained at 10 % relative humidity. A non-rotating steel ball is held in a vertically mounted chuck and forced against the outside diameter of an axially mounted cylindrical steel ring with an applied load. The test ring is rotated at a fixed speed while being partially immersed in the fluid reservoir. This maintains the ring in a wet condition and continuously transports the test fluid to the ball/ring interface. The wear scar generated on the test ball is a measure of the lubricating property of the fluid. For wear scar diameter (WSD) calibration and standardization, see Section 10.

5. Significance and Use

5.1 Wear due to excessive friction resulting in shortened life of engine components such as fuel pumps and fuel controls has sometimes been ascribed to lack of lubricity in an aviation fuel.

5.2 The relationship of test results to aviation fuel system component distress due to wear has been demonstrated for some fuel/hardware combinations where boundary lubrication is a factor in the operation of the component.

5.3 The wear scar generated in the ball-on-cylinder lubricity evaluator (BOCLE) test is sensitive to contamination of the fluids and test materials, the presence of oxygen and water in the atmosphere, and the temperature of the test. Lubricity measurements are also sensitive to trace materials acquired during sampling and storage. Containers specified in Practice D4306 shall be used.

5.4 The BOCLE test method may not directly reflect operating conditions of engine hardware. For example, some fuels that contain a high content of certain sulfur compounds can give anomalous test results.

6. Apparatus

6.1 For details of the *Ball-On-Cylinder Lubricity Evaluator* (BOCLE), apparatus required for each method see: Annex A1 for the semi-automatic method, Annex A2 for the fully automatic method.

6.2 *Microscope*, capable of 100× magnification and suitable of measuring the wear scar on the ball to the nearest 0.01 mm.

6.2.1 *Method of Measuring the Wear Scar*—This may be either a Glass Slide Micrometer, with a scale ruled in 0.01 mm divisions, or a digital micrometer and slide assembly, having a resolution of at least 0.01 mm.^{6,7}

6.3 *Cleaning Bath*—Ultrasonic seamless stainless steel tank with a capacity of 1.9 L and a cleaning power of 40W.

6.4 The test requirements are listed in Table 1.

TABLE 1 Standard Operating Conditions

Fluid Volume	50 mL ± 1.0 mL
Fluid Temperature	25 °C ± 1 °C
Conditioned Air	10 % ± 0.2 % relative humidity at 25 °C ± 1 °C
Fluid pretreatment	0.50 L/min flowing through and 3.3 L/min over the fluid for 15 min
Fluid test conditions	3.8 L/min flowing over the fluid
Applied Load	1000 g (500 g weight) (± 1 g)
Cylinder Rotational Speed	240 rpm ± 1 rpm
Test Duration	30 min ± 0.1 min

7. Reagents and Materials

7.1 *Test Ring*, of SAE 8720 steel, having a Rockwell hardness “C” scale, (HRC) number of 58 to 62 and a surface finish of 0.56 µm to 0.71 µm root mean square.^{6,8} The dimensions are given in Fig. 1.

7.2 *Test Balls*, chrome alloy steel, made from AISI standard steel No. E-52100, with a diameter of 12.7 mm, Grade 5 to 10. The balls are described in ISO 3290-1. The HRC shall be 64 to 66, a closer limit than is found in the ISO requirement.

7.3 *Additional Equipment*—Details of additional items of test equipment specific to each test method are given in the appropriate annex.

7.4 *Compressed Air* (**Warning**—Compressed gas under high pressure. Use with extreme caution in the presence of combustible material, since the autoignition temperatures of most organic compounds in air are drastically reduced at

⁸ The sole source of supply of the apparatus known to the committee at this time is (for the semi-automatic method) Test Rings Part No. F25061, Falex Corp., 2055 Comprehensive Drive, Aurora, IL 60505 and (for the fully automatic method) Test Rings, Part No. ABSRING, PCS Instruments, 78 Stanley Gardens, London, W3 7SZ, U.K.

INNER DIAMETER TO SUIT
TEST RING ADAPTER

MATERIAL AISI 8720
SPECIAL MODIFIED

HARDNESS 58-62
ROCKWELL C

FINISH 0.56-0.71 µm
(22-28 MICRO INCH)

DIMENSIONS MM

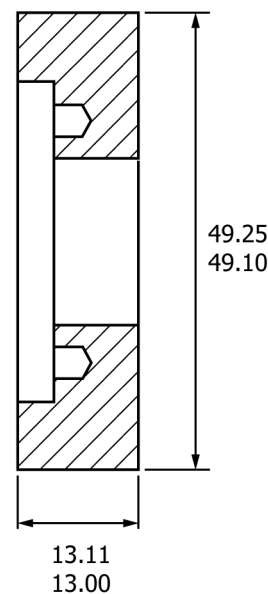


FIG. 1 Ball-on-Cylinder Test Ring

⁶ 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.

⁷ The sole source of supply of the apparatus known to the committee at this time is Microscope part number ABSMIC from PCS Instruments, 78 Stanley Gardens, London, W3 7SZ, U.K. A certificate of traceability from the National Institute of Standards and Technology is available.