Standard Test Method for Wear Preventive Properties of Lubricating Greases Using the (Falex) Block on Ring Test Machine in Oscillating Motion[1]

This standard is issued under the fixed designation D3704; 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 wear properties of lubricating greases by means of the Falex block-on-ring friction and wear test machine.

1.2 The values stated in SI units are to be regarded as standard except where equipment is supplied using inch-pound units and would then be regarded as standard. The metric equivalents of inch-pound units given in such cases in the body of the standard may be approximate.

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*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1403 Test Methods for Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment

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

G40 Terminology Relating to Wear and Erosion

3. Terminology

3.1 *Definitions:*

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

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

3.1.1.1 *Discussion*—A distinction is often made between *static coefficient of friction* and *kinetic coefficient of friction.* **G40**

3.1.2 *friction force, n*—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. **G40**

3.1.3 *kinetic coefficient of friction, n*—the coefficient of friction under conditions of macroscopic relative motion between two bodies. **G40**

3.1.4 *wear, n*—damage to a solid surface, generally involving progressive loss of material, due to relative motion between that surface and a contacting substance or substances. **G40**

4. Summary of Test Method

4.1 The tester is operated with a steel test ring oscillating against a steel test block. Test speed, load, angle of oscillation, time and specimen surface finish and hardness can be varied to simulate field conditions.

4.2 The width of the wear scar, developed on the test block from contact with the oscillating test ring, is measured.

5. Significance and Use

5.1 This test method is used to differentiate between greases having high, medium, and low wear preventive properties using oscillating motion. 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 *Falex Block-on-Ring Test Machine with Friction Recorder,*[3] described in detail in Annex A1 and illustrated in Fig. 1.

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[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.L0.05 on Solid Lubricants.

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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] 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.

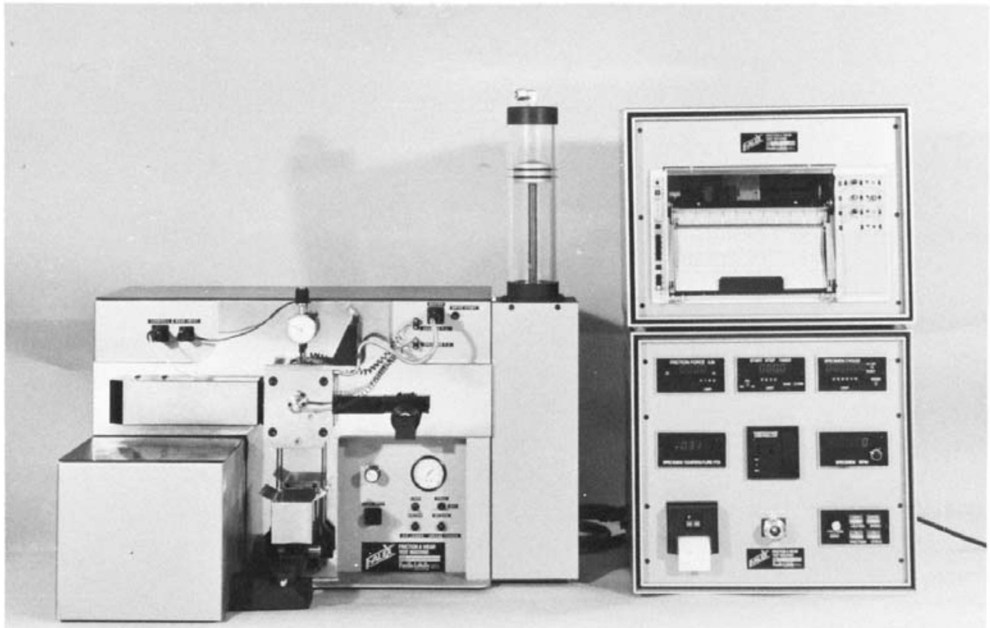

FIG. 1 Falex Block on Ring Test Machine

FIG. 1 Falex Ring and Block Test Machine *(continued)*

6.2 *Falex Oscillating Drive Accessory,*[3]described in detail in A1.6 and illustrated in Fig. 2.

6.3 *Microscope,* low-power (50× to 60×) having sufficient clearance under objective to accommodate the test block. It should be fitted with a filar micrometer so that scar width may be measured with accuracy of ±0.01 mm.

6.4 *Timer,* graduated in minutes and seconds.

7. Reagents and Materials

7.1 *Test Rings, Falex Type S-10 or S-25*[3]—SAE 4620 carburize steel, having a hardness of 58 to 63 HRC. The test ring has a width of 8.15 mm (0.321 in.), a diameter of 35 mm (1.3775 in.), and a maximum radial run out of 0.013 mm (0.0005 in.). The surface roughness of the S-10 ring shall be 0.15 to 0.30 µm (6 to 12 µin.) rms. The surface roughness of the S-25 ring shall be 0.51 to 0.71 µm (22 to 28 µin.) rms.

