Designation: D2714 – 94 (Reapproved 2014)

# Standard Test Method for Calibration and Operation of the Falex Block-on-Ring Friction and Wear Testing Machine[1]

This standard is issued under the fixed designation D2714; 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 standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope

1.1 This test method covers the calibration and operation of a block-on-ring friction and wear testing machine.

1.2 The values in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided 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.*

## 2. Terminology

2.1 *Definitions:*

2.1.1 *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.

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

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

2.1.2 *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.

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

2.1.4 *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.

## 3. Summary of Test Method

3.1 The test machine is operated using a steel test ring rotating against a steel test block, the specimen assembly being partially immersed in the lubricant sample. The velocity of the test ring is 7.9 ± 0.16 m/min (26 ± 0.52 ft/min) which is equivalent to a spindle speed of 72 ± 1 rpm. The specimens are subjected to 68 kg (150 lb) normal load applied by 6.8 kg (15 lb) of dead weight on the 10:1 ratio lever system. Test duration is 5000 cycles.

3.2 Three determinations are made: (*1*) The friction force after a certain number of revolutions, (*2*) the average width of the wear scar on the stationary block at the end of the test, and (*3*) the weight loss for the stationary block at the end of the test.

## 4. Significance and Use

4.1 This test method is used for the calibration of a block-on-ring testing machine by measuring the friction and wear properties of a calibration fluid under the prescribed test conditions.

4.2 The user of this test method should determine to his or her own satisfaction whether results of this test procedure correlate with field performance or other bench test machines. If the test conditions are changed, wear values can change and relative ratings of fluids can be different.

## 5. Apparatus

5.1 *Falex Block-on-Ring Test Machine,* [2] shown in Fig. 1 and Fig. 2 and described in detail in Annex A1.

NOTE 1—Consult the instruction manual for each machine to determine respective capabilities and limitations.

5.2 *Analytical Balance,* capable of weighing to the nearest 0.1 mg.

5.3 *Measuring Magnifier Glass,* with SI or inch-pound calibration so that the scar width can be measured with a precision of 0.01 mm, or equivalent.

[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.

This test method was prepared under the joint sponsorship of the American Society of Lubrication Engineers with the cooperation of the Coordinating Research Council, Inc. (CRC) Aviation Committee on Bonded Solid-Film Lubricants.

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[2] Trademarked and manufactured by Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554.

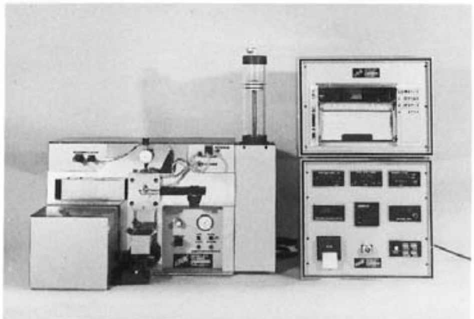

FIG. 1 Falex Block-On-Ring Variable Drive Testing Machine

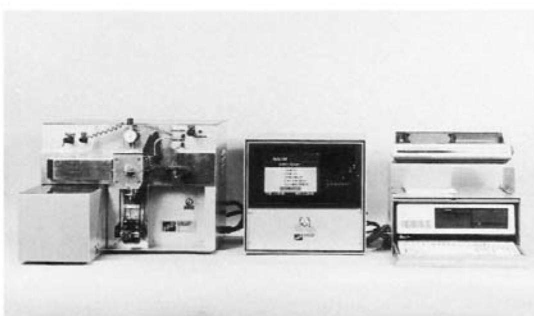

FIG. 2 Falex Block-On-Ring Test Machine with Microprocessor Data Acquisition and Control System

## 6. Reagents and Materials

6.1 *Test Rings, Falex Type S-10,* [2] SAE 4620 carburized 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 shall be 0.15 to 0.30 µm (6 to 12 µin.) rms.

