Designation: D 6079 – 99

An American National Standard

Standard Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR) [1]

This standard is issued under the fixed designation D 6079; 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 evaluates the lubricity of diesel fuels using a high-frequency reciprocating rig (HFRR).

1.2 This test method is applicable to middle distillate fuels, such as Grades Low Sulfur No. 1 D, Low Sulfur No. 2 D, No. 1 D, and No. 2 D diesel fuels, in accordance with Specification D 975; and other similar petroleum-based fuels which can be used in diesel engines

NOTE 1—It is not known that this test method will predict the performance of all additive/fuel combinations. Additional work is underway to further establish this correlation and future revisions of this test method may be necessary once this work is complete.

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

1.4 *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 applicable regulatory limitations prior to use.* Specific hazard statements are given in section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

D 329 Specification for Acetone [2]

D 362 Specification for Industrial Grade Toluene [3]

D 975 Specification for Diesel Fuel Oils [4]

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products [5]

D 4177 Practice for Automatic Sampling of Petroleum and Petroleum Products[5]

D 4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination [5]

D 5290 Test Method for Measurement of Oil Consumption, Piston Deposits, and Wear in a Heavy-Duty High-Speed Diesel Engine—NTC-400 Procedure [6]

D 6078 Test Method for Evaluating Lubricity of Diesel Fuels by the Scuffing Load Ball-On-Cylinder Lubricity Evaluator (SLBOCLE) [7]

E 18 Test Method for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials [8]

E 92 Test Method for Vickers Hardness of Metallic Materials [8]

2.2 *American Iron and Steel Institute Standard:* [9]

AISI E-52100 Chromium Alloy Steel

2.3 *American National Standards Institute Standard:* [10]

ANSI B3.12 Metal Balls

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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

3.1.1.1 *Discussion*—In this test method, the lubricity of a fluid is evaluated by the wear scar, in millimetres, produced on an oscillating ball from contact with a stationary disc immersed in the fluid operating under defined and controlled conditions.

3.1.2 *boundary lubrication, n*—a condition in which the friction and wear between two surfaces in relative motion are determined by the properties of the surfaces and the properties of the contacting fluid, other than bulk viscosity.

3.1.2.1 *Discussion*—Metal to metal contact occurs and the chemistry of the system is involved. Physically adsorbed or chemically reacted soft films (usually very thin) support contact loads. As a result, some wear is inevitable.

4. Summary of Test Method

4.1 A 2-mL test specimen of fuel is placed in the test reservoir of an HFRR and adjusted to either of the standard

[1] This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.E2 on Diesel Fuels. This test method was developed by ISO/TC22/SC7/WG6 and is a part of ISO 12156.

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[2] *Annual Book of ASTM Standards*, Vol 06.04.

[3] Discontinued—See 1998*Annual Book of ASTM Standards*, Vol 06.03.

[4] *Annual Book of ASTM Standards*, Vol 05.01.

[5] *Annual Book of ASTM Standards*, Vol 05.02.

[6] Discontinued–See 1997 *Annual Book of ASTM Standards*, Vol 05.03.

[7] *Annual Book of ASTM Standards*, Vol 05.04.

[8] *Annual Book of ASTM Standards*, Vol 03.01.

[9] Available from American Iron and Steel Institute, 1000 16th St., NW, Washington, DC 20036.

[10] Available from American National Standards Institute, 11 W. 42nd St., NW, Washington, DC 20036.

temperatures (25 or 60°C). The preferred test temperature is 60°C, except where there may be concerns about loss of fuel because of its volatility or degradation of the fuel because of the temperature.

4.2 When the fuel temperature has stabilized, a vibrator arm holding a nonrotating steel ball and loaded with a 200-g mass is lowered until it contacts a test disk completely submerged in the fuel. The ball is caused to rub against the disk with a 1-mm stroke at a frequency of 50 Hz for 75 min.

4.3 The ball is removed from the vibrator arm and cleaned. The dimensions of the major and minor axes of the wear scar are measured under 100× magnification and recorded.

5. Significance and Use

5.1 Diesel fuel injection equipment has some reliance on lubricating properties of the diesel fuel. Shortened life of engine components, such as diesel fuel injection pumps and injectors, has sometimes been ascribed to lack of lubricity in a diesel fuel.

5.2 The trend of HFRR test results to diesel injection system pump component distress due to wear has been demonstrated in pump rig tests for some fuel/hardware combinations where boundary lubrication is believed to be a factor in the operation of the component.[11]

5.3 The wear scar generated in the HFRR test is sensitive to contamination of the fluids and test materials and the temperature of the test. Lubricity evaluations are also sensitive to trace contaminants acquired during test fuel sampling and storage.

