Designation: G164 – 99 (Reapproved 2013)

Standard Test Method for Determination of Surface Lubrication on Flexible Webs[1]

This standard is issued under the fixed designation G164; 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 has been used since 1988 as an ANSI/ISO standard test for determination of lubrication on processed photographic films. Its purpose was to determine the presence of process-surviving lubricants on photographic films. It is the purpose of this test method to expand the applicability of this test method to other flexible webs that may need lubrication for suitable performance. This test measures the breakaway (static) coefficient of friction of a metal rider on the web by the inclined plane method. The objectives of the test is to determine if a web surface has a lubricant present or not. It is not intended to assign a friction coefficient to a material. It is not intended to rank lubricants.

1.2 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ANSI/ISO Standards:*[2]

ANSI/ISO 5769-1984, ANSI/NAPM IT9.4-1992 for Photography-Processed Films-Method for Determining Lubrication

3. Terminology

3.1 *Definitions:*

3.1.1 *coefficient of friction, μ, n, in tribology*—the dimensionless ratio of the friction force (*F*) between two bodies to the normal force (*N*) pressing these bodies together.

3.1.2 *friction force, n*—the resisting force tangential to the interface between two bodies when, under the action of external force, one body moves or tends to move relative to the other.

3.1.3 *lubricant, n*—any substance interposed between two surfaces for the purpose of reducing the friction and wear between them.

3.1.4 *static coefficient of friction, n*—the coefficient of friction corresponding to the maximum friction force that must be overcome to initiate macroscopic motion between two bodies.

3.1.5 *triboelement, n*—one of two or more solid bodies which comprise a sliding, rolling, or abrasive contact, or a body subjected to impingement or cavitation.

3.1.6 *tribology, n*—the science and technology concerned with interacting surfaces in relative motion, including friction, lubrication, wear, and erosion.

3.1.7 *tribosystem, n*—any system that contains one or more triboelements, including all mechanical, chemical, and environmental factors relevant to tribological behavior.

4. Summary of Test Method

4.1 This test method can be used to measure the friction characteristics of the surfaces of a flexible web sliding against the curved smooth surface of a paper clip.

4.2 This test method is conducted on a narrow strip taken from a web of interest. The strip is affixed to an inclined plane device with the surface of interest facing up. A paper clip is balanced on the web surface with the inclined plane in the horizontal position. The plane is then angled upward until the rider breaks away.

4.3 The angle at which breakaway occurred is recorded. The tangent of that angle is the friction coefficient for that tribosystem.

5. Significance and Use

5.1 Many web materials do not convey satisfactorily in manufacture or work, or both, as intended in service unless their surface contains a very thin layer of lubricant in the form of a wax, particulate, thin film coating, or fluid. It is often very expensive and time consuming to use surface chemical analysis techniques to quantify the presence of these films. A simple friction test like this one performs this function.

5.2 This test has been used for over twenty years to detect the presence of lubricants on the surface of photographic films at various stages in manufacture. In this instance the surfaces

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

Current edition approved Nov. 15, 2013. Published November 2013. Originally approved in 1999. Last previous edition approved in 2009 as G164–99(2009). DOI: 10.1520/G0164-99R13.

[2] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

are lubricated with waxes and this test reliably detects if the wax is present. It is not used to quantify the amount of wax, only if it is present. This test can be used as a quality test to make sure that a lubricant is present. Test samples are normally compared with an unlubricated reference specimen. The coefficient of friction of the test samples is compared with the coefficient of friction of the unlubricated reference specimens to determine if a lubricant is present.

6. Apparatus

6.1 *Friction Slider*—The rider in this friction test is a U-shaped device with a paper clip inserted in the center. This rider slides on the test web that is attached to the inclined plane. The material of construction is not important, but the center of gravity shall be at least 25 mm below the end of the paper clip. Acrylic sheet has been determined to be a suitable material of construction. The paper clip must be uncoated steel and have a smooth (as opposed to serrated or dull) finish. The overall dimensions of suitable paper clips are between 5 and 8 mm wide and between 25 and 35 mm long. The wire diameter should be in the range of 0.6 to 0.75 mm. The mass of the slider should be in the range of 50 to 100 g.

6.2 *Inclined Plane*—The dimensions and typical construction of the inclined plane test rig are shown in Fig. 1. The essential requirements of the inclined plane are:

6.2.1 The surface of the inclined plane should be smooth (<0.2 μm Ra surface roughness) rigid and not deformable under test conditions. Acrylic sheet has been determined to be an acceptable surface.

6.2.2 It shall be narrow and high enough to accommodate unobstructed slider motion.

6.2.3 It shall have a device for test material attachment or it shall have sufficient room to allow attachment with two-sided pressure sensitive adhesive.

6.2.4 It shall be capable of being raised and lowered with smooth uninterrupted motion and it shall have a means of clamping the plane at the angle at which rider breakaway occurs.

