Designation: D2783 – 03 (Reapproved 2014)

Standard Test Method for Measurement of Extreme-Pressure Properties of Lubricating Fluids (Four-Ball Method)[1]

This standard is issued under the fixed designation D2783; 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 determination of the load-carrying properties of lubricating fluids. The following two determinations are made:

1.1.1 Load-wear index (formerly Mean-Hertz load).

1.1.2 Weld point by means of the four-ball extreme-pressure (EP) tester.

1.2 For the determination of the load-carrying properties of lubricating greases, see Test Method D2596.

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.*

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2596 Test Method for Measurement of Extreme-Pressure Properties of Lubricating Grease (Four-Ball Method)

2.2 *ANSI Standard:*

B 3.12 Metal Balls[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *compensation line*—a line of plot on logarithmic paper, as shown in Fig. 1, 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*—Coordinates for the compensation line are found in Table 1, Columns 1 and 3.

3.1.1.2 *Discussion*—Some lubricants give coordinates which are above the compensation line. Known examples of such fluids are methyl phenyl silicone, chlorinated methyl phenyl silicone, silphenylene, phenyl ether, and some mixtures of petroleum oil and chlorinated paraffins.

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.

3.1.2.1 *Discussion*—The wear scar obtained shall be within 5 % of the values noted in Table 1, Column 3.

3.1.3 *corrected load*—the load in kilograms-force (or newtons) for each run obtained by multiplying the applied load by the ratio of the Hertz scar diameter to the measured scar diameter at that load.

3.1.4 *Hertz line*—a line of plot on logarithmic paper, as shown in Fig. 1, where the coordinates are scar diameter in millimetres and applied load in kilograms-force (or newtons), obtained under static conditions.

3.1.5 *Hertz scar diameter*—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

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

where:

D_h = Hertz diameter of the contact area, and
P = the static applied load.

3.1.6 *immediate seizure region*—that region of the scar-load curve characterized by seizure or welding at the startup or by large wear scars. Initial deflection of indicating pen on the optional friction-measuring device is larger than with nonseizure loads. See Fig. 1.

[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.L0.11 on Tribiological Properties of Industrial Fluids and Lubricates.

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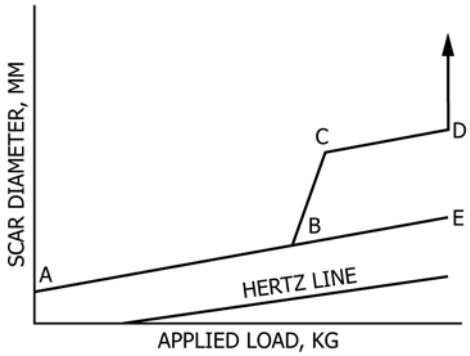
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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



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

TABLE 1 Suggested Form for Recording Test Results

Column 1 Applied Load, kg[A] (*L*)	Column 2 Average Scar Diameter, mm (*X*)	Column 3 Compensation Scar Diameter, mm	Column4 LD_h Factor	Column 5 Corrected Load, kg[A] (LD_h/X)
6			0.95	
8			1.40	
10		0.21	1.88	
13		0.23	2.67	
16		0.25	3.52	
20		0.27	4.74	
24		0.28	6.05	
32		0.31	8.87	
40		0.33	11.96	
50		0.36	16.10	
63		0.39	21.86	
80		0.42	30.08	
100		0.46	40.5	
126		0.50	55.2	
160		0.54	75.8	
200		0.59	102.2	
250			137.5	
315			187.1	
400			258	
500			347	
620			462	
800			649	

[A] To convert from kilograms-force to newtons, multiply by 9.806.

3.1.7 *incipient seizure or initial seizure region*—that region at which, with an applied load, there is a momentary breakdown of the lubricating film. This breakdown is noted by a sudden increase in the measured scar diameter and a momentary deflection of the indicating pen of the optional friction-measuring device. See Fig. 1.

3.1.8 *last nonseizure load*—the last load at which the measured scar diameter is not more than 5 % above the compensation line at the load. See Fig. 1.

3.1.9 *load-wear index (or the load-carrying property of a lubricant), n*—an index of the ability of a lubricant to minimize 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 sum of the corrected loads determined for the ten applied loads immediately preceding the weld point.

