Designation: D 2981 – 94 (Reapproved 2009)

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

This standard is issued under the fixed designation D 2981; 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 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D 2714 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.

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

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 ± 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 D 2714.)

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 ± 0.005 in.), a diameter of 34.9885 ± 0.0254, – 0.1270 mm (1.3775 ± 0.001, –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 to 750 nm (20 to 30 μin.) rms.

6.3 *Test Block,*[2] *SAE 01 Steel*[5] with test surface of 0.635 ± 0.021, –0.000 mm (0.250 ± 0.0005, –0.0000 in.) wide and 1.575 ± 0.005 mm (0.620 ± 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 to 200 nm (4 to 8 μin.) rms and be perfectly square with all outside edges.

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[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.L0.05 on Solid Lubricants.

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[2] The Block-on-Ring Test machine is available from Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554.

[3] 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.

[4] Available from Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554.

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

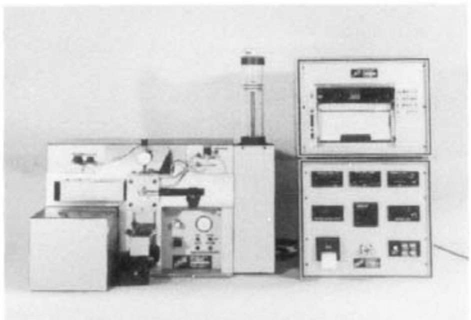

FIG. 1 Falex Block-on-Ring Test Machine with Recorder

7. Reagents

7.1 *Solvents,*[6] safe, nonfilming, nonchlorinated.

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.)

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 ± 3°C (75 ± 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:

$$f = F/W \tag{2}$$

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 working in different laboratories on identical test material would, in the long run, and in the normal and correct operation of the test method, exceed 33 % of the mean only in one case in twenty.

12.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Method D 2981 for measuring wear life, no statement on bias is being made.

13. Keywords

13.1 oscillating; solid film lubricant; wear friction

[6] 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.

ANNEX

(Mandatory Information)

A1. DESCRIPTION OF THE FALEX BLOCK-ON-RING TEST MACHINE

A1.1 A stationary rectangular test block bears under a predetermined load, maximum 548 kg (1300 lb), against a rotating (or oscillating) ring. The load is accurately maintained throughout the test. Bearing pressures (average Hertz pressures) in the line contact area between the rectangular specimen and the rotating ring may range up to 110 000 psi (759 MN/m^2).

A1.2 In rotational motion, friction is indicated throughout the test by a digital indicator. A load cell transducer and a recorder are used to obtain friction readings under oscillating motion. A counter records the number of revolutions or cycles of the test ring. One criterion of failure is when the friction reaches a pre-selected maximum. For this purpose a control on the friction indicator or recorder can be set for any pre-selected value of friction and the machine will automatically shut off upon reaching it.

A1.3 In an alternative method, a thermocouple is imbedded in the test block and a temperature controller terminates the test when the temperature of the test block reaches a previously set value.

A1.4 The test shaft of the machine is supported by two roller bearings and the mandrel end of the shaft protrudes through the front panel of the machine where the test specimens are mounted. The test block, which is held stationary against the rotating or oscillating ring, is restrained from horizontal movement by a unique type of holder. The design of this specimen holder allows the test block to align itself automatically in a manner prescribed by ASTM specifications for compression loaded specimens. This maintains uniform loading throughout the area of contact between the specimens regardless of the force existing between them. In oscillating tests, the holder for the stationary specimen is mounted on a special friction pin assembly. This assembly is connected to a load cell which is in turn connected to a digital friction meter and a recorder that monitors and records friction.

A1.5 The normal force between the test specimens is produced by suspending dead weights from the end of a lever system which is designed in such a way as to allow the full value of the friction force to be transmitted to the frictional load pick-up device.

A1.6 Speed ranges with variable speed control are available from 0.5 to 7200 rpm. Fluid lubricants can be tested up to a maximum of 204°C (400°F). With optional equipment, the test chamber can be pressurized to 1.03 MPa (150 psi) run in special atmospheres or run in vacuum.

A1.7 The friction force indicator used in rotational testing is direct reading in kilograms or pounds and is fitted with an infinitely adjustable limit control which allows the operator to preset the value of friction at which the machine will stop. The setting is accomplished by presetting the desired value on the automatic friction cut-off. In oscillating testing, the friction force-recorder system provides friction readings in both directions.

A1.8 A six-digit revolution counter is mounted in the digital instrumentation system. It is electronically actuated from the test shaft and is equipped with a reset.

A1.9 The machine is furnished complete with all electrical equipment ready to operate after removal of a few shipping bolts. In addition to the motor, the electrical equipment includes control circuit relays and a push-button-controlled magnetic motor starter for electrical overload and low-voltage protection.