Designation: D4170 – 10

Standard Test Method for Fretting Wear Protection by Lubricating Greases[1]

This standard is issued under the fixed designation D4170; 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 fretting wear protection provided by lubricating greases.

1.2 The values stated in SI units are to be regarded as the standard. Other units 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.* For specific warning statements, see 7.2 and 9.2.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

Test Methods for Rating Motor, Diesel, and Aviation Fuels; Motor Fuels (Section I), Reference Materials and Blending Accessories (Annex 2), Reference Fuels (A2.7.3.3), and Table 32 (Specification for *n*-Heptane Motor Fuel)

2.2 *Military Standard:*[3]

MIL-S-22473D Sealing, Locking and Retaining Compounds, Single-Component

3. Terminology

3.1 *Definitions:*

3.1.1 *fretting wear, n*—a form of attritive wear caused by vibratory or oscillatory motion of limited amplitude characterized by the removal of finely-divided particles from the rubbing surfaces.[4]

3.1.1.1 *Discussion*—Air can cause immediate local oxidation of the wear particles produced by fretting wear. In addition, environmental moisture or humidity can hydrate the oxidation product. In the case of ferrous metals, the oxidized wear debris is abrasive iron oxide (Fe_2O_3) having the appearance of rust, which gives rise to the nearly synonymous terms, fretting corrosion and friction oxidation. A related, but somewhat different phenomenon often accompanies fretting wear. False brinelling is localized fretting wear that occurs when the rolling elements of a bearing vibrate or oscillate with small amplitude while pressed against the bearing race. The mechanism proceeds in stages: (1) asperities weld, are torn apart, and form wear debris that is subsequently oxidized; (2) due to the small-amplitude motion, the oxidized detritus cannot readily escape, and being abrasive, the oxidized wear debris accelerates the wear. As a result, wear depressions are formed in the bearing race. These depressions appear similar to the Brinell depressions obtained with static overloading. Although false brinelling can occur in this test, it is not characterized as such, and instead, it is included in the determination of fretting wear.

4. Summary of Test Method

4.1 The tester is operated with two ball thrust bearings, lubricated with the test grease, oscillated through an arc of 0.21 rad (12°), at a frequency of 30.0 Hz (1800 cpm), under a load of 2450 N (550 lbf), for 22 h at room temperature (Note 1). Fretting wear is determined by measuring the mass loss of the bearing races.

NOTE 1—Arc, frequency, and load are factory-set operating conditions and should not be altered. The load spring constant may change over an extended time period. Spring calibration should be checked periodically and, if necessary, a suitable shim should be fabricated to obtain the required load (±3 %) at the assembled length of the spring.

5. Significance and Use

5.1 This test method is used to evaluate the property of lubricating greases to protect oscillating bearings from fretting wear. This method, used for specification purposes, differentiates among greases allowing low, medium, and high amounts of fretting wear under the prescribed test conditions. The test has been used to predict the fretting performance of greases in wheel bearings of passenger cars shipped long distances.[5] Test results do not necessarily correlate with results from other types of service. It is the responsibility of the user to determine whether test results correlate with other types of service.

[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.G0.04 on Functional Tests - Tribology.

Current edition approved May 1, 2010. Published June 2010. Originally approved in 1982. Last previous edition approved in 2002 as D4170–97(2002)$^{\varepsilon 1}$. DOI: 10.1520/D4170-10.

[2] See 1998 *Annual Book of ASTM Standards*, Vol 05.04.

[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

[4] *NLGI Lubricating Grease Guide*, 3rd edition.

[5] Verdura, T. M., "Development of a Standard Test to Evaluate Fretting Protection Quality of Lubricating Grease," *NLGI Spokesman*, Vol XLVII, No. 5, August 1983, pp. 157–67.

*A Summary of Changes section appears at the end of this standard

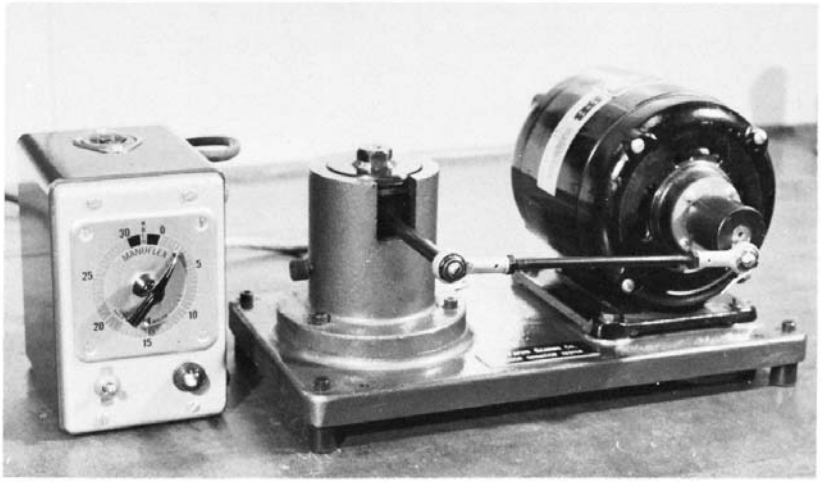

FIG. 1 Fafnir Friction Oxidation Tester and Time Switch

6. Apparatus

6.1 *Falex Fretting Wear Tester, Model F-1581,* [6,7] as purchased and illustrated in Figs. 1 and 2.