6.2 *Test Blocks, Falex Type H-30,* [2] SAE 01[3] tool steel having two ground test surfaces of 0.10 to 0.20 µm (4 to 8 µin.) rms. The test block has a test surface width of 6.35 mm (0.250 in.) and a length of 15.76 mm (0.620 in.). The test block has a hardness of 27 to 33 HRC.

6.3 *Solvents,* safe, nonfilming, nonchlorinated.

NOTE 2—Each user should select a solvent that can meet the applicable safety standards and still thoroughly clean the parts.

6.4 *Calibration Fluid,* consisting of white mineral oil conforming to *U. S. Pharmacopeia XVII*, p. 399, and with a viscosity at 37.8°C (100°F) of 63 to 65 cSt.

## 7. Preparation of Apparatus

7.1 Before each test, thoroughly clean the specimen holder and chamber as well as the tapered section, threaded section, lock nut, lock washer, a new test ring and block using solvents selected in 6.3.

7.2 Weigh each test ring and test block to the nearest 0.1 mg on the analytical balance. Then store the specimens in a desiccator until ready for use.

7.3 Place the block holder on the block and carefully place block and holder in upper specimen holder in test chamber. Mount the test ring on the test shaft, taking care not to touch the test area. Tighten the test ring on the shaft with 440 N (100 lbf) as measured on the friction force meter on the digital instrument unit.

7.4 Place the heater door in position and fill the chamber with test fluid to about halfway on the spindle (half of the test ring is immersed). This volume must be measured (approximately 100 mL) and the same amount used for each test. Set the temperature control of the oil reservoir to 43.3°C (110°F). It is preferable to control the temperature of the liquid being tested, but if the machine is not equipped with a temperature controller indicator, then record the liquid temperature.

## 8. Calibration

8.1 A machine shall be judged to be in acceptable condition when the results obtained on the calibration fluid fall within the following limits:

8.1.1 Wear measurement is between 1.70 and 2.90 mm.

8.1.2 Friction force after 4500 revolutions is between 66 and 97 N (15.0 and 22.0 lbf).

## 9. Procedure

9.1 With the revolution counter set at zero, gently place a 6.78-kg (15-lb) load on the bale rod, being very careful to avoid shock-loading. When the fluid reaches temperature of 43.3°C (110°F) start the machine and bring the speed to 72 rpm. Record the friction force and the temperature of the liquid at 200, 400, 600, and 4500 revolutions and check the speed at each of these times. Stop the machine at 5000 revolutions. Remove the test block and test ring and clean them thoroughly using solvents selected in 6.3. Remove any excess wear particles that have accumulated on the side of the scar by brushing with a camel's hair brush; weigh the test ring and test block to the nearest 0.1 mg and measure the width of the wear scar of the test block at three points: in the center and 1 mm away from each edge as shown in Fig. 3. Four tests are required to establish a satisfactory average.

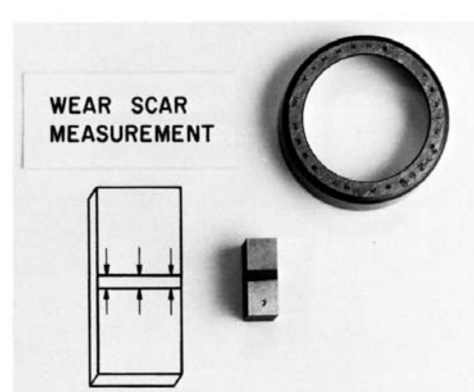


FIG. 3 Test Specimen Wear Scar Measurement

[3] SAE 01 is also known as Starrett 496 or Marshall Oil-crat.

## 10. Calculation and Report

10.1 Report the friction force at 200, 400, 600, and 4500 revolutions, the weight loss for the test block and test ring, and the average wear scar width. Fig. 3.

