Designation: D 5707 – 98 (Reapproved 2003)ε1

An American National Standard

Standard Test Method for Measuring Friction and Wear Properties of Lubricating Grease Using a High-Frequency, Linear-Oscillation (SRV) Test Machine[1]

This standard is issued under the fixed designation D 5707; 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.

ε[1] NOTE—Warning notes were editorially moved into the standard text in August 2003.

1. Scope

1.1 This test method covers a procedure for determining a lubricating grease's coefficient of friction and its ability to protect against wear when subjected to high-frequency, linear-oscillation motion using an SRV test machine at a test load of 200 N, frequency of 50 Hz, stroke amplitude of 1.00 mm, duration of 2 h, and temperature within the range of the test machine, specifically, ambient to 280°C. Other test loads (10 to 1400 N), frequencies (5 to 500 Hz), and stroke amplitudes (0.1 to 3.30 mm) can be used, if specified. The precision of this test method is based on the stated parameters and test temperatures of 50 and 80°C. Average wear scar dimensions on ball and coefficient of friction are determined and reported.

1.2 This test method can also be used for determining a fluid lubricant's ability to protect against wear and its coefficient of friction under similar test conditions.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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:*

D 217 Test Method for Cone Penetration of Lubricating Grease[2]

D 4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants[3]

D 5706 Test Method for Determining Extreme Pressure Properties of Lubricating Greases Using a High-Frequency, Linear-Oscillation (SRV) Test Machine[4]

G 40 Terminology Relating to Wear and Erosion[5]

2.2 *Other Standard:*

DIN 17230 Roller Bearing Steels[6]

DIN 51 834 Testing of Lubricants: Mechanical–Dynamic Test in the Oscillation Friction Apparatus[6]

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. **G 40**

3.1.2 *coefficient of friction, n— in tribology*, the dimensionless ratio of the friction force (*F*) between two bodies to the normal force (*N*) pressing these bodies together. **G 40**

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. **G 40**

3.1.4 *Hertzian contact pressure, n*—the magnitude of the pressure at any specified location in a Hertzian contact area, as calculated from Hertz's equations of elastic deformation. **G 40**

3.1.5 *lubricant, n*—any material interposed between two surfaces that reduces the friction or wear between them. **D 4175**

3.1.6 *lubricating grease, n*—a semifluid to solid product of a dispersion of a thickener in a liquid lubricant.

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.

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.G0 on Lubricating Grease.

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 05.02.

[4] *Annual Book of ASTM Standards*, Vol 05.03.

[5] *Annual Book of ASTM Standards*, Vol 03.02.

[6] Available from Beuth Verlag GmbH, Burggrafenstrasse 6, 1000 Berlin 30, Germany.

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3.1.7 *Ra*, *n*—in measuring surface finish, the arithmetic average of the absolute distances of all profile points from the mean line for a given distance.[7]

3.1.8 *Rz (DIN)*, *n*—in measuring surface finish, the average of all *Ry* values (peak to valley heights) in the assessment length.[8]

3.1.9 *Ry*, *n*—in measuring surface finish, the vertical distance between the top of the highest peak and the bottom of the deepest valley in one sampling length of the roughness profile.[9]

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

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3.1.11 *thickener*, *n—in lubricating grease*, a substance composed of finely divided particles dispersed in a liquid lubricant to form the product's structure.

3.1.11.1 *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.

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3.1.12 *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.

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3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.1.1 *Discussion*—Seizure is usually indicated by an 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 rise in the coefficient of friction from a steady state value.

4. Summary of Test Method

4.1 This test method is performed on an SRV test machine using a test ball oscillated under constant load against a test disk.

NOTE 1—The frequency of oscillation, stroke length, test temperature, test load, and test ball and disk material can be varied from those specified in this test method. The test ball yields Hertzian point contact geometry. To obtain line or area contact, test pieces of differing configurations can be substituted for the test ball.

