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.

Designation: D8316 – 20a

Standard Test Method for Measuring Friction and Wear Properties of Extreme Pressure (EP) Lubricating Oils with the Roller-Disk Geometry Using SRV Test Machine[1]

This standard is issued under the fixed designation D8316; 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.

INTRODUCTION

This test method represents the transformation of DIN 51834-4:2020.

1. Scope*

1.1 This test method covers an extreme pressure (EP) lubricating oil's coefficient of friction and its ability to protect against wear when subjected to high-frequency, linear oscillation motion. The test utilizes a roller-on-disc geometry, where the roller is inclined/deflected by 10° to the oscillating movement. The procedure is identical to that described in DIN 51834, Part 4.

1.2 This test method can also be used to determine the ability of a non-EP lubricating oil 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 standard. No other units of measurement are included in this standard.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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)

D5182 Test Method for Evaluating the Scuffing Load Capacity of Oils (FZG Visual Method)

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

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 *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 51631:1999 Mineral Spirits – Special Boiling Point Spirits – Requirements

[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.L0.11 on Tribological Properties of Industrial Fluids and Lubricates.

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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 e.V.(DIN), Am DIN-Platz, Burggrafenstrasse 6, 10787 Berlin, Germany, http://www.din.de.

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

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

DIN EN ISO 13565-2:1998 Geometrical Product Specifications (GPS) – Surface Texture: Profile Method; Surfaces Having Stratified Functional Properties – Part 2: Height Characterization using the Linear Material Ratio Curve (replacement of DIN 4776:1990)

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, that are uncharacteristic of the given tribological system's longterm behavior. (*Synonym*: **run-in, wear-in**) **G40**

3.1.2 *coefficient of friction,* μ or f, *n—in tribology*, the dimensionless ratio of the friction force (Ff) between two bodies to the normal force (Fn) pressing these bodies together. **G40**

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

3.1.3 *EP lubricating oil, n*—a liquid lubricant containing an extreme pressure (EP) additive.

3.1.4 *extreme pressure (EP) additive, n—in a lubricant*, a substance that minimizes damage to metal surfaces in contact under high stress rubbing conditions.

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. **G40**

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. **D7421**

3.1.6.1 *Discussion*—The Hertzian contact pressure can also be calculated and reported as maximum value P_{max} in the center of the contact or as $P_{average}$ as average over the total contact area.

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

3.1.8 P_{geom}, *n*—geometric contact pressure describes the load carrying capacity at test end (see 9.3.6).

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 *Rpk, n*—reduced peak height according to DIN EN ISO 13565-2:1998; half the Rpk value 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.[4]

3.1.13 *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. **G40**

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. **D5706**

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.

3.3 *Abbreviations:*

3.3.1 *FZG, n*—commonly referred to Forschungstelle für Záhnräder und Getriebebau (German); Research Site for Gears and Transmissions) Visual Method (English translation) **D5182**

3.3.2 *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 test roller oscillated at constant frequency and stroke amplitude and under constant load (F_n), against a test disk that has been wetted with the lubricant specimen. The movement of the roller is inclined/deflected by 10° to the oscillating axis (see Fig. 1). The test disk receiving block to which the 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 roller yields Hertzian line contact geometry. To obtain point or area contact, test pieces of differing configurations can be substituted for the test roller.

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 scar widths on the roller

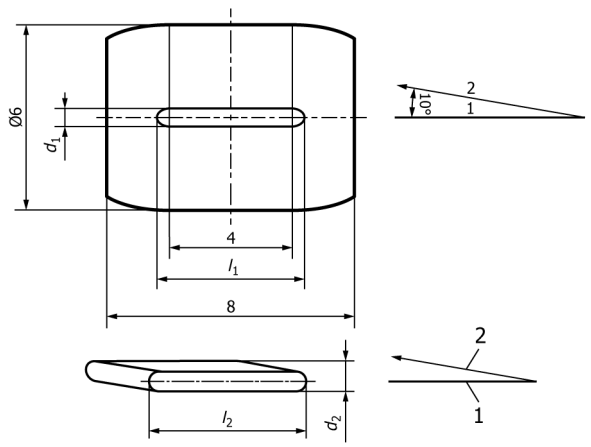

FIG. 1 Schematics on the Roller Designs, the Wear Quantities, and the Wear Scar Width d_1 on Roller (top) and Wear Track Width d_2 on Disk (bottom)

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

and disk are measured using a microscope. If a profilometer is available, a trace perpendicular to the wear track on the test disk and to the scar on the roller can also be used to obtain additional wear quantities.

5. Significance and Use

5.1 This test method can be used to determine antiwear properties and coefficient of friction of EP lubricating oils 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. In comparison to the ball-on-disk geometry as per Test Method D6425, the initial contact pressure is better retained over test time in this roller-on-disk geometry.