5.4 The HFRR and Scuffing Load Ball on Cylinder Lubricity Evaluator (SLBOCLE, Test Method D 6078) are two methods for evaluating diesel fuel lubricity. No absolute correlation has been developed between the two test methods.

5.5 The HFRR may be used to evaluate the relative effectiveness of diesel fuels for preventing wear under the prescribed test conditions. Correlation of HFRR test results with field performance of diesel fuel injection systems has not yet been determined.

5.6 This test method is designed to evaluate boundary lubrication properties. While viscosity effects on lubricity in this test method are not totally eliminated, they are minimized.

6. Apparatus

6.1 *High-Frequency Reciprocating Rig (HFRR)*[12], (see Fig. 1) capable of rubbing a steel ball loaded with a 200-g mass against a stationary steel disk completely submerged in a test fuel. The apparatus uses a 1-mm stroke length at a frequency of 50 Hz for 75 min. Complete operating conditions are listed in Table 1.

6.2 *Test Reservoir*, capable of holding a test disk in a rigid manner beneath the test fuel. The temperature of this reservoir, and consequently the test fuel contained in it, is maintained by means of a closely attached electrically controlled heater pad.

6.3 *Control Unit*, for controlling stroke length, frequency, test reservoir temperature, friction force, electrical contact potential, and test duration, with an electronic data acquisition and control system. [12]

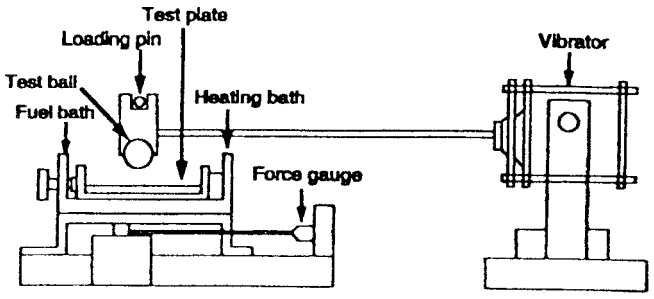

FIG. 1 Schematic Diagram of HFRR (not including instrumentation)

TABLE 1 Test Conditions

Fluid volume	2 ± 0.20 mL
Stroke length	1 ± 0.02 mm
Frequency	50 ± 1 Hz
Fluid temperature	25 ± 2°C or 60 ± 2°C
Relative humidity	> 30 %
Applied load	200 ± 1 g
Test duration	75 ± 0.1 min
Bath surface area	6 ± 1 cm^2

6.4 *Microscope*, capable of 100× magnification in graduations of 0.1 mm and incremented in divisions of 0.01 mm.

6.4.1 *Glass Slide Micrometer*, with a scale ruled in 0.01 mm divisions. [13]

6.5 *Cleaning Bath*, ultrasonic seamless stainless steel tank with adequate capacity and a cleaning power of 40 W or greater.

6.6 *Desiccator*, containing a non-indicating drying agent, capable of storing test disks, balls, and hardware.

7. Reagents and Materials

7.1 *Acetone*, (**Warning**—Extremely flammable. Vapors may cause flash fire.), conforming to Specification D 329.

7.2 *Compressed Air*, (**Warning**—Compressed gas under high pressure. Use with extreme caution in the presence of combustible material.), containing less than 0.1 ppmv hydrocarbons and 50 ppmv water.

7.3 *Gloves*, clean, lint-free, cotton, disposable

7.4 *Reference Fluids*:

7.4.1 *Fluid A*—High lubricity reference[14] (**Warning**—Flammable.). Store in clean, borosilicate glass with an aluminum foil-lined insert cap. Store in dark area.

7.4.2 *Fluid B*—Low lubricity reference[14] (**Warning**—Flammable. Vapor harmful.). Store in clean, borosilicate glass with an aluminum foil-lined insert cap. Store in a dark area.

7.5 *Test Ball*, (Grade 24 per ANSI B3.12) of AISI E-52100 steel, with a diameter of 6.00 mm, having a Rockwell hardness

[11] Nikanjam, M., Crosby, T., Henderson, P., Gray, C., Meyer, K, and Davenport, N., "ISO Diesel Fuel Lubricity Round Robin Program," SAE, Paper No. 952372, SAE Fuels and Lubricants Meeting, Oct. 16-19, 1995, Toronto, Canada.

[12] Available from PCS Instruments, 5 Warple Mews, London W3 ORF, England.

[13] Catalog No. 31-16-99 from Bausch and Lomb, Inc. has been found satisfactory. A certificate of traceability from the National Institute of Standards and Technology is available.

[14] Reference Fluids A and B are available from ASTM Test Monitoring Ctr., 6555 Penn Ave., Pittsburgh, PA 15026–4489..