3.1.10 *weld point*—under the conditions of this test, the lowest applied load in kilograms at which the rotating ball welds to the three stationary balls, indicating the extreme-pressure level of the lubricants-force (or newtons) has been exceeded.

3.1.10.1 *Discussion*—Some lubricants 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. Test lubricant covers the lower three balls. The rotating speed is 1760 ± 40 rpm. The machine and test lubricant are brought to 18 to 35°C (65 to 95°F) and then a series of tests of 10-s duration are made at increasing loads until welding occurs. Ten tests are made below the welding point. If ten loads have not been run when welding occurs and the scars at loads below seizure are within 5 % of the compensation line (AB Fig. 1) no further runs are necessary. The total can be brought to ten by assuming that loads below the last nonseizure load will produce wear scars equal to the "compensation scar diameter." Values of these "assumed" scars are given in Table 1. For clarification of "last nonseizure load" and "weld point" see Fig. 1.[4]

5. Significance and Use

5.1 This test method, used for specification purposes, differentiates between lubricating fluids having low, medium, and high level of extreme-pressure properties. The user of this 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 Extreme-Pressure Tester,* [5] illustrated in Figs. 2 and 3.

NOTE 1—It is important to distinguish between the four-ball EP tester and the four-ball wear tester. 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,* equipped with a 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.

[4] Further details applicable to this method may be found in: Sayles, F. S., et al., "The Four-Ball E. P. Tester, An ASTM Method of Test," *National Lubricating Grease Institute*, NLGIA, Vol 32, No. 5, August 1968, pp. 162–167.

[5] Satisfactory sources of supply for this instrument are Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554–9585 and Stanhope-Seta Ltd., Park Close, Egham, Englefield Green, Surrey, England TW20 OXD.

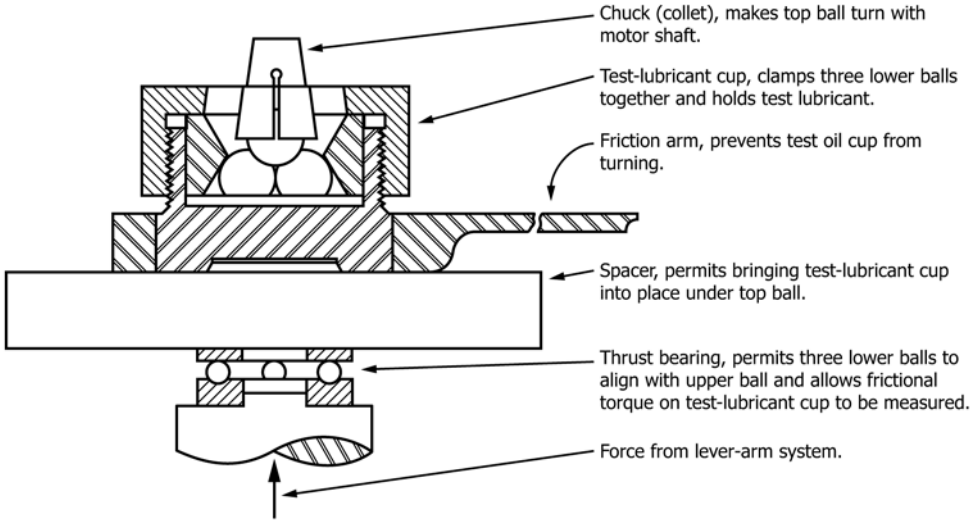


FIG. 2 Sectional View of Four-Ball Tester

FIG. 3 Four-Ball EP Test Machine

7. Materials

7.1 *Cleaning Solvent,* safe, non-film forming, nonchlorinated. (**Warning—** Flammable. Harmful if inhaled. See A1.1.)

NOTE 3—*Certain* petroleum distillates, formerly used as solvents, have been eliminated due to possible toxic effects. Each user should select a solvent that can meet applicable safety requirements and thoroughly clean machine parts. Reagent Grade Stoddard solvent is an example of a solvent that has been found suitable.

7.2 *Rinse Solvent,* same as in 7.1, but with higher volatility. ASTM *n*-Heptane is an example of one such rinse solvent that has been found suitable. (**Warning—**Flammable. Harmful if inhaled. See A1.2.)