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Standard Guide for Measuring and Reporting Friction Coefficients¹

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1. Scope

1.1 This guide covers information to assist in the selection of a method for measuring the frictional properties of materials. Requirements for minimum data and a format for presenting these data are suggested. The use of the suggested reporting form will increase the long-term usefulness of the test results within a given laboratory and will facilitate the exchange of test results between laboratories. It is hoped that the use of a uniform reporting format will provide the basis for the preparation of handbooks and computerized databases.

1.2 This guide applies to most solid materials and to most friction measuring techniques and test equipment.

1.3 *Units*—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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- C808** Guide for Reporting Friction and Wear Test Results of Manufactured Carbon and Graphite Bearing and Seal Materials
- C1028** Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method (Withdrawn 2014)³
- D1894** Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting

- D2047** Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine
- D2394** Test Methods for Simulated Service Testing of Wood and Wood-Base Finish Flooring
- D2534** Test Method for Coefficient of Kinetic Friction for Wax Coatings
- D2714** Test Method for Calibration and Operation of the Falex Block-on-Ring Friction and Wear Testing Machine
- D3108** Test Method for Coefficient of Friction, Yarn to Solid Material
- D3412** Test Method for Coefficient of Friction, Yarn to Yarn
- D3702** Test Method for Wear Rate and Coefficient of Friction of Materials in Self-Lubricated Rubbing Contact Using a Thrust Washer Testing Machine
- D4103** Practice for Preparation of Substrate Surfaces for Coefficient of Friction Testing
- D4917** Test Method for Coefficient of Static and Kinetic Friction of Uncoated Writing and Printing Paper by Use of the Horizontal Plane Method (Withdrawn 2010)³
- D4918** Test Method for Coefficient of Static Friction of Uncoated Writing and Printing Paper by Use of the Inclined Plane Method (Withdrawn 2010)³
- D5183** Test Method for Determination of the Coefficient of Friction of Lubricants Using the Four-Ball Wear Test Machine
- D6425** Test Method for Measuring Friction and Wear Properties of Extreme Pressure (EP) Lubricating Oils Using SRV Test Machine
- E122** Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
- E303** Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester
- E670** Test Method for Testing Side Force Friction on Paved Surfaces Using the Mu-Meter
- E1911** Test Method for Measuring Paved Surface Frictional Properties Using the Dynamic Friction Tester
- E2100** Practice for Calculating the International Runway Friction Index
- E2101** Test Method for Measuring the Frictional Properties of Winter Contaminated Pavement Surfaces Using an Averaging-Type Spot Measuring Decelerometer

¹ This guide is under the jurisdiction of ASTM Committee G02 on Wear and Erosion and is the direct responsibility of Subcommittee G02.50 on Friction.

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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 The last approved version of this historical standard is referenced on www.astm.org.

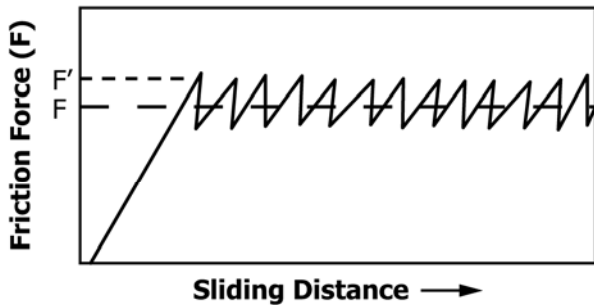


FIG. 1 Typical Force versus Distance Behavior for a System that Exhibits Stick-Slip Behavior

