Designation: ~~F3300 – 18~~ F3300 – 23

Standard Test Method for Abrasion Resistance of Flexible Packaging Films Using a Reciprocating Weighted Stylus[1]

This standard is issued under the fixed designation F3300; 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 abrasion resistance of flexible non-conductive films and packaging materials using a weighted stylus that wears completely through a film by oscillating or reciprocating back and forth along a linear path until an electrical circuit is completed shutting down the test.

1.2 *Units*—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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing
D6988 Guide for Determination of Thickness of Plastic Film Test Specimens
E171/E171M Practice for Conditioning and Testing Flexible Barrier Packaging
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
F2251 Test Method for Thickness Measurement of Flexible Packaging Material

3. Terminology

3.1 *Definitions:*

3.1.1 ~~*abrasion—*~~*abrasion, n—*the wearing away of any part of a material by rubbing against another surface.

[1] This test method is under the jurisdiction of ASTM Committee F02 on Primary Barrier Packaging and is the direct responsibility of Subcommittee F02.20 on Physical Properties.

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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.

3.1.2 *abrasion ~~cycle—~~cycle, n—in abrasion testing*, one or more movements of an abradant across a material surface, or the material surface across an abradant, that permits a return to its starting position.

3.1.2.1 *Discussion—*
In the case of the linear abrading device, an abrasion cycle consists of one complete forward and one complete backward stroke.

3.1.3 *abrasion ~~resistance—~~resistance, n—in abrasion testing*, the ability of a material to withstand ~~degradation~~wear caused by the rubbing of one material against another.

3.1.4 *~~durability—~~durability, n—*the ability of a material to withstand deterioration from the sum of all sources.

3.1.5 *non-conductive ~~film—~~film, n—*any film used in this test method that allows the stylus to completely abrade through the film, making a hole, and does not prematurely stop the test before the hole is made.

3.1.5.1 *Discussion—*
The stylus (on one side of the film) and the mandrel (on the other side of the film) form part of an electrical circuit that signals the end of the test. Wearing a hole through a non-conductive film closes the circuit and stops the test. A conductive film would conduct electricity between the stylus and the mandrel before the film completely abrades through and prematurely signal the end of the test.

4. Summary of Test Method

4.1 A specimen is abraded using a linear rubbing action. The test specimen, mounted over a mandrel and held in place by two plates, is rubbed back and forth with the hemispherical tip of a special stylus. The hemispherical tip rubs the specimen until it abrades through the film, contacts the mandrel below the film, and the test is automatically stopped. Resistance to abrasion in this test method is reported as the number of back-and-forth cycles to breakthrough. Variables that influence the rubbing action are pressure on the specimen, temperature, relative humidity, and speed.

5. Significance and Use

5.1 Materials such as engineered thermoplastic films are often used for flexible barrier packaging. However, handling and transportation can cause abrasion to the packaging film and possibly compromise the integrity of the contents ~~(e.g.,~~ (for example, sterility of a medical device). This test method provides a comparative ranking of material performance that can be used as an indication of relative end-use performance.

5.2 The resistance of material surfaces to abrasion, as measured on a testing machine under laboratory conditions, is only one of several factors contributing to wear performance or durability as experienced in the actual use of the material. While abrasion resistance and durability are frequently related, the relationship varies with different end uses and different factors may be necessary in any calculation of predicted durability from specific abrasion data.

5.3 The resistance of material surfaces to abrasion may be affected by factors including test conditions of temperature and humidity, type of abradant, pressure between the specimen and abradant, mounting or tension of the specimen, and type, kind, or amount of finishing materials such as coatings or additives. Other causes of variation include local material movement during testing, material direction alignment, material characteristics, and mandrel and stylus wear. For consistency, samples to be evaluated under special environmental conditions shall be conditioned under those same conditions. It is important that the test instrument be shown to operate properly under special environmental conditions.

5.4 This test method may not be suitable for all films, including the following cases:

5.4.1 Films that stretch and generate a ripple in the abraded region during testing,

5.4.2 Films that have a thickness greater than 0.25 mm (0.010 in.), or are of such rigidity that forming over the mandrel would cause internal stresses that weaken the film, and

5.4.3 Conductive films.

6. Apparatus

6.1 *Linear Abrading Device*,[3] as shown in Fig. 1, consisting of the following elements:

6.1.1 *Crank-Slide Drive Mechanism* (not shown) to operate an oscillating arm in a linear distance of 25.4 mm (1 in.) at a speed of 30 ~~cycles/min,~~cycles/min or as agreed upon by the interested parties,

6.1.2 *Splined Shaft,* such that it cannot rotate during the test, mounted vertically at the end of the oscillating arm,

6.1.3 A means to increase the vertical force on the stylus. This may be as simple as adding additional mass to the top of the splined shaft,

6.1.4 Attachment affixed to the end of the splined shaft to securely hold the stylus perpendicular to the test specimen,

6.1.5 Mechanism to keep stylus off specimen surface until time of test,

6.1.6 Means to automatically stop the test when the stylus abrades through the specimen and contacts the mandrel, and

6.1.7 *Specimen Table,* to which the flexible material holder can be secured.