7.2 *Test Blocks, Falex Type H-30 or H-60*[3]—SAE 01 tool steel having two ground test surfaces of 0.10 to 0.20 µm (4 to 8 µin.) rms. The test block has a width 6.35 mm (0.250 in.) and a 15.76 mm (0.620 in.) length. The H-30 test block has a hardness of HRC 27 to 33. The H-60 test block has a hardness of HRC 58 to 63.

7.3 *Solvent,* non-film forming, nonchlorinated.

NOTE 1—Solvents formerly used in this test method were eliminated due to possible toxic effects. Each user should select a solvent that can meet his applicable safety standards and still thoroughly clean the machine parts.

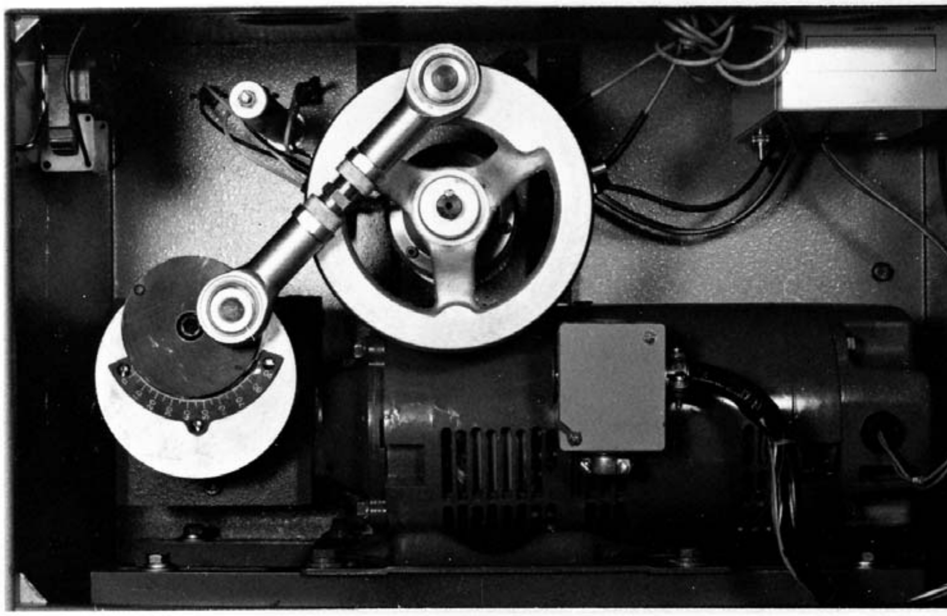

FIG. 2 Falex Oscillating Drive Assembly

8. Calibration and Standardization

8.1 Run Test Method D2714 calibration procedure to ensure good mechanical operation of test equipment.[4]

9. Procedure

9.1 Before each test, clean the apparatus with appropriate solvent chosen in 7.3 and blow dry.

9.2 Select a new test ring and block, wash with solvent, and dry with clean soft cloth or paper.

9.3 The grease sample should be worked 60 strokes, one-half scale or one-quarter scale (Test Methods D1403), prior to starting runs. One working per running day is sufficient. For those who may not have small workers, working briefly with a spatula is sufficient.

9.4 Adjust the amplitude of oscillation for the desired arc.

9.5 Lubricate the quarter segment (or the ball seat) of the specimen holder with the grease to be tested.

9.6 With no weights on the bale rod, apply a thin film of the test grease to the surface of a clean test block and mount the test block in the quarter segment (or ball seat) and position both securely in the specimen holder. On models with the ball seat, tighten the set screws so that the block is held lightly. Apply a thin film of the test grease along the test surface of the ring, and slip it on over the test shaft, taking care that grease does not get on the seat and the test surfaces are not scratched. Alternatively, the ungreased ring may be slipped on and tightened down and grease carefully applied to the ring surface with a small, thin spatula. Screw on the lock washer and locknut, and tighten with a torque wrench to 250 in.·lb (28.25 N·m). Apply additional test grease to the area of the test block, especially the area that overlaps the ring on both sides of the block. (Total grease is 1 to 2 g.)

9.7 The block should be seated squarely on the ring; otherwise, a wedge-shaped scar will result. One way to accomplish this is to loosen the block in the holder, apply a 3-lb (1.3-kg) load on the bale rod and rotate the ring by hand back and forth a few times. This also serves to distribute the grease between block and ring. The block is then tightened securely for running. If grease has pulled away from the block during the above operation, it should be reapplied as described in 9.6.

9.8 Place the desired weights on the bale rod keeping in mind the standard machine is built with a 10:1 ratio lever. Make sure the two load lever reference markers are aligned. If so equipped, position the friction force cutoff level at 40 lb (18.14 kg).