4.2 The wear scar on the test ball and coefficient of friction are measured. If a profilometer is available, a trace of the wear scar on the test disk can also be used to obtain additional wear information.

5. Significance and Use

5.1 This test method can be used to determine wear properties and coefficient of friction of lubricating greases at selected temperatures and loads specified for use in applications where high-speed vibrational or start-stop motions are present for extended periods of time under initial high Hertzian point contact pressures. This test method has found application in qualifying lubricating greases used in constant velocity joints of front-wheel-drive automobiles and for lubricating greases used in roller bearings. Users of this test method should determine whether results correlate with field performance or other applications.

6. Apparatus

6.1 *SRV Test Machine*[10], illustrated in Figs. 1 and 2.

6.2 *Microscope*, equipped with a filar eyepiece graduated in 0.01-mm division or equipped with a micrometer stage readable to 0.01 mm. Magnification should be sufficient to allow for ease of measurement. One to 10× magnification has been found acceptable.

7. Reagents and Materials

7.1 *Test Balls*[10], 52100 steel, 60 ± 2 Rc hardness, 0.025 ± 0.005-µm *Ra* surface finish, 10-mm diameter.

7.2 *Lower Test Disk*[10], 52100 steel, 60 ± 2 Rc hardness, 0.45 to 0.65-µm *Rz* lapped surface, 24-mm diameter by 7.85 mm thick.

NOTE 2—Test pieces made to 100 Crb steel (DIN 17230) are equivalent.

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, isopropanol, and toluene. (**Warning—**Flammable. Health hazard.)

8. Preparation of Apparatus

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 value position on the test apparatus in accordance with the manufacturer's directions.

NOTE 3—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.

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

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

[9] Amstutz, Hu, "Surface Texture: The Parameters," Bulletin MI-TP-003-0785, Sheffield Measurement Division, Warner and Swasey, 1985, p. 25.

[10] The sole source of supply of the apparatus known to the committee at this time is Optimol Instruments Prüftechnik GmbH, Friedenstrasse 10, D-81671 Munich, Germany. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

