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Standard Practice for Conditioning Flexible Barrier Materials for Flex Durability[1]

This standard is issued under the fixed designation F392/F392M; 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 practice covers conditioning of flexible barrier materials for the determination of flex resistance. Subsequent testing can be performed to determine the effects of flexing on material properties. These tests are beyond the scope of this practice.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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 *ASTM Standards:*[2]

E171 Practice for Conditioning and Testing Flexible Barrier Packaging

F2097 Guide for Design and Evaluation of Primary Flexible Packaging for Medical Products

3. Terminology

3.1 *pinhole, n*—a small opening of non-specific shape or dimension that passes completely through all layers of a flexible material.

3.1.1 *Discussion*—The use of the term "pin" provides the relative size reference as in a small hole made with or as if with a pin.

4. Summary of Practice

4.1 Specimens of flexible materials are flexed at standard atmospheric conditions defined in Specification E171, 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 cycles per minute (cpm.)

4.2 Flex failure is determined by measuring the effect of the flex conditioning on the barrier and/or mechanical performance of the structure. The property to be evaluated determines the appropriate conditioning level.

4.3 The various flex conditioning levels are summarized as follows:

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

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

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

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

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

5. Significance and Use

5.1 This practice is valuable in determining the resistance of flexible-packaging materials to flex-formed pinhole failures. Conditioning levels A, B, or C are typically used for this evaluation.

5.2 This practice is valuable for determining the effect of flexing on barrier properties such as gas and/or moisture transmission rates. Conditioning levels D or E are typically used for this evaluation.

5.3 This practice does not measure any abrasion component relating to flex failure.

5.4 Failures in the integrity of one or more of the plies of a multi-ply structure may require different testing than the detection of holes completely through the structure. Permeation tests using gas or water vapor 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. For a list of test methods refer to Guide F2097.

5.4.1 The various conditions described in this procedure are to prevent testing a structure under conditions that either give

[1] This practice is under the jurisdiction of ASTM Committee F02 on Flexible Barrier Packaging and is the direct responsibility of Subcommittee F02.50 on Package Design and Development.

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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.

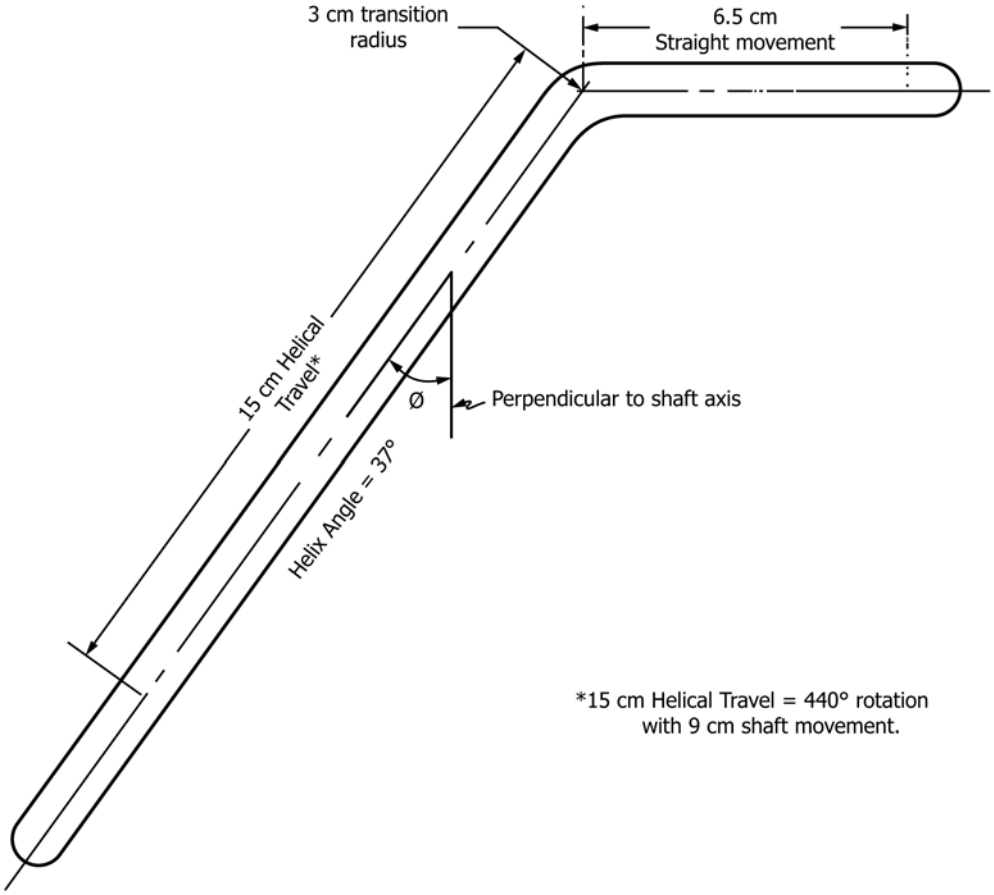

FIG. 1 Planar Evolution of Gelbo Shaft Helical Groove 30.70-mm [1.20-in.] Diameter Shaft)

too many holes to effectively count (normally greater than 50), or too few to be significant (normally less than five per sample). Material structure, purpose for testing and a mutual agreement between parties involved are important points to consider in the selection of conditioning level for testing.

