



Designation: D5706 – 16

# Standard Test Method for Determining Extreme Pressure Properties of Lubricating Greases Using a High-Frequency, Linear-Oscillation (SRV) Test Machine<sup>1</sup>

This standard is issued under the fixed designation D5706; 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 procedure for determining extreme pressure properties of lubricating greases under high-frequency linear-oscillation motion using the SRV test machine. This test method can also be used for evaluating extreme pressure properties of lubricating fluid.

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>

[A295/A295M Specification for High-Carbon Anti-Friction Bearing Steel](#)

[D217 Test Methods for Cone Penetration of Lubricating Grease](#)

[D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants](#)

[D6425 Test Method for Measuring Friction and Wear Properties of Extreme Pressure \(EP\) Lubricating Oils Using 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:*<sup>3</sup>

[DIN EN ISO 683-17 Heat-treated Steels, alloy steels and free-cutting steels—Part 17 : Ball and roller bearing steels](#)

[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 \[Replaces DIN 4776:1990: Measurement of surface roughness; parameters  \$R\_K\$ ,  \$R\_{PK}\$ ,  \$R\_{VK}\$ ,  \$M\_{T1}\$ ,  \$M\_{T2}\$  for the description of the material portion\]](#)

## 3. Terminology

3.1 *Definitions:*

3.1.1 *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**

3.1.2 *coefficient of friction,  $\mu$  or  $f$ ,  $n$ —in tribology*, the dimensionless ratio of the friction force ( $F$ ) between two bodies to the normal force ( $N$ ) pressing these bodies together. **G40**

3.1.3 *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**

3.1.4 *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**

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

<sup>1</sup> 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.G0.04 on Functional Tests - Tribology.

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<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 Deutsches Institut für Normung e.V.(DIN), Burggrafenstrasse 6, 10787 Berlin, Germany, <http://www.din.de>.

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

3.1.6 *lubricating grease, n*—a semi-fluid to solid product of a dispersion of a thickener in a liquid lubricant. **D217**

3.1.6.1 *Discussion*—The dispersion of the thickener forms a two-phase system and immobilizes the liquid lubricant by surface tension and other physical forces. Other ingredients are commonly included to impart special properties.

3.1.7 *thickener, n*—in *lubricating grease*, a substance composed of finely divided solid particles dispersed in a liquid lubricant to form the grease structure. **D217**

3.1.7.1 *Discussion*—The thickener can be fibers (such as various metallic soaps) or plates or spheres (such as certain non-soap thickeners) which are insoluble or, at most, only very slightly soluble in the liquid lubricant. The general requirements are that the solid particles be extremely small, uniformly dispersed, and capable of forming a relatively stable, gel-like structure with the liquid lubricant.

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.<sup>4</sup>

3.1.8.1 *Discussion*—C.L.A. means center line average, and it is a synonym for Ra.

3.1.9 *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.

3.1.10 *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.

3.1.11 *Rz (DIN), n*—in measuring surface finish, the average of all *Ry* values (peak to valley heights) in the assessment length.<sup>5</sup>

### 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.

3.2.2.1 *Discussion*—In this test method, seizure is indicated by a sharp rise in the coefficient of friction, over steady state, of greater than 0.2 for over 20 s. In severe cases, a stoppage in the motor will occur.

### 3.3 Abbreviations:

3.3.1 *SRV, n*—Schwingung, Reibung, 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 stationary steel test disk with lubricant between them. Test load is increased in 100 N increments until seizure occurs. The load, immediately prior to the load at which seizure occurs, is measured and reported.

<sup>4</sup> Amstutz, Hu, "Surface Texture: The Parameters," Bulletin MI-TP-003-0785, Sheffield Measurement Division, Warner and Swasey, 1985, p. 21.

<sup>5</sup> Amstutz, Hu, "Surface Texture: The Parameters," Bulletin MI-TP-003-0785, Sheffield Measurement Division, Warner and Swasey, 1985, pp. 29, 31.



FIG. 1 SRV Test Machine, Model III

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 lubricating greases at selected temperatures specified for use in 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 lubricating greases used in constant velocity joints of front-wheel-drive automobiles. Users of this test method should determine whether results correlate with field performance or other applications.

## 6. Apparatus

6.1 *SRV Test Machines*,<sup>6</sup> illustrated in Figs. 1-4.