6.2 *Accessory Weight Holder and Weights,* which can be perched on top of the splined shaft to change the load applied to the specimen.

6.2.1 *Flexible Material Holder,*—as shown in Fig. 2, consisting of a mandrel, base, and top plate to secure the specimen so that it is held rigidly during testing. The bottom plate shall have a ~~6.35 mm (0.25 in.)~~ 6.35 mm (0.25 in.) radius or cradle to accept the mandrel and have three holes to assist with alignment and set-up (see Fig. 3). The top plate shall include a 6.35 mm (0.25 in.) radius that is 5.60 mm (0.22 in.) deep to secure the specimen and mandrel and include a cutout center slot through which the stylus will be able to contact the test specimen. The mandrel shall have a diameter of ~~11.94 mm (0.47 in.)~~ 11.94 mm + 0.05 mm (0.47 in. + 0.002 in.) and include a hole to insert a banana plug for the automatic shut-off system.

FIG. 1 Linear Abrading Device

[3] The sole source of supply of the apparatus known to the committee at this time is Taber® Industries, 455 Bryant Street, North Tonawanda, NY 14120. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

FIG. 2 Flexible Material Holder

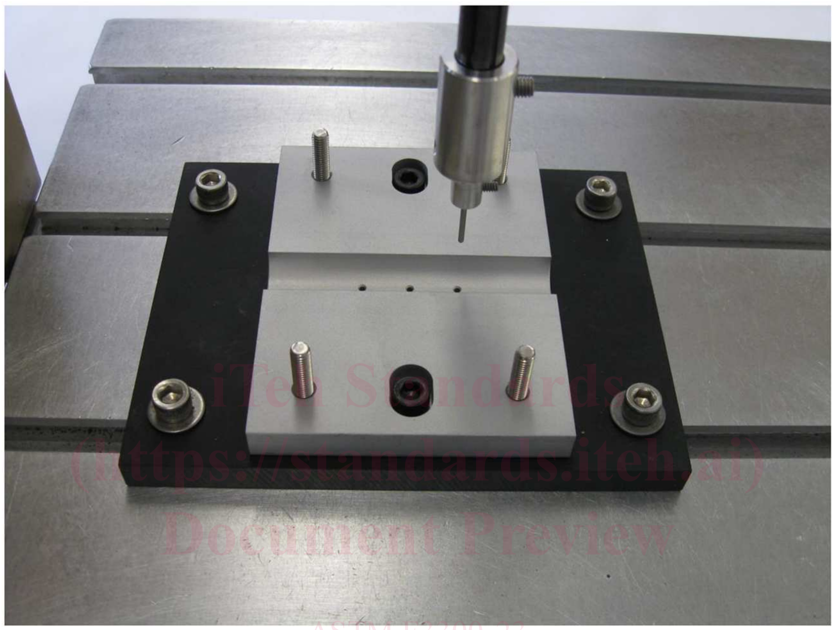

FIG. 3 Proper Alignment for Fixture Base

6.2.2 *Stylus,* which is of sufficient length to be anchored securely in the stylus holder mounted on the splined shaft with enough exposed length for the stylus holder to avoid rubbing against the upper sample holder plate. The stylus shall be ~~1.5 ± 0.1 mm~~ 1.5 mm ± 0.1 mm (0.059 in. ± 0.004 in.) in diameter and have a hemispherical tip of the same diameter. The stylus shall be made from steel heat treated to a hardness of Rockwell C55 to C61 and the spherical radius shall have a surface finish of ~~8 rms.~~8 rms.

7. Specimen Preparation

7.1 *Specimen Size*—Specimens shall be cut in a rectangular shape to a minimum of 38 mm (1.5 in.) wide and 50 mm (2 in.) long. Half of the specimens should be cut with the long side of the rectangle parallel to the film machine direction. The remainder of the specimens should be cut with the long side parallel to the film transverse direction. The long side of the rectangle is parallel to the linear path of stylus travel. The short side of the rectangle must be narrow enough to allow the film to lay flat on the base and not bunch up around the positioning pins of the flexible material holder. Material thickness shall be less than 0.25 mm (0.01 ~~in.).~~ in.), unless otherwise agreed upon by the interested parties.