10.2 Calculate the coefficient of friction values from the friction force value as follows:

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

*where:*

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

## 11. Precision and Bias

11.1 The following criteria should be used for judging the acceptability of results (95 % confidence):

11.1.1 *Wear Measurement:*

11.1.1.1 *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 the following value only in one case in twenty:

$$\text{Repeatability} = 0.73\ \text{mm} \quad (3)$$

11.1.1.2 *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 the following values only in one case in twenty:

$$\text{Reproducibility} = 1.20\ \text{mm} \quad (4)$$

11.1.2 *Friction Force after 4500 Revolutions:*

11.1.2.1 *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 the following values only in one case in twenty:

$$\text{Repeatability} = 29\ N\ (6.6\ \text{lbf}) \quad (5)$$

11.1.2.2 *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 the following values only in one case in twenty:

$$\text{Reproducibility} = 31\ N\ (7.0\ \text{lbf}) \quad (6)$$

11.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Method D2714 for measuring friction and wear, no statement on bias is being made.

## 12. Keywords

12.1 block-on-ring; coefficient of friction; friction; wear

# ANNEX

**(Mandatory Information)**

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

A1.1 A stationary rectangular test block is pressed with a predetermined load, maximum 584 kg (1300 lb), against a rotating ring (Fig. A1.1). 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 can range up to 758 $MN/m^2$ (110 000 psi).

A1.3 Resulting friction is indicated throughout the test by a digital indicator. A counter records the number of revolutions of the test specimen. One criterion in the test is a preselected maximum for friction. For this purpose an automatic cutoff on the friction indicator can be set for any preselected value of friction and the machine will shut off upon reaching it.

A1.4 In a substitute method, a thermocouple is embedded in the specimen and a temperature recorder controller terminates the test when the temperature of the test block reaches a previously set value.

A1.5 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 revolving ring, is restrained from horizontal movement. The design of this block 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.

A1.6 The normal force between the test specimens is produced by hanging dead weights on the lower end of a lever system that 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.

A1.7 Speed ranges with variable speed control are available from 0.5 to 7200 rpm. Fluid lubricants can be tested up to a

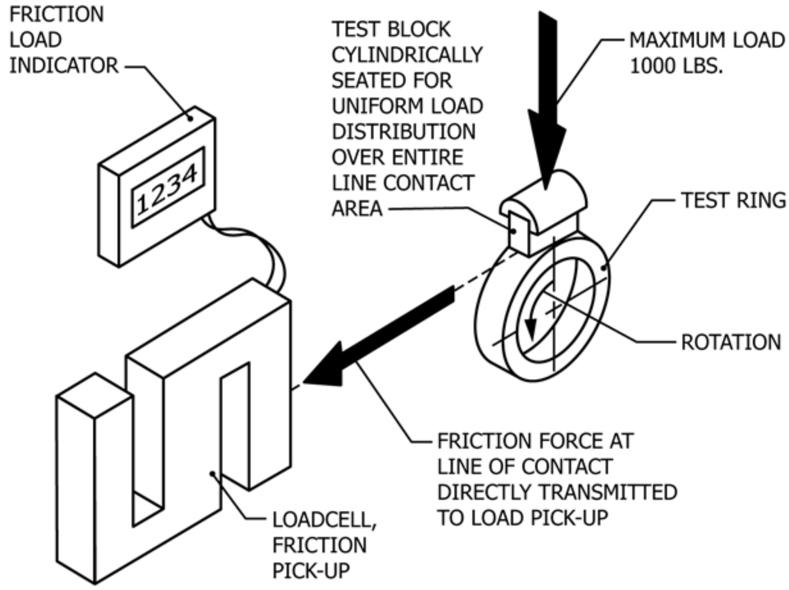


**FIG. A1.1 Functional Diagram of the Falex Block-On-Ring Testing Machine**

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.

A1.8 The friction force indicator is direct reading in pounds or kilograms and is fitted with an infinitely adjustable limit control that allows the operator to preset the value of friction at which the machine will stop.

A1.9 An electronic six-digit cycle counter is mounted on the front of the digital instrumentation unit. It is equipped with an automatic cut-off.

A1.10 A completely automated version is available incorporating a computer interface to automatically control load, speed, temperature, and duration.