Designation: D 5459 – 95 (Reapproved 2001)

Standard Test Method for Machine Direction Elastic Recovery and Permanent Deformation and Stress Retention of Stretch Wrap Film[1]

This standard is issued under the fixed designation D 5459; 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 measurement of recovery from extension, permanent deformation, and stress retention of stretch wrap film.

1.2 Several levels of extension are included to ascertain the effect of both small and large extensions.

1.3 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.4 *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:*

D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting[2]

D 1898 Practice for Sampling of Plastics[2]

D 996 Terminology of Packaging and Distribution Environments[3]

D 2103 Specification for Polyethylene Film and Sheeting[2]

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process[4]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

3. Terminology

3.1 *Definitions:* General definitions for packaging and distribution environments are found in Terminology D 996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *elastic recovery*—the percentage of a given deformation that behaves elastically, after 180 s when subjected to the extensions prescribed in this test method.

3.2.2 *permanent deformation*—the increase in length, expressed as a percentage of the original length, by which an elastic material fails to return to original length after subjected to the extensions prescribed in the test procedure in this method.

3.2.3 *stress retention*—the percentage of stress retained 60 s or 24 h, or both, after application.

4. Summary of Test Method

4.1 Elastic properties of the films are determined by subjecting specimens to known extensions and by measuring the quantity of recovery and the permanent change with respect to the original dimensions.

5. Significance and Use

5.1 Elastic recovery is related to the ability of a package to resume its original shape after being distended during its use cycle.

5.2 Elastic recovery also relates to the tightness or snugness of a package.

5.3 Stress retention is related to the tightness or snugness of a package.

6. Apparatus

6.1 *Tensile Testing Machine*, with a reversible chart, complying with the requirements listed for Method A of Test Methods D 882 with grips satisfactory for the purpose. Refer to section on grips in Test Methods D 882.

6.2 *Specimen Cutter*, capable of producing nick-free 1 ± 0.001 in. (25.4 ± 0.03 mm) testing strips, with a precision of 1 ± 0.001 in. (25.4 ± 0.03 mm).[5]

6.3 *Micrometer*, capable of measuring the thickness of specimens to 0.001 in. (0.03 mm) as described in 8.9.1.1 of Specification D 2103.

7. Sampling

7.1 *Acceptance Sampling*—Sampling shall be in accordance with Practice D 1898.

7.2 *Sampling for Other Purposes*—The sampling and the number of test specimens depend on the purposes of the testing. Practice E 122 is recommended. Test specimens are taken from several rolls of film, and when possible, from

[1] This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.25 on Palletizing and Unitizing of Loads.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] A JDC-1-10 precision cutter is available from Thwing-Albert Instrument Co., 10960 Dutton Rd. Philadelphia, PA 19154, or similar manufacturers.

several production runs of a product. Strong conclusions about a specific property of a film cannot be based on a single roll of product.

8. Specimen Preparation

8.1 Cut five strips parallel to the machine direction that are 1.0 in. (25.4 mm) wide and long enough to provide for an initial grip separation of 5 in. (127 mm).

8.2 Measure the thickness of each specimen at five equally spaced points in the area that will be between the grips to the nearest 0.001 in. (0.003 mm) and record the values.

9. Preparation of Apparatus

9.1 Select a load range so that the scans cover approximately two-thirds of the chart width.

9.2 Calibrate the strain gage as directed by the manufacturer of the machine. Set the rate of grip separation at 5 in./min (127 mm/min) and the initial grip separation at 5 in. (127 mm).

10. Conditioning

10.1 *Sample Conditioning*—Condition the test specimens at the standard atmospheric condition for not less than 24 h prior to testing, as described in Practice E 691.

10.2 *Test Conditions*—Testing shall be conducted under the condition specified for specimen conditioning in 10.1.

11. Procedure

11.1 Clamp the first specimen in the grips so that it is free to slack but is not under tension.

11.2 Start the testing machine and chart, and elongate the specimen at 5 in./min (127 mm/min) to an extension of 15, 50, 100, 150 or 200 % and stop the testing machine and chart. (In Fig. 1, at extension AE, curve AB is generated.)

11.3 Wait 60 s or 24 h, during which time the specimen will relax. See Note 1. (In Fig. 1, extension BG is generated.)

NOTE 1—Slack in the specimen and misalignment of the grips are the major causes of non-linearity of the early part of the load-extension curves.

