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Designation: D 2266 – 01

An American National Standard

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

This standard is issued under the fixed designation D 2266; 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 test method has been adopted for use by government agencies to replace Method 6514 of Federal Test Method Standard No. 791b.

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

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1. Scope

1.1 This test method covers the determination of the wear preventive characteristics of greases in sliding steel-on-steel applications. It is not intended to predict wear characteristics with metal combinations other than steel-on-steel or to evaluate the extreme pressure characteristics of the grease.

1.2 The values stated in SI units are to be regarded as the standard except where the test apparatus or consumable parts are only available in other units. In such cases, these will be regarded as standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety problems, 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.* ~~For specific hazard statement see 7.2, 7.3, and 9.1.~~

2. Referenced Documents

2.1 *ASTM Standards:*

D ~~235 Specification~~ 4172 Test Method for ~~Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)~~ Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method)[2]

~~2.2 *Other Document:*~~

~~ANSI Specifications B 3.12 for Metal Balls~~

D 6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products and Lubricants[3]

2.2 *ANSI Standard:*

B3.12 for Metal Balls[4]

3. Terminology

3.1 There are no terms in this ~~standard~~ test method that require new or other than dictionary definitions.

4. Summary of Test Method

4.1 ~~A~~Three ½ in. (12.7-mm) diameter steel balls are clamped together and covered with the lubricant to be evaluated. A fourth ½ in. diameter steel ball, referred to as the top ball, is ~~rotated under load against~~ pressed with a force of 40 kgf (392 N) into the cavity formed by the three ~~stationary steel~~ clamped balls ~~having grease-lubricated surfaces.~~ for three-point contact. The ~~diameters~~ temperature of the ~~wear scars on~~ lubricating grease specimen is regulated at 75°C (167°F) and then the ~~stationary balls~~ top ball is rotated at 1200 rpm for 60 min. Lubricants are ~~measured after completion~~ 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 setup and operation.

NOTE 2—Although the test can be run under other test parameters, the precision noted in Section 11 can vary when testing with other than test parameters listed in Section 8.

[2] *Annual Book of ASTM Standards*, Vol ~~06.04.~~ 05.02.

[3] ~~Available from American National~~

[3] *Annual Book of ASTM Standards ~~Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.~~*, Vol 05.04.

[4] ~~Further details on this test method may be found in: Stallings, L., et al., *NLGI Spokesman*, Vol 31, No. 11, February 1968, pp. 396–401.~~

[4] Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036.

5. Significance and Use

5.1 The four-ball wear-test method can be used to determine the relative wear-preventing properties of greases under the test conditions and if the test conditions are changed the relative ratings may be different. No correlation has been established between the four-ball wear test and field service. The test method cannot be used to differentiate between Extreme Pressure (EP) and Non-Extreme Pressure (Non-EP) Greases.[5]

6. Apparatus

6.1 *Four-Ball Wear-Tester and Accessories*—See Fig. 1 and Fig. 2.[6]

NOTE ~~1~~3—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 50 kgf. The Four-Ball~~ EP Tester is designed for testing under heavier loads and more severe conditions ~~and~~; it lacks the sensitivity necessary for ~~the~~ performing four-ball wear test.

6.2 *Microscope,*[7] 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. Reagents and Materials

7.1 *Test Balls*—~~Test balls shall be~~[8], chrome alloy steel, made from AISI standard steel No. E-52100, with diameter of ~~12.7 mm (0.5 in.),~~ 0.5 in. (12.7 mm), Grade 25 EP (Extra Polish). Such balls are described in ANSI Specifications B 3.12, 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.

NOTE ~~2~~4—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.~~ test.

7.2 ~~*ASTM n-Heptane.*~~ [6]

~~[5] The Four-Ball Wear Tester, available from Falex Corp., 2055 Comprehensive Drive, Aurora, IL 60505, has been found suitable for~~

[5] Further details on this ~~p~~ test method may be found in: Stallings, L., et al., *NLGI Spokesman,* Vol 31, No. 11, February 1968, pp. 396–401.

[6] ~~D~~The Four-Ball Wear Test Machine, available from Falex Corp., 1020 Airpark Drive, Sugar Grove, IL 60554 has been found satisfactory for this purpose. This company can also furnish a microscope with a special base to measure the ~~*Annual Book wear scars without removing the balls from the test-oil cup. Discontinued models of ASTM Standards,* Vol 05.04,~~ the Four-Ball Wear Test ~~Methods for Rating Motor Diesel~~ Machine made by Precision Scientific Co. and ~~Aviation Fuels, Annex 2, Section A2.7 Reference Materials.~~ Roxana Machine Works are also satisfactory.

