Designation: D 1894 – 00

An American National Standard

Standard Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting[1]

This standard is issued under the fixed designation D 1894; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This test method covers determination of the coefficients of starting and sliding friction of plastic film and sheeting when sliding over itself or other substances at specified test conditions. The procedure permits the use of a stationary sled with a moving plane, or a moving sled with a stationary plane. Both procedures yield the same coefficients of friction values for a given sample.

NOTE 1—For the frictional characteristics of plastic films partially wrapped around a cylinder, or capstan, see Test Method G 143 under the jurisdiction of ASTM Subcommittee G02.50.

1.2 Test data obtained by this test method is relevant and appropriate for use in engineering design.

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.* For a specific precautionary statement, see Note 6.

NOTE 2—This test method and ISO/DIS 8295–1994 are not technically equivalent.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 883 Terminology Relating to Plastics[2]

D 3574 Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams[3]

D 4000 Classification System for Specifying Plastic Materials[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

G 143 Test Method for Measurement of Web/Roller Friction Characteristics[5]

2.2 *ISO/DIS Standard:*

ISO/DIS 8295–1994[6]

3. Terminology

3.1 *Definitions:*

3.1.1 *friction, n*—resistance to relative motion between two bodies in contact.

3.1.1.1 *coefficient of friction*—the ratio of the force required to move one surface over another to the total force applied normal to those surfaces.

3.1.1.2 *kinetic coefficient of friction*—the ratio of the force required to move one surface over another to the total force applied normal to those surfaces, once that motion is in progress.

3.1.1.3 *static coefficient of friction*—the ratio of the force required to move one surface over another to the total force applied normal to those surfaces, at the instant motion starts. **D 996, D10**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *slip—in plastic films*, lubricity of two surfaces sliding in contact with each other.

4. Significance and Use

4.1 Measurements of frictional properties may be made on a film or sheeting specimen when sliding over itself or over another substance. The coefficients of friction are related to the slip properties of plastic films that are of wide interest in packaging applications. These methods yield empirical data for control purposes in film production. Correlation of test results with actual performance can usually be established.

4.2 Slip properties are generated by additives in some plastic films, for example, polyethylene. These additives have varying degrees of compatibility with the film matrix. Some of them bloom, or exude to the surface, lubricating it and making it more slippery. Because this blooming action may not always

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

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

[6] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

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

be uniform on all areas of the film surface, values from these tests may be limited in reproducibility.

4.3 The frictional properties of plastic film and sheeting may be dependent on the uniformity of the rate of motion between the two surfaces. Care should be exercised to ensure that the rate of motion of the equipment is as carefully controlled as possible.

4.4 Data obtained by these procedures may be extremely sensitive to the age of the film or sheet and the condition of the surfaces. The blooming action of many slip additives is time-dependent. For this reason, it is sometimes meaningless to compare slip and friction properties of films or sheets produced at different times, unless it is desired to study this effect.

4.5 Frictional and slip properties of plastic film and sheeting are based on measurements of surface phenomena. Where products have been made by different processes, or even on different machines by the same process, their surfaces may be dependent on the equipment or its running conditions. Such factors must be weighed in evaluating data from these methods.

4.6 The measurement of the static coefficient of friction is highly dependent on the rate of loading and on the amount of blocking occurring between the loaded sled and the platform due to variation in time before motion is initiated.

4.7 Care should be exercised to make certain that the speed of response of the recorder, either electronic or mechanical, is not exceeded.

4.8 For many materials, there may be a specification that requires the use of this test method, but with some procedural modifications that take precedence when adhering to the specification. Therefore, it is advisable to refer to that material specification before using this test method. Table 1 of Classification System D 4000 lists the ASTM materials standards that currently exist.

5. Apparatus

5.1 *Sled*—A metal block 63.5 mm (2½ in.) square by approximately 6 mm (0.25 in.) thick with a suitable eye screw fastened in one end. When a flexible film (see 6.2) is to be attached, the block shall be wrapped with a sponge rubber 63.5 mm (2 ½in.) in width and 3.2 mm (⅛in.) in thickness. The foam shall be flexible, smooth-faced, and have a nominal density of 0.25 g/cm^3 when measured in accordance with the Density Test of Methods D 3574. The pressure required to compress the foam 25 % shall be 85 ± 15 kPa (12.5 ± 2.5 psi). The foam shall also have a high hysteresis when deformed.[7] The rubber shall be wrapped snugly around the sled and held in place against the bottom and top of the sled with double-faced masking tape. When a sheet (see 6.3) is to be attached, double-faced tape shall be used to attach the specimen. The total weight of the (wrapped) sled and specimen shall be 200 ± 5 g.

