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Coefficient of static friction (slide angle) of packaging and packaging materials (including shipping sack papers, corrugated and solid fiberboard) (inclined plane method)

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 that angle.

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.

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

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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 $1.5^\circ \pm 0.5^\circ/\text{s}$ 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.