9.9 Starting at zero, bring the speed up rapidly to the predetermined setting necessary to give the desired speed. Measure time as soon as oscillation begins.

9.10 Run for desired time. Disassemble and wipe off the block and ring. Using the required microscope, measure the scar width on the test block in the center and 1 mm away from each edge to the nearest 0.01 mm. Report the average of these three measurements.

9.11 Report any unusual observation or an automatic friction cutoff. If a machine malfunctions or a test block has a wedge shaped scar, the test should be rerun.

10. Precision and Bias

10.1 *Precision*—The precision of this test method is not known to have been obtained in accordance with currently accepted guidelines (that is, in accordance with Committee

[4] Consult instruction manual for proper operation.

D02 Research Report RR:D02-1007, "Manual on Determining Precision Data for ASTM Methods on Petroleum Products and Lubricants").

10.1.1 *Repeatability*—The difference between successive 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 values only in one case in twenty.

23 % of the mean

10.1.2 *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, exceed the following values only in one case in twenty.

39 % of the mean

NOTE 2—The precision data were obtained from tests by nine laboratories using five different greases. Four greases used lithium hydroxystearate as a thickener; one used a calcium complex soap system. One grease contained no extreme pressure additive. The other four greases contained leaded, sulfur-phosphorus, MoS_2, or calcium complex, respectively, as extreme pressure systems.

10.2 The test conditions used to develop the precision data were:

10.2.1 *Time:* 5000 cycles (57.14 min),

10.2.2 *Angle of Oscillation:* 90°,

10.2.3 *Test Ring:* Type S-10,

10.2.4 *Test Block:* Type H-30,

10.2.5 *Test Speed:* 87½ cycles per minute, and

10.2.6 *Test Loads on Specimen:* 360 lb (163 kg), 480 lb (218 kg), 630 lb (286 kg).

NOTE 3—Supporting information and data for this method was presented in a research report by G. M. Stanton to the National Lubricating Grease Institute, October 1977 and published in the August 1978 NLGI *Spokesman.* Copies of this report "Wear Testing of Greases with the Falex I Ring and Block Friction and Wear Test Machine" are available upon request from NLGI.

10.3 *Bias*—The procedure in this test method has no bias because the value of wear can be defined only in terms of a test method.

11. Keywords

11.1 lubricating greases; oscillating motion; wear properties; wear test machine

ANNEX

(Mandatory Information)

A1. DESCRIPTION OF THE FALEX RING AND BLOCK FRICTION AND WEAR TESTING MACHINE

A1.1 A stationary rectangular test block bears under a predetermined load, maximum 286 kg (630 lb), against a rotating (or oscillating) ring (Fig. A1.1). Test specimen pressures (average Hertz pressures) in the line contact area between the rectangular specimen and the rotating ring may range up to a maximum of 760 MPa (110 000 MPa).

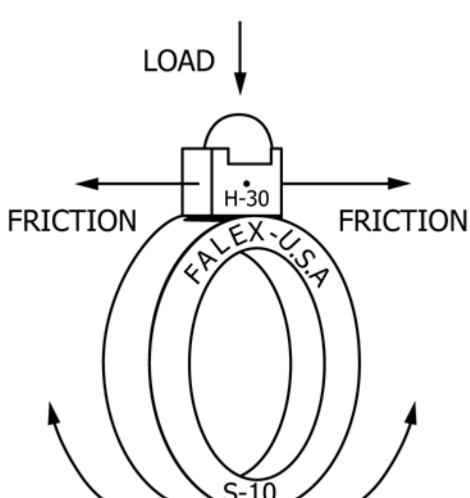

FIG. A1.1 Schematic Drawing of Ring & Block Specimens in Oscillating Motion

A1.2 In rotational motion, friction can be indicated throughout the test by hydraulic force gauge. A load cell transducer and a recorder or digital meter, or both 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 preselected maximum. For this purpose a control on the friction indicator or recorder can be set for any preselected 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 recorder controller (not standard equipment) terminates the test when the temperature of the test block reaches a previously set value.

A1.4 The test block, which is held stationary against the rotating or oscillating ring, is restrained from horizontal movement by a holder. The design of this specimen holder allows the test block to align itself 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.

A1.5 The normal force between the test specimens is produced by suspending dead weights from the lower end of a compound 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 Oscillating drive accessory converts rotary motion to oscillatory motion. Adjustable stroke 0 to 90°. Maximum frequency is 600 cycles per minute.

A1.7 Wear measuring accessory allows rate of wear and total wear measurements when used in conjunction with a recorder or digital indicator.

A1.8 Standard tester is built with a variable speed drive 0 to 1300 rpm. A panel mounted proportional temperature controller allows environmental control of temperature to 204°C (400°F) maximum.