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.

Designation: D7755 − 11 (Reapproved 2022)

Standard Practice for Determining the Wear Volume on Standard Test Pieces Used by High-Frequency, Linear-Oscillation (SRV) Test Machine[1]

This standard is issued under the fixed designation D7755; 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 practice covers a procedure for determining the wear volume W_V of wear scars and tracks on test pieces tribologically stresses under high-frequency, linear-oscillation motion using a SRV test machine by means of stylus tip profilometry.

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, 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. Referenced Documents

2.1 *ASTM Standards:*[2]

D2714 Test Method for Calibration and Operation of the Falex Block-on-Ring Friction and Wear Testing Machine

D2782 Test Method for Measurement of Extreme-Pressure Properties of Lubricating Fluids (Timken Method)

D3702 Test Method for Wear Rate and Coefficient of Friction of Materials in Self-Lubricated Rubbing Contact Using a Thrust Washer Testing Machine

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D5620 Test Method for Evaluating Thin Film Fluid Lubricants in a Drain and Dry Mode Using a Pin and Vee Block Test Machine (Withdrawn 2010)[3]

D5706 Test Method for Determining Extreme Pressure Properties of Lubricating Greases Using a High-Frequency, Linear-Oscillation (SRV) Test Machine

D5707 Test Method for Measuring Friction and Wear Properties of Lubricating Grease Using a High-Frequency, Linear-Oscillation (SRV) Test Machine

D6425 Test Method for Measuring Friction and Wear Properties of Extreme Pressure (EP) Lubricating Oils Using SRV Test Machine

2.2 *DIN Standards:*[4]

DIN 51631:1999-04 Special-boiling-point spirit – Requirements and testing

DIN 51834-3:2008-12 Testing of lubricants – Tribological test in translatory oscillation apparatus – Part 3: Determination of tribological behaviour of materials in cooperation with lubricants

DIN EN ISO 13565-2:1998 Geometrical Product Specifications (GPS) – Surface texture: Profile method; Surfaces having stratified functional properties – Part 2: Height characterization using linear material ratio curve (replaces of DIN 4776:1990: Measurement of surface roughness; parameters R_K, R_{PK}, R_{VK}, M_{r1}, M_{r2} for the description of the material portion)

3. Terminology

3.1 *Definitions:*

3.1.1 *Hertzian contact area, n*—the apparent area of contact between two non-conforming solid bodies pressed against each other.

3.1.2 *Hertzian contact pressure, n*—magnitude of the pressure at any specified location in a Hertzian contact area, as calculated from Hertz's equations of elastic deformation. The Hertzian contact pressure can also be calculated and reported as maximum value P_{max} in the centre of the contact or as $P_{average}$ as average over the total contact area. **D4175**

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[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.L0.11 on Tribological Properties of Industrial Fluids and Lubricates.

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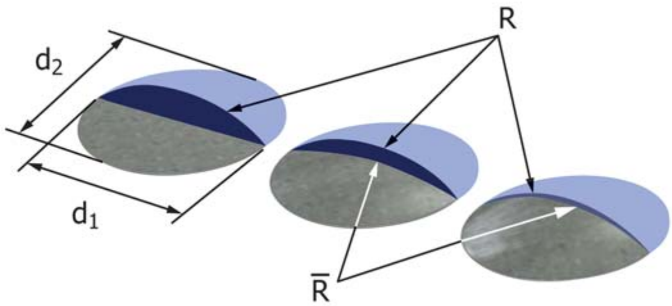
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Deutsches Institut fur Normung e.V.(DIN), Beuth Verlag GmbH, Burggrafenstraße 6, D-10787 Berlin 30, Germany, http://www.din.de.



NOTE 1—R is smaller than $\bar{R}$. The wear volumes are marked in blue.

FIG. 1 Ball–Comparison of Iso-wear Scar Diameters with Wear Volume in Relation to the Initial Radius R and the Radius in the Scar $\bar{R}$ at Test End

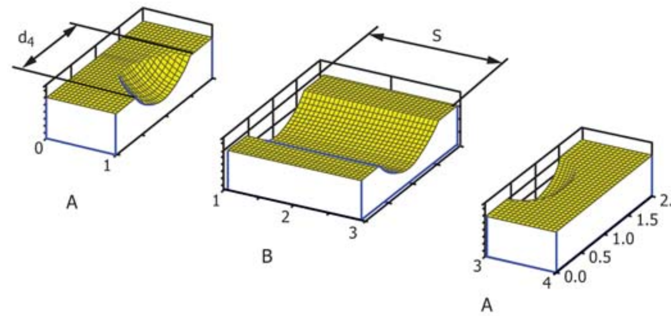


FIG. 2 Schematic Illustration of the Segmentation of the Wear Track

3.1.3 *seizure, n*—localized fusion of metal between the rubbing surfaces of the test pieces. **D5706**

3.1.3.1 *Discussion*—Seizure is usually indicated by a sharp increase in coefficient of friction, wear, or unusual noise and vibration. In this test method, increase in coefficient of friction is displayed on the chart recorder as permanent rise in the coefficient of friction from a steady value.

3.1.4 *wear, n*—damage to a solid surface, generally involving progressive loss of material, due to the relative motion between that surface and a contacting substance or substances. **D2714, D2782, D5620**

3.1.5 *wear rate, n*—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.

3.1.5.1 *Discussion*—Another term sometimes used synonymously is wear factor. **D3702**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *planimetric wear, Wq, n*—seen in the center of the wear track of the disk perpendicular to the sliding direction at test end and can be understood as cross section area of wear.

3.2.2 *wear volume, Wv, n*—the irreversible loss of volume to the ball or the disk (flat) at end of test. **D5707, D6425**

3.3 *Abbreviations:*

3.3.1 *SRV, n*—Schwingung, Reibung, Verschleiß, (German); oscillating, friction, wear (English translation).

4. Summary of Practice

4.1 This practice applies to test pieces tribologically stressed on a SRV test machine typically used in different ASTM (and DIN) test methods and are a test ball oscillating against a flat test disk.

4.2 As illustrated in Fig. 1, the same wear scar diameter on the ball not consequently indicates materials loss, the amount of material loss and different volumetric material losses can be related to exact one wear scar diameter.

NOTE 1—An extreme and ideal, but frequent case, is the case of a lubricant, which fully protects against wear, but a wear scar diameter is marked only visibly by tribo-chemistry and the wear scar diameter corresponds to the initial Hertzian contact diameter describing the elastic deformation. By using the ball diameter of diameter Ø = 10 mm, the elastic constants for AISI 52100 (100Cr6H) and F_N = 200 N, the initial Hertzian contact diameter calculates to 0.374 mm and for F_N = 300 N is 0.428 mm. When now unloading the ball after test, the elastic deformation is released and the initial shape recovers, showing, for example, no wear, but a marked wear scar, which is reported as wear scar diameter, even no, less or minor wear can be detected by means of stylus tip profilometry.

4.3 The wear scar diameter on the test ball is measured and the shape of the wear track on the disk is determined by means of a stylus tip profilometer in the centre of the track length (see Fig. 2) and this perpendicular to the sliding direction.

4.3.1 The worn or displaced volume ($W_{v,ball}$; $W_{v,flat}$) can be calculated by numerical methods[5-7] from the stylus tip profile data and assuming an ideal shape of the test specimen.

NOTE 2—In general, the wear volume is calculated by integrating a multitude of cross section area taken at different lengths of the wear track. The wear volume in this practice is based only on one cross section area (planimetric wear) in the centre of the wear track.

4.4 The planimetric wear $W_{q,flat}$ of the disk is derived from a 2D-profilogram by using a stylus tip profilometer.

5. Significance and Use

5.1 The determination of the wear volume becomes in tribological testing a key element, as it is more discriminative than the wear scar diameter, because an optically visible wear scar diameter may or may not indicate wear on the surface of the ball and the wear track as an irreversible loss of material. Users of this test method should determine whether results correlate with field performance or other applications.

NOTE 3—It is believed, that tactile stylus tip profilometer determines the most realistic figure and are more frequent in use, than it can be achieved by optical profilometers operating in a non-contacting mode.

6. Apparatus

6.1 *Microscope,* equipped with a filar eyepiece graduated in 0.005 mm division or equipped with a micrometer stage readable to 0.005 mm. Magnification should be sufficient to allow for ease of measurement. One to ten times magnification has been found acceptable.

6.2 *Stylus Tip Profilometer:*

[5] Ruff, A. W., "Wear Measurement," *ASM Handbook*, Vol 18, 1992, pp. 362–369.

[6] Klaffke, D., "Fretting Wear of Ceramics," *Tribology International*, Vol 22, No. 2, 1989, pp. 89–101.

[7] Kalin, M., and Vižintin, J., "Use of Equations for Wear Volume Determination in Fretting Experiments," *WEAR*, 237, 2000, pp. 39–48.

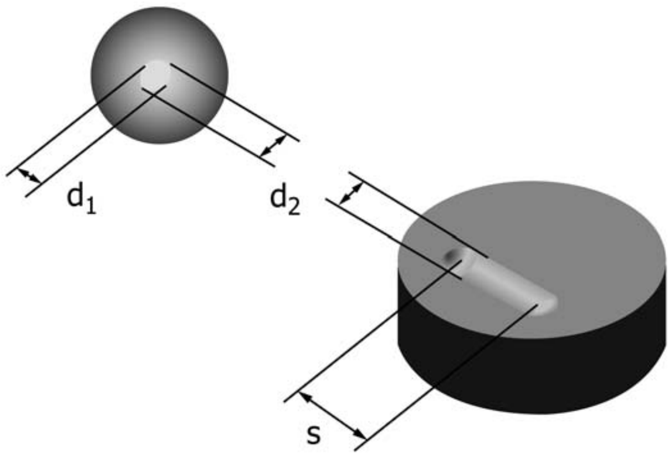


FIG. 3 Scheme of Wear Scar (Ball) and Track (Disk, Flat) on the Test Specimen

6.2.1 The stationary working place of the stylus tip profilometer should be composed of a stone (granite) base plate, the column, a transverse unit, a skidless tracing arm (skidless pick-up) and have the necessary software.

6.2.2 The stylus tip has a tip radius of 2 µm and a tip angle of 60° with a tip orientation (stylus position) of 90°. The resolution of the transverse unit is 0.1 µm or better.

7. Reagents and Materials

7.1 *Cleaning Solvent,* the test balls and disks have to be cleaned by a liquid solvent (non-chlorinated, non-film forming). (**Warning—**Flammable. Health Hazard.)

NOTE 4—It is recommended to use special boiling point spirit type 2 according to DIN 51631:1999.

8. Preparation of Apparatus

8.1 Most ASTM test methods related to SRV run with a ball sliding on a flat. In consequence and after the test, a wear scar marks the ball and a wear track the flat (see Fig. 3).

9. Procedure

9.1 *Cleaning of the Specimen*—Clean the test ball and disk by wiping the surfaces with laboratory tissue soaked with the cleaning solvent. Repeat wiping until no dark residue appears on the tissue. Immerse the specimen ball and disk in a beaker of the cleaning solvent under ultrasonic vibration for 10 min. Dry the test ball and disk with a clean tissue ensuring no streaking occurs on the surface.

9.2 *Stylus Tip Profilometry:*

9.2.1 The wear scar and track should be free of seizure marks.

9.2.2 The measuring length should have on each side of the track at least 0.500 mm in order to define the base line of the surface topography. A tracing speed of 0.15 mm⁄s has been found acceptable.

9.2.3 Set manually the bars on the left side and right side of the track shown in the profilogram displayed on the screen in order to define the borders. Set manually the horizontal bar for the base of the surface topography (see Fig. X1.1). The software iterates (calculates) the planimetric wear area.

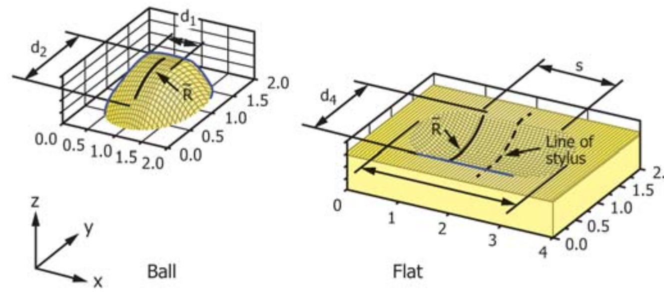


FIG. 4 Scheme of Variables Used to Calculated the Wear Volume of Ball and Disk

9.3 *Calculation of the Wear Volume*—The variables used in Eq 1-4 are illustrated in Figs. 2 and 4.

9.3.1 The wear volume of the ball $W_{v,ball}$ in mm^3 is calculated by using Eq 1.

$$W_{v,ball} = \frac{\pi \cdot d_1^2 \cdot d_2^2}{64}\left(\frac{1}{R} - \frac{1}{\bar{R}}\right) \quad (1)$$

and by using:

$$\bar{R} = \frac{d_2^3}{12\, W_{q,\, flat}} \quad (2)$$

where:

$\bar{R}$ = resulting radius of the shape of the wear scar after the test in mm;
R = initial radius of the ball in mm;
d_1 = the wear scar diameter on the ball parallel to the sliding direction in mm;
d_2 = wear scar diameter on the ball perpendicular to the sliding direction in mm and
$W_{q,\, flat}$ = planimetric wear of the wear track in the middle of the wear track length and seen perpendicular to the sliding direction in mm^2.

9.3.2 The shape of the wear track on the disk (flat) can be composed from three sections in Fig. 2 and represent the basis for Eq 3. Thus Eq 3 contains the element, B, plus the two elements, A, describing the ball scar.

9.3.2.1 The wear volume of the wear track on the flat disk $W_{v,flat}$ in mm^3 is calculated by using Eq 3.

$$W_{v,flat} = \frac{\pi \cdot d_4^2\,(d_3 - s)^2}{64} \cdot \frac{1}{\bar{R}} + s \cdot W_{q,flat} \quad (3)$$

where:

d_3 = the total length of wear track in sliding direction in mm,
d_4 = the width of the wear track in mm, and
s = stroke in mm.

and

$$\bar{R} = \frac{d_4^3}{12 \cdot W_{q,flat}} \quad (4)$$

where:

measured diameter d_4 = d_2 in mm.

NOTE 5—The equations represent an approximation for strokes smaller than 2 mm to 2.5 mm and assume that R < R' and the wear height of the scar is <<R.

NOTE 6—The wear tracks produced by other oscillating test methods