6. Apparatus

6.1 *SRV Test Machine*[5], illustrated in Figs. 2 and 3 consists of a linear oscillation drive, a test chamber (see Fig. 3) 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 roller is mounted in the holder so that the longitudinal axis of the roller is deflected by 10° to the sliding direction. This test is limited to SRV IV&V models, because SRVIII and older models do not execute a movement of the roller exactly parallel to the disk surface.

6.1.2 On the firmly mounted receiving block (*1*) in the test chamber (see Fig. 2 and Fig. 3), 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 roller (*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 disk (*9*) and the test roller (*10*) are inserted into their respective holders (*3*, *4*) (see Fig. 2 and Fig. 3).

6.1.4 Disks are generally used as the lower test piece.

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.

FIG. 2 SRV Test Machine (Model 5)

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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

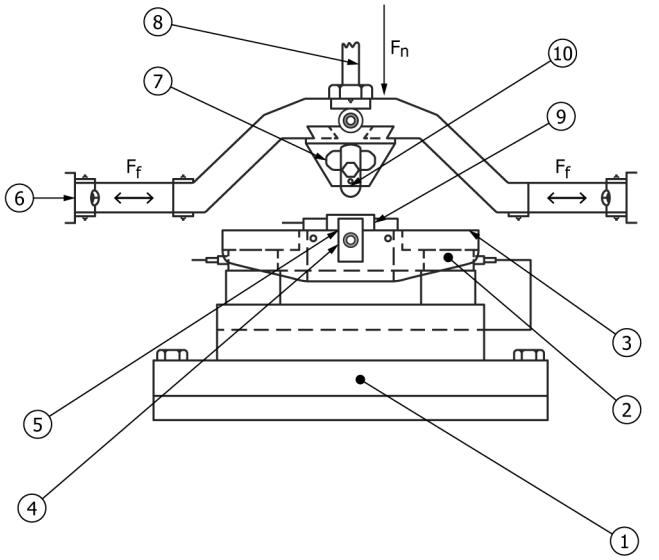
7.1 *Test Roller*[6] in AISI 52100 Steel, 60 HRC hardness ± 2 HRC hardness, 0.025 µm ± 0.005 µm Ra (C.L.A.) polished surface finish, is a cylinder Ø 6 mm × 8 mm with crowned ends, so that the contact length l_1 at the beginning of the test is 4 mm. The shape and geometry of the roller is as per DIN 5402, Part 1.

7.2 *Test Disk*[7] 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

[5] The sole source of supply of the apparatus known to the committee at this time is Optimol Instruments, Prüftechnik GmbH, Flößergasse 3, D-81369 Munich, Germany. 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.

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

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



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 test disk receiving block	9	Test disk
4	Lower specimen holder	10	Test roller
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. 3 Test Chamber Elements of SRV Models IV and V

according to DIN EN ISO 683-17 and spherodized annealed to obtain globular carbide, 720-775 HV0.2 (62 HRC ± 1 HRC) hardness, the surfaces of the disk being lapped and free of lapping raw materials. The topography of the disk will be determined by four quantities: 0.500 µm < Rz < 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; 24 mm ± 0.5 mm diameter by 7.85 mm ± 0.1 mm thick.

NOTE 2—DIN 17230-1980 was replaced by DIN EN ISO 683-17.

NOTE 3—An initial hardness of 62.5 HRC at room temperature of AISI 52100 will drop to 61 HRC after 100 h at 149 ºC and will exist as a hot hardness of 60 HRC over 100 h.[7]

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

NOTE 4—In the case of unavailability, please refer to Specification D235 regarding Type 1, Class C (with less than 2 % by volume of aromatics), mineral spirits.

8. Preparation of Apparatus

8.1 Clean and install the specimens as specified under 9.1. 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.

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

8.2.1 Start conditions (thermostatic stabilization):

Temperature: for exmaple +80 °C ± 1 K
Test load: 50 N ± 1 N
Start delay: 600 s (is displayed by all versions of the SRV software).

8.2.2 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

8.3 Test parameters:

Frequency:	50 Hz
Stroke:	2.00 mm
Temperature:	+80 °C
Pre-load:	50 N for 30 s
Test load:	running-in under 50 N for 30 s, then increase to a constant load of 1100 N

NOTE 6—The initial Hertzian contact stresses for the roller-disk geometry calculate for F_N = 1100 N to P_{0mean} of 1441 MPa and P_{0max} of 1835 MPa.

8.4 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

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 *Installation of the Test Pieces and Lubricating Oil 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 7.3 or Note 4. (**Warning—** This mixture is flammable and health hazard.) Repeat wiping until no dark residue appears on the tissue. Immerse the roller and disk in a beaker of the cleaning solvent under ultrasonic vibration (if available) for 10 min. Dry the roller holder. Dry the test roller 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 Place 0.3 mL of the lubricating oil to be tested on the cleaned disk where the contact with the roller will occur. Then install the disk (place on the block). Tighten the fastening screw until resistance just begins.

9.1.4 Place the cleaned roller, using the tweezers, in the disassembled, cleaned, and dried roller holder. Tighten the fastening screw until resistance just begins.

9.1.5 Install the roller holder and test roller in the test chamber.

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.

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