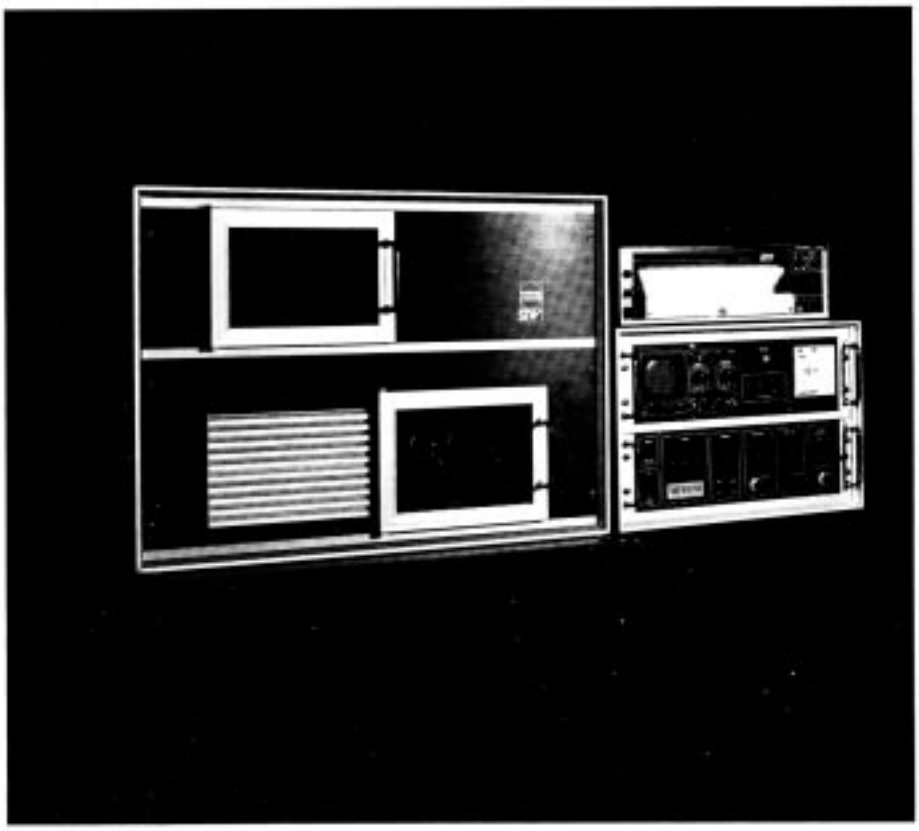


FIG. 1 SRV Test Machine

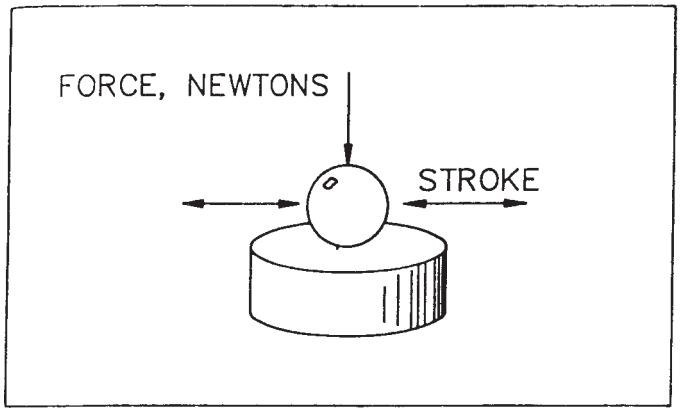


FIG. 2 Test Specimen Diagram

8.5 Set the frequency to 50 Hz and duration to 2 h, 00 min, 30 s, in accordance with the manufacturer's instructions.

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

9. Procedure

9.1 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 Place a small amount (approximately 0.1 to 0.2 g, the size of a pea) of lubricating grease to be tested on the cleaned lower test disk in an area such that overlapping with previous wear scars will not occur.

9.3 Place the cleaned test ball on the top and in the middle of the lubricating grease specimen so that the grease makes a circular symmetric pad between the ball and disk.

9.4 Ensure the machine is unloaded (indicated by a load reading of −13 or −14 N) and carefully place the disk containing the lubricating grease specimen and test ball on the test area platform.

9.5 Tighten both the ball and disk clamps until resistance to tightening just begins. Load unit to 100 N and tighten the ball and disk clamps to a torque of 2.5 N·m. Reduce the load to 50 N for break-in.

9.6 Turn on the heater control and set to the desired temperature.

9.7 When temperature has stabilized, turn on the chart recorder paper feed, and lower the recording pens. Depress the drive start toggle switch until the timer begins to count and then adjust the stroke amplitude knob to 1.00 mm.

9.8 When the digital timer reaches 30 s, increase the load to 200 N on the slow ramp speed setting and run at that load for 2 h ± 15 s. The test machine will automatically stop.

9.9 At the end of the test, turn off the heater control, turn power back on, and reduce the load to −13 or −14 N for disassembly.

NOTE 4—Power automatically turns off at the end of the test.

9.10 Remove and clean the test ball and disk in accordance with 9.1.

9.11 Place the test ball on a suitable holder and by means of a microscope, measure to the nearest 0.01 mm the minimum scar width and again at 90° to the first measurement. Measure the minimum coefficient of friction values from the chart recorder graph. Although not specifically part of the procedure, when additional wear analysis is required, perform a profilometric trace across the wear scar on the test disk in accordance with the profilometer manufacturer's instructions.

10. Report

10.1 Report the following information:

10.1.1 All parameters used to evaluate material as follows:

10.1.1.1 Test temperature, °C,

10.1.1.2 Test break-in load, N,

10.1.1.3 Test load, N,

10.1.1.4 Test frequency, Hz,

10.1.1.5 Test stroke, mm,

10.1.1.6 Test ball material,

10.1.1.7 Test disk material, and

10.1.1.8 Test sample.

10.2 Report both wear scar measurements taken on the ball.

10.3 Report the minimum coefficient of friction and, when required by specification, include a copy of the friction recording.

