Designation: ~~D7217 – 16~~ D7217 – 22

Standard Test Method for Determining Extreme Pressure Properties of Solid Bonded Films Using a High-Frequency, Linear-Oscillation (SRV) Test Machine[1]

This standard is issued under the fixed designation D7217; 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 procedure for determining extreme pressure properties of solid bonded films under high-frequency linear-oscillation motion using the SRV test machine.

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~~ safety, health, and ~~health~~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]

A295/A295M Specification for High-Carbon Anti-Friction Bearing Steel

D2510 Test Method for Adhesion of Solid Film Lubricants

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

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

D7421 Test Method for Determining Extreme Pressure Properties of Lubricating Oils Using High-Frequency, Linear-Oscillation (SRV) Test Machine

E45 Test Methods for Determining the Inclusion Content of Steel

G40 Terminology Relating to Wear and Erosion

2.2 *Other Standards:*

DIN EN ISO 683-17 Heat-treated Steels, Alloy Steels and Free-Cutting Steels—Part 17: Ball and Roller Bearing Steels[3]

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 [Replacement of DIN

[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] 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] Available from Beuth Verlag GmbH, Burggrafenstrasse 6, D-10787 Berlin, Germany.

***A Summary of Changes section appears at the end of this standard**

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]

SAE AS5272 Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting Procurement Specification[4]

AMS ~~2562B~~2526D Biaxial Wheel Fatigue Test[4]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology D4175.

3.1.2 *break-in, n—in tribology*, an initial transition process occurring in newly established wearing contacts, often accompanied by transients in coefficient of friction or wear rate, or both, which are uncharacteristic of the given tribological system's long-term behavior. **G40**

3.1.3 *coefficient of friction, μ or f, n—in tribology*, the dimensionless ratio of the friction force ~~(F)~~(F_f) between two bodies to the normal force ~~(N)~~(F_n) pressing these bodies together. **G40**

3.1.4 *Hertzian contact area, n*—the apparent area of contact between two nonconforming solid bodies pressed against each other, as calculated from Hertz's equations of elastic deformation. **G40**

3.1.5 *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. **D7421**

3.1.6 *lubricant, n*—any material interposed between two surfaces that reduces the friction or wear, or both, between them. **D4175**

3.1.7 *solid bonded film (sbf), n*—consists of physically dried or chemically hardened (cured) bonded solid films as well as of inorganic matrices containing embedded organic or inorganic, or both, solid lubricants with or without lattice layers or soft metals or combinations of these. Synonyms—*solid film lubricants* (Test Method D2510), *bonded solid film lubricant* (SAE AS5272), and *thin lubricating ~~film~~film.* ~~(AMS 2562B).~~(Biaxial Wheel Fatigue Test AMS 2562D)

3.1.7.1 *Discussion—*

Dry solid film lubricants are dry coatings consisting of lubricating powders in a solid matrix bonded to one or both surfaces to be lubricated. **D2510**

3.1.8 *Ra (C.L.A.), n—in measuring surface finish*, the arithmetic average of the absolute distances of all profile points from the mean line for a given distance.[5]

3.1.9 *Rz (DIN), n—in measuring surface finish*, the average of all *Ry* values (peak to valley heights) in the assessment length.[6]

3.1.10 *Rpk, n*—reduced peak height according to DIN EN ISO 13565-2:1998. Rpk is the mean height of the peak sticking out above the core profile section.

3.1.11 *Rvk, n*—reduced valley height according to DIN EN ISO 13565-2:1998. Rvk is the mean depth of the valley reaching into the material below the core profile section.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *extreme pressure, adj—in lubrication*, characterized by metal surfaces in contact under high-stress rubbing conditions.

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

3.2.2.1 *Discussion—*

Seizure is indicated by a sharp rise in the coefficient of friction, over steady ~~state, of greater than 0.2 for over 20 s.~~ state. In severe cases, a stoppage in the motor will occur.

[4] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[5] Amstutz, Hu, "Surface Texture: The Parameters," *Bulletin MI-TP-003-0785*, Sheffield Measurement Division, Warner and Swasey, 1985, p. 21.

[6] Amstutz, Hu, "Surface Texture: The Parameters," *Bulletin MI-TP-003-0785*, Sheffield Measurement Division, Warner and Swasey, 1985, pp. 31, 29.