6.2 *Spring Guide,* conforming to description in Fig. 3, if not supplied with tester.

6.3 *Test Bearings,* [7,8] of the ball thrust type having an inside diameter of 16.00 ± 0.025 mm (0.630 ± 0.001 in.), an outside diameter of 35.69 ± 0.025 mm (1.405 + 0.001 in.), and assembled height of 15.75 ± 0.25 mm (0.620 ± 0.010 in.) and equipped with nine 7.142-mm (0.2812-in.) diameter balls in a pressed steel retainer; all surfaces (except retainer) to be ground. Different surface finishes are provided on commercial bearings. Bearings with ground surfaces are lustrous; tumbled bearings appear slightly dulled or grayish. Bearings with ground races, as specified in 6.3 are required to obtain correct results. Tumbled bearings with reground races are satisfactory. Magnification should be used to inspect the races to verify that they have been ground. Part-number bearings[7,8] are provided with ground races. A drawing of the test bearing, giving complete, detailed dimensions and specifications is available in RR:D02-1159.[9]

6.4 *Vibration Mount,* [7,10] upon which the tester is placed.

6.5 *Time Switch,* (optional) shown in Fig. 1 and described in detail in Fig. 4, or a commercial equivalent.

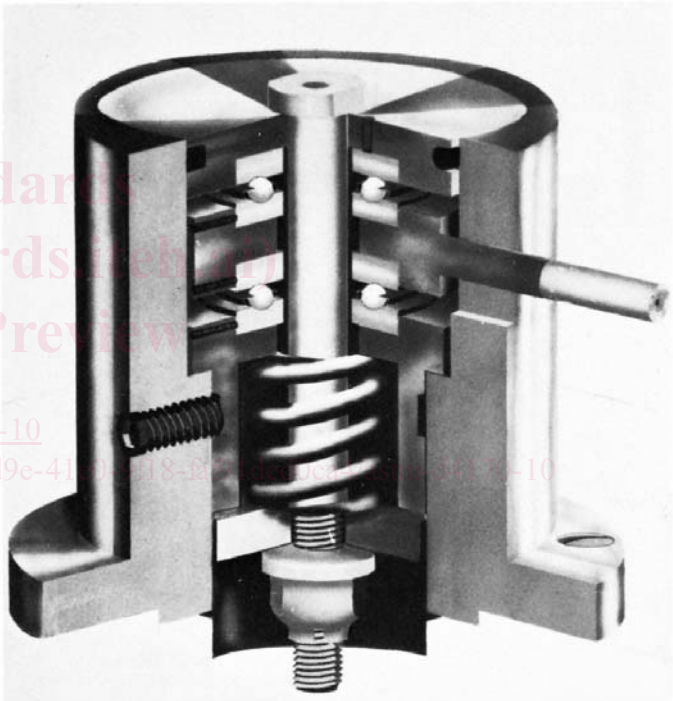

FIG. 2 Chuck and Housing Assembly

6.6 *Ultrasonic Cleaner.* [7,11]

6.7 *Analytical Balance* having a capacity of about 100 g and with a minimum sensitivity of 0.1 mg.

7. Reagents and Materials

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society

[6] Falex Fretting Wear Tester, formerly known as the Fafnir Friction Oxidation Tester, is available from Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554.

[7] The sole source of supply of the apparatus known to the committee at this time is listed. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[8] Andrews (Part No. 06X65) have been found to be satisfactory. Prepared bearings (part number F-1581-50 (formerly FL-1081)), that is, with set screw flat (see 8.1), are available from Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554.

[9] Supporting data (the results of the cooperative test program, from which these values have been derived) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1159.

[10] Isomode Vibration control Pad No. 3451801 has been found satisfactory and is available from rubber products suppliers.

[11] A Bransonic 2200 cleaner (Branson Ultrasonics Co., Danbury, CT 06813) having a capacity of about 3 L (¾ gal) operating at a frequency of about 55 kHz, with a power input of about 125 W, has been found satisfactory.

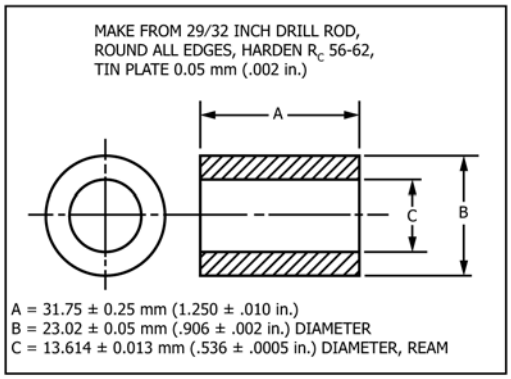

FIG. 3 Spring Guide

where such specifications are available.[12] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *n-heptane,* reagent grade or ASTM Motor Fuel Grade 3. (**Warning—**Flammable. Health hazard.)

