



## Standard Test Method for Coefficient of Friction, Yarn to Yarn<sup>1</sup>

This standard is issued under the fixed designation D 3412; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the measurement of frictional properties for both continuous filament and spun-staple yarns under boundary friction conditions.

1.2 This test method has been used with yarns having linear densities ranging from 1.5 to 200 tex, but may be used with yarns outside these ranges (15 to 1800 denier).

NOTE 1—For coefficient of friction, yarn to metal, see Test Method D 3108.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units 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.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 123 Terminology Relating to Textiles<sup>2</sup>
- D 1776 Practice for Conditioning Textiles for Testing<sup>2</sup>
- D 1907 Test Method for Yarn Number by the Skein Method<sup>2</sup>
- D 2258 Practice for Sampling Yarn for Testing<sup>2</sup>
- D 3108 Test Method for Coefficient of Friction, Yarn to Solid Material<sup>2</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *boundary friction, n*—friction at low sliding speeds (0.02 m/min or less) where lubrication occurs under thin-film lubricant conditions.

3.1.2 *coefficient of friction, n*—the ratio of the tangential force that is needed to maintain uniform relative motion between two contacting surfaces to the perpendicular force holding them in contact.

3.1.3 *friction, n*—the resistance to the relative motion of one

body sliding, rolling, or flowing over another body with which it is in contact.

3.1.4 *radian, n*—the plane angle between two radii of a circle which intersects the circumference of the circle making an arc equal in length to the radius.

3.1.4.1 *Discussion*—A radian is equal to  $180^\circ$  divided by  $\pi$  and is approximately  $57.3^\circ$ .

3.1.5 *stick-slip, n*—a phenomenon occurring when boundary lubrication is deficient, manifested by alternative periods of sticking and slipping of the surfaces in contact.

3.1.5.1 *Discussion*—At the specified sliding speed, in yarn friction testing, stick-slip cycles are long enough that they can be readily recorded. During sticking, the frictional force slowly rises to a peak value, at which the slipping occurs with the frictional force rapidly decreasing to a minimum value.

3.1.6 *wrap angle, n*—in yarn friction testing, the cumulative angular contact of the test specimen against the friction-inducing device, expressed in radians.

3.1.7 For definitions of other textile terms used in this method, refer to Terminology D 123.

### 4. Summary of Test Method

4.1 A length of yarn is moved at a known speed in contact with itself or similar yarn at a specified wrap angle. The input and output tensions are measured and the coefficient of friction calculated. Alternatively, apparatus may be used in which the ratio of input to output tension is measured allowing the coefficient of friction to be indicated directly.

4.2 Two optional procedures are included. Option 1 is based on the Twisted Strand Method, using a wrap angle of 15.71 rad ( $900^\circ$ ). Option 2 is based on the Capstan Method, using a wrap angle of 3.14 radians ( $180^\circ$ ).

NOTE 2—Editions of Test Method D 3412 prior to the 1986 revision incorrectly stated the wrap angle for Option 1 to be 18.85 rad. This is incorrect, since 3 turns of the swivel pulley do not result in a wrap angle of 18.85 radians. This has now been corrected to 15.71 rad. This should be taken into account in comparing with earlier results.

### 5. Significance and Use

5.1 This test method for testing yarn-to-yarn friction is being used, but is not recommended, for acceptance testing of commercial shipments since between-laboratory precision is known to be poor.

5.1.1 In some cases, the purchaser and supplier may have to test a commercial shipment of one or more specific materials

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D-13 on Textiles and is the direct responsibility of Subcommittee D 13.58 on Yarn Test Methods, General.

Current edition approved May 15, 1995. Published July 1995. Originally published as D 3412 – 75T. Last previous edition D 3412 – 89.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 07.01.