- F609 Test Method for Using a Horizontal Pull Slipmeter (HPS)
- F695 Practice for Ranking of Test Data Obtained for Measurement of Slip Resistance of Footwear Sole, Heel, and Related Materials
- F732 Test Method for Wear Testing of Polymeric Materials Used in Total Joint Prostheses
- G40 Terminology Relating to Wear and Erosion
- G77 Test Method for Ranking Resistance of Materials to Sliding Wear Using Block-on-Ring Wear Test
- G99 Test Method for Wear Testing with a Pin-on-Disk Apparatus
- G133 Test Method for Linearly Reciprocating Ball-on-Flat Sliding Wear
- G137 Test Method for Ranking Resistance of Plastic Materials to Sliding Wear Using a Block-On-Ring Configuration
- G143 Test Method for Measurement of Web/Roller Friction Characteristics
- G163 Guide for Digital Data Acquisition in Wear and Friction Measurements
- G164 Test Method for Determination of Surface Lubrication on Flexible Webs
- G176 Test Method for Ranking Resistance of Plastics to Sliding Wear Using Block-on-Ring Wear Test—Cumulative Wear Method
- G181 Test Method for Conducting Friction Tests of Piston Ring and Cylinder Liner Materials Under Lubricated Conditions
- G182 Test Method for Determination of the Breakaway Friction Characteristics of Rolling Element Bearings
- G194 Test Method for Measuring Rolling Friction Characteristics of a Spherical Shape on a Flat Horizontal Plane

3. Terminology

3.1 For definitions relating to frictional properties of materials, refer to Terminology G40.

3.2 Definitions:

3.2.1 *stick-slip, n*—relaxation oscillation usually associated with a decrease in the coefficient of friction as the relative velocity increases.

3.2.1.1 *Discussion*—The usual manifestation is a cycling decrease and subsequent increase in the friction force as sliding proceeds (Fig. 1).

4. Summary of Guide

4.1 Current ASTM International friction test standards are tabulated in this guide so that users can review available test methods and determine which method may be most applicable for a particular application. Any of the listed tests or other accepted test may be used. General friction testing precautions are cited and a prescribed method of recording friction data is recommended. This guide is intended to promote the use of this standard reporting system and standard friction test methods.

4.2 The use of one of the test methods (Table 1) cited in this guide will give assurance of a testing procedure that has been agreed-to for a particular application. In addition, it is important to keep in mind that friction is a system property. The coefficient of friction of polystyrene on mild steel measured on a sled test (Test Method D1894) will probably be different than the coefficient of the same couple measured on a block-on-ring tester (Test Method G176) since the coefficient of friction is a system effect.

4.3 Data developed by others can be useful if sufficient information is presented to characterize the tribosystem used in testing. Conformance with this guide in testing and reporting should produce data that can be reviewed for applicability to a particular tribosystem.

5. Significance and Use

5.1 In this guide, factors that shall be considered in conducting a valid test for the determination of the coefficient of friction of a tribosystem are covered, and the use of a standard reporting format for friction data is encouraged.

5.2 The factors that are important for a valid test may not be obvious to non-tribologists, and the friction tests referenced will assist in selecting the apparatus and test technique that is most appropriate to simulate a tribosystem of interest.

5.3 The tribology literature is replete with friction data that cannot readily be used by others because specifics are not presented on the tribosystem that was used to develop the data. The overall goal of this guide is to provide a reporting format that will enable computer databases to be readily established. These databases can be searched for material couples and tribosystems of interest. Their use will significantly reduce the need for each laboratory to do its own testing. Sufficient information on test conditions will be available to determine applicability of the friction data to the engineer's specific needs.

6. Apparatus

6.1 Any of the devices shown schematically in Table 1 can be used to measure the friction forces in a sliding system. Wear test machines are often equipped with sensors to measure friction forces also. The appropriate device to use is the one that closely simulates a tribosystem of interest.

6.2 The key part of simulating a tribosystem is to use specimen geometries that resemble the components in the system of interest. A continuous sliding system needs to be simulated by a continuous friction test; a reciprocating system needs to be simulated by a reciprocating test. Entry geometry

