



Designation: D3702 – 94 (Reapproved 2019)

Standard Test Method for Wear Rate and Coefficient of Friction of Materials in Self- Lubricated Rubbing Contact Using a Thrust Washer Testing Machine¹

This standard is issued under the fixed designation D3702; 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 rate and coefficient of friction for self-lubricated materials in rubbing contact by a testing machine² that utilizes a thrust washer specimen configuration.

NOTE 1—This machine may also be used to measure coefficient of friction.

1.2 The values in SI units are to be regarded as the standard. In cases where materials, products, or equipment are available only in inch-pound units, SI values in parentheses 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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. 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 bodies together.

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

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 An example known to the committee at this time is the Falex Multispecimen Test Machine, available from Falex Corp., 1020 Airpark Drive, Sugar Grove, IL 60554. This manufacturer recommends a maximum test load of 808 lb (367 kg). 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.

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

2.1.2 *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.

2.1.3 *wear rate*—the rate of material removal or dimensional change due to wear per unit of exposure parameter; for example, quantity of material removed (mass, volume, thickness) in unit distance of sliding or unit time.

2.2 Definitions of Terms Specific to This Standard:

2.2.1 *torque*—reaction of a tendency to turn due to friction forces between specimens traveling in a circular path. It is the product of a restraining force and the radius at which it acts to balance the frictional torque.

3. Summary of Test Method

3.1 The test machine is operated with a test specimen rotating under load against a stationary steel washer. Each test consists of break-in for 40 h followed by a selected test duration, each at the same selected normal load and speed. Load is obtained by application of dead weights to the 10:1 lever arm. The contact area is 1.29 cm² (0.20 in.²). The mean rubbing velocity is related to spindle rotational speed: 1 r/min = 0.0848 m/min (0.278 ft/min).

3.2 The thickness change of the test specimen and torque during test are measured for each test.

3.3 Wear rate in centimetres per hour (inches per hour) and coefficient of friction is reported.

4. Significance and Use

4.1 This test method is used to determine the equilibrium rate of wear and coefficient of friction of materials in rubbing contact under useful operating conditions, that is, combinations of pressure and velocity that fall below the PV (pressure \times velocity) limit of the test material. The user of this test method should determine to his own satisfaction whether the results of this test procedure correlate with field performance or other bench test machines. If the test conditions are changed, the wear rates may change and the relative value of one material with respect to another may also change.

4.2 Test conditions may be selected from **Table 1**.

4.3 The precision of wear measurement is relatively independent of test duration or amount of wear, but the precision of wear rate (calculation) improves with test duration and amount of wear. It is generally believed that useful wear rate precision requires the selection of a test duration sufficient to produce 0.1 mm (0.004 in.) of wear. Test durations will often be in the 50 h to 4000 h range.

5. Apparatus

5.1 *Falex Multispecimen Test Machine*, **Fig. 1**, shown schematically in **Fig. 2** and described in **Annex A1**.

5.2 *Test Specimen or Rotating Wafer*, shown in **Fig. 3**.

5.3 *Stationary Washer*, AISI C-1018 steel, shown in **Fig. 4**. The surface finish should be 16 $\mu\text{in.} \pm 2 \mu\text{in.}$ AA, the hardness Rc 20 ± 5 .

5.4 *Micrometer* (**Note 4**), capable of measuring to the nearest 0.003 mm (0.0001 in.).

6. Reagents and Materials

6.1 *Solvent*, safe, non-film forming, nonchlorinated.

NOTE 2—Petroleum distillates, formerly used as solvents, have been eliminated due to possible toxic effects. Each user should select a solvent

that can meet applicable safety requirements and thoroughly clean machine parts.

6.2 Appropriate reagents for cleaning the test specimen as recommended by the manufacturer of the test material.

7. Preparation of Apparatus

7.1 Measure the finish of the steel mating surface perpendicular to the finishing direction.

7.2 Before each test, thoroughly clean the steel washer and both specimen holders using the solvent per **5.1**.

NOTE 3—Remove all solvents from the washer before testing.

7.3 Clean the test specimen as recommended by the manufacturer of the test material.

7.3.1 Store cleaned test specimens prior to testing in a glass jar.

7.3.2 Following the cleaning, do not handle the test specimens with bare hands. It is recommended that clean cotton gloves or clean tweezers or tongs be used.

NOTE 4—Check compatibility of the test specimen cleaning procedure and reagents with the specific material to be tested.

7.4 Preset the speed control to provide the desired speed as measured in revolutions per minute using the built-in tachometer. Refer to **Table 1** to convert the specified velocity to revolutions per minute.

TABLE 1 Test Conditions^A

Rotational speed, r/min	Rubbing Velocity, ft/min (m/min)	Load, lb (kg), to Obtain PV, psi \times ft/min (kg/cm ² \times m/min) at Selected Speeds			
		PV ₁ 1250 (26.8)	PV ₂ 2500 (53.6)	PV ₃ 5000 (107.1)	PV ₄ 10 000 (214.3)
36	10 (3.05)	25.0 (11.3)	50.0 (22.7)	100 (45.4)	200 (90.7)
180	50 (15.2)	5.0 (2.3)	10.0 (4.5)	20.0 (9.1)	40.0 (18.1)
900	250 (76.2)	1.0 (0.5)	2.0 (0.9)	4.0 (1.8)	8.0 (3.6)

^AFor many applications a wear rate exceeding 1.0×10^{-5} in./h (2.5×10^{-7} m/h) is considered excessive. Typical wear rates for some commonly used materials at different PV levels are:

Acetal homopolymer at PV ₁ :	5×10^{-6} in./h to 1×10^{-5} in./h (1.3×10^{-7} m/h to 2.5×10^{-7} m/h)
Acetal homopolymer at PV ₂ :	1×10^{-5} in./h to 3×10^{-5} in./h (2.5×10^{-7} m/h to 7.5×10^{-7} m/h)
22 % PTFE-filled acetal homopolymer at PV ₂ :	3×10^{-6} in./h to 6×10^{-6} in./h (7.5×10^{-8} m/h to 1.5×10^{-7} m/h)
Polyamide (Type 6-6) at PV ₂ :	1×10^{-5} in./h to 5×10^{-5} in./h (2.5×10^{-7} m/h to 1.3×10^{-6} m/h)
15 % graphite filled polyimide resin at PV ₃ :	1×10^{-5} in./h to 2×10^{-5} in./h (2.5×10^{-7} m/h to 5×10^{-7} m/h)

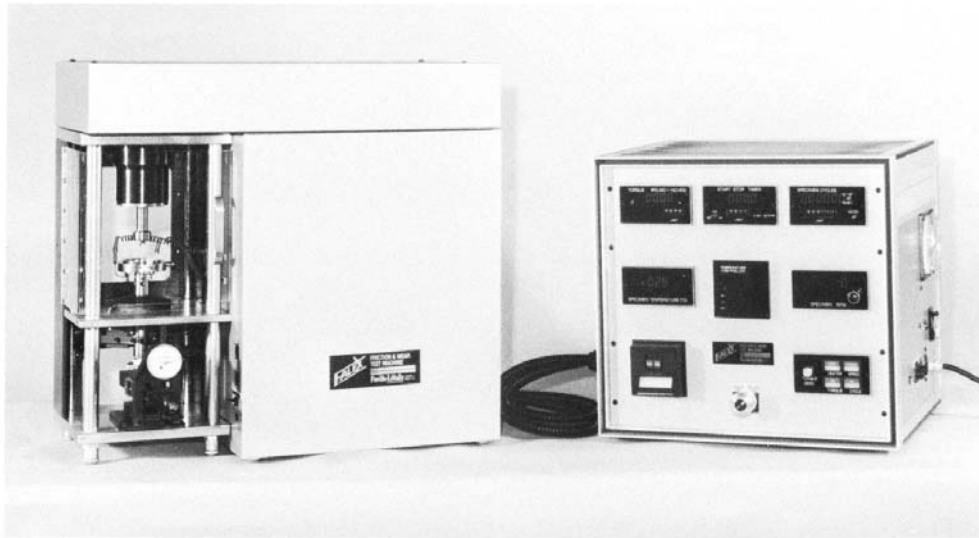


FIG. 1 The Falex Multispecimen Test Machine

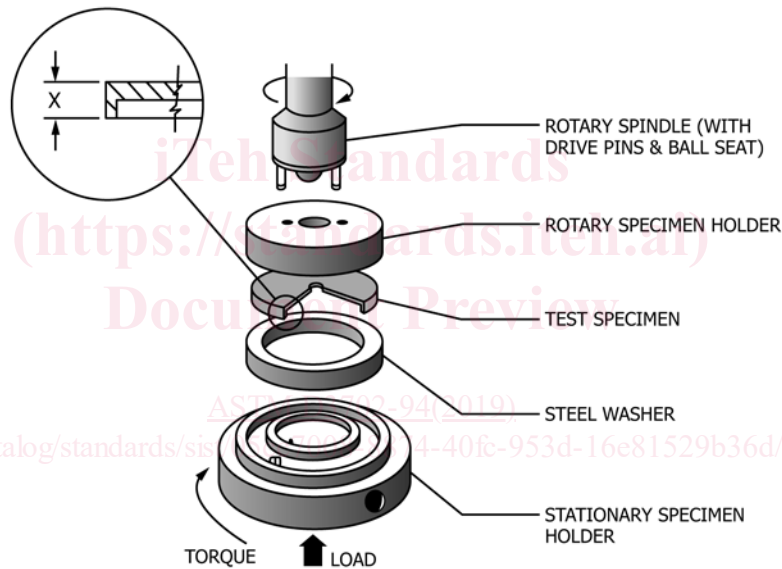


FIG. 2 Thrust Washer Test Specimen Arrangement

7.5 Install the test specimen in the upper specimen holder with the bolt and washer provided. Torque the bolt to

$$2.8\text{J} \pm 0.6\text{ J} \quad (25\text{in.}\cdot\text{lbf} \pm 5\text{ in.}\cdot\text{lbf}) \quad (2)$$

7.6 Place the steel washer in the lower specimen holder.

7.7 Balance the load lever arm with the bale rod attached.

7.8 Mount the test specimen together with its specimen holder in the rotary spindle so that the drive pins of the spindle are inserted in the drive pin holes of the specimen holder and the specimen holder is free to pivot on the ball seat.

7.9 Determine the dead weight, w , to be applied to the bale rod as follows:

$$W = \frac{F}{10} \quad (3)$$

where:

F = normal force.

7.10 If coefficient of friction is to be determined, check calibration of torque meter and adjust, if required, according to equipment manufacturer's instructions.

NOTE 5—Calibrate torque meter such that the anticipated test torque is approximately two-thirds of calibration value.

NOTE 6—A chart recorder can be used to continuously record torque throughout the test. Zero and span the recorder according to the manufacturer's instructions.

8. Procedure

8.1 With the specimens and bale rod in position, gently apply the appropriate weight to the bale rod.

8.2 Turn on the machine.