10.4 Report the depth of the wear scar on the lower specimen disk if profilometer reading was made.

11. Precision and Bias

11.1 Eighteen cooperators tested eight greases in the SRV apparatus. Average minimum coefficients of friction ranged from 0.056 to 0.122 and average ball wear scar diameter ranged from 0.50 mm to 0.90 mm.[11]

11.2 The precision of this test method, as determined by statistical examination of interlaboratory test results obtained at 200 N load, 50 Hz frequency, and 1 mm stroke at 50°C and 80°C is:

11.2.1 *Average Ball Wear Scar Diameter*:

11.2.1.1 *Repeatability*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following value only in one case in twenty.

0.07 mm

11.2.1.2 *Reproducibility*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test method would, in the long run, exceed the following values only in one case in twenty.

For tests run at 50°C, 0.29 mm
For tests run at 80°C, 0.24 mm

11.2.2 *Minimum Coefficient of Friction*:

11.2.2.1 *Repeatability*—The difference between succesive results obtained by the same operator with the same apparatus under constant operating condition on identical test material would, in the long run, in the normal and correct operation of the test method exceed the following values only in one case in twenty.

For tests run at 50°C, 0.012
For tests run at 80°C, 0.008

11.2.2.2 *Reproducibility*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test materials would, in the long run, exceed the following values only in one case in twenty.

For tests run at 50°C, 0.031
For tests run at 80°C, 0.032

11.3 *Bias*—The evaluation of friction and wear properties of lubricating grease by this test method has no bias because coefficients of friction and wear scar diameter can be defined only in terms of the test method.

12. Keywords

12.1 coefficient of friction; lubricating grease; oscillation; SRV; wear

[11] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1410.

APPENDIX

(Nonmandatory Information)

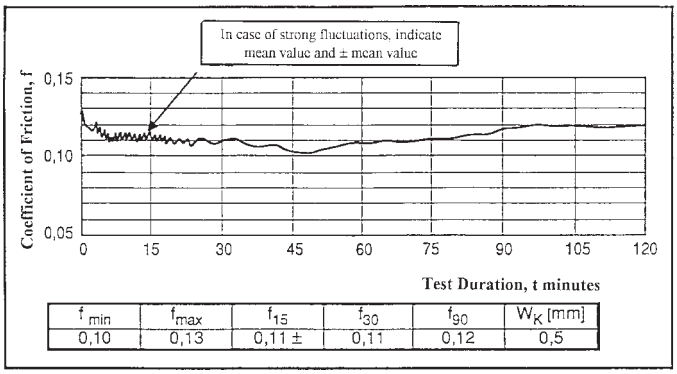
X1. MEASUREMENTS OF COEFFICIENT OF FRICTION

X1.1 Other values of the coefficient of friction, in addition to the minimum value, can be read from the friction recording chart. An example of the recording and evaluation of friction coefficients, which appears in the German Standard SRV procedure DIN 51 834, is shown in Fig. X1.1. In this procedure, the minimum and maximum coefficients and the average coefficient at 15, 30, and 90 min of the test are reported as is the ball wear scar diameter, W_K.

X1.1.1 The precision of friction and wear measurements according to DIN 51834 is:

	Repeatability	Reproducibility
Coefficient of Friction, f	0.02	0.04
Ball Wear Scar Diameter, w_K	0.1 mm	0.2 mm

X1.1.1.1 These precision data were obtained in an interlaboratory test program involving 22 laboratories and 3 lubricating oils, an antiwear hydraulic oil, an engine oil, and an EP gear oil.



f_{min}	f_{max}	f_{15}	f_{30}	f_{90}	W_K [mm]
0,10	0,13	0,11 ±	0,11	0,12	0,5

FIG. X1.1 Example: Recording and Evaluation of Friction Coefficients