TABLE 1 ASTM Friction Tests and Applicable Materials

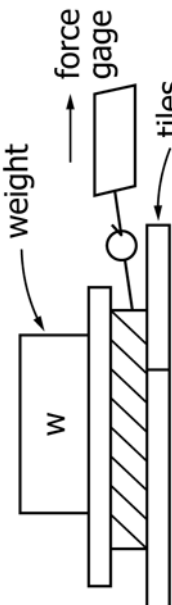
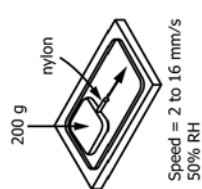
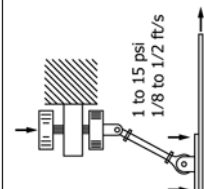
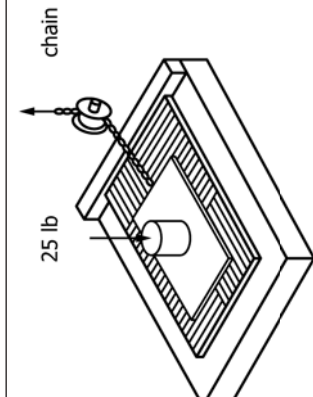
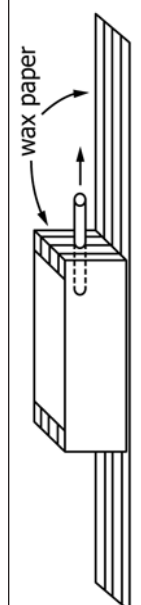
Standard/Committee	Title	Measured Parameters	Test Configuration
C808/D02.F0 on Manufactured Carbon and Graphite Products	Guide for Reporting Friction and Wear Test Results of Manufactured Carbon and Graphite Bearing and Seal Materials	Carbon versus other materials (μ_s and μ_k)	any
C1028/C21 on Ceramic Whitewares and Related Products	Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method	Static COF wet and dry	
D1894/D20 on Plastics	Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting	Plastic film versus stiff or other solids (μ_s and μ_k)	
D2047/D21 on Polishes	Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine	Walking materials versus shoe heels and soles (μ_s and μ_k)	
D2394/D07 on Wood	Test Methods for Simulated Service Testing of Wood and Wood-Base Finish Flooring	Wood and wood base flooring versus sole leather (μ_s and μ_k)	
D2534/D02 on Petroleum Products and Lubricants	Test Method for Coefficient of Kinetic Friction for Wax Coatings	Kinetic coefficient of friction	

TABLE 1 Continued

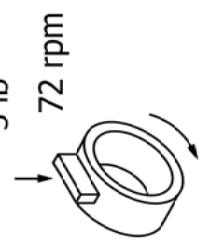
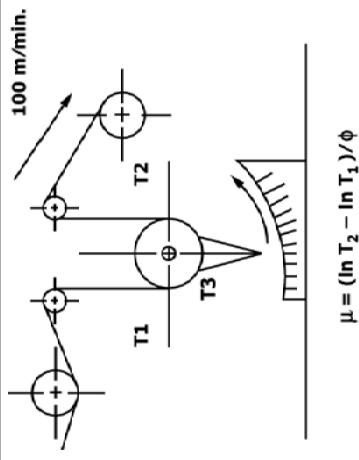
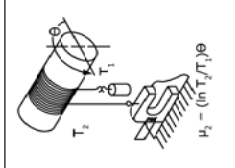
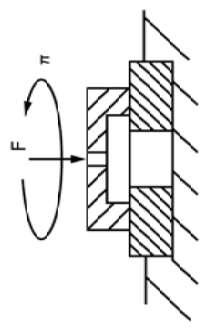
Standard/Committee	Title	Measured Parameters	Test Configuration
D2714/D02 on Petroleum Products and Lubricants	Test Method for Calibration and Operation of the Faxlex Block-on-Ring Friction and Wear Testing Machine	Steel ring versus steel block (lubricated with standard oil) (μ_k)	
D3108/D13 on Textiles	Test Method for Coefficient of Friction, Yarn to Solid Material	Textile yarn versus solids (μ_k)	
D3412/D13 on Textiles	Test Method for Coefficient of Friction, Yarn to Yarn	Continuous filament and spun yarns self-mated (μ_s and μ_k)	
D3702/D02 on Petroleum Products and Lubricants	Test Method for Wear Rate and Coefficient of Friction of Materials in Self-Lubricated Rubbing Contact Using a Thrust Washer Testing Machine	Kinetic COF	
D4103/D21 on Polishes	Practice for Preparation of Substrate Surfaces for Coefficient of Friction Testing	Vinyl and wood tiles (preparation)	any