[7] Falex Corp. Microscope F-1519-~~2~~31 has been found suitable for this purpose. F-1519-~~2~~31 measures directly to 0.1 mm ~~directly~~ and by interpolation to 0.01 ~~mm by interpolation.~~ mm. A higher resolution version, F-1519-~~2~~31A, measures to 0.001 mm.

~~*Annual Book*~~

[8] Steel balls meeting this description were used in developing the precision of ~~ASTM Standards, Vol 05.03. The article Stalling, L., NLGI Spokesman, Vol 31, No. 11, February 1988, pp. 396–401 has been submitted as~~ the test. They are available from the manufacturer of the test machine and some ball manufacturers. Some operators prefer to check ~~a research report. The article does not follow research report guidelines because~~ new box of balls by running an oil or a lubricating grease with a known reference. All balls used in one test should be taken from one carton (of 500 balls) as received from the ~~work was conducted before research report guidelines were instituted.~~ supplier.

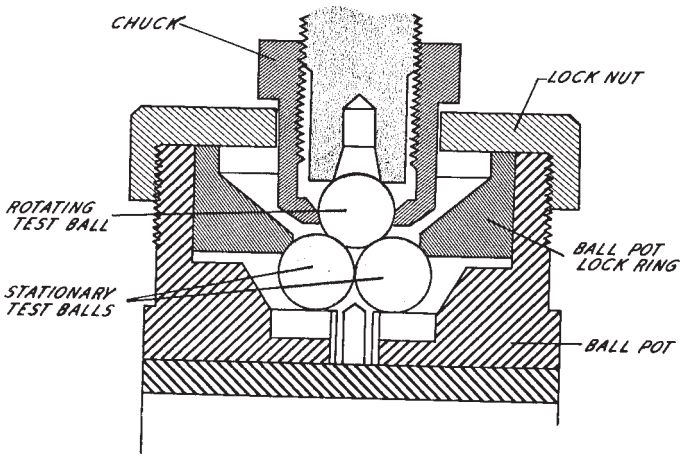

FIG. 1 Precision Scientific Company Four-Ball Test Arrangement

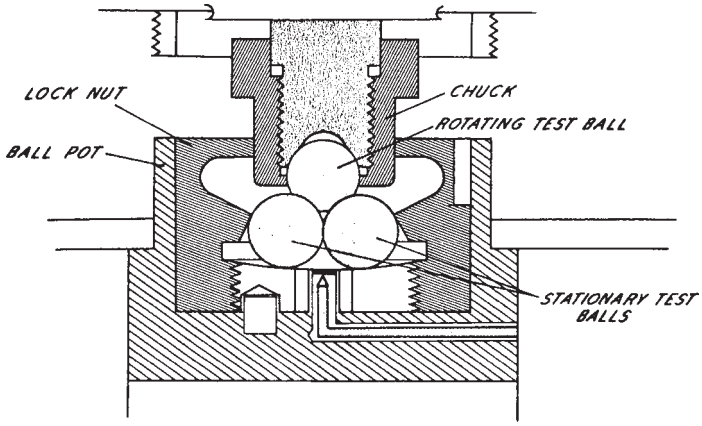

FIG. 2 Falex Corporation (Roxanna) Four-Ball Test Arrangement

~~NOTE 3—**Warning:** Flammable. Harmful if swallowed.~~

~~7.3 *Stoddard Solvent*, conforming~~Cleaning Fluids for preparing balls and apparatus for the test should be those capable of removing metal preservative coating from the balls, eliminating carryover effects from one test to~~r~~ the~~q~~ next. The cleaning flui~~r~~d selected should be non-film-forming and not contribute to the wear or antiwear properties of ~~Specification D 235.~~

~~NOTE 4—**Warning:** Combustible. Vapor harmful.~~ the test lubricant. (for example, chlorinated solvents should not be used.)

8. Test Conditions

8.1 The test shall be conducted under the following conditions:

~~Temperature~~	~~75 ± 1.7°C (167 ± 3°F)~~
Temperature	75 ± 2°C (167 ± 4°F)
~~Speed~~	~~1200 ± 50 rpm~~
Speed	1200 ± 60 rpm
Duration	60 ± 1 min
Load	40 ± 0.2 kgf (392 ± 2 N)
	~~Duration of test~~

NOTE 5—Although the test can be run under other conditions, the precision limits described in Section 11 apply only to tests conducted under the conditions described in Section 8.

