Designation: F392 – 93 (Reapproved 2004)

Standard Test Method for Flex Durability of Flexible Barrier Materials[1]

This standard is issued under the fixed designation F392; 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 covers the determination of the flex resistance of flexible barrier materials. Pinhole formation is the criterion presented for measuring failure, but other tests such as gas-transmission rates can be used in place of the pinhole test.

1.2 *This standard does not purport to address all of the safety problems, 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.* Specific precautionary statements are given in 5.7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D722 Test Method for Grease Resistance of Paper

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Summary of Test Method

3.1 Specimens of flexible materials are flexed at standard atmospheric conditions (23°C and 50 % relative humidity), unless otherwise specified. Flexing conditions and number and severity of flexing strokes vary with the type of structure being tested. The flexing action consists of a twisting motion followed, in most cases, by a horizontal motion, thus, repeatedly twisting and crushing the film. The frequency is at a rate of 45 cpm.

3.2 Flex failure is determined by measuring the pinholes formed in the structure. These pinholes are determined by using colored turpentine and allowing it to stain through the holes onto a white backing. In addition, other failure criteria such as gas permeation or moisture-vapor transmission can be used at the discretion of the tester.

3.3 The various test conditions are summarized as follows:

3.3.1 *Condition A*— Full flex for 1 h (that is, 2700 cycles).

3.3.2 *Condition B*— Full flex for 20 min (that is, 900 cycles).

3.3.3 *Condition C*— Full flex for 6 min (that is, 270 cycles).

3.3.4 *Condition D*— Full flex for 20 cycles.

3.3.5 *Condition E*— Partial flex only for 20 cycles.

4. Significance and Use

4.1 This test method is valuable in determining the resistance of flexible-packaging materials to flex-formed pinhole failures.

4.2 This test method does not measure any abrasion component relating to flex failure.

4.3 Physical holes completely through the structure are the only failures measured by the colored-turpentine-pinhole portion of this test. Failures in the integrity of one of the plies of a multi-ply structure will not be determined by the colored-turpentine test. Gas permeation or moisture vapor transmission tests, or both, can be used in conjunction with the flex test to measure the loss of ply integrity. However, any permeation test requiring a pressure differential will not measure the permeation coefficient in the presence of pinholes.

4.3.1 The various conditions described in this procedure are to prevent testing a structure under conditions that either give too many holes to effectively count and be significant (normally greater than 50), or too few to be significant (normally less than five per sample).

4.4 Measurements on nylon film, possibly because of its hydrophilic nature, have not shown good reproducibility (between laboratories), although the repeatability of the data within a laboratory was good.

5. Apparatus and Reagent

5.1 *Flex Tester*, [3] designed so that it can be set up in accordance with the specifications listed in Section 8. This apparatus shall consist essentially of a 90-mm (3.5-in.) diameter stationary mandrel and a 90-mm diameter movable mandrel spaced at a distance of 180 mm (7 in.) apart from face-to-face at the starting position (that is, maximum distance) of the stroke. Mandrels shall contain vents to prevent pressurization of samples. The specimen supporting shoulders on the

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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 Gelbo Tester, which is capable of producing the prescribed flexing action, available from the United States Testing Co., Inc., 1415 Park Ave., Hoboken, NJ 07030, or its equivalent, has been found satisfactory for this test method.