7.2 Using an indelible marker, label each specimen with sample identification, such as machine direction and sample number. Other useful information may include, for example, sealant versus non-sealant side and top versus bottom for non-symmetric film. Markings shall not be in the path of the stylus movement.~~.~~

7.3 When testing different types of materials or film structures for comparison purposes, it is advised to measure film thickness in accordance with either Guide D6988 or Test Method F2251 before the test. To simplify comparison testing, it is recommended that the same weight should be used on the stylus for all samples, letting the number of cycles to breakthrough differentiate the abrasion resistance.

8. Preparation of Apparatus

8.1 The pressure of the top plate against the sample should prevent film distortion or movement during testing.

NOTE 1—If there are concerns of slippage during a test, a piece of double-sided pressure-sensitive adhesive tape, such as 3M 9492MP, may be applied to the recessed portion of the flexible material holder top plate as a way to prevent specimen movement during the test.

8.2 The stylus shall be inserted into its holder such that the hemispherical end is exposed.

NOTE 2—The condition of the abrading tip of the stylus should be monitored and the stylus replaced when test results are affected. Alternatively, the stylus may be replaced according to a preventive maintenance schedule. Do not allow the stylus to rub against any hard or rough surface. Wear may be evaluated either with the use of a microscope or by control charting the number of cycles to breakthrough of a control film. A control film can be any lot of film similar to those undergoing abrasion testing in which the analyst has confidence in the consistency of its abrasion resistance. This control film can be set aside and periodically sampled and tested to generate a body of data that validates the confidence in the test and the equipment.

8.3 *Stroke Length*—~~Set the stroke length using the~~ Using the recommended method given in the instrument ~~instructions (see~~ instructions, set the stroke length as specified in 6.1.1~~).~~ unless otherwise agreed upon by the interested parties.

8.4 *Speed*—Set the speed using the recommended method given in the instrument instructions. A typical starting point is 30 cycles/min (see 6.1.1).

8.5 *Load*—The weight applied to the film sample is the sum of the shaft-stylus assembly of the instrument and any added weights. For the apparatus described in 6.1, the shaft-stylus assembly consists of a standard weight holder, a splined shaft, a stylus holder and a stylus. One approach to the selection of a starting weight applied to the film may be found in Appendix X1.

NOTE 3—The weight of the shaft-stylus assembly is provided by the instrument manufacturer. Disassembling the spline shaft from the instrument is not recommended due to possible damage to the bearing guiding the shaft.

NOTE 4—Sets of weights may be obtained from the manufacturer that fit the standard weight holder. These have been scribed and weighed to the nearest gram and may be used without re-weighing.

8.6 *Alignment of Flexible Material Holder*—Sections 8.6.1 – 8.6.4 describe the alignment procedure for the base plate of the flexible material holder to a specimen table or other type of mounting fixture that is attached to or incorporated in the linear abrading device.

8.6.1 Position the oscillating arm so it is at the end of its stroke (to the right most position). Align the base plate by lowering the stylus into the right most alignment hole. Lift the stylus out of the hole (see Fig. 3).

8.6.2 Position the oscillating arm so it is at the beginning of its stroke (to the left most position). Lower the stylus into the left most alignment hole. If necessary, pivot the position of the base plate so the stylus can be lowered into the left alignment hole.

8.6.3 Once aligned, tighten the fasteners to secure the base plate of the flexible material holder to the specimen table.

8.6.4 Verify that the base plate is properly aligned by following 8.6.1 and 8.6.2, and adjust as necessary.

8.7 *Test Cycles*—Set the number of cycles to breakthrough to a number greater than 1000 unless otherwise specified. With the automatic shutoff, the linear abrading device will stop automatically should the stylus abrade through the specimen material before the number of cycles is completed.

8.8 *Automatic Shutoff*—Follow the manufacturer's recommended instructions to connect the automatic shutoff feature to the linear abrading device and flexible material holder.

9. Conditioning

9.1 Prior to testing, condition all specimens according to established procedures specific to the material being evaluated or as agreed upon between the interested parties. If none are specified, condition samples in accordance with either Practice E171/E171M or D4332.

10. Procedure

10.1 Visually inspect the test specimen to ensure it is free from blemishes, imperfections, particulate matter, or debris. If any are found, discard and select a new test specimen.

10.2 Place one test specimen over the recess of the top plate with the desired film direction parallel to the testing direction and the side to be tested facing the recess. Center the mandrel over the specimen, then use a gentle force to press the mandrel into the recess while ensuring that there are no wrinkles in the specimen.