9. Preparation of Apparatus

~~9.1 Thoroughly clean~~

9.1 Set up the~~ test balls, chuck, and ball pot assembly by rinsing with Stoddard solvent (**Warning**—See Note 4) and wiping with a soft lint-free cloth. Follow with a second wash in clean Stoddard solvent and a final wash in ASTM *n*-heptane (**Warning**—See Note 3). Dry~~ drive of the test~~ balls, chuck, and ball pot assembly by allowing the solvent~~ machine to~~ evaporate in air.~~

~~9.2 Place one~~ obtain a spindle speed of 1200 ± 60 rpm.

9.2 Set the~~ clean steel~~ temperature controller to maintain a test~~ balls into the chuck. Tighten the chuck holding the test ball firmly onto the shaft~~ temperature of~~ the machine.~~

~~9.3 Place~~ 75 ± 2°C [167 ± 4°F].

9.3 When an automatic timer is used to terminate a~~ small amount of~~ 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 grease~~ (approximately 5 g) in the ball pot. Insert the three test balls~~ place. To demonstrate proper precision, an addition or subtraction of 0.2 kgf (19.6 N) should be detectable in~~ the ball pot~~ imbalance. Determination of accuracy of loading at 40 kgf (392 N) is difficult and~~ lock the balls in position by tightening the locknut on the ball pot.~~

~~9.4 Coat the test balls located in the chuck~~ generally is limited to careful measurement of lever-arm ratios and~~ pot completely and thoroughly~~ weights with~~ the test grease; fill the ball pot with grease~~ dead-weight loading apparatus or piston diameter and~~ level off with the top surface~~ calibration of~~ the locknut.~~ pressure gage with pneumatic loading systems.

10. Procedure

~~10.1 *For Falex (Roxanna) Deadweight Loaded Four-Ball Wear Tester*—Place~~

10.1 Thoroughly clean four test balls, clamping parts for the~~ ball pot into the ball-pot holder~~ upper and~~ position this assembly~~ lower balls and the oil cup using a cleaning fluid or fluids selected in 7.2. Ultrasonic vibration can be used to assist the~~ test unit. Raise~~ cleaning process. Wipe the parts using a fresh (unused) lint-free industrial wipe. After cleaning, handle all parts using a fresh wipe. No trace of cleaning fluid should rembain when the test oily is introduced and~~ insert~~ the~~ pivot pin so that~~ machine assembled.

10.2 Insert one of the ~~tapered ends (pivot points) rest in hardened seats. Lower~~ clean test balls into the ~~assembly, thereby applying~~ ball chuck. Insert the ~~load at a specific point on~~ ball chuck into spindle of the ~~balance beam. Check~~ test machine and tighten according to ~~see that no binding occurs. Turn~~ the ~~adjusting screw on~~ equipment manufacture's directions.

NOTE 6—Insertion of the ~~balance beam until~~ ball into the ~~arm is balanced. Check sensitivity by moving~~ ball chuck should require moderate force and result in an audible snap as the ~~poise on~~ test ball enters the ~~balance beam. A change in loading of 0.2 kgf (2 N)~~ ball chuck. The ball should ~~produce a noticeable deflection~~ be free from any movement. If the ~~balance point.~~

~~10.2 *For Precision Four-Ball Wear Tester*—Lock~~ ball rotates or moves within the ~~load arm by means~~ ball chuck, replace the ball chuck.

10.3 Place a small amount of the ~~sliding lock. Place~~ grease in the ball cup sufficient to fill the void space between the three balls to be inserted and ~~weight support on~~ the ~~load arm. Position~~ bottom of the ~~ball-pot assembly on~~ ball cup. Insert the ~~torque arm~~ three test balls in the ball cup and ~~heater assembly. Remove~~ lock the ~~ring assembly, place the ball-pot assembly~~ balls in position ~~and replace~~ by hand tightening the ~~ring assembly. Disengage~~ locknut into the ~~sliding lock~~ ball cup using the wrench supplied by the equipment manufacturer.

NOTE 7—Hand tightening has been found to ~~release~~ be between 33.8 and 67.8 N· m (25 to 50 lb· ft.).

10.4 Coat the ~~load arm~~ test balls located in the ball chuck and ~~balance by adjusting~~ ball cup completely and thoroughly with the ~~load arm counterweight~~ test grease and ~~locknut.~~

~~10.3 Ensure that~~ then fill the ~~drive is arranged for~~ ball cup with grease and level off with the ~~specified speed (1200 rpm). Apply~~ top surface of the ~~specified load 40 kgf (392 N) by appropriate means such as pneumatic or dead weight loading. Set~~ locknut.

10.5 Place the ~~mercury~~ ball cup assembly ~~and rotating-ball pot assembly so that~~ containing the ~~proper electrical contacts are made,~~ three test balls and ~~connect~~ grease specimen on the ~~dynamometer to~~ test machine. Avoid shock loading by slowly applying the ~~torque arm. Set~~ test load.