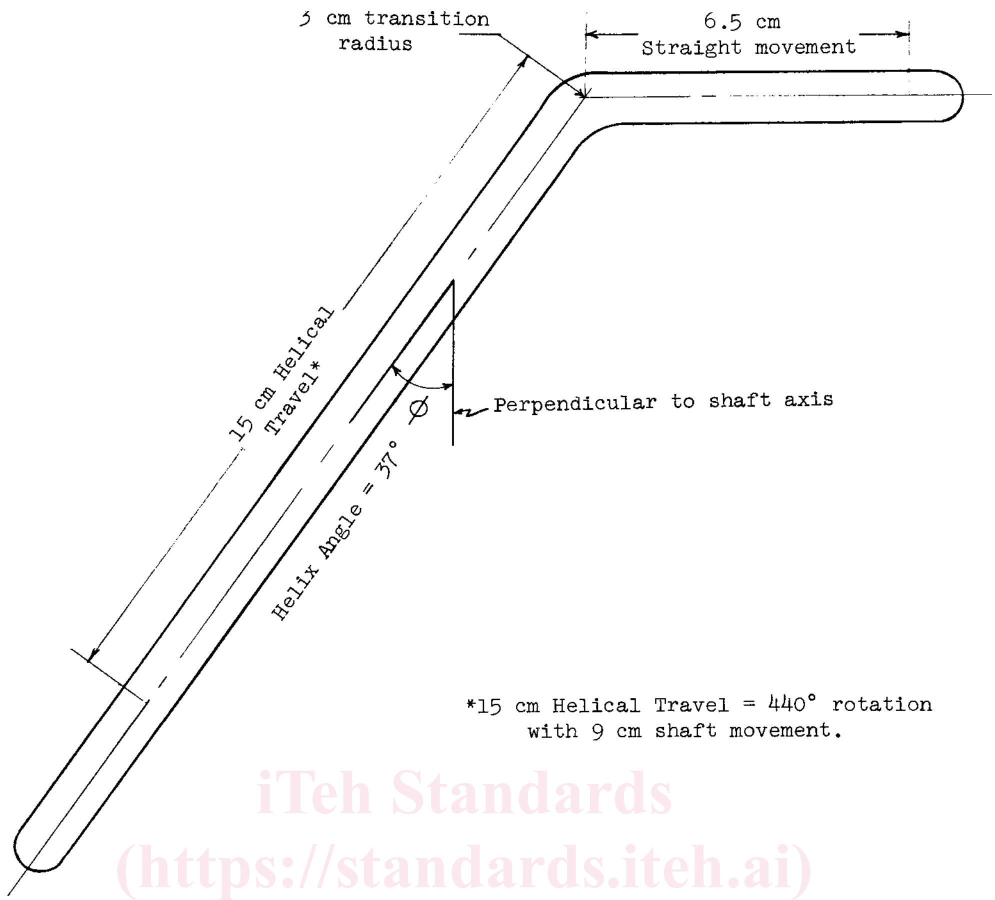

FIG. 1 Planar Evolution of Gelbo Shaft Helical Groove (31.8-mm (1.25-in.) Diameter Shaft)

mandrels shall be 13 mm (0.5 in.) wide. The motion of the movable mandrel is controlled by a grooved shaft to which it is attached. For the full or maximum stroke the groove is designed to give a twisting motion of 440° in the first 90 mm of the stroke of the movable mandrel, followed by a straight horizontal motion of 65 mm (2.5 in.), so that at the closed position the mandrels are 25 mm (1 in.) apart. The motion of the machine is reciprocal with a full cycle consisting of the forward and return strokes. The machine operates at 45 cpm.

5.1.1 Fig. 1 shows the planar evolution of the helical groove in the driven shaft to give the required 440° (37° helix angle) twisting motion and the straight horizontal motion.

5.1.2 For the partial flex used with Condition E the movable head is set to travel only 80 mm (3.25 in.) of the 180-mm (7-in.) spacing. Therefore, only approximately 90 % of the twisting stroke is utilized giving a twisting motion of only 400°, and none of the horizontal stroke is utilized.

5.2 *Tape*, flexible, double-sided, pressure-sensitive, not more than 13 mm (0.5 in.) wide.

5.3 *Template*, for cutting 200 by 280-mm (8 by 11-in.) samples.

5.4 *Paint Brush*, large, 50 to 150 mm wide.

5.5 *Tissue Paper*, absorbent.

5.6 *White Paper*, such as uncoated bond paper, at least as large as the film samples.

5.7 *Turpentine* (*Colored*, *Water-Free*)—To 100 mL of pure gum spirits of turpentine (chemically pure grade, sp gr 0.860 to 0.875 at 15°C) add 5 g of anhydrous calcium chloride ($CaCl_2$) and 1.0 g of oil-soluble red dye. Stopper the container, shake well, and let stand for at least 10 h, shaking occasionally. Then filter through a dry filter paper at a temperature of approximately 21°C, and store in an airtight bottle.

NOTE 1—**Caution:** Use of these materials requires that appropriate safeguards be used to avoid hazards of skin contact, inhalation, and flammability.

6. Test Specimens—All Conditions

6.1 Cut the samples into 200 by 280-mm (8 by 11-in.) flat sheets with the 200-mm dimension in the direction to be tested. This will also be in the direction of the flex-tester axis.

6.2 Flex test four specimens in their machine direction and four in their transverse direction. In addition, test a control set of four, adjacent, unflexed specimens (either direction) for pinholes.

6.3 Do not seal or tape the sides of the specimens, but leave them open. Use double-sided pressure-sensitive tape, not more than 13 mm (0.5 in.) wide, to attach the unsealed specimen in the shape of a cylinder to the flex-tester mandrels.

7. Conditioning

7.1 Condition the specimens for at least 24 h at 50 ± 5 % relative humidity and 23 ± 2°C, unless otherwise specified as agreed upon between the purchaser and the seller. (See Practice D618 for other standard atmospheric conditions.)