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T 815

BALLOT NO. 03-SARG

DRAFT NO. 02

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WORKING GROUP
CHAIR Sara Young

SUBJECT
CATEGORY
Fiberboard Shipping Container Testing

RELATED
METHODS See "Additional Information"

CAUTION:
This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Coefficient of Static Friction (Slide Angle) of Packaging and Packaging Materials (Including Shipping Sack Papers, Corrugated and Solid Fiberboard) (Inclined Plane Method)

Five-year review of Official Method T 815 om-18

(Underscores, notes, and strikethroughs show changes from Draft 2)

1. Scope

1.1 This method determines the coefficient of static friction of most packaging materials by measuring the angle at which one test surface begins to slide against another inclined surface as the incline is increased at a constant and prescribed rate.

1.2 The test is frequently referred to as slide angle. The coefficient of friction is numerically equivalent to the tangent of the angle when the test surface begins to slide.

1.3 TAPPI T 549 describes a horizontal method for determining static and kinetic friction but is intended for application to printing and writing papers and the procedures are somewhat different.

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2. Significance

2.1 The coefficient of friction of packaging materials indicates how packages made from that material will perform in many critical applications. A high coefficient of one surface of paper or paperboard (containerboard) to itself means that containers having that surface will tend to resist sliding in unit loads. A low coefficient may indicate potential problems with the packages slipping from the load.

2.2 The coefficient of static friction test is empirical. It describes the condition of that surface at the moment of test. This may or may not relate to the condition of that surface in use. Its condition will depend upon the historical treatment of the surface, especially if frictionizing materials have been used to treat the surface. These materials may be rubbed off in handling downstream. For surfaces treated with frictionizing agents, experience has shown that variability is significantly reduced after the third slide. Coefficient of friction is also significantly affected by contamination with very small amounts of materials which lower the friction such as waxes and other oily materials. As with surfaces treated with frictionizing agents, coefficient of friction test results on surfaces containing waxes or other oily materials also show reduced variability when preliminary conditioning in the form of slides are made before the results are recorded. Where the surfaces are known to have been treated with a frictionizing agent or suspected to contain wax or oily materials or when the previous history of the packaging material is unknown, test results are not recorded until the third slide. When it is known that the packaging materials being tested are untreated, test results may be recorded on the first slide with little or no loss in accuracy (*5*).

3. Definitions

3.1 The coefficient of friction is the ratio of the frictional force resisting movement of the surface being tested to the force applied normal to that surface (the weight of the material above that surface). For the inclined plane, the coefficient is numerically equal to the tangent of the angle of incline.

3.2 The static coefficient is the ratio of the force resisting initial motion of the surface to the normal force.

4. Apparatus

4.1 *Timer*, stopwatch or electric timer reading in seconds.

4.2 *Inclined plane and sled*, consisting of the following:

4.2.1 *Sled*, a metal block, rectangular, of size and mass to produce a pressure of 1.4 ± 0.7 kPa (0.2 ± 0.1 psi) with a plane lower surface faced with a foamed rubber or plastic padding, 3mm (1/8 in. thick). While the exact measurements are not critical, dimensions of 90 x 100 mm (3.5 x 4 in.) for the surface and a mass of 1300 g (2.9 lb) is acceptable. The foamed material on the surface should be compressed by 25% of its original thickness when under a pressure of 85 kPa (12.5 psi). A means for clamping the test specimen to the sled is desirable but not necessary.

NOTE 1: Theoretically the coefficient of friction being a ratio is independent of the normal force being applied (the weight of the sled). However, because paper is a compressible material this theoretical relationship does not hold and the coefficient determined is mildly influenced by the pressure applied.

4.2.2 *Inclined plane*, a smooth, plane, incompressible surface of suitable material, hinged so that it can be tilted and having a width at least 12.5 mm (0.5 in.) wider than the sled and a length sufficient to permit the sled to move at least 25 mm (1 in.), provided with a clamp at its upper end to fix the test specimen in place and a bumper stop at its lower end (Fig. 1). All units do not have upper clamps but instead may utilize side clamps or non-slip pads to prevent the bottom sample from moving during testing.

4.2.2.1 Means to smoothly increase the angle of inclination of the plane at a rate of 1.5° ± 0.5°/s from the horizontal through an arc of 45°. The motion should be free of vibration.

4.2.2.2 Means to indicate the angle of inclination within 0.5°.

4.2.2.3 Means to level the instrument in two directions when the inclined plane is in its horizontal position.

5. Sampling and test specimens

5.1 If the packaging material being tested is in the form of a lot being tested to determine conformance to specifications, obtain a sample according to TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard or Related Product." Obtain at least 5 samples representative of the material as a whole. Each sample must be large enough to be cut into the two pieces required for each test.

5.2 If the specimens are from a package, carefully cut them from areas which normally come into contact with the next package in unit loads and away from obvious defects or scored areas.

5.3 Identify each paper specimen for both direction and surface, viz. MD (machine direction), CD (crosswise direction), felt (top) and wire (bottom) side. For corrugated board, the CD is the direction parallel to the flutes. Do not mark the sheet in the area to be tested.

5.4 The face of the paper or board to be tested will be that side that forms the exterior of the package, normally the top or felt side of the sheet.

5.5 Since paper is anisotropic and the coefficient of friction is particularly so, care must be taken in making the test to orient the surfaces just as they will be in actual use. Therefore if the layers of packages are to be alternated in palletization, the coefficient should be measured with one surface MD and the other CD. It should also be noted that the coefficient of friction may also be sensitive to the way the fibers are laid down during the papermaking process so that MD and anti-MD are also frequently significantly different. The procedure spells out that for each test, the piece oriented MD must be reversed 180° for each succeeding measurement and this should be done whatever pattern of orientation is employed.

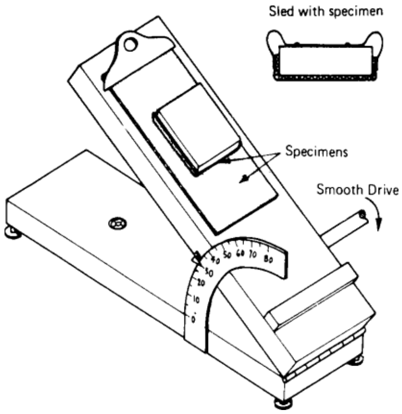

Fig 1. Inclined plane.

5.6 Each test unit consists of two specimens.

5.6.1 Cut the smaller specimen to be fixed to the sled a little (ca. 3 mm or 1/8 in.) larger than the base of the sled so that it will extend beyond the bottom edges of the sled. Flexible materials can be folded around the edges of the sled and perhaps clamped to the sled. For heavier grades, for example paperboard (containerboard) it may be expedient to score the specimen on the face opposite that to be tested in the position where it will contact the edge of the sled, so that the sheet can be easily folded to conform to the sled without creating any bulging of the test surface.

5.6.2 Cut another specimen slightly larger to cover the working surface of the inclined plane and long enough in the direction of slide to permit the required length of slide.

NOTE 2: Exercise special care in handling the test specimens because any abnormal contact or rubbing prior to testing may significantly affect the test results. Take care to avoid contamination of the test surface with wax or skin oil. Do not touch the test area with the fingers. Thoroughly clean the specimen cutters used to prepare the test specimens with solvent or detergent prior to preparing the test specimens (1).

6. Conditioning

6.1 Precondition and condition and test the specimens in accordance with TAPPI T 402, "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets and Related Products."

7. Procedure

7.1 Level the plane so that it is horizontal (two directions at 90° to each other) when the inclinometer indicates zero degrees.

7.2 Mount the larger test specimen on the inclined plane with the surface to be tested facing upward. Clamp in place if necessary (see 4.2.2). Attach the other specimen with surface to be tested facing downward and rotated 90° to the direction of the specimen on the plane. (The 90 deg. rotation was established to simulate one type of box stacking pattern (interlocking) and as such is referenced as the standard. Other orientations which may be more appropriate to represent actual field conditions may be used but are not considered adequate to meet T 815). There should be no obvious looseness or slack in the specimen. Position the sled and its test specimen on top of the other test specimen near the end of the inclined plane that is away from the hinge and stop.

NOTE 3: Exercise care when placing the sled and test specimen on the test specimen mounted on the inclined plane that there is no reverse relative motion of the test specimens. Avoid side to side motion, but this is not normally encountered in the very brief slide used in this test.

7.3 If the end use of the materials has dictated that a different machine orientation is more applicable, record the direction of orientation of the test samples and include that orientation in the final report (see 9.1).

7.4 Allow a dwell time of 10 s, and then increase the angle of incline at the specified rate of 1.5 ± 0.5°/s. Stop the incliner when the sled starts to move and permit the sled to slide to the stop. If it is known that no frictionizing treatment has been applied, record this angle at which the sled has begun its slide to the nearest 0.5°. Return the inclined plane to its horizontal position. If frictionizing agents have been applied or this condition is unknown, carefully lift the sled and attached specimen and place in the original starting position on the inclined plane (in horizontal position). Again after the dwell time of 10 s, repeat the inclination to the start of sliding, let the sled come to a stop, return the incline to horizontal, but make no record of the angle at which sliding begins. For the third time, carefully lift the sled and specimen to the starting position, allow it to dwell 10 s and raise the incline to the inception of sliding, record the angle at which sliding begins on this third slide to the nearest 0.5°.

7.5 Place the next pair of test specimens on the sled and inclined plane but this time rotate 180° the specimen that has been the oriented with the MD in the direction of slide. Test as in 7.4.

7.6 Complete the testing of the remaining three test units, reversing the one specimen as in 7.5 for each succeeding measurement.

8. Calculations

8.1 Determine the average angle, to the nearest 0.5 degree, at which sliding begins for the five determinations. This will be for either the first slide or for the third slide.

8.2 Calculate the coefficient of friction by finding the tangent of this angle in a suitable table of trigonometric functions.

9. Report

9.1 Report the average angle of slide. Also report the orientation of the test specimens and the face of the material tested and report whether the first or third slide was recorded.

9.2 Report the average coefficient of friction calculated from the average angle of slide and report any alternative conditions as in 9.1.

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10. Precision

10.1 For the maximum expected difference between two test results, each of which is the average of five test determinations, the following applies only to untreated, uncoated packaging papers (third slide). Repeatability and reproducibility are derived from data provided by CTS on January 11, 2023.

10.1.1 Repeatability (within a laboratory) = 8.64%.

10.1.2 Reproducibility (between laboratories) = 28.56%; in accordance with the definitions of these terms in TAPPI T 1200 "Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility."

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11. Keywords

Slide angle, Friction factor, Friction, Packaging materials, Packaging papers, Bag papers, Inclined planes, Paperboard, Container boards, Shipping containers, Multiwall bags.

12. Additional information

12.1 Effective date of issue: To Be Assigned.

12.2 This method is written specifically for the inclined-plane apparatus and is confined to the measurement of static friction. Commercial instruments are available for measuring the coefficient of static friction by moving a similar sled on a horizontal plane and measuring the force required for relative movement (TAPPI T 549). Some manufacturers claimed some of these were appropriate for determining the coefficient of kinetic friction (sliding friction). By measuring speeds, an inclined-plane instrument may also be used for measuring sliding friction, but not with the same precision as the static coefficient. The static coefficient is usually of greater importance. For most packaging materials, the static and kinetic coefficients are usually correlated, that is a surface with a high static coefficient will usually (but not always) have a higher kinetic coefficient (*2*). Not all surfaces retain this relationship, particularly those with some surface treatment such as wax. Therefore if it is desirable to know the kinetic coefficient, it should be measured. There is no TAPPI test method for determining the kinetic coefficient of packaging papers, but TAPPI T 549 may be referenced.

12.3 An important requirement of this procedure is the provision to slide the specimen three times prior to making a reading, particularly when a frictionizing treatment has been made to the surface. Normal handling often reduces the effectiveness of this treatment and of course it would be best to test the surface just as it will be used in actual shipment, but if the handling history of the samples to be tested is unknown, making two slides before recording the slide angle can significantly reduce the variability of test results (*3*,*4*) and have those results correlate better with the packaging material after its conversion into the final package. However, there have been other studies (*5*) which show less variability on the first slide, especially with untreated papers, and thus the additional time required to make the three slides may not be warranted.

12.4 It is recognized that factors other than friction influence the resistance of packages to slip during handling, warehousing and transit. There is no direct correlation between static friction and smoothness or roughness of the surfaces (*2*).

12.5 Paper is a compressible, viscoelastic material and the indicated angle of slide is dependent upon dwell time and the pressure applied at the time of measurement. The selection of 1.4 kPa (0.2 psi) is based on the pressure normally applied in filled multiwall shipping sacks in most applications.

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12.6 The initial dwell time of 10 s is important. Molecular bonding, to varying degrees, begins between two surfaces as soon as they are brought into contact. The bonding is the reason that starting friction is usually greater than sliding friction. With packaging papers, the increase in bonding appears to occur in the first 15 s of contact and the 10 s dwell time seems to be a reasonable compromise between accuracy and expediency (*4*).

12.7 The foam padding on the surface of the sled more closely simulates the non-rigid contact normally found between packages. The foam also compensates for any small deviations in flatness of the plane or sled and reduces the likelihood of the hard edge of the sled from influencing the results of tests on very thin or soft papers.

12.8 If the sample is coated and/or printed, the friction may not be uniform overall, therefore, different areas of the sample may give different test results. The coefficient of friction is extremely sensitive to very small degree of contamination with materials which impart slipperiness.

12.9 Friction of the packaging material against another surface can be determined as well by substituting that surface material for the test specimen that is to be mounted directly on the inclined plane.

12.10 *Testing erected and filled packages*: With most commercially available instruments, it is not possible to test actual packages unless they are unusually small (e.g. folding cartons). However, some inclined-plane instruments are large enough to test whole packages (corrugated and solid fiber shipping containers and multiwall shipping sacks). With such equipment, perform the test as follows:

NOTE 4: The package should be filled with the material to be shipped or simulated with material of like density. Therefore, it would be possible that the pressure on the lower test surface would not conform to 4.2.1 in some instances.

12.10.1 Characteristics for the inclined plane shall conform to the specifications in 4.2.2.

12.10.2 Clamp one paper or board specimen (top of a bag or box) to the inclined plane; or if friction is to be measured against another surface such as a metal chute or rubber conveyor belt, clamp or otherwise fix that material to the inclined plane.

12.10.3 Place the filled package to be tested on top of the test surface with the plane in its horizontal position. Orientation should correspond to the orientation of the two surfaces in actual use. Remember to reverse the direction 180° for each succeeding determination for each test specimen or package that is oriented MD to the direction of slide.

12.10.4 After a 10 s dwell time, raise the inclined plane at the prescribed rate (4.2.2.1) until sliding just begins. Stop the inclination.

12.10.5 If it is known that the packaging material has not been treated with a frictionizing material, record the angle at which sliding has begun. If it is known that treatment has been applied or if this condition is unknown, repeat

12.10.3 and 12.10.4 twice with the same package and record the angle at which sliding begins on the third slide.

12.10.6 Repeat 12.10.2 through 12.10.5 for four more packages.

12.10.7 Calculate the average angle at which sliding begins for the five determinations. Find the tangent of that angle and report this as the coefficient of static friction.

12.11 Related Methods: TAPPI T 549 "Coefficients of Static and Kinetic Friction of Uncoated Printing and Writing Papers by Use of the Horizontal Plane Method."

12.12 Changes in the 2012 version were editorial corrections. Changes in the 2022 version were editorial corrections as well as adding a new updated precision statement from CTS.

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Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department.