10.6 After reaching the ~~temperature controller to the specified temperature of 75°C (167°F),~~ desired test load, turn on the ~~h~~ temperature controller and ~~adjust~~ set the ~~variable transformer so that equilibrium will~~ controller to maintain 75 ± 2°C (167 ± 4°F).

NOTE 8—Heater voltage or offset on proportional controllers should be ~~reached at~~ capable of bringing stabilized temperature within the ~~test temperature. Turn on~~ prescribed limits.

10.7 When the ~~motor when the~~ desired test temperature ~~has been reached. The temperature can rise rapidly after the motor~~ is ~~operating~~ reached, simultaneously start the timer and ~~may level off above~~ the ~~preset temperature. In such cases the temperature must be preset at a lower temperature level~~ drive motor, previously set to ~~allow for~~ 1200 ± 60 rpm.

10.8 After the ~~higher thermal input~~ drive motor has been on ~~starting.~~

~~10.4 After a period of~~ for 60 ± 1 min., turn off the heaters and drive motor and ~~heater. Lower the assembly and~~ remove the ball ~~pot.~~

~~10.5 Measure~~ cup and three-ball assembly. (**Warning**—Parts may be hot at the end of the test. Exercise care when handling parts.)

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

10.5~~9~~.1 *Option A*—~~Remove~~—Clean the ~~locknut and release~~ grease from the ~~test balls. Clean~~ ball cup assembly without loosening the test balls ~~with Stoddard solvent~~ and ~~*n*-heptane and~~ wipe ~~dry~~ the scar area with a ~~soft cloth. Place~~ tissue. Leave the ~~individual~~ three balls ~~on a suitable holder~~ clamped and ~~by means~~ set the ball cup assembly on the special base of ~~a microscope, measure~~ the ~~scar diameters at~~ microscope that has been designed for this purpose.[4] Make two ~~positions~~ measurements on each of the ~~three test balls. Measure to~~ wear scars. Take one measurement of the ~~nearest 0.01 mm the minimum~~ scar ~~diameter. Again to~~ along a radial line from the ~~nearest 0.01 mm, measure~~ center of the ~~minimum scar diameter~~ holder; take the second measurement along a line that is 90° from the first ~~position of~~ measurement. Report the arithmetic average of the six ~~readings~~ measurements as the scar diameter~~;~~ in millimet~~r~~ers.

10.5~~9~~.2 *Option B*—~~Retain~~—Remove the three lower balls ~~in the ball pot. Wipe excess grease~~ from their clamped position. Wipe the ~~b~~ scar area. Take two measurements at 90° to each other. If a scar is elliptical, take one measurement with the striations and ~~ball pot. Wash~~ the ~~ball surfaces with Stoddard solvent and *n*-heptane. Using a microscope assembly,[7] measure and report~~ other across the striations. Take care to ensure that the line of sight is perpendicular to the surface being measured. As in Option A, average the six scar ~~diameters~~ readings and report as ~~specified under Option A.~~ scar diameter in millimeters.

NOTE 9—In Test Method D 4172, it is stated that if the average of the two measurements on one ball varies from the average of all six readings by more than 0.04 mm, the user should investigate the alignment of the three lower balls with the top ball.

11. Precision and Bias

11.1 The precision of this test is not known to have been obtained in accordance with currently accepted guidelines (for example, ~~in Committee D-2 Research Report RR:D02-1007, Manual on Determining Precision Data for ASTM Test Methods on Petroleum Products and Lubricants).[8]~~ Practice D 6300).[10]

11.2 The precision of this test method as determined by statistical examination of interlaboratory results is as follows:

11.2.1 The difference between two test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the

following value only in one case in twenty:

0.20 mm.

11.2.2 The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following value only in one case in twenty:

0.37 mm.

11.3 *Bias*—The procedure in this test method for measuring wear preventing characteristics of lubricating grease has no bias because the value of wear preventing characteristics can only be defined in terms of a test method.

NOTE 10—The following equipment, as listed in the submitted research report, was used to develop the precision statement and no statistically significant differences were found between these pieces of equipment: 1. Falex Corporation (formerly Roxanna Machine Works), 1020 Airpark Drive, Sugar Grove, IL 60555; 2. Precision Scientific (no longer manufactured). To date, no other equipment has demonstrated through ASTM interlaboratory testing the ability to meet the precision of this test. This is not an endorsement or certification by ASTM International.

12. Keywords

12.1 four-ball; grease; wear

[10] The article Stalling, L., *NLGI Spokesman*, Vol 31, No. 11, February 1988, pp. 396–401 has been submitted as a research report. The article does not follow research report guidelines because the work was conducted before research report guidelines were instituted.