NOTE 2—This test method was originally developed using chloroform, which was subsequently replaced by 1,1,1-trichloroethane because of its lower toxicity. Since then, 1,1,1-trichloroethane was declared an Ozone Depleting Substance by the U.S. Environmental Protection Agency (EPA). Federal regulations ban the production of this material after December 31, 1995, but existing stocks may continue to be used. Currently there are no EPA restrictions on the use of chloroform, but the user should be aware of its health hazards if it is used as a functionally equivalent solvent. No other solvent intended as a substitute for 1.1.1-trichloroethane in this test method has been cooperatively evaluated. However, it is the experience of the Grease Subcommittee that elimination of the cleaning step using 1,1,1–trichloroethane does not affect the reported results from this test.

8. Bearing Preparation

8.1 Grind a suitable set screw flat (approximate dimensions; 8 by 4 by 0.5 mm) on the periphery of each bearing race;[8] flat must be square with face to prevent cocking of races when set screws are tightened.

NOTE 3—It is extremely difficult to grind the flat square with the face when using a hand or bench grinder. Good results have been obtained by racking a number of bearing races in a V-block and using a surface grinder.

8.2 Scribe suitable identification marks on the outer lands of bearing races to distinguish races of upper bearing from races of lower bearing. Identification marks should not be scribed on back or periphery of the bearing race.

8.3 Fill tank of ultrasonic cleaner with distilled water to a depth of 30 to 40 mm. Place two bearing sets in a 250-mL beaker containing about 125-mL of *n*-heptane. Cover beaker and place in ultrasonic bath. After cleaning for 10 to 15 min, transfer bearing parts to second beaker containing 125 mL of *n*-heptane (see 7.2). Clean for 8 to 10 min, then repeat operation for two additional 4 to 5-min washes, using new *n*-heptane and clean beakers each time.

8.4 Place bearing parts onto freshly cleaned, glass Petri dishes or aluminum moisture dishes to air dry. Bearings should be propped against rim of dish to permit air circulation. Clean bearings must not be rotated or air blown. Do not place bearings on any surface other than freshly cleaned glass or metal. Do not touch bearings with bare hands; use forceps or tongs, or wear surgeon gloves or finger cots.

8.5 When bearings are dry, place dishes containing bearings in a desiccator and let stand for a minimum of 30 min.

8.6 Weigh the upper and lower bearing race pairs separately to the nearest 0.1 mg. (Each race pair consists of two races.)

9. Procedure

9.1 In a dust-free environment, install the test grease in unused, cleaned, weighed bearings.

9.1.1 Fill the ball tracks of the bearing races with the test grease. Use a suitable spatula to strike the grease level with the bearing lands. Bearing backs and bearing seats must be kept free of grease and particulate matter. Clean with a lint–free cloth slightly moistened with *n*-heptane.

9.1.2 Fill each ball retainer with test grease taking care to fill all the cavities around the balls on both sides of the retainer. Remove excess grease from the bore and rim of the retainer, but leave an excess of grease on the cupped side. Adjust the mass of the grease in each bearing to 1.0 ± 0.05 g.

9.2 Assemble the chuck. Use Fig. 5 as a guide to chuck assembly. Use minimal force when tightening set screws. Locate bearing set screw flats normal to set screws. Purpose of set screws is to prevent rotation of races in seats. To preclude overtightening set screws, grasp hex-key (Allen wrench) by shank rather than by lever arm. If set screws tend to loosen during the test, use a low-strength anaerobic sealant (MIL-S-22473D, Grade H or similar) on the threads rather than more force. Bearing races must bottom on bearing seats. Bottoming can be verified by visual and tactile inspection. (**Warning—** Tight set screws, misalignment between set screws and flats, or set screw flats that are not square with the bearing face can cock the bearing upon tightening set screws, causing uneven wear. Loose set screws combined with oily or greasy bearing backs and seats could allow a poor grease to give erroneous test results because of race creep effects.)

9.2.1 Install an upper bearing race in the chuck top and tighten the set screw, using minimal force.

9.2.2 Invert the chuck top and secure in a bench vise.

9.2.3 Place the retainer of the upper bearing on the race in the chuck top (9.2). The cupped side must be positioned upward during assembly (downward during operation).

9.2.4 Install the other race of the upper bearing in the oscillating bearing seat. Using minimal force, tighten the set screw. (With all bearing set screws oriented alike, permanently mark the underside of the oscillating bearing seat crank arm. Thereafter, when using the same orientation for assembly the lower bearing race will always be installed in the same seat.)

9.2.5 Install a lower bearing race in the oscillating bearing seat. Using minimal force tighten the set screw.

[12] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.