Designation: D2981 – 94 (Reapproved 2019)

Standard Test Method for
Wear Life of Solid Film Lubricants in Oscillating Motion[1]

1. Scope

1.1 This test method covers the evaluation of wear life of a bonded solid film lubricant under oscillating motion by means of a block-on-ring[2] friction and wear testing machine.

1.2 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D2714 Test Method for Calibration and Operation of the Falex Block-on-Ring Friction and Wear Testing Machine

3. Terminology

3.1 *Definitions:*

3.1.1 *coefficient of friction, μ or f—in tribology*, the dimensionless ratio of the friction force (F) between two bodies to the normal force (N) pressing these two bodies together.

$$\mu \text{ or } f = (F/N) \tag{1}$$

3.1.1.1 *Discussion*—A distinction is often made between *static coefficient of friction* and *kinetic coefficient of friction*.

3.1.2 *friction force*—the resisting force tangential to the interface between two bodies when, under the action of an external force, one body moves or tends to move relative to the other.

3.1.3 *kinetic coefficient of friction*—the coefficient of friction under conditions of macroscopic relative motion between two bodies.

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

4. Summary of Test Method

4.1 The test machine is operated using a coated steel testing ring oscillating against a steel test block. The oscillating speed is 87.5 cpm ± 1 cpm at a 90° arc. The specimens are worn-in for 1 min at 13.6 kg (30 lb) normal load obtained by application of 0.454 kg (1 lb) of dead weight to the 0:1 ratio lever system. Wear-in is followed by application of a normal load of 283 kg (630 lb) obtained by application of 9.53 kg (21 lb) of dead weight to the 30:1 ratio lever system for the duration of the test.

4.2 One measurement is made:

4.2.1 *wear life*—the number of cycles required for the frictional force to rise to a predetermined value.

5. Significance and Use

5.1 This test method is used for determining the wear life properties of bonded solid lubricants in oscillating motion under the prescribed test conditions. This test method differentiates between bonded solid lubricants with respect to their wear life. If the test conditions are changed, relative wear life may change and relative ratings of the bonded solid film lubricants may be different.

6. Apparatus

6.1 *Block-on-Ring Test Machine,*[2] equipped with oscillating drive, load cell transducer and recorder described in detail in Annex A1 and illustrated in Fig. 1. (See Test Method D2714.)
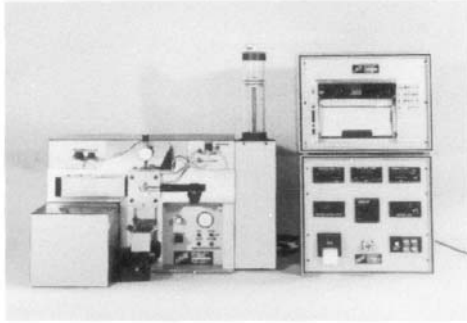
FIG. 1 Falex Block-on-Ring Test Machine with Recorder

6.2 *Test Ring,*[4] *SAE 4620 Steel*, having a Rockwell hardness of HRC 58-63. Each ring had a ground face of 8.163 mm ± 0.127 mm (0.321 in. ± 0.005 in.), a diameter of 34.9885 mm ± 0.0254 mm, −0.1270 mm (1.3775 in. ± 0.001 in., −0.005 in.) and an eccentricity between the inner and outer surface of ±0.038 mm (0.0015 in.). The surface finish of the outside diameter of each ring prior to lubricant coating application should be from 500 nm to 750 nm (20 µin. to 30 µin.) rms.

6.3 *Test Block,*[2] *SAE 01 Steel*[5] with test surface of 0.635 mm ± 0.021 mm, −0.000 mm (0.250 in. ± 0.0005 in., −0.0000 in.) wide and 1.575 mm ± 0.005 mm (0.620 in. ± 0.0002 in.) long and having a Rockwell hardness of HRC 58-63. Each block should have the test surface ground to a finish of 100 nm to 200 nm (4 µin. to 8 µin.) rms and be perfectly square with all outside edges.

7. Reagents

7.1 *Solvents,* safe, nonfilming, nonchlorinated. (See Note 1.)

NOTE 1—Benzene, *n*-hexane or *iso*octane, formerly used in this test method, has been eliminated due to possible toxic effects. Though it is not expected that there will be any adverse influence on results, principal users will advise experiences to guide future work.

8. Preparation of Apparatus

8.1 Before each test, thoroughly clean the test block, the shaft, specimen holder, lock nut, lock washer, and the tapered and threaded sections of the test shaft, using the solvents described in 6.1.

8.2 Using clean, lint-free cotton gloves, mount the test block in the block holder and position both securely in the cylindrical slot of the specimen holder. Holding the test block in place, mount the test ring over the test shaft and press into position beneath the block exercising care not to scratch the coated test surface. Position the lock washer and lock nut and tighten with the torque wrench to 2 N·m (100 lb·in.).

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[4] The sole source of supply of the apparatus known to the committee at this time is Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[5] SAE 01 is also known as Starrett 406 or Marshall Oilcrat.

8.3 Calibrate the load cell transducer and recorder in accordance with the equipment manufacturer's directions.

8.4 Adjust the arc of oscillation to 90°.

8.5 Place a 1.4 kg (3 lb) weight in position on the bale rod.

8.6 Set the friction force cut-off level to terminate the test at a frictional force of 280 N (63 lb) or a coefficient of friction of 0.1 after wear-in.

9. Procedure

9.1 Conduct the test in a temperature- and humidity-controlled atmosphere (24 °C ± 3 °C (75 °F ± 5 °F), 50 % ± 5 %) and allow sufficient static time for the specimens to reach a state of equilibrium.

9.2 With 1.4 kg (3 lb) on the bale rod, which is equivalent to a 13.6 kg (30 lb) normal load on the specimen, start the machine. Standard drive machines will operate only at 87.5 cpm; for variable drive units the 87.5 cpm speed is set before specimens are mounted. Run the machine for 1 min to accomplish initial wear-in of the coated specimen and then stop the machine. Gently lower 27.3 kg (60 lb) of additional weight onto the bale rod, bringing the total to 28.3 kg (63 lb) or 283 kg (630 lb) normal load on the specimen. Start the machine again and run until failure occurs due to excessive friction, as described above. Record friction during the break-in cycle and also record the number of revolutions to failure.

10. Calculation

10.1 Calculate the coefficient of friction from the friction force values as follows:

$$f = F/W \qquad (2)$$

where:
f = coefficient of friction,
F = friction force, kg (lb), and
W = normal load, kg (lb).

11. Report

11.1 The report shall include the following:

11.1.1 Report the friction force in both directions at 50, 100, and 1000 cycles. Record the number of revolutions to failure, (point after wear-in at which a coefficient of friction of 0.1 is reached).

11.1.2 Indicate where failure occurred, whether in the inside, middle, or outside of the wear track of the test ring.

12. Precision and Bias

12.1 *Precision*—The following criteria should be used for judging the acceptability of test results (95 % probability).

12.1.1 *Wear Life Measurement:*

12.1.1.1 *Repeatability*—The difference between successive test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, and in the normal and correct operation of the test method, exceed 25 % of the mean only in one case in twenty.

12.1.1.2 *Reproducibility*—The difference between two, single and independent results, obtained by different operators