



## Designation: **G99–05 (Reapproved 2010) G99 – 05 (Reapproved 2016)**

# Standard Test Method for Wear Testing with a Pin-on-Disk Apparatus<sup>1</sup>

This standard is issued under the fixed designation G99; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers 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. No other units of measurement are included in this 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:*<sup>2</sup>

[E178 Practice for Dealing With Outlying Observations](#)

[G40 Terminology Relating to Wear and Erosion](#)

[G117 Guide for Calculating and Reporting Measures of Precision Using Data from Interlaboratory Wear or Erosion Tests](#)

2.2 *DIN Standard:*<sup>3</sup>

[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.

<sup>1</sup> 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. Current edition approved April 1, 2010 June 1, 2016. Published April 2010 June 2016. Originally approved in 1990. Last previous edition approved in 2005 2010 as G99G99 – 05 (2010), –05. DOI: 10.1520/G0099-05R10.10.1520/G0099-05R16.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from Beuth Verlag GmbH (DIN-- DIN Deutsches Institut für Normung e.V.), Burggrafenstrasse 6, 10787, Berlin, Germany, <http://www.en.din.de>.

**TABLE 1 Characteristics of the Interlaboratory Wear Test Specimens**

NOTE 1—See Note 4 for information.

	Composition (weight% )	Microstructure	Hardness (HV 10)	Roughness <sup>A</sup>	
				$R_z$ (mean) ( $\mu\text{m}$ )	$R_a$ (mean) ( $\mu\text{m}$ )
Steel ball (100 Cr6) (AISI 52 100) <sup>B</sup> 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) <sup>C</sup> 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 <sup>D</sup>	← 95 % Al <sub>2</sub> O <sub>3</sub> (with addi- tives of TiO <sub>2</sub> ,	equi-granular alpha alumina with very minor secondary phases	1610 ± 101 (HV 0.2)	1.369	0.123
Alumina disc, diameter = 40.6 mm <sup>D</sup>	← MgO, and ZnO)		1599 ± 144 (HV 0.2)	0.968	0.041

<sup>A</sup> Measured by stylus profilometry.  $R_z$  is maximum peak-to-valley roughness.  $R_a$  is arithmetic average roughness.

<sup>B</sup> Standard ball-bearing balls (SKF).

<sup>C</sup> Standard spacers for thrust bearings (INA).

<sup>D</sup> Manufactured by Compagnie Industrielle des Ceramiques Electroniques, France.

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, and so forth. The extent 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, pressure, contact geometry, removal of wear debris, and presence of corrosive environment), there is no insurance 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.<sup>4</sup> One type of typical system consists of a driven spindle and chuck for holding the revolving disk, a lever-arm device to hold the pin, and attachments to allow the pin specimen to be forced against the revolving disk specimen with a controlled load. Another type of system loads a pin revolving about the disk center against a stationary disk. In any case the wear track on the disk is a circle, involving multiple wear passes on the same track. The system may have a friction force measuring system, for example, a load cell, that allows the coefficient of friction to be determined.

5.2 *Motor Drive*—A variable speed motor, capable of maintaining constant speed ( $\pm 1$  % of rated full load motor speed) under load is required. The motor should be mounted in such a manner that its vibration does not affect the test. Rotating speeds are typically in the range 0.3 to 3 rad/s (60 to 600 r/min).

5.3 *Revolution Counter*—The machine shall be equipped with a revolution counter or its equivalent that will record the number of disk revolutions, and preferably have the ability to shut off the machine after a pre-selected number of revolutions.

5.4 *Pin Specimen Holder and Lever Arm*—In one typical system, the stationary specimen holder is attached to a lever arm that has a pivot. Adding weights, as one option of loading, produces a test force proportional to the mass of the weights applied. Ideally,

<sup>4</sup> 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). Three commercially-built pin-on-disk machines were either involved in the interlaboratory testing for this standard or submitted test data that compared adequately to the interlaboratory test data. Further information on these machines can be found in Research Report RR:G02-1008.

TABLE 2 Results of the Interlaboratory Tests<sup>A</sup>

NOTE 1— See Note 4.

NOTE 2—Numbers in parentheses refer to all data received in the tests. In accordance with Practice E178, 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—Data were provided by 28 laboratories.

NOTE 5—Calculated quantities (for example, wear volume) are given as mean values only.

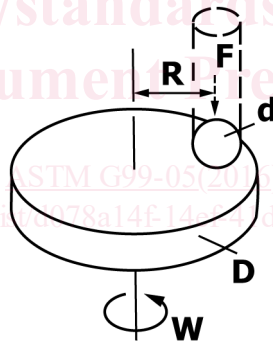
NOTE 6—Values labeled “NM” were found to be smaller than the reproducible limit of measurement.

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 <sup>-3</sup> mm <sup>3</sup> )	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 <sup>-3</sup> mm <sup>3</sup> )	...	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

<sup>A</sup> Test conditions:  $F = 10\text{ N}$ ;  $v = 0.1\text{ ms}^{-1}$ ,  $T = 23^\circ\text{C}$ ; 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 =  $\alpha\text{-Al}_2\text{O}_3$ .

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NOTE 1— $F$  is the normal force on the pin,  $d$  is the pin or ball diameter,  $D$  is the disk diameter,  $R$  is the wear track radius, and  $w$  is the rotation velocity of the disk.

FIG. 1 Schematic of Pin-on-Disk Wear Test System

the pivot of the arm should be located in the plane of the wearing contact to avoid extraneous loading forces due to the sliding friction. The pin holder and arm must be of substantial construction to reduce vibrational motion during the test.

5.5 *Wear Measuring Systems*—Instruments to obtain linear measures of wear should have a sensitivity of 2.5  $\mu\text{m}$  or better. Any balance used to measure the mass loss of the test specimen shall have a sensitivity of 0.1 mg or better; in low wear situations greater sensitivity may be needed.

## 6. Test Specimens and Sample Preparation

6.1 *Materials*—This test method may be applied to a variety of materials. The only requirement is that specimens having the specified dimensions can be prepared and that they will withstand the stresses imposed during the test without failure or excessive flexure. The materials being tested shall be described by dimensions, surface finish, material type, form, composition, microstructure, processing treatments, and indentation hardness (if appropriate).

6.2 *Test Specimens*—The typical pin specimen is cylindrical or spherical in shape. Typical cylindrical or spherical pin specimen diameters range from 2 to 10 mm. The typical disk specimen diameters range from 30 to 100 mm and have a thickness in the range of 2 to 10 mm. Specimen dimensions used in an interlaboratory test with pin-on-disk systems are given in Table 1.