Designation: D4172 – 94 (Reapproved 2004)$^{\varepsilon 1}$

Standard Test Method for Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method)[1]

This standard is issued under the fixed designation D4172; 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 Department of Defense.

ε^1 NOTE—Hand tightening information in 10.3 was modified editorially in May 2006.

1. Scope

1.1 This test method covers a procedure for making a preliminary evaluation of the anti-wear properties of fluid lubricants in sliding contact by means of the Four-Ball Wear Test Machine. Evaluation of lubricating grease using the same machine is detailed in Test Method D2266.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2266 Test Method for Wear Preventive Characteristics of Lubricating Grease (Four-Ball Method)

2.2 *ANSI Standard:*[3]

B3.12 Specification for Metal Balls

3. Terminology

3.1 *Definitions:*

3.1.1 *lubricant*, *n*—any material interposed between two surfaces that reduces the friction or wear between them.

3.1.2 *wear*, *n*—damage to a solid surface, generally involving progressive loss of material due to relative motion between that surface and a contacting substance or surface.

4. Summary of Test Method

4.1 Three 12.7-mm [½-in.] diameter steel balls are clamped together and covered with the lubricant to be evaluated. A fourth 12.7-mm diameter steel ball, referred to as the top ball, is pressed with a force of 147 or 392 N [15 or 40 kgf] into the cavity formed by the three clamped balls for three-point contact. The temperature of the test lubricant is regulated at 75°C [167°F] and then the top ball is rotated at 1200 rpm for 60 min. Lubricants are compared by using the average size of the scar diameters worn on the three lower clamped balls.

NOTE 1—Because of differences in the construction of the various machines on which the four-ball test can be made, the manufacturer's instructions should be consulted for proper machine set up and operation.

NOTE 2—Although the test can be run under other parameters, the precision noted in Section 10 may vary. No aqueous fluid was included in the round-robin to establish the precision limits.

5. Significance and Use

5.1 This test method can be used to determine the relative wear preventive properties of lubricating fluids in sliding contact under the prescribed test conditions. No attempt has been made to correlate this test with balls in rolling contact. The user of this test method should determine to his own satisfaction whether results of this test procedure correlate with field performance or other bench test machines.

6. Apparatus

6.1 *Four-Ball Wear Test Machine*[4]—See Figs. 1-3.

NOTE 3—It is important to distinguish between the Four-Ball E.P. and the Four-Ball Wear Test Machines. The Four-Ball E.P. Test Machine is designed for testing under heavier loads and lacks the sensitivity necessary for wear tests.

[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.L0 on Industrial Lubricants.

Current edition approved Nov. 1, 2004. Published November 2004. Originally approved in 1982. Last previous edition approved in 1999 as D4172 – 94 (1999). DOI: 10.1520/D4172-94R04E01.

[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 National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] The Four-Ball Wear Test Machine and the Falex Model #6, Multi-Specimen Friction and Wear Test Machine, both made by Falex Corp., 1020 Airpark Drive, Sugar Grove, IL 60554, have been found satisfactory for this purpose. This company can also furnish a microscope with a special base to measure the wear scars without removing the balls from the test-oil cup. Discontinued models of the Four-Ball Wear Test Machine made by Precision Scientific Co. and Roxana Machine Works are also satisfactory.

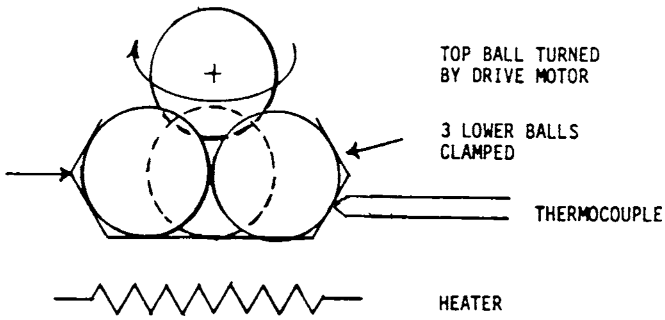

FIG. 1 Schematic of a Four-Ball Wear Test Machine

6.2 *Microscope*, [4] capable of measuring the diameters of the scars produced on the three stationary balls to an accuracy of 0.01 mm. It is more efficient to measure the scars without removing the three balls from the holder.

7. Materials

7.1 *Test Balls*, [5] chrome alloy steel, made from AISI standard steel No. E-52100, with diameter of 12.7 mm [0.5 in.] Grade 25 EP (Extra Polish). Such balls are described in ANSI B3.12. The extra-polish finish is not described in that specification. The Rockwell C hardness shall be 64 to 66, a closer limit than is found in the ANSI requirement.

