



Coefficient of Friction Measurement for Elastomers

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To evaluate the friction (the resistance between two contacting surfaces) of elastomeric material and dry test surface and wet test surface. (See Table 1, Test Description.)

Note: The words, "Must" indicates a requirement, "Shall" indicates a requirement and "Should" implies a preference or desired conformance.

Table 1: Test Description

Test Method A1 and A2			Purpose/Technique	Evaluation
A1	Horizontal Dry	Schedule 1 (subsection)	To evaluate the friction between dry test surfaces. A sled of specified material with the desired surface finish is pulled across a stationary flat elastomer slab at 23 °C. Sled surface finish directional influences on friction are tested by rotating the sled 90 degrees and repeating the measurement procedure. Procedural control of significant test parameters (finish, finish direction, pull rate and time between measurements) provides repeatable and reproducible measurement.	Material and finish effects on starting (static) and sliding (kinetic) coefficient of friction on clean, dry surfaces.
A2	Horizontal Wet	Schedule 2 (subsection)	To evaluate the friction between wet test surfaces. A sled of specified material with the desired surface finish is pulled across a stationary flat elastomer slab. Both contact surfaces are covered with a designated liquid. Tests are run at 23 °C. Sled surface finish directional influences on friction are tested by rotating the sled 90 degrees and repeating the measurement procedure. Procedural control of significant test parameters (finish, finish direction, pull rate and time between measurements) provides repeatable and reproducible measurement.	Material and finish effects on starting (static) and sliding (kinetic) coefficient of friction on wet surfaces.

1.2 Applicability. Elastomer needing finite element analysis for elastomeric parts for an assembled joint.

1.2.1 Measured Finishes. Such as cast and machined groove, or surface finishes for static mating surfaces (e.g., engine block, head, covers, etc.) It does not represent rotating or reciprocating surfaces like crankshaft or valve stems.

1.3 Remarks. See ISO 15113, Rubber - Determination of Frictional Properties. The Coefficient of Friction (CoF) (the ratio of the force required to move one surface over another to the total force applied normal to those surfaces) depends on the rubber composition, test duration and type of test rig. The type of test rig affects the CoF mostly via the contact pressure and transport of debris from the contact area (on repeat measurements).

1.3.1 The force to start the sled (Static Coefficients of Friction (μ_s) which is the coefficient of friction at the instant motion between surfaces starts) and to keep the sled moving (Kinetic Coefficients of Friction (μ_k) which is the coefficient of friction after motion between surfaces is established) are both measured by the load cell, and recorded on a graphical device or stored in a data acquisition system. The acquired force data is divided by the sled weight to mathematically determine the static and kinetic coefficient of friction.

1.3.2 Static friction is derived from the first maximum peak (force) on the load curve, and the kinetic friction is derived from an averaged force value between two defined points within the region beyond the first peak on the load curve.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASME B46.1	ASTM D1894	ISO 2230	ISO 23529
ASTM D412	ASTM D3182	ISO 6194-4	SAE AS7949
ASTM D1329	ASTM E18	ISO 15113	SAE AS21443

2.2 GM Standards/Specifications.

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2.3 Additional References.

- Commercial Grade - Specifications SD 117
- MIL-A-8625
- MS20219A1 (Bearing, Ralmark Company)
- Print Requirements

2.3.1 Aluminum Alloys.

- 2024-T351
- 6061-T6

2.3.2 Air Atomizing Sprayer.

- 7054T8 (McMaster Carr Supply Company)
- 7054T41 (McMaster Carr Supply Company)

2.3.3 Horizontal Test Line.

- 3458T961 (McMaster Carr Supply Company)
- SC01217 (Loos and Company, Incorporated, Pomfret, Connecticut 06528)

3 Resources

3.1 Facilities. A suitable area or room for conduction testing with a stable and known environment (see 4.2.1).

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment. The following items are needed to perform Test Method A1 and Test Method A2 (see Table 1).

3.2.1 Testing Machine. See ASTM D412 apparatus description. All tests are made on a power driven machine equipped to produce a uniform rate of grip separation that allows 1% strain per second in the test specimen. The testing machine must have a suitable dynamometer and indicating or recording system for measuring the applied force. The applied force must be within $\pm 1\%$ of the readings throughout the entire range/distance of testing (to normalize readings).

3.2.2 Surface Finish Measuring Equipment. Test labs must be able to produce and measure/verify the desired test finish internally or have it performed by qualified pay for service facility.

3.2.3 Test Method A1 and Test Method A2 (see Table 1). Figure 1 shows the setup for attaching two horizontal friction surfaces. The test apparatus may be a dedicated device or a tensile testing machine adapted for that purpose. On the tensile test machine the load cell is mounted on the crosshead, and the friction fixture is mounted on the base of the test instrument. The crosshead moves up during the test. The equipment must be capable of providing linear motion between the surfaces for a distance of 50 mm to 100 mm, and a rate of 0.5 mm/minute to 150 mm/minute.



Figure 1: Friction Test Setup

3.2.4 Clamping Force or Load.

3.2.4.1 Weights. For Test Method A1 and Test Method A2 (see Table 1) to provide a 1 N to 20 N range over the minimum contact area (sled). The weight must not cause Stick-Slip (a condition where the actual velocity between the surfaces oscillates, resulting in corresponding oscillations in the measured frictional force. See Figure 6) or promote sled misalignment during measurement.

3.2.4.2 Clamps. For Test Method A1 and Test Method A2 (see Table 1) provide a secure positioning of elastomer slab during testing.

