Designation: D8227 – 18

Standard Test Method for Determining the Coefficient of Friction of Synchronizer Lubricated by Mechanical Transmission Fluids (MTF) Using a High-Frequency, Linear-Oscillation (SRV) Test Machine[1]

This standard is issued under the fixed designation D8227; 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 lubricants (fluids) tribologically interacting with materials used in synchronizers in mechanical transmission (MT) gears under high-frequency linear-oscillation motion using the SRV test machine. A flat areal contact geometry is applied.

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]

D235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D5579 Test Method for Evaluating the Thermal Stability of Manual Transmission Lubricants in a Cyclic Durability Test

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

D7421 Test Method for Determining Extreme Pressure Properties of Lubricating Oils Using High-Frequency, Linear-Oscillation (SRV) Test Machine

G40 Terminology Relating to Wear and Erosion

2.2 *Other Standards:*

DIN 51631 Special-boiling-point spirits—Requirements and testing[3]

DIN EN ISO 13565-2 Geometrical Product Specifications (GPS)—Surface texture: Profile method—Surfaces having stratified functional properties—Part 2: Height characterization using linear material ratio curve[3]

DIN EN 17022–3 Heat treatment of ferrous materials; heat treatment methods; case hardening[3]

CEC L-66-99 Evaluation of synchronizer loading parameters and their ability to predict failure[4]

GB/T 3077-2015 Alloy structural steel[5]

YS/T 669-2013 Copper alloy tube of extruded product for synchronizer rings[6]

TL-VW084 (1993) Kupfer-Zink-Legierungen – Werkstoffanforderungen (Copper-Zinc alloys—Material requirements)[7]

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

[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.L0.07 on Engineering Sciences of High Performance Fluids and Solids (Formally D02.1100).

Current edition approved Oct. 1, 2018. Published November 2018. DOI: 10.1520/D8227-18.

[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 Beuth Verlag GmbH (DIN Deutsches Institut für Normung e.V.), Burggrafenstrasse 6, 10787 Berlin, Germany, http://www.en.din.de

[4] Available from Coordinating European Council (CEC), Services provided by Kellen Europe, Avenue Jules Bordet 142 - 1140, Brussels, Belgium, http://www.cectests.org.

[5] Available from Standardization Administration of China, No. 9 Madian Donglu, Haidian District, Beijing 100088, P.R. China.

[6] Available as a standard of nonferrous industry from Standardization Administration of China, No. 9 Madian Donglu, Haidian District, Beijing 100088, P.R. China.

[7] Available from Volkswagen AG, corporate IP, post stop 1770, D-38346 Wolfsburg, Germany, www.vwgroupsupply.com.

both, which are uncharacteristic of the given tribological system's long-term behavior. G40

3.1.2 *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

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

3.1.4 *carburization, n*—carburizing is not defined in the ASTM Dictionary of Engineering Science and Technology, but is defined in DIN EN 17022-3 "Heat treatment of ferrous materials; heat treatment methods; case hardening".

3.1.5 *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.[8]

3.1.6 *Rpk, n*—reduced peak height according to DIN EN ISO 13565-2; Rpk is the mean height of the peak sticking out above the core profile section.

3.1.7 *Rvk, n*—reduced valley height according to DIN EN ISO 13565-2; Rvk is the mean depth of the valley reaching into the material below the core profile section.

3.1.8 *Rz (DIN), n—in measuring surface finish*, the average of all Ry values (peak to valley heights) in the assessment length.[9]

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *metal specimen, n*—represented by the lower specimen disk in manganese brass alloys, but also friction layers in thermally sprayed molybdenum coatings, sinter iron, paper and carbon fiber tapes are in use.

3.2.2 *seizure, n*—localized fusion of metal between the rubbing surfaces of the test pieces. D5706

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 0.3 for over 20 s. In severe cases, a stoppage in the motor will occur (for example, see Test Methods D5706 and D7421).

3.3 *Acronyms:*

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

3.3.2 *UNS, n*—the Unified Numbering System (UNS) is an accepted alloy designation system in North America.

4. Summary of Test Method

4.1 This test method is performed on SRV test machine using a areal flat-on-flat geometry oscillating at 50 Hz against a steel test disk with lubricant (grease) between them. Test load is fixed to 260 N (corresponding to a geometrical contact pressure of 3.1 MPa) using a test temperature of 60 °C and a stroke of 1.0 mm during a test time of 2 h. This test is limited to SRV Models 4 and 5.

NOTE 1—Synchronizer rings operate typically under geometric contact pressures from 2 MPa to 6 MPa.

NOTE 2—Test frequency, stroke length, temperature, and materials and/or coatings used as/on disk and flat material can be varied to simulate field conditions.

NOTE 3—This test runs in the SRV Models 4 and 5 models horizontally and untilted. SRV Models 4 and 5 can be equipped with a maximum test load unit of 2500 N.

5. Significance and Use

5.1 This test method can be used to quickly determine the lubricating ability of fully-formulated lubricants used as mechanical transmission fluids (MTF) to display a frictional behavior against materials used in synchronizers of mechanical gears in automotive vehicles. This test method has found to be complementary to bench tests (for example, Test Method D5579 and CEC L-66-99) by using the present test conditions. This test method is a material and application oriented approach based on inputs from field experiences for characterizing the frictional behavior (coefficient of friction (cof)) using random, discrete, and constant parameter combinations as seen in field experiences. Users of this test method should determine whether results correlate with field performance or other applications prior to commercialization.

6. Apparatus

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

7. Reagents and Materials

7.1 Flat ring disk in carburized 20CrMnTi (similar to ~20MnCr5 and ~SAE 5120) bearing steel in =200.05 mm outer diameter oil quenched from 800 °C ± 10 °C and tempered at 180 °C ± 10 °C during 8 h followed by air cooling to 60 ± 2 HRC. The contact face has an inner cavity with a diameter of 17 mm ± 0.05 mm with a depth of 1.5 mm ± 0.10 mm (see Fig. 3 and Fig. X1.1). The contact face has two straight slits at 180° opposite to each other with a width of 1 mm with a depth of 1.5 mm ± 0.10 mm. Functional surfaces shall be free from scratches and any surface damages. The topography of the disk will be determined by four values:

0.200 µm < Rz (DIN) < 0.350 µm
0.040 µm < Ra (C.L.A.) < 0.060 µm
0.150 µm < R_{pk} < 0.300 µm
0.200 µm < R_{vk} < 0.350 µm

7.2 *Lower Test Disk*—Extruded manganese brass HMn64-8-5-1.5 according to YS/T 669-2013, homologue to TL-VW084, with HBW2.5/62.5210-260 hardness or 28025 HV0.2, the surfaces of the disk being lapped and polished. α/ß-phase ratio is 50/50. Test disks have an outer diameter of 24 mm ± 0.5 mm diameter with a height of 7.8 mm ± 0.1 mm. (spherodization at 450 °C to 590 °C during 2 h to 6 h in air.) The topography of the disk will be determined by four values:

0.500 µm < Rz (DIN) < 0.700 µm
0.040 µm < Ra (C.L.A.) < 0.060 µm
0.250µm R_{pk} <0.450µm

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

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

[10] The sole source of supply of the apparatus known to the committee at this time is Optimol Instruments 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.

FIG. 1 SRV Model 5 Test Machine

0.300µm R_{vk} <0.500µm

If other surface roughnesses are applied, they shall be measured and stated in the report. The type of coating and/or thermomechanical treatment shall be reported.

NOTE 4—The steel 20CrMnTi has its origin in the Russian 18KHGT steel (GHOST 18ХГТ), homologue to DIN 20MnCr5G (1.7147). GHOST= GOST are the national standards of the Russian Federation and CIS countries.

7.3 *Cleaning Solvent,* single boiling point spirit type 2-A according to DIN 51631 (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. Chinese reference: XK13-201-00181(substitute for GB/T15894- 2008).

8. Preparation of Apparatus

8.1 When using SRV Models 4 and 5, 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.

8.2 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.

8.2.1 Start conditions (thermostatic stabilization):

Temperature: for example, 60 °C ± 1 °C

Test load: 50 N ± 1 N for 30 s

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 or a coefficient of friction, f (cut-off value for one-off increase of level): 0.35.

8.2.3 Test parameters:

Frequency: 50 Hz

Stroke: 1.00 mm

Temperature: e.g. +60 °C (+80 °C, +100 °C or +120 °C)