NOTE 5—For non-symmetric laminated film structures, it is recommended to test both sides or the side where abrasion failures are likely to occur. This approach should also be considered for films that have a sealant.

10.3 Carefully place the mandrel and top plate of the flexible material holder in position over the bottom plate. Fasten two thumb nuts at a diagonal from each other, until all four fasteners are tight and the specimen is secured in place.

NOTE 6—Sections 10.2 and 10.3 describe one method of mounting film. Other methods are possible. The goal is to mount the film securely without wrinkles and for the film to remain unwrinkled by the abrasion action.

10.4 Position the oscillating arm so that the stylus is located at the beginning of its stroke (to the left most position).

10.5 Prior to each test, clean the stylus with isopropyl alcohol. Load the desired weight on the shaft.

10.6 Gently lower the stylus onto the specimen and begin the test immediately (see Fig. 4). Do not allow the stylus to drop onto the specimen.

NOTE 7—The stylus should not sit on the specimen surface for longer than 2 s before the test commences. Otherwise, the stylus may indent the specimen, which can have an influence on the test results.

10.7 When breakthrough occurs, testing will automatically cease. Raise the stylus and remove the specimen. Examine the specimen to be sure that the stylus abraded completely through the specimen.

10.8 Record the number of abrasion cycles to breakthrough and the total weight applied.

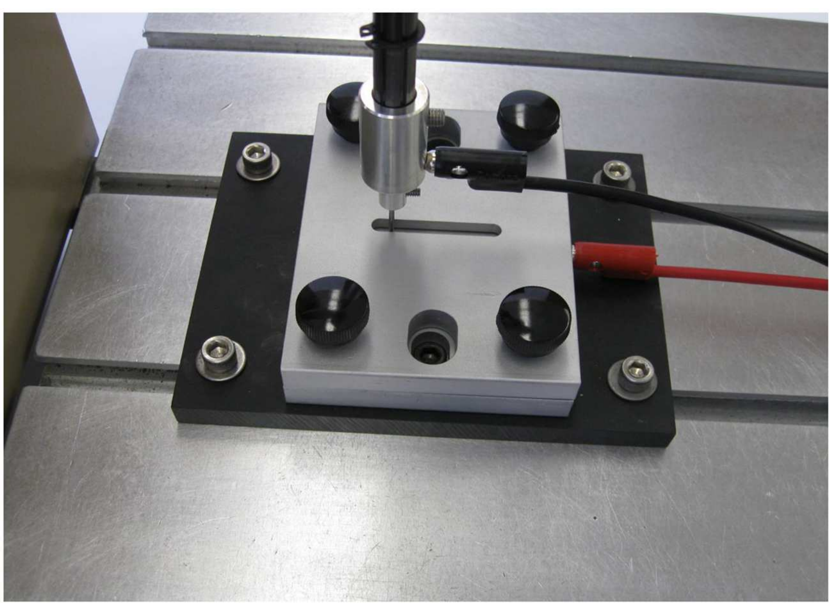

FIG. 4 Close-up of Test Set-Up

10.9 Repeat 10.1 – 10.8 for replicates of the film using the load as determined in 8.5. Statistical methods should be employed to determine the number of replicates. Calculate the average of the test results and standard deviation.

11. Interpretation of Results

11.1 *Cycles to Breakthrough*—The number of cycles to breakthrough provides an indication of abrasion resistance. Generally, the greater the number of cycles, the higher the abrasion resistance.

12. Report

12.1 State that the specimens were tested in accordance with Test Method F3300. Describe the product sampled, including characteristics such as machine or cross machine (transverse) direction, film structure, side in contact with the stylus, and number of samples per web width.

12.2 Report the following information:

12.2.1 Identification of the equipment used,

12.2.2 Temperature and humidity during conditioning and at time of testing,

12.2.3 Total weight applied,

12.2.4 ~~Film thickness,~~Thickness of each sample tested,

12.2.5 Number of cycles to breakthrough for each of the specimens tested,

12.2.6 Average and standard deviation of the number of cycles to breakthrough if replicate testing is performed, and

12.2.7 Any deviation from the procedure described in this test method.

13. Precision and Bias

13.1 The precision of this test method is based on an interlaboratory study conducted in 2015. Eight laboratories tested several variations of three packaging films. Every "test result" represents an individual determination, and the laboratories reported five replicate test results for each material combination. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report RR:F02-1042.[4]

13.1.1 ~~*Repeatability,*~~ *Repeatability Limit, r*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

13.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.1.2 Repeatability limits are listed in Table 1.

13.1.2 ~~*Reproducibility,*~~ *Reproducibility Limit, R*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

13.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F02-1042. Contact ASTM Customer Service at service@astm.org.