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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Measurement of Extreme-Pressure Properties of Lubricating Grease (Four-Ball Method)[1]

This standard is issued under the fixed designation D 2596; 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.

1. Scope

1.1 This test method covers the determination of the load-carrying properties of lubricating greases. Two determinations are made:

1.1.1 Load-Wear Index (formerly called Mean-Hertz Load), and

1.1.2 Weld Point, by means of the Four-Ball Extreme-Pressure (EP) Tester.

1.2 The values stated in SI units are to be regarded as the standard. The values 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.* Specific precautionary statements are given in Note 3 and Note 4.

2. Referenced Documents

2.1 *ASTM Standards:*

D 235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)[2]

2.2 *American National Standard:*

B3.12 Metal Balls[3]

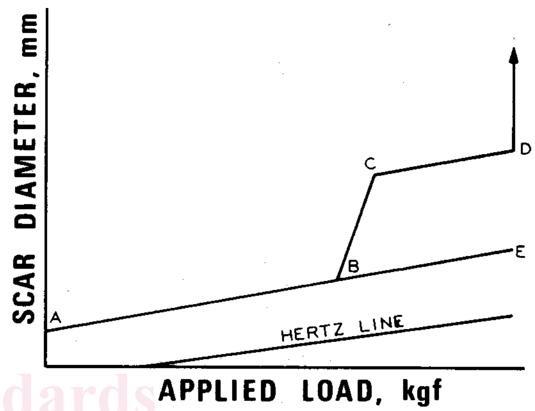
3. Terminology

3.1 *Definitions:*

3.1.1 *compensation line*, *n*—a line of plot on log-log paper where the coordinates are scar diameter in millimetres and applied load in kilograms-force (or Newtons) obtained under dynamic conditions.

3.1.1.1 *Discussion*—Shown in Fig. 1 as line ABE.

3.1.2 *compensation scar diameter*—the average diameter, in millimetres, of the wear scar on the stationary balls caused by the rotating ball under an applied load in the presence of a lubricant, but without causing either seizure or welding.



ABE—compensation line.
B—Point of last nonseizure load.
BC—Region of incipient seizure.
CD—Region of immediate seizure.
D—Weld point.

FIG. 1 Schematic Plot of Scar Diameter Versus Applied Load

3.1.3 *corrected load*, *n*—the load in kilograms-force (or Newtons) obtained by multiplying the applied load by the ratio of the Hertz scar diameter to the measured scar diameter at that load.

3.1.3.1 *Discussion*—In this test method, the corrected load is calculated for each run.

3.1.4 *hertz line*, *n*—a line of plot on log-log paper where the coordinates are scar diameter in millimetres and applied load in kilograms-force (or Newtons) obtained under static conditions.

3.1.4.1 *Discussion*—Shown in Fig. 1 as a *hertz line*.

3.1.5 *hertz scar diameter*, *n*—the average diameter, in millimetres, of an indentation caused by the deformation of the balls under static load (prior to test). It may be calculated from the equation:

$$D_h = 8.73 \times 10^{-2}(P)^{1/3} \tag{1}$$

where:

D_h is the Hertz diameter of the contact area in millimetres and
P is the static applied load in kilograms-force.

3.1.6 *immediate seizure region*, *n*—that region of the scar-load curve characterized by seizure or welding at the startup or by large wear scars.

3.1.6.1 *Discussion*—Under conditions of this test method, the immediate seizure region is shown by line CD. Also, initial

[1] This method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.G on Lubricating Grease.

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

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

deflection of indicating pen on the optional friction-measuring device is larger than with nonseizure loads.

3.1.7 *incipient seizure or initial seizure region, n*—that region at which, with an applied load, there is a momentary breakdown of the lubricating film.

3.1.7.1 *Discussion*—This breakdown is noted by a sudden increase in the measured scar diameter, shown in Fig. 1 as line BC, and a momentary deflection of the indicating pen of the optional friction-measuring device.

3.1.8 *last nonseizure load, n*—the last load at which the measured scar diameter is not more than 5 % greater than the compenation value at that load.

3.1.8.1 *Discussion*—Shown in Fig. 1 as Point B.

3.1.9 *load-wear index (or the load-carrying property of a lubricant), n*—an index of the ability of a lubricant to prevent wear at applied loads.

3.1.9.1 *Discussion*—Under the conditions of this test, specific loadings in kilograms-force (or Newtons) having intervals of approximately 0.1 logarithmic units, are applied to the three stationary balls for ten runs prior to welding. The load wear index is the average of the corrected loads determined for the ten applied loads immediately preceding the weld point.

