Designation: D8317 – 23

Standard Test Method for Measuring Friction and Wear Properties of Greases Under Rolling Motion Using SRV Test Machine[1]

This standard is issued under the fixed designation D8317; 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 the coefficient of friction of greases and their ability to protect against wear under a rolling type of motion when subjected to high-frequency, linear oscillation.

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]

A295 Specification for High-Carbon Anti-Friction Bearing Steel

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

D7755 Practice for Determining the Wear Volume on Standard Test Pieces Used by 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 *DIN Standards:*[3]

DIN EN ISO 683–17 Heat-treated steels, alloy steels and free-cutting steels – Part 17: Ball and roller bearing steels

DIN 5402-1 Rolling bearings - Parts of rolling bearings – Part 1: Cylindrical rollers

DIN 51631:2019 Mineral spirits; special boiling point spirits; requirements

DIN 51834 Tribological Test in the Translatory Oscillation Apparatus (Part 4: Determination of friction and wear data for lubricating oils with the cylindrical roller-disk geometry)

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminologies D4175 or G40.

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, that are uncharacteristic of the given tribological system's longterm behavior. (Synonym: *run-in, wear-in*)

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

$$\mu = (F_f / F_n) \quad (1)$$

3.1.4 *extreme pressure (EP) lubricant, n*—formulations whose effects may become observable at different operating conditions, preventing adhesive wear under mixed or boundary lubrication regimes and are characterized by an increased load carrying capacity or increased tribofilm strength.

3.1.5 *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.

[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.

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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 Deutsches Institut für Normung, Beuth Verlag GmbH, Burggrafenstraße 6, D-10787 Berlin, Germany, http://www.din.de.

3.1.6 *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.

3.1.6.1 *Discussion*—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.

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

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 P_{geom}, *n*—geometric contact pressure describes the load carrying capacity at test end.

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]

3.1.10 *Rz (DIN), n—in measuring surface finish*, the average of all *Ry* values (peak to valley heights) in the assessment length.[4]

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

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*—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.

3.2.2 *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.

3.2.2.1 *Discussion*—In the understanding of this test method, the planimetric wear area is determined on cleaned surfaces, but with tribofilm, if formed. Some cleaning solvents have the ability to clean away or dissolve solid tribofilms, like ethylene diaminetetraacetate (EDTA).

3.3 *Abbreviations:*

3.3.1 *SRV*®—Schwingung, Reibung, Verschleiss (German); oscillation, friction, wear (English translation).

4. Summary of Test Method

4.1 This test method is performed on a SRV test machine using two test rollers oscillated between two flat disks at constant frequency and stroke amplitude and under constant load (F_n), against a test disk. The type of movement of the rollers is rolling with a small portion of slip. The receiving block to which the lower test disk is attached is held at a constant temperature.

NOTE 1—The frequency of oscillation, stroke length, test temperature, test load, test duration, and test roller and disk material can be varied from those specified in this test method. The test rollers yield Hertzian line contact geometry

4.2 The friction force, F_f, is measured by a piezo-electric device in the test disk assembly. Peak values of coefficient of friction, *f*, are determined and recorded as a function of time.

4.3 After the preset test period, the test machine and data acquisition are stopped and the wear on the disks is determined by means of profilmetry and expressed as planimetric wear (µm^2). The planimetric wear is measured in the middle of the wear track perpendicular to the wear track on the test disk.

NOTE 2—No wear scars on the rollers can be detected due to the lubricated rolling movement.

5. Significance and Use

5.1 This test method can be used to determine anti-wear properties and coefficients of friction of greases under rolling type of movement at selected temperatures and loads specified for use in slip-rolling contacts in which high-speed vibrational or start-stop motions are present for extended periods of time under initial high Hertzian line contact pressures. It has found application as a screening test for lubricants used in gears, rolling bearings or cam/follower systems. Users of this test method should determine whether results correlate with field performance or other applications.

6. Apparatus

6.1 *SRV Test Machine,* [5] illustrated in Figs. 1 and 2 consists of an linear oscillation drive capable to parallel movement of the tribological contact, a test chamber (see Fig. 2) and a loading device with a servomotor and a load cell. The machine is operated by a control device for the oscillating drive, a timer, a load control, a frequency control, a stroke control, a data amplifier to determine the friction coefficient, and a switch and a controller for the heating. An oscilloscope may be used for monitoring of quantities. Friction coefficients are recorded in relation to time by data acquisition in a computer.

6.1.1 The axis of the two rollers are mounted in the holder so that the longitudinal axis of the rollers is perpendicular to the rolling direction.

