



Standard Test Method for Protrusion Puncture Resistance of Stretch Wrap Film¹

This standard is issued under the fixed designation D5748; 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 determines the resistance of a stretch wrap film to the penetration of a probe at a standard low rate, a single test velocity. Performed at standard conditions, the test method imparts a biaxial stress that is representative of the type of stress encountered in many product end-use applications. The maximum force, force at break, penetration distance, and energy to break are determined.

1.2 *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

- D618 Practice for Conditioning Plastics for Testing
- D996 Terminology of Packaging and Distribution Environments
- D1898 Practice for Sampling of Plastics (Withdrawn 1998)³
- D2103 Specification for Polyethylene Film and Sheeting
- E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
- E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—General definitions for packaging and distributions environments are found in Terminology D996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *break force*—force achieved at break.

3.2.2 *energy*—work to break.

3.2.3 *maximum force*—greatest force achieved.

3.2.4 *penetration distance*—depth probe traveled in penetrating film specimen, from initial probe contact with film specimen, to penetration at break.

3.2.5 *protrusion puncture resistance*—the ability of a plastic film to withstand the force exerted by a protrusion.

3.2.6 *thickness (caliper, gage)*—the perpendicular distance between the opposite surfaces of a plastic film.

4. Significance and Use

4.1 Puncture resistance is very important in end-use performance of stretch wrap film used in consumer and industrial product applications. Puncture resistance is a measure of the energy-absorbing ability of a stretch wrap film in resisting a protrusion. The test method is designed to provide the user with a means of measuring the stretch wrap film's puncture resistance performance under essentially biaxial deformation conditions. A biaxial stress is representative of the type of stress encountered by stretch wrap products in many end-use applications.

4.2 Although this test method cannot be expected to duplicate all field experiences, since the rate of speed, weight, and configuration of such destructive forces vary widely, a generally reliable comparison of samples may be made from the data obtained.

5. Apparatus

5.1 *Universal Testing Apparatus.*

5.2 *Integrator and Chart Recorder.*

5.3 *Appropriate Load Cell*—The test may be performed using compression or tension load cell.

5.4 *Probe*—A 0.75 in. (19 mm) diameter pear-shaped TFE-fluorocarbon coated probe⁴ (Fig. 1), for general application and standard comparison of plastic films and interlaboratory results.

5.5 *Specimen Clamping Fixture* (Fig. 2).

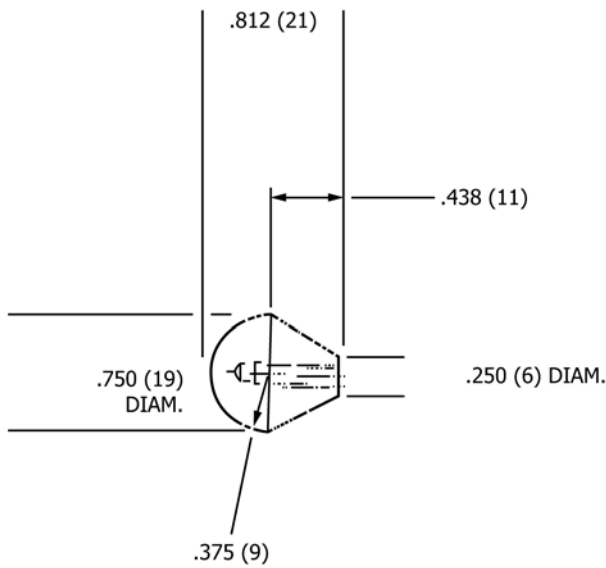
¹ This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.25 on Palletizing and Unitizing of Loads.

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² 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 last approved version of this historical standard is referenced on www.astm.org.

⁴ The probe is coated with duPont 954-101 Teflon S a thickness of 0.0015 in. (0.0381 mm). Available from duPont.



PROBE IS TEFLON COATED

NOTE 1—Measurements are in inches (millimetres).

FIG. 1 Probe

5.6 *Micrometre*, conforming to Specification D2103.

5.7 *Template*, 6 by 6 in. (150 by 150 mm).

5.8 *Specimen Cutter*.

6. Sampling

6.1 *Acceptance Sampling*—Sampling shall be in accordance with Practice D1898.

6.2 *Sampling for Other Purposes*—The sampling and the number of test specimens depend on the purpose of the testing. Practice E122 is recommended. Test specimens are taken from several rolls of film, and where possible, from several production runs of film. Strong conclusions about a specific property of a film cannot be based on a single roll of film.