TABLE 1 Continued

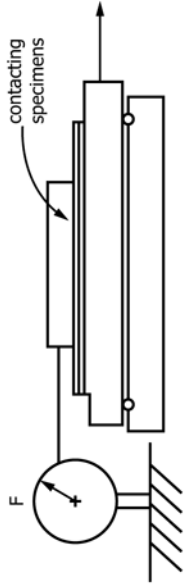
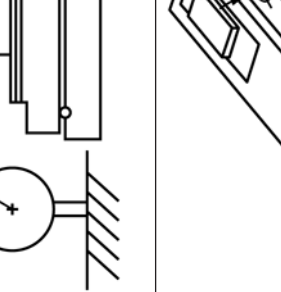


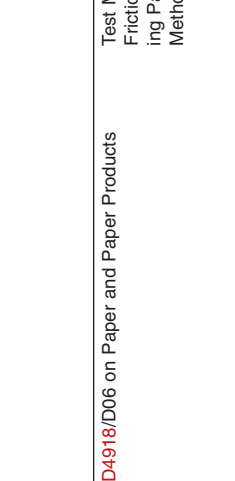
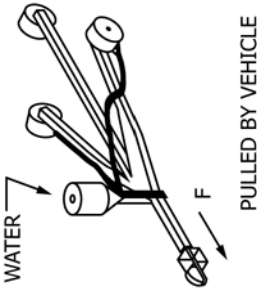
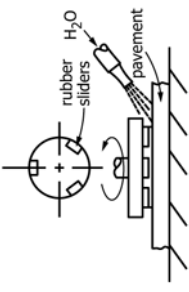
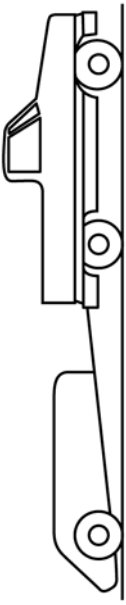

Standard/Committee	Title	Measured Parameters	Test Configuration
D4917/D06 on Paper and Paper Products	Test Method for Coefficient of Static and Kinetic Friction of Uncoated Writing and Printing Paper by Use of the Horizontal Plane Method	μ_s and μ_k	
D4918/D06 on Paper and Paper Products	Test Method for Coefficient of Static Friction of Uncoated Writing and Printing Paper by Use of the Inclined Plane Method	Static COF	
D5183/D02 on Petroleum Products and Lubricants	Test Method for Determination of the Coefficient of Friction of Lubricants Using the Four-Ball Wear Test Machine	Coefficient of force for each increment of 10 kgf	
D6425/D02 on Petroleum Products and Lubricants	Test Method for Measuring Friction and Wear Properties of Extreme Pressure (EP) Lubricating Oils Using SRV Test Machine	Coefficient of friction for test (min, max, and at increments throughout the test)	
E303/E17 on Vehicle-Pavement Systems	Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester	Rubber versus pavement (BPN British Pendulum Number)	

TABLE 1 Continued

Standard/Committee	Title	Measured Parameters	Test Configuration
E670/E17 on Vehicle-Pavement Systems	Test Method for Testing Side Force Friction on Paved Surfaces Using the Mu-Meter	Tires versus pavement Mu Number (F dry - F wet)	
E1911/E17 on Vehicle-Pavement Systems	Test Method for Measuring Paved Surface Frictional Properties Using the Dynamic Friction Tester	Dynamic friction numbers (DNF) at 12, 24, 36, and 48 mph	
E2100/E17 on Vehicle-Pavement Systems	Practice for Calculating the International Runway Friction Index	Friction index for snow on a runway	 <p>special trailer</p>
E2101/E17 on Vehicle-Pavement Systems	Test Method for Measuring the Friction Properties of Winter Contaminated Pavement Surfaces Using an Averaging-Type Spot Measuring Decelerometer	Friction index for pavement	 <p>braking deceleration</p>
F609/F13 on Pedestrian/Walkway Safety and Footwear	Test Method for Using a Horizontal Pull Slipmeter (HPS)	Footwear materials versus walking surfaces (μ_s)	Same as D2047
F695/F13 on Pedestrian/Walkway Safety and Footwear	Practice for Ranking of Test Data Obtained for Measurement of Slip Resistance of Footwear Sole, Heel, and Related Materials	Footwear materials versus walking surfaces (reliable ranking of footwear for slip resistance) (μ_s)	Same as D2047