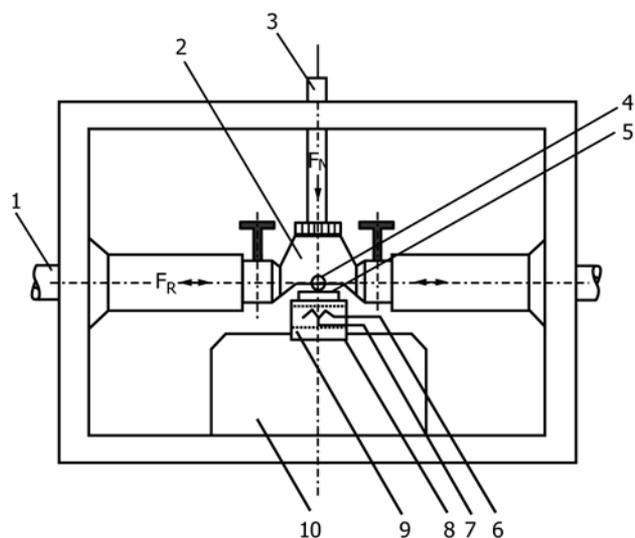
## 7. Reagents and Materials

7.1 *Test Ball*,<sup>6</sup> 52100 steel, Rockwell hardness number of 60 HRC  $\pm$  2 HRC, 0.025  $\mu$ m  $\pm$  0.005  $\mu$ m Ra surface finish, 10 mm diameter.

7.2 *Lower Test Disk*,<sup>6</sup> vacuum arc remelted (VAR) AISI 52100 steel with an inclusion rating using Method D, Type A, as severity level number of 0.5 according to Test Methods E45 and Specification A295/A295M or an inclusion sum value  $K1 \leq 10$  according to DIN EN ISO 683-17 and spheroidized annealed to obtain globular carbide, Rockwell hardness number of 60 HRC  $\pm$  2 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 diameter by 7.85 mm thick:

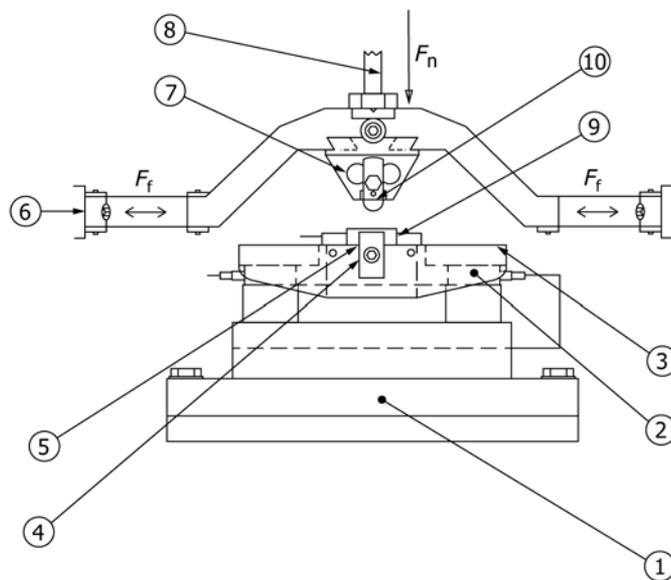
$$0.5 \mu\text{m} < R_z \text{ (DIN)} < 0.650 \mu\text{m}$$

<sup>6</sup> The sole source of supply of the apparatus known to the committee at this time is Optimol Instruments Prüftechnik GmbH, Westendstrasse 125, D-80339, Munich Germany, <http://www.optimol-instruments.de>. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.



- |                          |                                   |
|--------------------------|-----------------------------------|
| 1. Oscillation drive rod | 6. Electrical resistance heater   |
| 2. Test ball holder      | 7. Resistance thermometer         |
| 3. Load rod              | 8. Test disk holder               |
| 4. Test ball             | 9. Piezoelectric measuring device |
| 5. Test disk             | 10. Receiving block               |

FIG. 2 Test Chamber Elements of SRV III



- |   |                                |
|---|--------------------------------|
| 1. Base of the receiving block  | 7. Upper specimen holder       |
| 2. Piezo force measuring 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 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



FIG. 3 SRV Test Machine, Model IV

$0.035 \mu\text{m} < R_a \text{ (C.L.A.)} < 0.050 \mu\text{m}$   
 $0.020 \mu\text{m} < R_{pk} < 0.035 \mu\text{m}$   
 $0.050 \mu\text{m} < R_{vk} < 0.075 \mu\text{m}$

NOTE 2—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*, the test disks have to be cleaned by a liquid solvent (non-chlorinated, non-film forming).

NOTE 3—It is recommended to use a mixture of equal volumes of *n*-heptane, isopropanol, and toluene, all as reagent grades. (**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 and allow to warm up for 15 min prior to running tests.

8.2 Select the friction data to be presented in the crest peak 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 on the back panel of the control unit.

8.3 Turn the amplitude knob to ZERO.

8.4 Switch the stroke adjustment to AUTO position.

8.5 Set the frequency to 50 Hz.

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

**TABLE 1 Pass Load according to Procedure B in Test Method D5706 of Different Greases using  $\Delta x = 1.5$  mm stroke at 80 °C**

NOTE 1—The repeatability and the reproducibility were calculated using ADJD6300 (D2PP software).