FIG. 1 SRV Test Machine (Model III)

3.3 *Abbreviations:*

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

4. Summary of Test Method

4.1 This test method is performed on an SRV test machine using a steel test ball oscillating against a steel test disk with lubricant between them. Test load is increased in ~~100 N~~10 N increments until seizure occurs. The load, immediately prior to the load at which seizure occurs, is measured and reported.

NOTE 1—Test frequency, stroke length, temperature, and ball and disk material can be varied to simulate field conditions. The test ball yields point-contact geometry. To obtain line or area contact, test pieces of differing configurations can be substituted for the test balls.

5. Significance and Use

5.1 This laboratory test method can be used to quickly determine extreme pressure properties of parts coated with solid bonded films at selected temperatures specified for use in unlubricated applications where high-speed vibrational or start-stop motions are present with high Hertzian point contact. This test method has found wide application in qualifying solid bonded films used in automotive door lock mechanisms, hinge joints, bolts, and in aerospace. This test method is a material and application oriented approach for characterizing the tribological behaviour using random, discrete and constant parameter combinations. Users of this test method should determine whether results correlate with field performance or other applications.

6. Apparatus

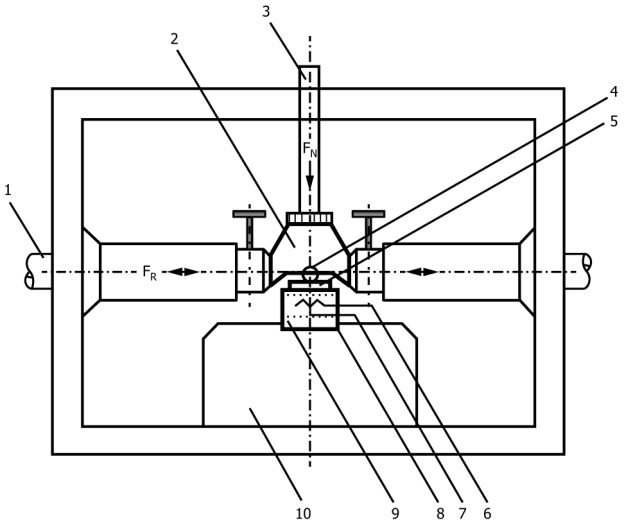
6.1 *SRV Test Machine,*[7] illustrated in Figs. 1-4.

7. Reagents and Materials

7.1 *Test Balls,*[7] 52100 steel, ~~60 HRC ± 2 HRC,~~ 660-730 HV0.2 (60 HRC ± 1 HRC), 0.025 µm ± 0.005 µm Ra surface finish, Ø = 10 mm diameter.

NOTE 2—The test can also be performed using rollers of antifriction bearings (Ø = 15 mm; length = 22 mm, parabolic border regions on each side of 3.5 mm). Using 2000 N as normal force possible in SRV III to SRV V models conducts only to a maximum initial Hertzian contact pressure of P_{0max} = 808 MPa, which is far away from the capability of most SBFs. Alternatively, a smaller roller in Ø = 6 mm with length = 8 mm and 2 mm parabolic border regions on each side generates P_{0max} = 2474 MPa.

[7] The sole source of supply of the apparatus known to the committee at this time is Optimol Instruments GmbH, ~~Westendstr. 125, D-80339~~Flößergasse 3, D-81369 Munich, Germany. If you are aware of alternative suppliers, please provide this information with round robin data to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

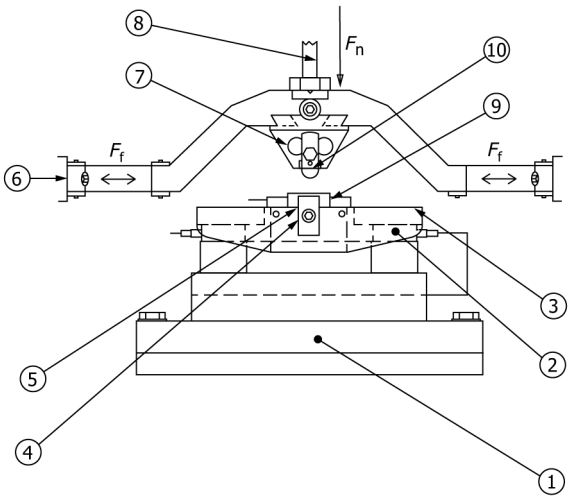


1. Oscillation Drive Rod
2. Test Ball Holder
3. Load Rod
4. Test Ball
5. Test Disk
6. Electrical Resistance Heater
7. Resistance Thermometer
8. Test Disk Holder
9. Piezoelectric Measuring Device
10. Receiving Block