3.2.5 Sled. A 50 mm × 50 mm × 6 mm platform made of the specified material with referenced standard, grade, process and finish. Examples include cast and machined surfaces of aluminum, magnesium and cast iron and 30% glass filled nylon. Eyelets are secured at the opposite ends of the leading edge to attach the horizontal test line. All edges will be rounded (not beveled). See Figure 2, Sled and Line Configuration.

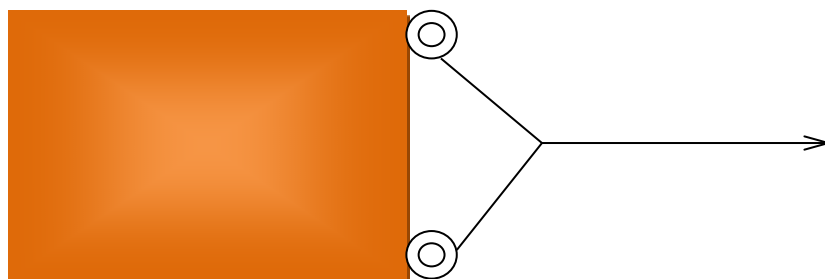
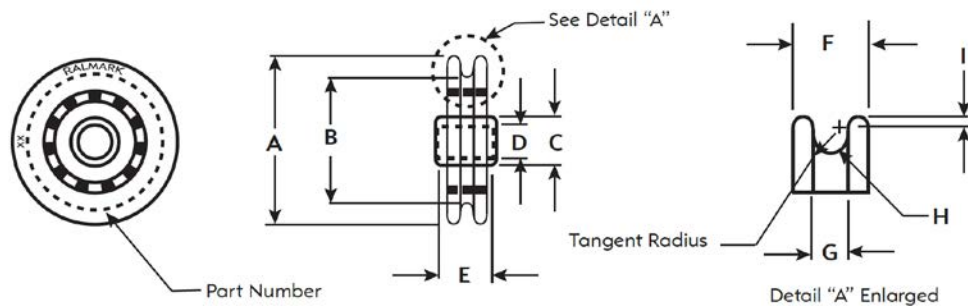


Figure 2: Sled and Line Configuration

3.2.6 Grooved Bearing Wheel with Mounting Feature. Provides alignment for the monofilament line between the test cell and the sled. Wheel is a metallic sheave, aluminum alloy 2024-T351. Aluminum sheaves are anodized per MIL-A-8625, Type II, Class I. Bearing retention sleeve is aluminum alloy 6061-T6. Bearing

conforms to the requirements of Aerospace Standard SAE AS7949 and SAE AS21443. MS20219A1 (Bearing, Ralmark Company) meets the requirements. See Figure 3, Bearing Wheel Dimensions.



A	B	C	D	E
Outside Diameter ± 0.005	Groove Diameter ± 0.005	Shoulder Diameter (approximately)	Bore Diameter $+0.0000/-0.0005$	Width Inside Radius (IR) $+0.000/-0.005$
1.312	1.000	0.372	0.2500	0.438
F	G	H	I	
Material Width	Groove Width $+0.000/-0.010$	Groove Radius $+0.000/-0.003$		$+0.000/-0.010$
0.310 Maximum	0.150	0.050		0.055

Figure 3: Bearing Wheel Dimensions (all dimensions in millimeters (mm))

3.2.7 Load Cell. 0.1 N to 1 kN.

3.2.8 Horizontal Test Line. Nylon monofilament, Teflon coated, 5.4 kg test load. "Spiderwire" meets the requirements. Commercial Grade - Specifications SD 117 - 302/304 stainless steel strand (1 × 7 construction, 0.3048 mm (0.012 in) diameter, 11.3 kg (25 lb) minimum break strength).

3.2.8.1 Manufacturer. Part Number SC01217, (Loos and Company, Incorporated, Pomfret, Connecticut 06528). This product is also available from McMaster Carr Supply Company, part number 3458T961 (McMaster Carr Supply Company).

3.2.8.2 A wire test/tow line may be necessary for material combinations found to have excessive stick-slip tendency, in which the kinetic portion of the test degenerates into a series of static tests as a result of rapid jumps from the sled. This necessitates making separate measurements for static and kinetic friction coefficients. The test technician can determine what level of stick-slip is considered excessive for its materials. If there is disagreement, the nylon tow line remains the prevailing choice.

3.2.9 Air Atomizing Sprayer. A 250 mL or 500 mL corrosion resistant bottle or carafe shaped container with nozzle capable of delivering a uniform wet coating of Wet Assembly Aids, solutions used to temporarily reduce assembly force (friction) between press and interference fit stationary mating elements (e.g., hose to fitting), containing water/soap or emulsion type solutions. The unit is pressurized with filtered compressed air in a range suitable for multiple applications without loss of uniform coating coverage. After repeated use the container can be depressurized, refilled and recharged.

3.2.9.1 This product is available from McMaster Carr Supply Company; part number 7054T41 (McMaster Carr Supply Company) or 7054T8 (McMaster Carr Supply Company).

3.2.9.2 Spray Nozzle (Mist). A unit capable of a full cone pattern with a 70 degree or larger coverage angle. A built-in pressure activated check valve is desired to eliminate drip with strainer to prevent fluid contaminant transfer to the tested surface. Nozzle material shall be corrosion resistant to wet assembly aids containing water/soap or emulsion type solutions.

3.3 Test Vehicle/Test Piece. Elastomer test surfaces are as molded or with a dry friction reduction Coating, a dry substance introduced between two surfaces to lower the coefficient of friction. The production release intent coating is applied using the same production method as the coated part. Allowances for pilot or lab scale coating application are permitted if coating by full scale production is impractical. Test specimen surfaces are fully coated