NOTE 3—Round-robin testing[8] has shown that the physical properties of the backing can drastically affect both the coefficient of friction and stick-slip behavior of the film.

5.2 *Plane*—A polished plastic, wood, or metal sheet,[9] approximately 150 by 300 by 1 mm (6 by 12 by 0.040 in.). A smooth, flat piece of glass may cover the upper surface of the plane. This provides a smooth support for the specimen.

5.3 *Scissors or Cutter*, suitable for cutting specimens to the desired dimensions.

5.4 *Adhesive Tape*, cellophane or pressure-sensitive.

5.5 *Adhesive Tape*, double-faced.

5.6 *Nylon Monofilament*, having a 0.33 ± 0.05-mm (0.013 ± 0.002-in.) diameter and capable of supporting a 3.6-kg (8-lb) load.

5.7 *Beaded Chain*, flexible metal cable, or equivalent, having a spring rate no less than 600 lbs per inch of stretch per inch of length (40 lbs/in. (7000 N/m) for a 15-in. chain) in the range of 50 to 150 g of tension (such as beaded lampswitch pull chain).

5.8 *Low-Friction Pulleys*—A phenolictype pulley mounted in hardened steel cone bearings on a metal fork. A ball-bearing type pulley may also be used.

5.9 *Force-Measuring Device*, capable of measuring the frictional force to ±5 % of its value. A spring gage[10] (Note 3), universal testing machine, or strain gage may be used.

NOTE 4—The capacity of the spring gage (Fig. 1(*a* and *b*)) needed will depend upon the range of values to be measured. For most plastic, a 500-g capacity gage with 10-g or smaller subdivisions will be satisfactory. This spring will measure coefficients of friction up to and including 2.5.

5.10 *Supporting Base*—A smooth wood or metal base approximately 200 by 380 mm (8 by 15 in.) is necessary to support the plane. The supporting base may be a simple rectangular box. If a universal testing machine is used to pull a moving plane, a supporting base of sufficient structural strength and rigidity to maintain a firm position between the moving crosshead and the force-measuring device will be necessary.

5.11 *Driving or Pulling Device for Sled or Plane*—The plane may be pulled by a driven pair of rubber-coated rolls not less than 200 mm (8 in.) long, capable of maintaining a uniform surface speed 150 ± 30 mm/min (0.5 ± 0.1 ft/min) (Fig. 1(*b*)), by the crosshead of a universal testing machine (Fig. 1(*d*)) (Note 6), or a worm drive driven with a synchronous motor (Fig. 1(*e*)). A constant-speed chain drive system has also been found satisfactory (Fig. 1(*a*)). A power-operated source may be used for pulling the sled over the horizontally-mounted specimen at a uniform speed of 150 ± 30 mm/min (0.5 ± 0.1 ft/min). A universal testing machine equipped with a load cell in its upper crosshead and a constant rate-of-motion lower crosshead has been found satisfactory (see Fig. 1(*c*)).

