



Designation: G99 – 17

Standard Test Method for Wear Testing with a Pin-on-Disk Apparatus¹

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 (ϵ) 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 This test method standard uses a specific set of test parameters (load, sliding speed, materials, etc.) that were then used in an interlaboratory study (ILS), the results of which are given here (Tables 1 and 2). (This satisfies the ASTM form in that “The directions for performing the test should include all of the essential details as to apparatus, test specimen, procedure, and calculations needed to achieve satisfactory precision and bias.”) Any user should report that they “followed the requirements of ASTM G99,” where that is true.

1.3 Now it is often found in practice that users may follow all instructions given here, but choose other test parameters, such as load, speed, materials, environment, etc., and thereby obtain different test results. Such a use of this standard is encouraged as a means to improve wear testing methodology. However, it must be clearly stated in any report that, while the directions and protocol in Test Method G99 were followed (if true), the choices of test parameters were different from Test Method G99 values, and the test results were therefore also different from the Test Method G99 results. This use should be described as having “followed the procedure of ASTM G99.” All test parameters that were used in such case must be stated.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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*

appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 *ASTM Standards:*²

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 (Withdrawn 2016)³

2.2 *DIN 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

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 last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from Beuth Verlag GmbH (DIN-- DIN Deutsches Institut für Normung e.V.), Burggrafenstrasse 6, 10787, Berlin, Germany, <http://www.en.din.de>.

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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TABLE 1 Characteristics of the Interlaboratory Wear Test Specimens

NOTE 1—See Note 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 ₂ O ₃ (with addi- tives 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 A for test conditions.

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 ⁻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: $F = 10\text{ N}$; $v = 0.1\text{ ms}^{-1}$, $T = 23^\circ\text{C}$; 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 = α -Al₂O₃.

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 Tables 1-3. Other test conditions may be selected depending on the purpose of the test. In such cases, the user should report their results as “following the procedure of ASTM G99.”

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