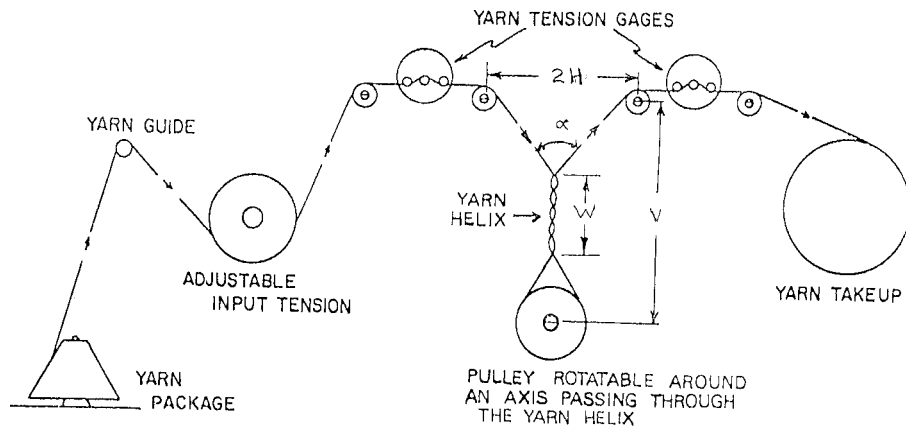


FIG. 1 Twisted Strand Yarn-to-Yarn Friction Apparatus—Twisted-Yarn Method

by the best available method even though the method has not been recommended for acceptance testing of commercial shipments. In case of a dispute arising from differences in reported test results when using Test Method D 3412 for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are as homogeneous as possible and that are from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results with consideration to the known bias.

5.2 This test method is intended for the determination of yarn-to-yarn boundary friction coefficients measured over a specified length of yarn.

5.3 The test method is useful for quality control, research, and the characterization of yarn boundary lubricants.

NOTE 3—Because the geometry of the yarns is different, Options 1 and 2 should not be expected to give the same numerical values on the same yarns.

## 6. Apparatus

6.1 *Option 1 (Twisted Strand Method)*—A schematic diagram of the elements required for twisted strand friction measurement is shown in Fig. 1. The yarn is run over upper pulleys and under a lower pulley and is intertwisted between these pulleys. One end of the yarn (output) is taken up at a controlled rate. The other end of yarn (input) is maintained at a controlled tension. The number of intertwisting wraps, the apex angle between the input and output yarns, and the input and output tensions are precisely known or recorded. From these data the coefficient of yarn-on-yarn friction is calculated. The required elements are:

6.1.1 *Friction Testing Apparatus (Indirect)*<sup>3</sup>—Apparatus in which the input tension is measured, or controlled to a set value, the output tension is measured, and the coefficient of friction is calculated within or outside the apparatus.

6.1.1.1 *Yarn Input Tension Control*—A means of controlling the yarn input tension to the nearest 5 % is required. A demand-feed apparatus tensioned with a fixed weight is suitable.

6.1.1.2 *Yarn Input Tension Measurement*—The yarn input tension is measured to within  $\pm 5.0$  mN ( $\pm 0.5$  gf), using a suitable tension gage producing an electrical signal. The signal is recorded as millinewtons (grams-force) or is used in combination with the yarn output tension measured to calculate the coefficient of friction. If a demand-feed apparatus tensioned with a precise, known fixed mass is used, the yarn input tension need not be constantly measured and recorded.

6.1.1.3 *Yarn Output Tension Measurement*—Yarn output tension is measured to within  $\pm 5.0$  mN ( $\pm 0.5$  gf), using a suitable tension gage producing an electrical signal. The signal is recorded as millinewtons, (grams-force), or is used in combination with the yarn input tension setting or measurement to calculate the coefficient of friction.

6.1.2 *Friction Testing Apparatus (Direct)*<sup>4</sup>—Apparatus in which the ratio of output to input tensions are compared directly and the coefficient of friction is indicated on a scale.

6.1.3 *Auxilliary Equipment (Indirect and Direct)*:

6.1.3.1 *Guide Pulley Arrangement*—The upper and lower pulleys shall be of the same diameter. The recommended pulley diameter is 38 mm (1.5 in.). The separation distance between the upper pulleys,  $2H$ , shall be  $140 \pm 2$  mm ( $5.5 \pm 0.1$  in.). The separation distance between the axis of the lower pulley and a line connecting the upper pulley axes,  $V$ , shall be

<sup>3</sup> Equipment meeting these requirements may be obtained commercially from: Custom Scientific Instruments Inc, 13 Wing Drive, Cedar Knolls, NJ 07292, and Rothschild-Messinstruments, Traubstr 3, 8002 Zurich, Switzerland, represented in the U.S. by Lawson Hemphill Sales Inc, PO Drawer 6388, Spartanburg, SC 29304.

<sup>4</sup> Equipment meeting these requirements may be obtained commercially from: Rothschild-Messinstruments, Traubstr 3, 8002 Zurich, Switzerland, represented in the U.S. by Lawson Hemphill Sales Inc, PO Drawer 6388, Spartanburg, SC 29304, and Shirley Developments Ltd, PO Box 6, Didsbury, Manchester M20 8SA, England, represented in the U.S. by Lawson Hemphill Sales Inc, PO Drawer 6388, Spartanburg, SC 29304.