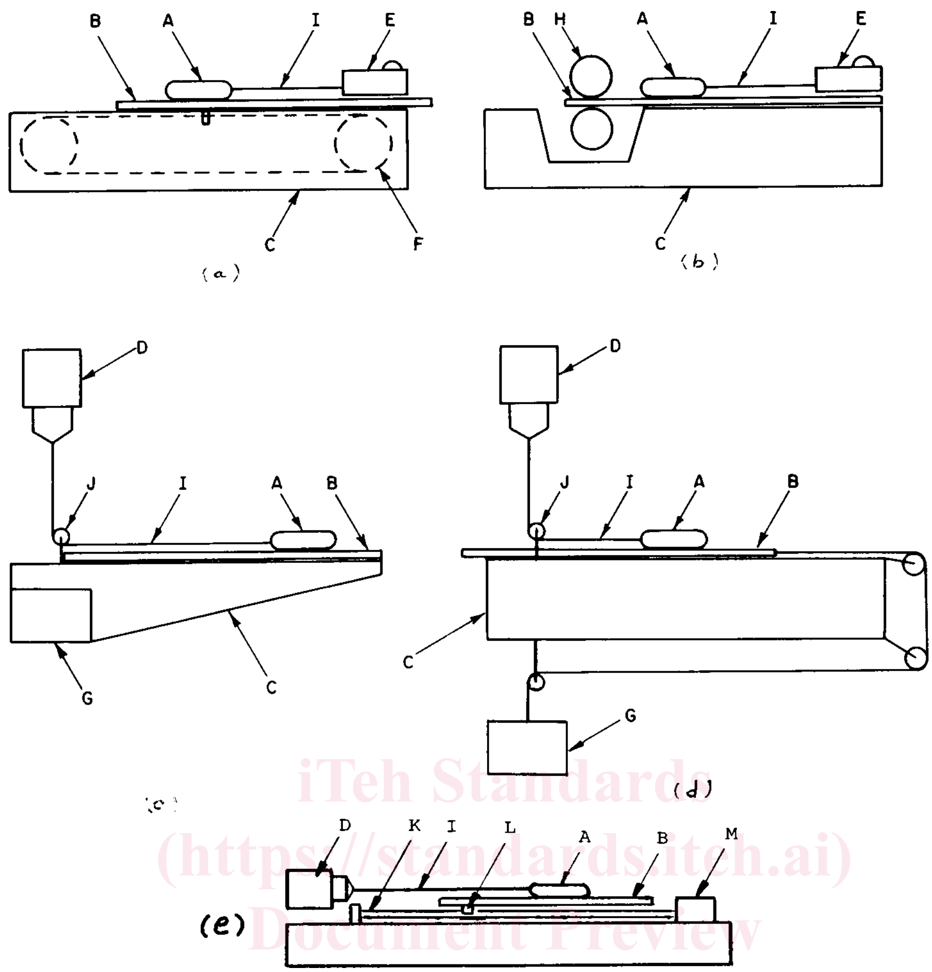
NOTE 5—Where the moving crosshead of a universal testing machine is used to pull the moving plane through a pulley system (Fig. 1(*d*)), the strain gage load cell, or other load-sensing instrument in the testing machine, acts as the force-measuring device.

[7] Sheet stock, available from Greene Rubber Co., 59 Broadway, North Haven, CT 06473, has been found satisfactory.

[8] Supporting data are available from ASTM Headquarters. Request RR: D20-1065.

[9] Acrylic or rigid poly(vinyl chloride) sheeting has been found satisfactory for this purpose.

[10] Model L-500, available from Hunter Spring Co., Lansdale, PA, has been found satisfactory for this purpose.



A. Sled
B. Plane
C. Supporting base
D. Gage
E. Spring gage
F. Constant-speed chain drive
G. Constant-speed tensile tester crosshead
H. Constant-speed drive rolls
I. Nylon monofilament
J. Low-friction pulley
K. Worm screw
L. Half nut
M. Hysteresis, synchronous motor

FIG. 1 Five Methods of Assembly of Apparatus for Determination of Coefficients of Friction of Plastic Film

6. Test Specimens

6.1 The test specimen that is to be attached to the plane shall be cut approximately 250 mm (10 in.) in the machine direction and 130 mm (5 in.) in the transverse direction when such extrusion directions exist and are identifiable.

6.2 A film specimen that is to be attached to the sled shall be cut approximately 120 mm (4½in.) square. Film is defined as sheeting having a nominal thickness of not greater than 0.254 mm as indicated in Terminology D 883.

6.3 A sheeting specimen (greater than 0.254 mm nominal thickness) or another substance that is to be attached to the sled shall be cut 63.5 mm (2½ in.) square.

6.4 Sheeting specimens shall be flat and free of warpage. Edges of specimens shall be rounded smooth.

6.5 Five specimens shall be tested for each sample unless otherwise specified.

NOTE 6—Plastic films and sheeting may exhibit different frictional properties in their respective principal directions due to anisotropy or extrusion effects. Specimens may be tested with their long dimension in either the machine or transverse direction of the sample, but it is more common practice to test the specimen as described in 6.1 with its long dimension parallel to the machine direction.

NOTE 7—**Caution:** Extreme care must be taken in handling the specimens. The test surface must be kept free of all dust, lint, finger prints, or any foreign matter that might change the surface characteristics of the specimens.

7. Preparation of Apparatus

7.1 Fig. 1 shows five ways in which the apparatus may be assembled. The support bases for all apparatus assemblies shall be level.

7.2 If the apparatus of Fig. 1(*a*) or (*b*) is used, calibrate the scale of the spring gage as follows:

7.2.1 Mount the low-friction pulley in front of the spring gage.

7.2.2 Fasten one end of the nylon filament to the spring gage, bring the filament over the pulley, and suspend a known weight on the lower end of the filament to act downward.

NOTE 8—The reading on the scale shall correspond to the known