7. Number of Test Specimens

7.1 Test a minimum of five specimens for each sample.

8. Preparation of Apparatus

8.1 For specific instruction in setting up and operating the apparatus, consult the operations manual.

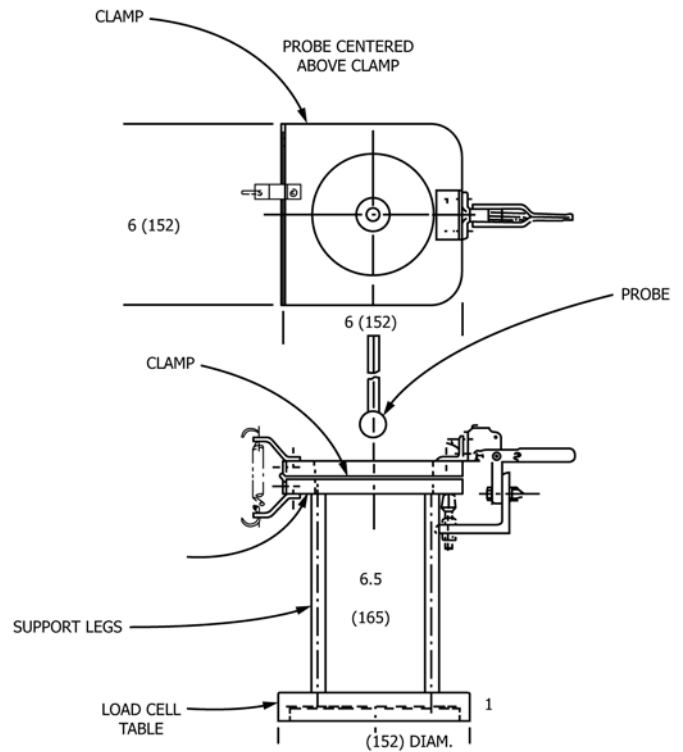
8.2 Install probe apparatus (Fig. 2).

8.3 Center the probe (Fig. 1) over the specimen clamping fixture (Fig. 2).

9. Conditioning

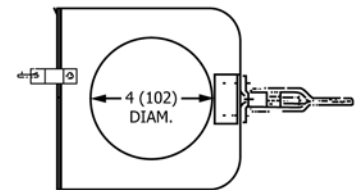
9.1 Condition the test specimens at $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 5\%$ relative humidity for not less than 40 h prior to testing in accordance with Procedure A of Practice D618.

9.2 Conduct tests in the standard laboratory atmosphere of $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and $50 \pm 5\%$ relative humidity unless otherwise specified in the test method.



NOTE 1—Measurements are in inches (millimetres).

FIG. 2 Clamp



10. Procedure

10.1 With the probe apparatus installed, calibrate the test equipment following the manufacturer's instructions.

10.2 Select an equipment load range so that specimen puncture occurs within 20 to 80 % of the same.

10.3 Using the template and specimen cutter, prepare a minimum of five specimens from each sample.

10.4 Measure the caliper (average of three readings) in the center of each specimen and record the average.

10.5 Set universal tester crosshead speed at 10 in./min (250 mm/min) and chart recorder speed at 10 in./min (250 mm/min). If using an integrator instead of a data acquisition system, set the counters to zero.

10.6 Clamp the specimen in the holder. Lower the probe as close as possible to the specimen without actually touching.

10.7 Set the appropriate stops and returns on the universal tester. Reset data collection devices if applicable.

10.8 Activate the universal tester. Stop the crosshead when the puncture probe passes completely through the film. Where holes occur other than at the probe point, the specimen test results should be discarded. See Fig. 3.

10.9 Record specimen identification, peak force at break, maximum force, energy (work) to break, and probe penetration distance at break, from mechanical testing software output. If using chart recording instruments, record specimen identification on chart and integrator reading if used. Return crosshead to start position and remove specimen. See Fig. 4 for graphical output of test performed.

10.10 Repeat test sequence (10.1 through 10.9) for the remaining sample specimens.

11. Calculations

11.1 Compute the values of peak force at break, maximum force, energy (work) to break and probe penetration distance. In some instances, peak force at break and maximum force will be the same value (Fig. 4).

11.1.1 Software computed values are acceptable.

11.2 Use the following formulas for calculating the required values for data acquisition with a time based chart recorder.

11.2.1 Calculate peak force to break—peak force to achieve break, lb (N):

$$N = R \times L \text{ or } \frac{D}{W} \times L \tag{1}$$

where:

- N* = peak force to break, lb (N),
- R* = chart reading, expressed as a decimal, %,
- L* = full scale load (FSL), lb, N,
- D* = recorded actual in. (mm) of chart in vertical axis, from start of test to finish, and
- W* = full scale width of chart, in. (mm).

11.2.2 Calculate the maximum force—highest force achieved during a test, lb (N):

$$M = R \times L \text{ or } \frac{D}{W} \times L \tag{2}$$



FIG. 3 Universal Tester

where:

- M* = maximum force achieved, lb (N),
- R* = chart reading, expressed as a decimal, %,
- L* = full scale load (FSL), lb, N,
- D* = recorded actual in. (mm) of chart in vertical axis, from start of test to maximum force point, and
- W* = full scale width of chart, in. (mm).