FIG. 2 Test Chamber Elements

FIG. 3 SRV Test Machine (Model IV)

7.2 *Lower Test Disk,*[7] vacuum arc remelted (VAR) AISI 52100 steel with a inclusion rating using method D, Type A, as severity level number of 0.5 according to Test Methods E45, Specification A295/A295M, or a inclusion sum value K1 ≤ 10 according to DIN EN ISO 683-17 and spherodized annealed to obtain globular carbide, Rockwell hardness number of ~~60 HRC ± 2 HRC,~~ 720-775 HV0.2 (62 HRC ± 1 HRC), the surfaces of the disk being lapped and free of lapping raw materials. The topography of the disk will be determined by four ~~values, 24 mm~~ values: 0.500 µm < Rz (DIN) < 0.650 µm; 0.035 µm < Ra (C.L.A.) < 0.050 µm, 0.020 µm < Rpk < 0.035 µm and 0.050 µm < Rvk < 0.075 µm, Ø = 24 mm diameter by 7.85 mm thick:



1	base of the receiving block	7	upper specimen holder
2	piezo force measurement elements	8	drive rods of the load unit
3	supporting surface (head plate) of the receiving block	9	test disk
4	lower specimen holder	10	test ball
5	position of the electrical resistance heating and resistance thermometer	F_n	normal force (test load)
6	oscillation drive rods	F_f	friction force

FIG. 4 Test Chamber Elements of SRV Models IV and V

0.5 µm < Rz (DIN) < 0.650 µm
0.035 µm < Ra (C.L.A.) < 0.050 µm
0.020 µm < Rpk < 0.035 µm
0.050 µm < Rvk < 0.075 µm

NOTE 3—The DIN 17230-1980 was replaced by DIN EN ISO 683-17.

7.3 *n-Heptane,* reagent grade. (**Warning—**Flammable. Health hazard.)

7.4 *Isopropanol,* reagent grade. (**Warning—**Flammable. Health hazard.)

7.5 *Toluene,* reagent grade. (**Warning—**Flammable. Health hazard.)

7.6 *Cleaning Solvent,* a mixture of equal volumes of *n*-heptane, ispropanol, and toluene. (**Warning—**Flammable. Health hazard.)

8. Preparation of Apparatus

~~**Preparation of SRV I and II Models**~~

8.1 ~~Turn on the test machine and chart recorder or the PC and allow to warm up for 15 min prior to running tests.~~*Preparation of SRV I and II Models:*

8.1.1 Turn on the test machine and chart recorder or the PC and allow to warm up for 15 min prior to running tests.

8.1.2 Select the friction data to be presented in the crest peak value position in accordance with the manufacturer's directions.

NOTE 4—In most cases, this is accomplished by positioning the sliding switch on electronic card NO. 291.35.20E (front side of electronics behind the front panel) and the sliding switch located back on the panel of the control unit.

8.1.3 Turn the stroke knob to ZERO.

8.1.4 Switch the stroke adjustment to AUTO position.

8.1.5 Set the frequency to 20 Hz.

8.1.6 Set the desired span and calibrate the chart recorder in accordance with the manufacturer's instructions. Select the desired chart speed.

