ASTM INTERNATIONAL

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Standard Test Method for
Wear Testing with a Pin-on-Disk Apparatus[1]

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1. Scope

1.1 This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined.

1.2 The values stated in SI units are to be regarded as standard.

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:*
E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process[2]
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[2]
E 178 Practice for Dealing with Outlying Observations[2]
G 40 Terminology Relating to Wear and Erosion[3]
2.2 *Other Standard:*[4]
DIN-50324 Testing of Friction and Wear

3. Summary of Test Method

3.1 For the pin-on-disk wear test, two specimens are required. One, a pin with a radiused tip, is positioned perpendicular to the other, usually a flat circular disk. A ball, rigidly held, is often used as the pin specimen. The test machine causes either the disk specimen or the pin specimen to revolve about the disk center. In either case, the sliding path is a circle on the disk surface. The plane of the disk may be oriented either horizontally or vertically.

NOTE 1—Wear results may differ for different orientations.

3.1.1 The pin specimen is pressed against the disk at a specified load usually by means of an arm or lever and attached weights. Other loading methods have been used, such as, hydraulic or pneumatic.

NOTE 2—Wear results may differ for different loading methods.

3.2 Wear results are reported as volume loss in cubic millimetres for the pin and the disk separately. When two different materials are tested, it is recommended that each material be tested in both the pin and disk positions.

3.3 The amount of wear is determined by measuring appropriate linear dimensions of both specimens before and after the test, or by weighing both specimens before and after the test. If linear measures of wear are used, the length change or shape change of the pin, and the depth or shape change of the disk wear track (in millimetres) are determined by any suitable metrological technique, such as electronic distance gaging or stylus profiling. Linear measures of wear are converted to wear volume (in cubic millimetres) by using appropriate geometric relations. Linear measures of wear are used frequently in practice since mass loss is often too small to measure precisely. If loss of mass is measured, the mass loss value is converted to volume loss (in cubic millimetres) using an appropriate value for the specimen density.

3.4 Wear results are usually obtained by conducting a test for a selected sliding distance and for selected values of load and speed. One set of test conditions that was used in an interlaboratory measurement series is given in Table 1 and Table 2 as a guide. Other test conditions may be selected depending on the purpose of the test.

3.5 Wear results may in some cases be reported as plots of wear volume versus sliding distance using different specimens for different distances. Such plots may display non-linear relationships between wear volume and distance over certain portions of the total sliding distance, and linear relationships over other portions. Causes for such differing relationships include initial "break-in" processes, transitions between regions of different dominant wear mechanisms, etc. The extent

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[1] This test method is under the jurisdiction of ASTM Committee G02 on Wear and Erosion and is the direct responsibility of Subcommittee G02.40 on Non-Abrasive Wear.
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[2] *Annual Book of ASTM Standards*, Vol 14.02.
[3] *Annual Book of ASTM Standards*, Vol 03.02.
[4] Available from Beuth Verlag GmbH, Burggrafenstrasse 6, 1000 Berlin 30, Germany.

TABLE 1 Characteristics of the Interlaboratory Wear Test Specimens

NOTE 1—See Note 4 in 10.4 for information.

	Composition (weight%)	Microstructure	Hardness (HV 10)	Roughness[A]	
				R_z(mean) (µm)	R_a(mean) (µm)
Steel ball (100 Cr6) (AISI 52 100)[B] Diameter 10 mm	1.35 to 1.65 Cr ← 0.95 to 1.10 C 0.15 to 0.35 Si 0.25 to 0.45 Mn	martensitic with minor carbides and austenite	838 ± 21	0.100	0.010
Steel disc (100 Cr6) (AISI 52 100)[C] Diameter 40 mm	← <0.030 P <0.030 S	martensitic with minor carbides and austenite	852 ± 14	0.952	0.113
Alumina ball, diameter = 10 mm[D]	← 95 % Al_2O_3 (with additives of TiO_2,	equi-granular alpha alumina with very minor secondary phases	1610 ± 101 (HV 0.2)	1.369	0.123
Alumina disc, diameter = 40.6 mm[D]	← MgO and ZnO)		1599 ± 144 (HV 0.2)	0.968	0.041

[A] Measured by stylus profilometry. R_z is maximum peak-to-valley roughness. R_a is arithmetic average roughness.
[B] Standard ball-bearing balls (SKF).
[C] Standard spacers for thrust bearings (INA).
[D] Manufactured by Compagnie Industrielle des Ceramiques Electroniques, France.

TABLE 2 Results of the Interlaboratory Tests[A]

NOTE 1— See Note 4 in 10.4.
NOTE 2—Numbers in parentheses refer to all data received in the tests. In accordance with Practice E 178, outlier data values were identified in some cases and discarded, resulting in the numbers without parentheses. The differences are seen to be small.
NOTE 3—Values preceded by ± are one standard deviation.
NOTE 4—Between eleven and twenty laboratories provided these data.
NOTE 5—Calculated quantities (for example, wear volume) are given as mean values only.
NOTE 6—Values labeled "NM" were found to be smaller than the reproducible limit of measurement.
NOTE 7—A similar compilation of test data is given in DIN–50324.

Results (ball) (disk)	Specimen Pairs			
	Steel-steel	Alumina-steel	Steel-alumina	Alumina-alumina
Ball wear scar diameter (mm)	2.11 ± 0.27 (2.11 ± 0.27)	NM	2.08 ± 0.35 (2.03 ± 0.41)	0.3 ± 0.06 (0.3 ± 0.06)
Ball wear volume (10^{-3} mm^3)	198 (198)	...	186 (169)	0.08 (0.08)
Number of values	102 (102)	...	60 (64)	56 (59)
Disk wear scar width (mm)	NM	0.64 ± 0.12 (0.64 ± 0.12)	NM	NM
Disk wear volume (10^{-3} mm^3)	...	480 (480)	...	...
Number of values	...	60 (60)	...	...
Friction coefficient	0.60 ± 0.11	0.76 ± 0.14	0.60 ± 0.12	0.41 ± 0.08
Number of values	109	75	64	76

[A] Test conditions: F = 10 N; v = 0.1 ms^{-1}, T = 23°C; relative humidity range 12 to 78 %; laboratory air; sliding distance 1000 m; wear track (nominal) diameter = 32 mm; materials: steel = AISI 52 100; and alumina = α-Al_2O_3.

of such non-linear periods depends on the details of the test system, materials, and test conditions.

3.6 It is not recommended that continuous wear depth data obtained from position-sensing gages be used because of the complicated effects of wear debris and transfer films present in the contact gap, and interferences from thermal expansion or contraction.

4. Significance and Use

4.1 The amount of wear in any system will, in general, depend upon the number of system factors such as the applied load, machine characteristics, sliding speed, sliding distance, the environment, and the material properties. The value of any wear test method lies in predicting the relative ranking of material combinations. Since the pin-on-disk test method does not attempt to duplicate all the conditions that may be experienced in service (for example; lubrication, load, pres-

sure, contact geometry, removal of wear debris, and presence of corrosive environment), there is no ensurance that the test will predict the wear rate of a given material under conditions differing from those in the test.

5. Apparatus

5.1 *General Description*—Fig. 1 shows a schematic drawing of a typical pin-on-disk wear test system, and photographs of two differently designed apparatuses.[5] One type of typical

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[5] A number of other reported designs for pin-on-disk systems are given in "A Catalog of Friction and Wear Devices," American Society of Lubrication Engineers (1973). The sole source of supply of commercially built machines 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 Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, [1] which you may attend.