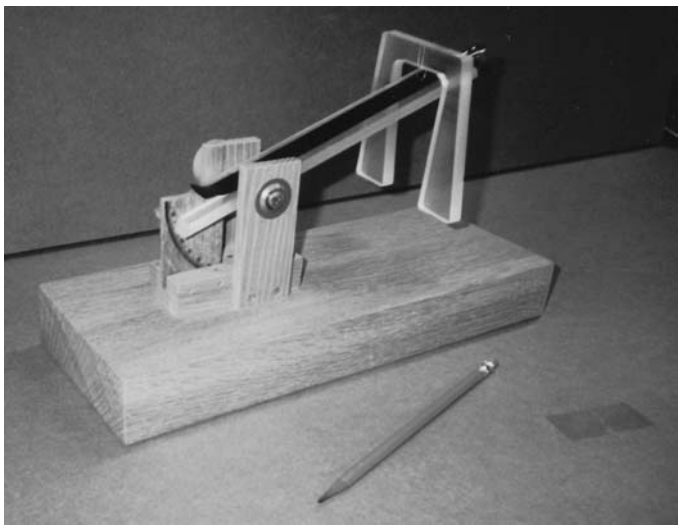

FIG. 1 Apparatus

6.3 *Angle Measurement*—The test metric is the angle inclination of the inclined plane (θ) when rider motion occurs. This angle can be measured by a protractor or by calibration of a gage on the device. A suitable device for angle measurement is an electronic level. These devices present a digital angle readout to two places. The devices reputedly are accurate to ±0.1°. The least count on the angle-measuring protractor shall be 1°.

7. Test Procedure

7.1 *Sample Preparation*—Test samples shall be the thickness of the test material with a width between 25 and 35 mm and a length of at least 150 mm. Take care to not contaminate the test with fingerprints or other material that is not normally found on the test surface. Outer convolutions of web rolls are often contaminated by operators holding the film tight while the roll is taped. Do not use outer convolutions for testing.

7.2 *Test Materials*—Any material that will lay flat on the inclined plane may be tested, but the test was developed for the flexible webs used to make photographic film. Do not use this test for sandpaper and the like that will damage the paperclip rider during the test.

7.3 *Test Conditions*—Conduct tests with relative humidity between 35 and 55 % and at a temperature of 20 ± 5°C. Condition samples for 24 h in the test atmosphere prior to testing.

7.4 *Mounting the Web*—Mount the test web with a clamp or adhere it in such a manner that it is flat to the inclined plane with no wrinkles or bows. If the sample is taped to the inclined plane, do not put the tape in the test area.

7.5 *Conducting the Test*—Clamp the test rig to a level horizontal surface. Raise the sample plane to an arbitrary angle; place the rider (paper-clip) on the inclined plane so that only the paper clip touches the test surface. If the rider slides down the plane, lower the plane and repeat placement of the rider on the test surface. If the rider still freely slides repeat the procedure until the rider no longer moves on the inclined plane. Repeat this operation until the maximum angle is determined (to the precision desired) at which point the rider fails to slide.

7.5.1 Repeat the procedure twice more on a different area of the test sample. Calculate the arithmetic average of the three angle determinations. Take the tangent of the average and this is the test result, a unitless static coefficient of friction for a paperclip/film tribosystem.

$$\mu_s = \tan \theta_{\text{avg of 3 determinations}} \quad (1)$$

8. Report

8.1 *Test Data*—The following values shall be recorded:

8.1.1 The name and number of the test sample,

8.1.2 Identify the test surface,

8.1.3 The average friction coefficient(s) of the surface(s) tested,

8.1.4 The number of samples tested, and

8.1.5 The temperature and relative humidity of the test.

8.2 *Interpretation of Results*—Totally unlubricated cellulose triacetate films generally produce static friction coefficients in

TABLE 1 Interlaboratory Test Data-Statistical Analysis Summary

NOTE 1—The within-laboratory coefficient of variation ranged from 5 to 10.6 %; between laboratory ranged from 16.9 to 27.7 %.

	Interlatoratory Friction Measurements (μ_s)						
Test Surface	Laboratory 1	Laboratory 2	Laboratory 3	Laboratory 4	Laboratory 5	Between Laboratory Average	Between Laboratory Standard Deviation
PVC	0.54	0.44	0.7	0.61	0.59	0.587	0.097
PVC plus wax	0.18	0.12	0.24	0.26	0.35	0.23	0.064
Pet	0.13	0.27	0.31	0.33	0.27	0.26	0.075
Pet plus wax	0.09	0.06	0.12	0.12	0.11	0.1	0.024
PTFE	0.07	0.08	0.14	0.1	0.14	0.1	0.029
PTFE plus wax	0.05	0.05	0.09	0.1	0.09	0.076	0.024

excess of 0.4. Effective lubricants, well applied, will generally produce static coefficients of friction of 0.15 or lower. However the presence of lubrication can only be determined with certainty if the paper clip test is conducted on a control sample with known lubrication. This test is intended to identify surfaces that are supposed to be lubricated and are not, or if they are improperly lubricated.

9. Precision and Bias

9.1 *Precision*—The test variability in interlaboratory tests on three lubricated (carnauba wax) and unlubricated plastic webs is shown in Table 1. The research report includes a graphical presentation of all of the test results.[3]

9.1.1 The within-laboratory variation was essentially 10 % or less; the between-laboratory variation was in the range of 17 to 27 %.

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:G02-1011.

9.2 *Bias*—There is no absolute value of a friction coefficient. It is a product of a particular tribosystem. Therefore, the value can have no bias. Some of the factors in this test method that can cause reproducibility and repeatability problems are as follows:

9.2.1 Contamination of the test surfaces,

9.2.2 A burr or nick on the rider,

9.2.3 Irregular motion (jerking) in raising or lowering the plane,

9.2.4 Temperature or humidity differences,

9.2.5 A buckle or bubble of the web in the path of the rider, and

9.2.6 Air currents directed on the rider.

10. Keywords

10.1 friction testing; photographic films; plastic sheet; static coefficient of friction; webs