11.2.3 Calculate the probe penetration distance—depth probe traveled in penetrating specimen in. (mm), from initial probe contact with specimen, to penetration at break:

$$P = \frac{D \times S}{C} \tag{3}$$

where:

- P* = probe travel to penetration at break, in. (mm),
- D* = recorded actual in. (mm) of chart in vertical axis, from start of test to finish,
- S* = crosshead speed, in./min (mm/min), and
- C* = chart speed, in./min (mm/min).

11.2.4 Calculate energy – in./lb (J) to break:

$$J = I \times L \times \frac{S}{Z} \tag{4}$$

where:

- J* = energy, in./lb (J),
- L* = full scale load (FSL), lb (N),
- S* = crosshead speed, in./min (mm/min),
- I* = integrator reading (counts), and
- Z* = integrator (counts/min).

12. Report

12.1 Report the following information:

- 12.1.1 Sample identification,
- 12.1.2 Mean and standard deviation of five values for the following:
 - 12.1.2.1 Peak force at break, lb (N),
 - 12.1.2.2 Maximum force achieved, lb (N),
 - 12.1.2.3 Energy to break, in./lb (J),
 - 12.1.2.4 Probe penetration distance, in. (mm), and
 - 12.1.2.5 Caliper (average) of film specimens for each sample, in. (mm).

13. Precision and Bias

13.1 *Precision*—The following summaries involve four materials tested by six laboratories, based on a round robin conducted in 1993, in accordance with Practice E691. Sample rolls of each material were provided to each participating laboratory, and that laboratory evaluated the material five times to produce a final result.

13.1.1 *Peak Force to Break Data*—The average peak force to break was 0.66 lb with a standard deviation of 4.0 percentage points within each laboratory and a standard deviation of 15.2 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 11.1 percentage points and the estimated reproducibility limits are 42.5 percentage points.

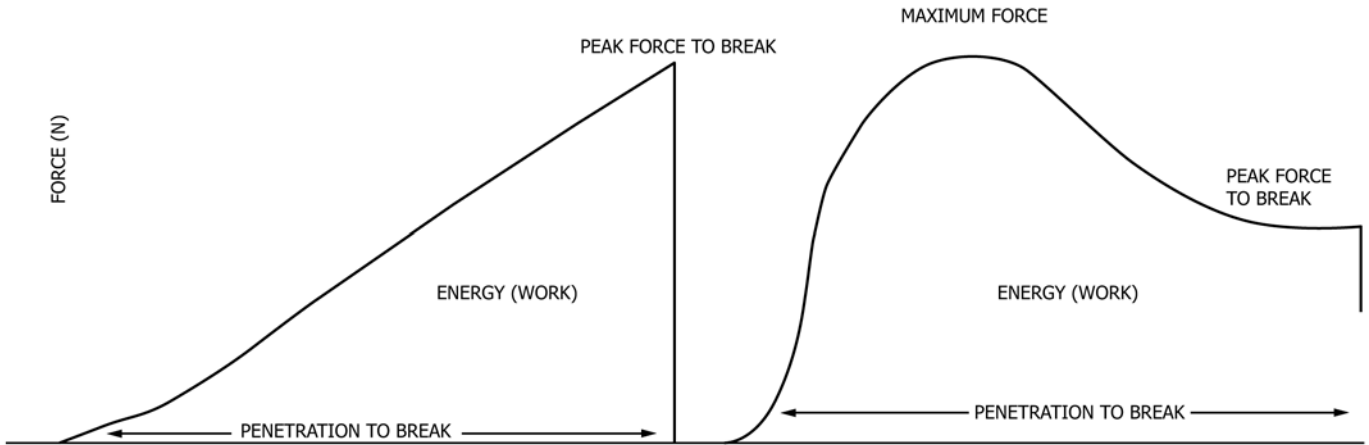


FIG. 4 Graphical Output of Protrusion Puncture Resistance Test—Stress/Strain Curve Examples

13.1.2 *Maximum Force Data*—The average maximum force was 0.65 lb, with a standard deviation of 2.9 percentage points within each laboratory and a standard deviation of 13.4 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 8.2 percentage points and the estimated reproducibility limits are 37.5 percentage points.

13.1.3 *Probe Penetration Distance Data*—The average probe penetration distance was 0.39 in., with a standard deviation of 3.5 percentage points within each laboratory and a standard deviation of 9.8 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 9.8 percentage points and the estimated reproducibility limits are 27.5 percentage points.

13.1.4 *Energy to Break Data*—The average energy to break was 3.55 in·lb with a standard deviation of 5.4 percentage points within each laboratory and a standard deviation of 25.6 percentage points between laboratories; other materials may have higher or lower variability. Based on this, the estimated 95 % repeatability limits are 15.1 percentage points and the estimated reproducibility limits are 71.5 percentage points.

13.2 *Bias*—The procedure in this test method has no bias because the values of peak force to break, maximum force, probe penetration distance, and energy to break are defined in the terms of this test method.

14. Keywords

14.1 plastic films; protrusion puncture; puncture resistance

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