Designation: ~~D5706 – 16~~ D5706 – 23

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

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 (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 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~~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]

A295/A295M Specification for High-Carbon Anti-Friction Bearing Steel
D217 Test Methods for Cone Penetration of Lubricating Grease
D235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)
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:*[3]

DIN 51631:1999 Mineral spirits, special boiling point spirits; requirements
DIN EN ISO 683-17 Heat-treated Steels, alloy steels and free-cutting steels—Part 17 : Ball and roller bearing steels

[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.G0.04 on Functional Tests - Tribology.

Current edition approved ~~Nov. 15, 2016~~Dec. 1, 2023. Published ~~February 2017~~January 2024. Originally approved in 1995. Last previous edition approved in ~~2011~~2016 as ~~D5706 – 11.~~D5706 – 16. DOI: ~~10.1520/D5706-16.~~10.1520/D5706-23.

[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 Deutsches Institut fur 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**

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_{r1}, M_{r2} _for the description of the material portion]

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*) between two bodies to the normal force (*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 *lubricating grease, n*—a semi-fluid to solid product of a dispersion of a thickener in a liquid lubricant. **D217**

3.1.7.1 *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.

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

3.1.8.1 *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.

3.1.9 *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.[4]

3.1.9.1 *Discussion—*

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

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.

3.1.12 *Rz (DIN), n*—in measuring surface finish, the average of all *Ry* values (peak to valley heights) in the assessment length.[5]

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.

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

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~~0.1 for over 20 ~~s.~~ s in combination with associated changes in the stroke signal of greater than ±10 % (see 9.12 and Appendix X1 for more detailed information). 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.

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.

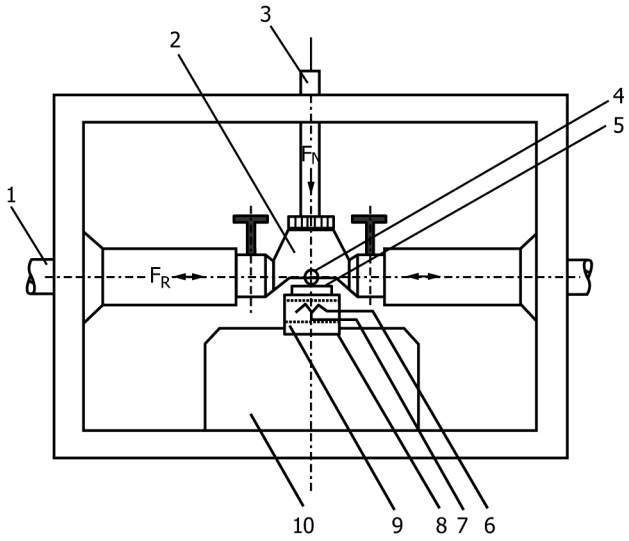
6. Apparatus

6.1 *SRV Test Machines,*[6] illustrated in Figs. 1-4.

7. Reagents and Materials

7.1 *Test Ball,*[6] 52100 steel, ~~Rockwell~~ Vickers micro-hardness of 660 HV0.2 to 730 HV0.2 (Rockwell hardness number of 60 HRC ± ~~2 HRC,~~2 HRC), 0.025 µm ± 0.005 µm Ra surface finish, 10 mm diameter.

[6] The sole source of supply of the apparatus known to the committee at this time is Optimol Instruments ~~Prüftechnik GmbH, Westendstrasse 125, D-80339,~~GmbH, Flößergasse 3, D-81639, 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,[1] which you may attend.