6. Apparatus

6.1 *Flex Tester,* [3] designed so that it can be set up in accordance with the specifications listed in Section 9. This apparatus shall consist essentially of a 90 ± 1-mm [3.5-in.] diameter stationary mandrel and a 90 ± 1 mm diameter movable mandrel spaced at a distance of 180 ± 2 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 mandrels shall be 13 ± 1 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 ± 4° 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 ± 1 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 ± 2 cpm.

6.1.1 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.

6.1.2 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.

6.2 *Tape,* flexible, double-sided, pressure-sensitive, not more than 13 mm [0.5 in.] wide.

6.3 *Template,* for cutting 200 by 280 ± 2-mm [8 by 11-in.] samples.

7. Test Specimens—All Conditions

7.1 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.

7.2 Flex condition four or more specimens in their machine direction and an additional four or more in their transverse direction. In addition, collect an equal number of control specimens from adjacent locations to undergo the same tests for pinholes and/or barrier properties.

[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 practice.

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

8. Environmental Conditioning

8.1 If appropriate, condition the specimens for at least 24 h at 50 ± 5 % relative humidity and 23 ± 2°C, unless otherwise specified in agreements.

9. Procedure

9.1 *Flexing:*

9.1.1 *Atmospheric Conditions*—If required, conduct flexing at the standard atmospheric conditions of 23 ± 2°C and 50 ± 5 % relative humidity, unless otherwise specified.

9.1.2 *Flex Tester Setup*—Setup the flex tester for maximum throw and twisting action. This setup gives a twisting motion of 440° in the first 90 mm [3.5 in.] of stroke, and is followed by a straight horizontal motion of 65 mm [2.5 in.] at 45 cpm. With this setup, space the face of the moving mandrel at a distance of 180 mm [7 in.] from the face of the stationary mandrel when the moving mandrel is at its starting position. In the closest position the moving mandrel is 25 mm [1 in.] from the stationary mandrel. Attach the long edges of the flexible barrier specimen to the flex-tester mandrels, which have been lined with double-sided pressure-sensitive tape. Hose clamps may also be used to supplement the double-sided tape to secure the specimen to the mandrels.

9.1.3 *Condition A*—Turn the flex tester on, and allow the specimen to flex for 1 h at 45 cpm (that is, 2700 cycles).

9.1.4 *Condition B*—Test conditions are the same as Condition A, except that the flex period is 20 min at 45 cpm (that is, 900 cycles at full flex and twisting action).

9.1.5 *Condition C*—Test conditions are the same as Condition A, except that the flex period is 6 min at 45 cpm (that is, 270 cycles at full flex and twisting action).

9.1.6 *Condition D*—Test conditions are the same as Condition A, except that the flex period is 20 cycles at 45 cpm (that is, 20 cycles at full flex and twisting action).

9.1.7 *Condition E*—Set up the flex tester for the partial flex described in 9.1.2 with the following exception: the movable head is set to travel only 80 mm [3.25 in.] of the 180-mm [7-in.] spacing (the distance between the mandrels at their maximum separation or starting position). Therefore, only about 90 % of the twisting stroke giving a twisting motion of only 400° is utilized and none of the horizontal stroke is utilized. When the mandrels are at their closest position they will be 95 mm [3.75 in.] apart. The partial flex period under this "short stroke" setup will be 20 cycles at 45 cpm.

9.2 *Determination of Results:*

9.2.1 Remove the flexible barrier specimen from the flex tester and mark the 150 by 200-mm [6 by 8-in.] center location. Samples for flex durability testing, for either pinholes or ply integrity, should be taken from this region.

9.2.2 Perform the test method to be used to measure the property required after conditioning for flex. Proceed with testing material sample as directed by test method standard.

10. Report

10.1 The report shall include the following:

10.1.1 Flex Conditioning level, including the number of cycles and whether full or partial flex was used.

10.1.2 Identification of the test method(s) used to determine presence of pinholes or effect on barrier properties. Report data as individual and average pinhole count per 300 cm^2 [48 $in.^2$] in machine direction and in transverse direction or with other units as appropriate for test method used.

10.1.3 Report data on unflexed control in appropriate units for method used to test.

10.1.4 Sample conditioning and test conditions used, and where applicable, sample thickness and structure.

10.1.5 Report any unusual failures such as tears.

10.1.6 Description of deviations from the indicated practice.

11. Keywords

11.1 barrier; barrier materials; flex crack; flex resistance; flexible; gas permeation; gas transmission rate; pinhole ; water vapor transmission rate; WVTR