NOTE 2—With a mean of  $\sim 1.100$  N, it is not clear that seizures occurred using machines with a highest load of 1200 N.

| Year                            | RR2003  | RR2002                                       | RR2001                | RR2003  | RR2002                                       | RR2001                      |
|---------------------------------|---|--|-----------------------|---|--|-----------------------------|
| Test greases, Test Method D5706 | Li/Ca-12-OH-Stearat   | Li/Ca-12-OH-Stearat                          | Li/Ca-12-OH-Stearat   | PAO<br>Polybuten-bentonit                                   | PAO<br>Polybuten- bentonit                   | PAO<br>Polybuten/- Bentonit |
| Modifications                   | $\Delta x = 1.5$ mm,<br>grease apply caliper,<br>O.K.- load | $\Delta x = 1.5$ mm,<br>grease apply caliper | $\Delta x = 1.5$ mm   | $\Delta x = 1.5$ mm,<br>grease apply caliper,<br>O.K.- load | $\Delta x = 1.5$ mm,<br>grease apply caliper | $\Delta x = 1.5$ mm         |
| Statistical Quantities          | Highest test load [N]                                       | Highest test load [N]                        | Highest test load [N] | Highest test load [N]                                       | Highest test load [N]                        | Highest test load [N]       |
| Number of Results               | 33  | 50   | 56                    | 38  | 53   | 54                          |
| Degree of freedom               | 22  | 28   | 30                    | 33  | 27   | 39                          |
| Mean                            | 1088  | 1180   | 1028                  | 434   | 486  | 505                         |
| Standard deviation              | $\pm 247$   | $\pm 235$                                    | $\pm 217$             | $\pm 71.1$  | $\pm 129$                                    | $\pm 106$                   |
| Reproducibility, <i>R</i>       | 726   | 680  | 627                   | 205   | 374  | 303                         |
| Repeatability, <i>r</i>         | 265   | 267  | 219                   | 173   | 201  | 197                         |

8.7 Turn on the heater control, and preheat the disk holder to the desired temperature. 50 °C, 80 °C, and 120 °C are recommended (see Table 1). When the temperature has stabilized, turn on the chart recorder and depress the drive start toggle switch until the timer begins to count and then adjust the stroke amplitude knob to 2.00 mm.

8.8 Set the load charge amplifier to setting that corresponds to the 400 N load.

8.9 Change the load charge amplifier at each load in accordance with the manufacturer's instructions when the coefficient of friction at each test load is to be studied.

8.10 When the digital timer reaches 30 s, increase the load to 100 N using the slow ramp speed rate, and maintain this load for 15 min.

8.11 The 15 min interval includes the loading ramp sequence. The load has to be increased by 100 N every 2 min using the slow ramp until a load of 1200 N is reached, or the load limit of the test apparatus is attained, or failure occurs. Failure is indicated by a rise in coefficient of friction of greater than 0.2 over steady state for over 20 s or a stoppage in the oscillating of the test machine (see Test Method D5706 or D6425).

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.

8.12 When the 1200 N load run or maximum load of the test apparatus is completed or failure occurs, turn off the heater control, release the load to minimum setting, (typically  $-13$  N or  $-14$  N), and remove the test ball, disk, and lubricating oil test specimen.

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

8.13 When using SRV III, SRV IV, and SRV V models, clean and install the specimens as specified under 9.1 to 9.7. Turn on the test machine and the PC and allow to warm up for 15 min prior to running tests.

8.14 Create a set point profile in the SRV control software with the following parameters:

NOTE 6—Depending on the software version, names and availability of the parameters can vary.

#### 8.14.1 Start conditions (thermostatic stabilization):

Temperature: for example, 50 °C  $\pm$  1 K or 80 °C  $\pm$  1 K

Test load: 50 N  $\pm$  1 N

Start delay: 300 s (is displayed by all versions of the SRV software)

#### 8.14.2 Cut-off criteria for friction, if occurs:

Coefficient of friction, *f* (cut-off value for permanent increase of level):

0.3 during  $t > 20$  s

Coefficient of friction, *f* (cut-off value for one-off increase of level): 0.35

#### 8.14.3 Test parameters:

Frequency: 50 Hz

Stroke: 1.00 mm for procedure A with 2 min run-in; 1.50 mm for procedure B with 15 min run-in

Temperature: for example, 50 °C or 80 °C

Pre-load: 50 N for 30 s

Test load: running-in under 100 N for 15 min, then steps of 100 N with a duration of 2 min until the maximum test load (usually 2000 N) has been reached.

Total test duration: up to 53.5 min

NOTE 7—Because a 30 s break-in at 50 N is used, the load increase times will occur on the half minute of even minutes.

NOTE 8—For optimal comparability with older SRV models I and II, the test load should be set as a ramp function with a gradient of 7.5 N/s.

#### 8.14.4 Sample rates for result-relevant measurement channels:

Coefficient of friction, *f*:  $\leq 32$  ms

Stroke:  $\leq 2$  s

Test load:  $\leq 2$  s

Frequency:  $\leq 2$  s

Temperature:  $\leq 2$  s

After that, apply a load increment of 100 N every 2 min.

NOTE 9—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 Using solvent-resistant gloves, 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 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.

9.2 Ensure that the test load unit is in the release position (refer to the operating manual for details).

### 9.3 Procedure A and B: