



Designation: D8576 – 24

Standard Test Method for Measuring the Thread Length and Pull-off Force of a Lubricating Grease by using the Falex TAA Instrument¹

This standard is issued under the fixed designation D8576; 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 measuring the thread length and pull of force of lubricating greases, using the Falex Tackiness Analyzing Apparatus (TAA). Data from this test can be used to characterize cohesive, adhesive, and tackiness properties of lubricating greases, with respect to changes in retraction speed and temperature.

1.2 *Units*—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

[D217 Test Methods for Cone Penetration of Lubricating Grease](#)

[D1403 Test Methods for Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment](#)

[D4057 Practice for Manual Sampling of Petroleum and Petroleum Products](#)

[D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants](#)

[D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products, Liquid Fuels, and Lubricants](#)

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this test method, refer to Terminology [D4175](#).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *cycle, n*—one indentation-retraction experiment.

3.2.1.1 *Discussion*—The experiment can be repeated on the same position, in the same grease volume, so several cycles can be programmed repetitively.

3.2.2 *force-displacement curve, n*—the curve of force versus distance when a probe is moved into a sample of grease, covering a metal substrate, and being retracted again with a given retraction speed.

3.2.2.1 *Discussion*—See [Fig. 1](#) for an example of the force-displacement curve.

3.2.3 *grease adhesion, n*—the force (mN) needed to separate two surfaces that are connected by a grease layer.

3.2.4 *grease cavity, n*—an individually defined cavity of fixed volume and geometry that holds a pocket of test grease, formed by the mounting of a mask on top of the substrate plate of the tester.

3.2.4.1 *Discussion*—The TAA has a standard of 15 cavities.

3.2.5 *indentation-retraction experiment, n*—a probe connected to a high precision force sensor is pressed into the grease sample, held with a pre-set load for a given time, then retracted under a pre-set speed, and at a preset substrate temperature.

3.2.5.1 *Discussion*—The forces with respect to the motion of the probe are recorded to determine pull-off force and thread length. The curve is referred as the force displacement curve.

3.2.6 *probe, n*—a spherical probe with a 3 mm diameter copper tip (ball) connected to a 1000 mN sensor with a 0.01 mN resolution.

3.2.7 *pull-off force, n*—the maximum force that must be overcome to start separating the two grease-covered surfaces.

3.2.7.1 *Discussion*—Pull-off force is an indication for the adhesion of the ball to the substrate, caused by the grease film

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.G0.07](#) on Research Techniques.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

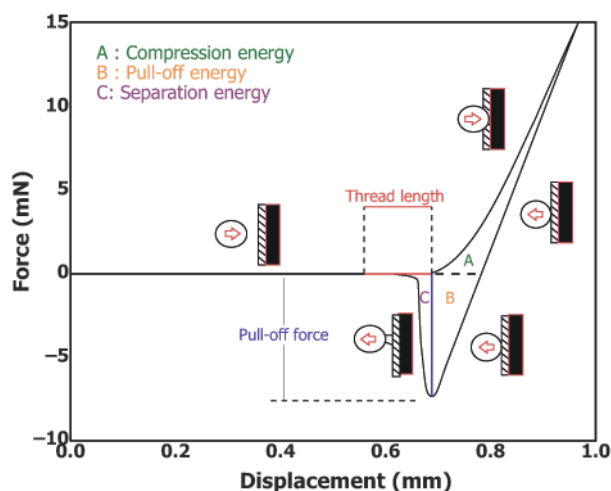


FIG. 1 Schematic Representation of Force-displacement Curve during Indentation-retraction Experiment

in between, under the conditions of temperature and retraction speed used. It is the maximum (negative) value in the force-displacement curve. See Fig. 1.

3.2.8 *substrate, n*—the bottom plate onto which grease is applied.

3.2.8.1 *Discussion*—A constant thickness of grease layer is ensured by a mask on top of the bottom substrate.

3.2.9 *tackiness, n*—ability of a grease to form threads when being pulled apart between two surfaces.

3.2.9.1 *Discussion*—This ability depends strongly on the grease itself, but also on the speed of separation (retraction speed in the indentation-retraction experiment), the temperature and possible other factors. In this test method, only speed is variable.

3.2.10 *tackiness number, n*—the averaged length of threads generated in this test at a defined temperature and retraction speed.

3.2.11 *thread length, n*—the maximum length of the thread being formed in an indentation retraction experiment.

3.2.11.1 *Discussion*—The presence of the grease thread is sensed by the force sensor connected to the probe. If there is an unbroken thread between probe and substrate, a force is measurable. When the thread breaks, the force returns to 0 mN. The length between maximum pull-off force and zero pull-off force is defined as the thread length in this experiment. See Fig. 1.

4. Summary of Test Method

4.1 This method consists of performing a series of indentation-retraction experiments by a probe into a well-defined volume and thickness of grease, spread on a substrate. The indentation is done with a set force of $20 \text{ mN} \pm 1 \text{ mN}$. When the selected indentation force is reached, the probe is kept in this position for a wait time of 3 s to allow the grease to settle around the probe. The probe is retracted with a constant programmable speed, and with a high acceleration of 1000 mm/s^2 to obtain a constant retraction velocity as quickly as possible. The programmable speeds for this test method are (0.1, 0.5, 1.0, 2.0, 5.0) mm/s.

4.2 Up to 15 positions, or grease cavities, are available, that can each be programmed to perform several cycles at different conditions. For purposes of determining repeatability and reproducibility, two positions are used for each set of conditions. The preprogrammed sequence is run at five different retraction speeds according to the sequence listed in Table 1. At each position, five indentation-retraction experiments (or five cycles) are performed and statistically calculated. It is up the user to define which conditions correlate with any field data.

4.3 Each position will return one set of test data of the average and the standard deviation of thread length and pull-off force. Thread length and pull-off force are derived in each of the indentation-retraction curves on the same position, the statistical average is also determined and reported. See Table 2.

5. Significance and Use

5.1 This method is used to characterize a grease using the described instrument to obtain a quantitative measurement of properties defined in this method as thread length and pull-off

TABLE 1 Test Sequence for Determination of r and R

NOTE 1—Two repeats at each position are done, results of positions 11 to 15 are optional and not used in the calculation of the r and R .

Position Number	Temperature (°C)	Retraction Speed (mm/s)	Cycles (n)	Compressive Load (mN)	Dwell Time at Compression (s)
1	25	0.1	5	50	3
2	25	0.5	5	50	3
3	25	1.0	5	50	3
4	25	2.0	5	50	3
5	25	5.0	5	50	3
6	25	0.1	5	50	3
7	25	0.5	5	50	3
8	25	1.0	5	50	3
9	25	2.0	5	50	3
10	25	5.0	5	50	3
11	25	0.1	5	50	3
12	25	0.5	5	50	3
13	25	1.0	5	50	3
14	25	2.0	5	50	3
15	25	5.0	5	50	3

TABLE 2 Example of Test Result Report

Position Number	Temperature (°C)	Retraction Speed (mm/s)	Cycles (n)	Thread Length Average (mm)	Thread Length Stand. Dev. (mm)	Pull Off Force Average (mN)	Pull Off Force Stand. Dev. (mN)
1	25	0.1	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
2	25	0.5	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
3	25	1	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
4	25	2	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
5	25	5	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
6	25	0.1	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
7	25	0.5	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
8	25	1	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
9	25	2	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
10	25	5	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
11	25	0.1	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
12	25	0.5	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
13	25	1	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
14	25	2	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx
15	25	5	5	xxx.xxx	xxx.xxx	xxx.xx	xxx.xx

force. These properties are measured under repetitive and consistent testing conditions as defined by this method. This standard uses a copper ball to isolate a single thread out of a grease volume (see Fig. 2). Previously, tackiness was evaluated qualitatively by subjective methods without controlled retraction speeds or temperatures, or by indirect methods such as water washout, hammer impact, etc. A widely used quick test is known as the finger test (see Fig. 2). The finger test indicates major differences in grease tackiness, specifically the thread formation, but it lacks control and is subjective to the operator's execution. It does not result in quantitative data that can be used to classify or compare lubricating greases.

5.2 This test standard will allow quantitative data to be measured for the characterization of lubricating greases. The test results can be correlated with requirements of field applications of lubricating grease and for use in specifications, the significance is to be determined by the user of this method.

5.3 In applications, thread formation can be a desirable or undesirable quality. For example, a higher tackiness is desired in industrial machinery, agricultural and automotive equipment, open gears and one sliding surfaces, where transfer and refreshment of the grease between contacts is essential to

maintain lubrication. On the other hand, low tackiness may be favorable in lubrication of processing machines in food industry, where grease transfer can cause contamination of the product and should be avoided.

6. Apparatus

6.1 *Falex Tackiness Analyzing Apparatus (TAA)*³—See Fig. 3.

6.2 Grease Worker:

6.2.1 Grease is worked before testing, to obtain a more repeatable consistency or condition of the grease. It is known that lubricating greases can be poorly consistent or stable, and working a grease immediately prior to executing tackiness tests has shown to improve the repeatability and reproducibility.

NOTE 1—Any suitable grease worker can be used, suggested procedure according to Test Methods D217. In the ILS, a ¼ scale cup grease worker

³ The sole source of supply of the apparatus known to the committee at this time is Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL 60554. 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.

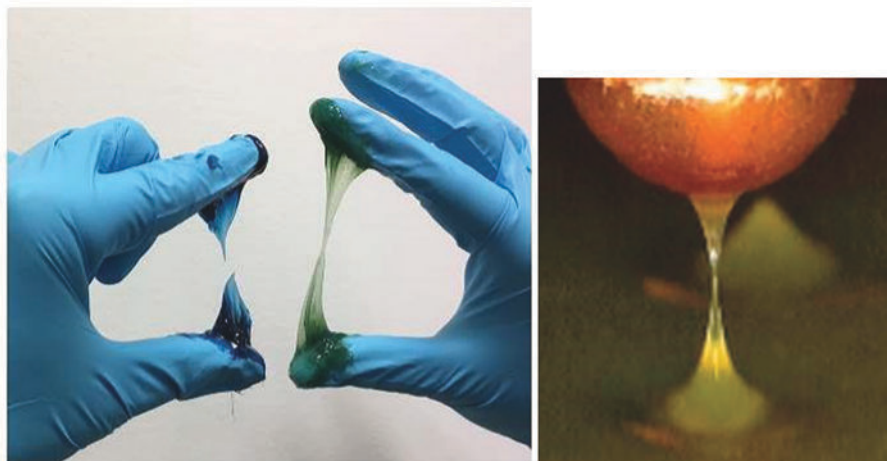


FIG. 2 Thread Formation Illustrated in Qualitative 'Finger Test' (left) and Copper Ball Isolating a Single Thread in Instrumented Indentation-retraction Experiment (right)