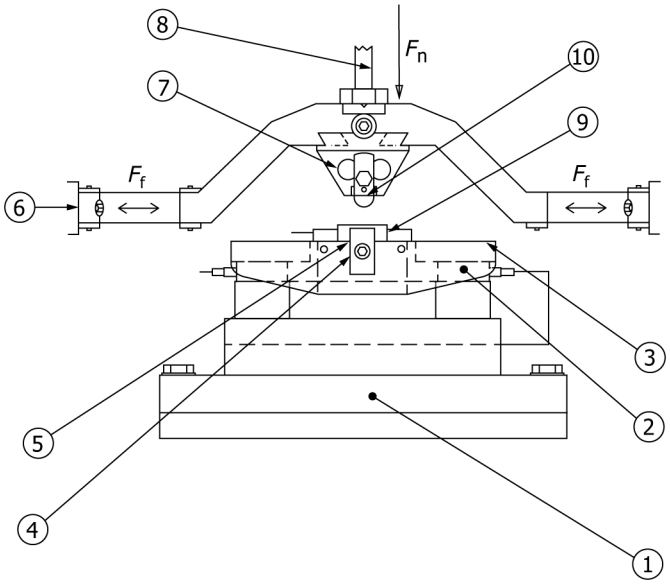


1. Oscillation drive rod
2. Test ball holder
3. Load rod
4. Test ball
5. Test disk
6. Electrical resistance heater
7. Resistance thermometer
8. Test disk holder
9. Piezoelectric measuring device
10. Receiving block

FIG. 2 Test Chamber Elements of SRV III

FIG. 3 SRV Test Machine, Model IV

7.2 *Lower Test Disk,*[6] 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 ≤ 10 according to DIN EN ISO 683-17 and spherodized annealed to obtain globular carbide, ~~Rockwell~~ Vickers micro-hardness of 660 HV0.2 to 730 HV0.2 (Rockwell hardness number of 60 HRC ± ~~2 HRC,~~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~~ 7.850 mm ± 0.100 mm thick:



1. Base of the receiving block
2. Piezo force measuring elements
3. Supporting surface (head plate) of the receiving block
4. Lower specimen holder
5. Position of the electrical resistance heating resistance thermometer
6. Oscillation drive rods
7. Upper specimen holder
8. Drive rods of the load unit
9. Test disk
10. Test ball

F_n Normal force (test load)

F_f Friction force

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

~~0.5 µm~~ 0.500 µm < Rz (DIN) < 0.650 µm
~~0.035 µm~~ 0.035 µm < Ra (C.L.A.) < 0.050 µm
~~0.020 µm~~ 0.020 µm < Rpk < 0.035 µm
~~0.050 µm~~ 0.050 µm < Rvk < 0.075 µm

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)~~

7.3 *Cleaning Solvent,* the test disks have to be cleaned by a liquid solvent (non-chlorinated, non-film forming). The cleaning solvent can be either a mixture of equal volumes of n-heptane, isopropanol, and toluene, all as reagent grades (**Warning—** Flammable. Health hazard.) or a single boiling point spirit type 2 according to DIN 51631:1999 published in English (**Warning—**Flammable. Health hazard.)

NOTE 3—~~It is recommended to use a mixture of equal volumes~~ In the case of unavailability of ~~n~~DIN ~~heptane, isopropanol, and toluene, all as~~ 51631:1999, please refer to Specification D235 ~~reagent grades.~~ (– 12 regarding Type ~~**Warning—**Flammable. Health hazard.)~~ I, Class C (with less than 2 % by volume of aromatics), mineral spirits.

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~~ warm-up for 15 min prior to running tests.

TABLE 1 Pass Load according to Procedure B in Test Method D5706 of Different Greases using Δx = 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 ~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 Polybuten-bentonit	PAO Polybuten- bentonit	PAO Polybuten/- Bentonit
Modifications	Δx = 1.5 mm, grease apply caliper, O.K.- load	Δx = 1.5 mm, grease apply caliper	Δx = 1.5 mm	Δx = 1.5 mm, grease apply caliper, O.K.- load	Δx = 1.5 mm, grease apply caliper	Δx = 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	±247	±235	±217	±71.1	±129	±106
Reproducibility, *R*	726	680	627	205	374	303
Repeatability, *r*	265	267	219	173	201	197

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 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.~~50 Hz.

8.6 Set as a ramp function with a gradient of 7.5 N⁄s.

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

8.8 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.~~1.50 mm.

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

8.10 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.

8.11 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.

8.12 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~~0.1 over steady state for over 20 s or a stoppage in the oscillating of the test ~~machine (see Test Method~~ machine.~~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.