~~8.2 Select the friction data to be presented in the crest peak value position in accordance with the manufacturer's directions.~~

~~NOTE 4—In most cases, this is accomplished by positioning the sliding switch on electronic card NO. 291.35.20E (front side of electronics behind the front panel) and the sliding switch located back on the panel of the control unit.~~

~~8.3 Turn the stroke knob to ZERO.~~

~~8.4 Switch the stroke adjustment to AUTO position.~~

~~8.5 Set the frequency to 20 Hz.~~

~~8.6 Set the desired span and calibrate the chart recorder in accordance with the manufacturer's instructions. Select the desired chart speed.~~

~~Preparation of SRV III, IV, and V Models~~

~~8.7 When using SRV III, SRV IV, and SRV V models, clean and install the specimens as specified under 9.1.1 – 9.1.3. Turn on the test machine and the PC and allow to warm up for 15 min prior to running tests.~~

8.2 ~~Create a set point profile in the SRV control software with the following parameters:~~*Preparation of SRV III, IV, and V Models:*

~~NOTE 5—Depending on the software version, names and availability of the parameters can vary.~~

8.2.1 ~~Start conditions (thermostatic stabilization):~~When using SRV III,

~~Temperature: for example, 50 °C ± 1 K or 80 °C ± 1 K~~
~~Test load: 20 N ± 1 N~~
~~Start delay: 300 s (is displayed by all versions of the SRV software).~~

SRV IV, and SRV V models, clean and install the specimens as specified under 9.1.1 – 9.1.3. Turn on the test machine and the PC and allow to warm up for 15 min prior to running tests.

~~8.8.2 Cut-off criteria for friction, if occurs:~~

~~Coefficient of friction, f (cut-off value for permanent increase of level):~~
~~— 0.5 during t > 20 s~~
~~Coefficient of friction, f (cut-off value for one-off increase of level): 0.55~~

8.2.2 ~~Test~~ Create a set point profile in the SRV control software with the following parameters:

~~Frequency: 20 Hz~~
~~Stroke: 2.00 mm~~
~~Pre-load: 20 N for 30 s~~
~~Test load: running-in under 20 N for 2 min, then steps of 10 N with a~~
~~— duration of 1 min, 3 min, or 6 min until the maximum test load~~
~~— (usually 2000 N) has been reached.~~
~~Total test duration:~~
~~— With 1 min step duration up to 172.5 min;~~
~~— With 3 min step duration up to 512.5 min;~~
~~— With 6 min step duration up to 1022.5 min~~

NOTE 5—~~Because a 30 s break-in at 50 N is used, the load increase times will occur on the half minute of even minutes.~~Depending on the software version, names and availability of the parameters can vary.

8.2.2.1 Start conditions (thermostatic stabilization):

Temperature: for example, 50 °C ± 1 °C or 80 °C ± 1 °C
Test load: 20 N ± 1 N
Start delay: 300 s (is displayed by all versions of the SRV software).

8.2.2.2 Cut-off criteria for friction, if occurs:

Coefficient of friction, f (cut-off value for permanent increase of level):
0.5 during t > 20 s
Coefficient of friction, f (cut-off value for one-off increase of level): 0.55

8.2.2.3 Test parameters:

Frequency: 20 Hz
Stroke: 2.00 mm
Pre-load: 20 N for 30 s
Test load: running-in under 20 N for 2 min, then steps of 10 N with a duration of 1 min, 3 min, or 6 min until the maximum test load (usually 2000 N) has been reached.
Total test duration:
With 1 min step duration up to 172.5 min;
With 3 min step duration up to 512.5 min;
With 6 min step duration up to 1022.5 min

NOTE 6—Because a 30 s break-in at 50 N is used, the load increase times will occur on the half minute of even minutes.

8.2.2.4 Sample rates for result-relevant measurement channels:

Coefficient of friction, f: ≤32 ms
Stroke: ≤2 s
Test load: ≤2 s
Frequency: ≤2 s
Temperature: ≤2 s.
After that, apply a load increment of 100 N every 2 min.

NOTE 7—For SRV V models, it is recommended to do one sampling per period (that is, 20 ms) for coefficient of friction and stroke.

~~8.8.4 Sample rates for result-relevant measurement channels:~~

~~Coefficient of friction, f: ≤32 ms~~
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~~Frequency: ≤2 s~~
~~Temperature: ≤2 s~~
~~After that, apply a load increment of 100 N every 2 min.~~

~~NOTE 7—For SRV V models, it is recommended to do one sampling per period (that is, 20 ms) for coefficient of friction and stroke.~~

9. Procedure

9.1 *Procedure for All SRV Models*—SRV III, IV, and V models are fully computer-controlled and allow automated tests.

9.1.1 Check the coated disk for visible damage or corrosion. Clean the test ball and coated 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 test 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 to ensure no streaking occurs on the surface.