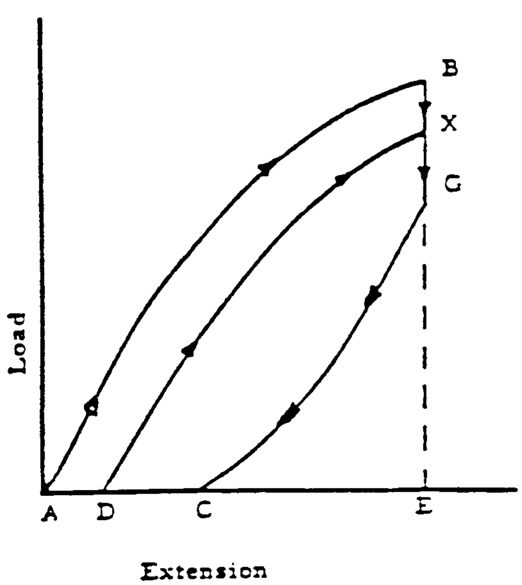

FIG. 1 Determination of the Elastic Properties of Films

11.3.1 When testing materials of unknown response, investigate a series of times for recovery.

11.4 Return the crosshead to the original grip separation, simultaneously reversing the chart. (In Fig. 1, curve GCA is generated.)

11.5 Wait 180 s.

11.6 Re-elongate the specimen to the same extension as used originally in 11.2. (In Fig. 1, curve ADX is generated.)

11.7 Repeat the procedure described in 11.1-11.6 on the other four specimens.

12. Calculation (See Fig. 1)

12.1 Determine the length of AD and AE in chart units. Calculate the permanent deformation in percent using Eq 1:

$$\textit{permanent deformation}, \% = (AD/AE) \times 100 \tag{1}$$

12.2 Determine the lengths of DE and AE in chart units. Calculate the elastic recovery in percent using Eq 2 (see Note 2):

$$\textit{elastic recovery}, \% = (DE/AE) \times 100 \tag{2}$$

NOTE 2—Percent of permanent deformation plus percent of elastic recovery = 100 %.

12.3 Determine the length of BE and GE in chart units. Calculate the stress retention in percent using Eq 3:

$$\textit{stress retention}, \% = (GE/BE) \times 100 \tag{3}$$

12.4 Read and record the force at point G in grams-force, lbs-force, or Newtons.

12.5 Calculate the average, standard deviation, and 95 % confidence limits of the average for each factor measured, including thickness, for each set of five specimens tested.

13. Report

13.1 Report the following information:

13.1.1 Complete sample identification,

13.1.2 Extensions tested,

13.1.3 Number of specimens tested,

13.1.4 Permanent deformation of each specimen and time if different than 180 s,

13.1.5 Elastic recovery of each specimen and time if different than 180 s,

13.1.6 Stress retention in both percentage and grams-force or pounds-force and time if different in 60 s. (Stress retention can be reported as a plot of GE versus time),

13.1.7 Thickness of each specimen, and

13.1.8 Average results, standard deviations, and confidence limits where applicable.

14. Precision and Bias

14.1 *Precision*—The following summaries involve five materials tested by six laboratories, based on a round robin conducted in 1989, in accordance with Practice E 691. Each material was tested at two different stretch percentages, 50 and 150 %. Slabs of material were removed from each film roll, with one slab of each type being sent to each participating lab. One layer of film was removed from a slab for each repetition, and five repetitions were conducted for each test result.

14.1.1 *Stress Retention Data at 50 % Elongation*—The average stress retention at 50 % elongation was 70.4 % with a standard deviation of 2.6 percentage points within each laboratory and a standard deviation of 4.4 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 7.1 percentage points and the estimated reproducibility limits are 12.2 percentage points.

14.1.2 *Stress Retention Data at 150 % Elongation*—The average stress retention at 150 % elongation was 69.4 % with a standard deviation of 1.6 percentage points within each laboratory and a standard deviation of 3.3 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 4.4 percentage points and the estimated reproducibility limits are 9.3 percentage points.

14.1.3 *Permanent Deformation Data at 50 % Elongation*—The average permanent deformation at 50 % elongation was 24 % with a standard deviation of 1.5 percentage points within each laboratory and a standard deviation of 1.9 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 4.2 percentage points and the estimated reproducibility limits are 5.4 percentage points.

14.1.4 *Permanent Deformation Data at 150 % Elongation*—The average permanent deformation at 150 % elongation was 40.1 % with a standard deviation of 1.0 percentage points within each laboratory and a standard deviation of 2.7 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 2.9 percentage points and the estimated reproducibility limits are 7.5 percentage points.

14.1.5 *Elastic Recovery Data at 50 % Elongation*—The average elastic recovery at 50 % elongation was 64.4 % with a standard deviation of 1.5 percentage points within each laboratory and a standard deviation of 2.5 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 4.2 percentage points and the estimated reproducibility limits are 7.1 percentage points.

14.1.6 *Elastic Recovery Data at 150 % Elongation*—The average elastic recovery at 150 % elongation was 59.9 % with a standard deviation of 1.0 percentage points within each laboratory and a standard deviation of 2.7 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 2.9 percentage points and the estimated reproducibility limits are 7.5 percentage points.

14.2 *Bias*—The procedure in this test method has no bias because the values of elastic recovery, permanent deformation, and stress retention are defined in the terms of this method.

15. Keywords

15.1 elastic recovery; permanent deformation; stress retention; stretch wrap; thin films