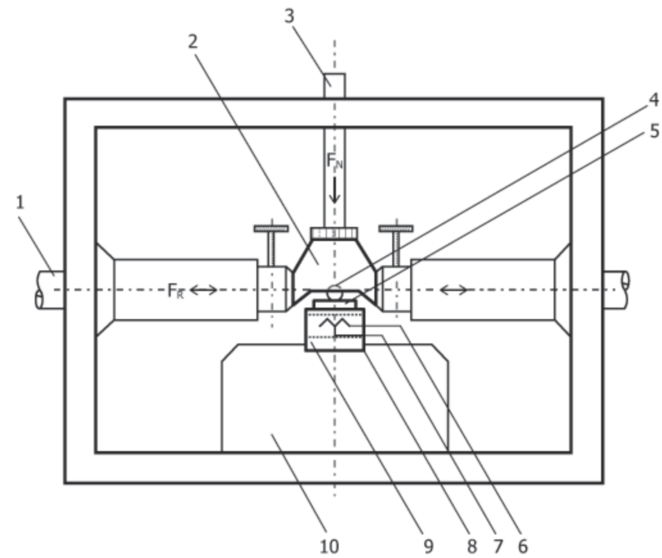
6.1.2 On the firmly mounted receiving block (1) in the test chamber (see Fig. 1 and Fig. 2), there is a piezoelectric device (2) to measure the friction force, F_f, and the friction coefficient, *f*, the holder for the test disk (3) with a thermostat-controlled electrical resistance heating element (4); a resistance thermometer (5); the oscillation drive rods (6); an exchangeable holder for the test rollers (7); and the load rods of the loading device (8).

6.1.3 The design of the receiving block for the test disk should be such that it has integrated cooling coils, or that cooling coils are wound around it, so that the receiving block must be capable to maintaining test temperatures down to 233 K. The test disks (9) and the test roller (10) are inserted into their respective holders (3, 4) (see Fig. 1 and Fig. 2).

6.1.4 Disks are generally used as the lower and upper test piece.

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

FIG. 1 SRV Test Machine (Model 5)



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 specimen
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. 2 Test Chamber Elements of SRV Models IV and V

6.2 *Microscope,* equipped with a filar eyepiece graduated in 0.005 mm divisions or equipped with a micrometre stage readable to 0.005 mm. Magnification should be sufficient to allow for ease of measurement.

6.3 *Syringe,* suitable for applying 0.3 mL of the lubricating oil under test.

6.4 *Tweezers,* straight, round, about 200 mm long, with non-marring tips.

6.5 *Torque Wrench,* initial torque 0.5 Nm to 5 Nm.

6.6 *Ultrasonic Cleaner.*

7. Reagents and Materials

7.1 *Test Roller,* [6] in AISI 52100 Steel, Vickers microhardness of 660 HV0.2 to 730 HV0.2 (Rockwell hardness number of 60 HRC ± 2 HRC), 0.025 µm ± 0.005 µm Ra (C.L.A.) polished surface finish, is a cylinder Ø 5 mm by 5 mm with crowned ends, so that the contact length l_1 at the beginning of the test is 2.5 mm. The shape and geometry of the roller is as in accordance with DIN 5402, Part 1.

7.2 *Test Disk,* [6] vacuum arc remelted (VAR) AISI 52100 steel with an inclusion rating using method D, Type A, a severity level number of 0.5 according to Test Method E45 and Specification A295 or an inclusion sum value K1 ≤ 10 according to DIN EN ISO 683-17 and spherodized annealed to obtain globular carbide, Vickers micro-hardness of 660 HV0.2 to 730 HV0.2 (Rockwell hardness number of 60 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 means of two quantities: 0.500 µm < *Rz* < 0.650 µm and 0.035 µm < *Ra* (C.L.A.) < 0.050 µm.

7.2.1 *Lower Test Disk*—24.0 mm ± 0.5 mm in diameter by 6.9 mm ± 0.1 mm in height.

7.2.2 *Upper Test Disk*—20.0 mm ± 0.5 mm in diameter by 12.5 mm ± 0.1 mm in height.

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

NOTE 4—An initial hardness of 62.5 HRC at room temperature of AISI 52100 will drop to 61 HRC after 100 h at 149 °C and will exist as a hot hardness of 60 HRC over 100 h.[7]

7.3 *Guide holder* having two recesses for two rollers and grease (see Fig. 3).

[6] ASM Handbook, "Friction, Lubrication, and Wear Technology," Vol 18, October 1992.

[7] Zaretsky, E. V., "Tribology for Aerospace Applications," STLE SP-37, 1997, p. 358.

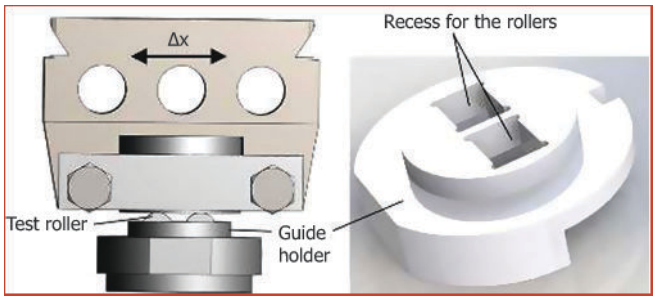


FIG. 3 Animation of the Sample and Guide Holder with Recess for the Rollers

7.4 *Cleaning Solvent,* single boiling point spirit type 2-A according to DIN 51631-1999 (published in English). (**Warning—**Flammable. Health hazard.)