7.2 *Cleaning Fluids* for preparing balls and apparatus for the test should be those approved as nontoxic, capable of removing antirust coatings from the balls, eliminating test-oil carryover from one test to the next, and not contribute to wear or antiwear of the test lubricant. When the fluid(s) is flammable, appropriate precautions should be taken (see Note 1). In the round-robin tests to determine repeatability and reproducibility no specific directions were given for cleaning balls and machine parts. Operators reported using various solvents with and without a sonic cleaning bath. Cleaning techniques reported by some cooperators are included in Research Report D02-1152, see Note 4.

8. Test Conditions

8.1 The test conditions used to develop the precision data as stated in Section 10 were:

	A	*B*
Temperature	75 ± 2°C [167 ± 4°C]	75 ± 2°C [167 ± 4°C]
Speed	1200 ± 60 rpm	1200 ± 60 rpm
Duration	60 ± 1 min	60 ± 1 min
Load	147 ± 2 N [15 ± 0.2 kgf]	392 ± 2 N [40 ± 0.2 kgf]

9. Preparation of Apparatus

9.1 Set up the drive of the machine to obtain a spindle speed of 1200 ± 60 rpm.

9.2 Set temperature regulator to produce a test-oil temperature of 75 ± 2°C [167 ± 4°F].

9.3 When an automatic timer is used to terminate a test, it should be checked for the required ±1 min accuracy at 60 min elapsed time.

9.4 The loading mechanism must be balanced to a zero reading with all parts and test oil in place. To demonstrate proper precision an addition or subtraction of 19.6 N [0.2 kgf] should be detectable in imbalance. Determination of accuracy of loading at 147 and 392 N [15 and 40 kgf] is difficult and generally limited to careful measurement of lever-arm ratios and weights or piston diameter and pressure gage calibration.

10. Procedure

10.1 Thoroughly clean four test balls, clamping parts for upper and lower balls and the oil cup using solvent or solvents with precautions indicated in 6.2. The parts can be final wiped using a fresh (unused) lint free industrial wipe. After cleaning, all parts are only to be handled using a fresh wipe. No trace of solvent should remain when the test oil is introduced and the machine assembled.

10.2 Tighten one of the clean balls into the spindle of the test machine.

10.3 Assemble three of the clean test balls in the test-oil cup and hand tighten using the wrench supplied by the equipment manufacturer, which has been found to be approximately 33.8 to 67.7 N·m [25 to 50 ft·lb].

10.4 Pour the oil to be evaluated into the test-oil cup to a level at least 3 mm [⅛ in.] above the top of the balls. Observe that this oil level still exists after the test-oil fills all of the voids in the test-oil cup assembly. In the round-robin to establish this test method the effect of oil level on wear was not determined.

10.5 Install the test-oil cup/three balls in the machine and avoid shock loading by slowly applying the test load (147 or 392 N) [15 or 40 kgf].

10.6 Turn on the heaters and set controls to obtain 75 ± 2°C [167 ± 4°F]. Heater voltage or offset on proportional controllers should be capable of bringing stabilized temperature within the prescribed limits.

10.7 When the test temperature is reached, start the drive motor which was previously set to drive the top ball at 1200 ± 60 rpm. Machines with automatic start using a proportional controller will start below the set temperature. The proportional band should be set narrow enough to limit the "under temperature" at start to near 2°C [4°F].

10.8 After the drive motor has been on for 60 ± 1 min, turn off the heaters and drive motor and remove the test-oil cup and three-ball assembly.

10.9 Measure the wear scars on the three lower balls to an accuracy of ±0.01 mm by one of the following methods:

10.9.1 *Option A*—Drain the test oil from three-ball assembly and wipe the scar area with a tissue. Leave the three balls clamped and set the assembly on a special base of a microscope that has been designed for the purpose.[4] Make two measurements on each of the wear scars. Take one measurement of the scar along a radial line from the center of the holder. Take the second measurement along a line 90° from the first measurement. Report the arithmetic average of the six measurements as scar diameter in millimetres.

10.9.2 *Option B*—Remove the three lower balls from their clamped position. Wipe the scar area. Make two measurements of each of the three scars. Make the two measurements at 90° to each other. If a scar is elliptical take one measurement with the striations and the other across the striations. Take care to

[5] Steel balls meeting this description were used in developing the precision of the test. They are available from the manufacturer of the test machine and some ball manufacturers. Some operators prefer to check a new box of balls by running an oil with a known result.