3.1.10 *weld point, n*—the lowest applied load at which sliding surfaces seize and then weld.

3.1.10.1 *Discussion*—Under the conditions of this test, the lowest applied load in kilograms-force (or Newtons) at which the rotating ball seizes and then welds to the three stationary balls, indicating the extreme-pressure level of the lubricating grease has been exceeded. See Fig. 1, Point D.

3.1.10.2 *Discussion*—Some lubricating greases do not allow true welding, and extreme scoring of the three stationary balls results. In such cases, the applied load which produces a maximum scar diameter of 4 mm is reported as the weld point.

4. Summary of Test Method

4.1 The tester is operated with one steel ball under load rotating against three steel balls held stationary in the form of a cradle. The rotating speed is 1770 ± 60 rpm. Lubricating greases are brought to 27 ± 8°C (80 ± 15°F) and then subjected to a series of tests of 10-s duration at increasing loads until welding occurs.

5. Significance and Use

5.1 This test method, used for specification purposes, differentiates between lubricating greases having low, medium, and high level of extreme-pressure properties. The results do not necessarily correlate with results from service.[4]

5.2 It is noted that lubricating greases that have as their fluid component a silicone, halogenated silicone, or a mixture comprising silicone fluid and petroleum oil, are not applicable to this method of test.

[4] Further details on this method may be found in: Sayles, F. S., et al, *National Lubricating Grease Institute Spokesman*, Vol 32, No. 5, August 1968, pp. 162–167.

6. Apparatus

6.1 *Four-Ball Extreme-Pressure Lubricant Tester*,[5] illustrated in Fig. 2.

NOTE 1—It is important to distinguish between the Four-Ball EP Tester and the Four-Ball Wear Tester. The Four-Ball Wear Tester can be used under a variety of test conditions at loads up to 490 N (50 kgf). The Four-Ball EP Tester is designed for testing under more severe conditions and lacks the sensitivity necessary for the Four-Ball Wear Test.

6.2 *Microscope*,[5] equipped with calibrated measuring scale and readable to an accuracy of 0.01 mm.

6.3 *Timer*, graduated in tenths of a second.

NOTE 2—Optional equipment with Four-Ball apparatus consists of a friction-measuring device electrically driven and conveniently graduated in 10-s markings.

7. Materials

7.1 *Stoddard Solvent* Specifications D 235.

NOTE 3—**Warning:** Combustible. Health hazard.

7.2 *ASTM n-Heptane*[6]

NOTE 4—**Warning:** Flammable. Health hazard.

7.3 *Test Balls*[7]—Test balls shall be 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 Specifications B 3, for Metal Balls. 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.

[5] Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554, Microscopes 103.10 A and 103.10 B have been found satisfactory for this purpose.

[6] Described in the *Annual Book of ASTM Standards*, Vol 05.04, Motor Fuels, Section I, Annex 2, Section A2.7, Reference Materials.

[7] Steel balls meeting this description were used in developing the precision of the test. They are available from ball bearing or laboratory equipment manufacturers and distributors. All balls used in one test should be taken from one carton (of 500 balls) as received from the supplier.

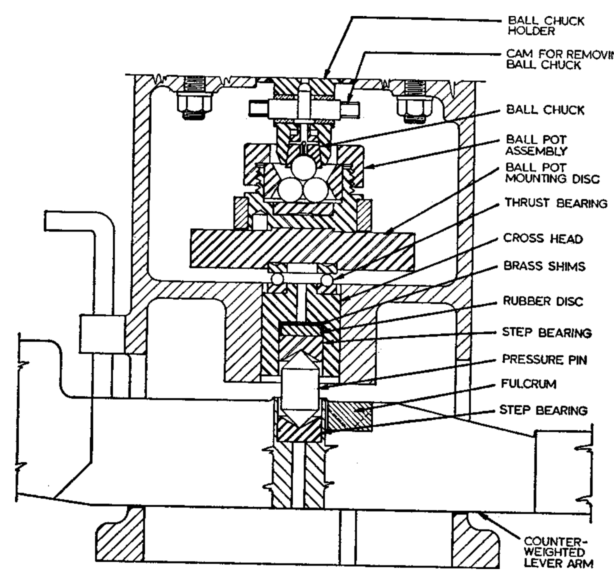

FIG. 2 Sectional View of Four-Ball EP Tester