NOTE 5—In the case of unavailability, please refer to Specification D235 regarding Type I, Class C (with less than 2 % by volume of aromatics), mineral spirits.

8. Preparation of Apparatus

8.1 The test cycle consists of a running-in period of one hour followed by a test phase of 18 h.

8.2 Clean and install the specimens as specified under 9.1. Turn on the test machine and the PC and allow them to warm up for 15 min prior to running tests.

8.3 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.

8.3.1 Start conditions of the machine (thermostatic stabilization). Allow 10 min for the test pieces and test oil to reach and stabilize at the test temperature. Depending from the grease properties, the test can be run at constant temperatures selected in +10 K (+10 °C) increments starting at +233 K to +553 K (–40 °C to +200 °C).

8.3.2 *Cut-off Criteria for Friction, if Occurs:*

8.3.2.1 *Coefficient of Friction,* f *(Cut-off Value for Permanent Increase of Level)*—0.05 during $t > 20$ s.

8.3.2.2 *Coefficient of Friction,* f *(Cut-off Value for One-off Increase of Level)*—0.10.

8.4 *Test Parameters:*

8.4.1 *Running-in:*

8.4.1.1 *Frequency,* 20 Hz.

8.4.1.2 *Stroke,* 1.0 mm.

8.4.1.3 *Temperature,* +100 °C.

8.4.1.4 *Pre-load,* 50 N for 30 s.

8.4.1.5 *Test Load*—Running-in under 500 N for 3600 s ± 15 s (1 h) then increase to a constant load of 2000 N.

NOTE 7—The initial Hertzian contact stresses for this roller-disk geometry calculate for F_n = 500 N for one roller to P_{0mean} of 710 MPa and P_{0max} of 903 MPa.

8.4.2 *Test Conditions:*

8.4.2.1 After running-in increase to a constant load of 2000 N.

8.4.2.2 *Frequency,* 20 Hz.

8.4.2.3 *Stroke,* 1.000 mm.

8.4.2.4 *Temperature,* +100 °C.

8.4.2.5 *Test Load,* 2000 N for 64 800 s ± 30 s (18 h).

NOTE 8—The initial Hertzian contact stresses for this roller-disk geometry calculate for F_N = 2000 N for one roller to P_{0mean} of 1419 MPa and P_{0max} of 1807 MPa.

8.5 *Sample Rates for Result-relevant Measurement Channels:*

8.5.1 *Coefficient of Friction,* f, ≤ 32 ms.

8.5.2 *Stroke,* ≤ 2 s.

8.5.3 *Test Load,* ≤ 2 s.

8.5.4 *Frequency,* ≤ 2 s.

8.5.5 *Temperature,* ≤ 2 s.

8.5.6 *COF Original Value,* 400 µs.

NOTE 9—For SRV V models, it is recommended to do one sampling per period (that is 50 ms) for coefficient of friction and stroke.

NOTE 10—For SRV 4 and 5 models, it is recommended to activate sampling of COF with a resolution of 0.00001. See manufacturer's instruction for assessing this resolution.

9. Procedure

9.1 *Installation of the Test Pieces and Lubricating Grease Specimen in the Test Chamber:*

9.1.1 Using solvent-resistant gloves, clean the test roller, and disk by wiping the surfaces with laboratory tissue soaked with cleaning solvent as stated in 7.4 or Note 5 (**Warning—** This mixture is flammable and health hazard). Repeat wiping until no dark residue appears on the tissue. Immerse the rollers, the holder for rollers and disk in a beaker of the cleaning solvent under ultrasonic vibration (if available) for 10 min. Dry the roller holder. Dry the test rollers and disk with a clean tissue, ensuring that no streaking occurs on the surface.

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

9.1.3 The grid is placed on a disk and filled bubble-free with the grease to be tested. Remove excess grease with a spatula. The two small and cleaned rollers (5 mm by 5 mm) are placed on the grease in vertical alignment to the movement direction and are pressed down with a spatula. The grease that is pressed out of the grid is applied to the free surface of the rollers by means of a spatula, so that free metal surface of roller are covered with grease. The test disk including grid, grease and rollers (as prepared) are placed on the oscillation block as shown in Fig. 3 and will be fixed with the clamp.

9.1.4 Mount the upper disk into the holder and place it in the swing arm. Tighten the screws.

9.2 *Preparing Test:*

9.2.1 Open the Assistant for starting a test in the SRV control software. Select the created set-point profile and, if necessary (for example SRV V), the data logger configuration and proceed through the Assistant until the pre-load has been applied.

9.2.2 Then set the test load unit to 50 N and tighten the disk clamps to a torque of 2.5 Nm.

9.2.3 The heater control starts automatically and heats up to the pre-set and desired temperature: for example, +100 °C.

9.2.4 Follow the directions in the Assistant for starting a test in the SRV control software until the automated test run mode (waiting for reaching start conditions) is started. The test starts