ASTM INTERNATIONAL

Designation: ~~F1306 – 90 (Reapproved 2008)ᵋ¹~~ F1306 – 16

Standard Test Method for
Slow Rate Penetration Resistance of Flexible Barrier Films and Laminates[1]

1. Scope

1.1 This test method permits flexible barrier films and laminates to be characterized for slow rate penetration resistance to a driven probe. The test is performed at room temperature, by applying a biaxial stress at a single test velocity on the material until perforation occurs. The force, energy, and elongation to perforation are determined.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered 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]
D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]
D618 Practice for Conditioning Plastics for Testing
D638 Test Method for Tensile Properties of Plastics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *elongation (stretch)*—the elastic/plastic deformation of flexible sheet material under penetration by a driven probe.

3.1.2 *penetration resistance*—the ability of a flexible sheet material to withstand elongation and/or puncture by a driven probe.

3.1.3 *perforation*—the development of a measurable flaw through a barrier film undergoing penetration.

3.1.4 *probe penetration to failure*—distance probe travels from film contact to an instantaneous drop in load as observed on Universal Testing Equipment recorder.

3.1.5 *puncture*—the brittle elastic fracture of a flexible sheet material under penetration by a driven probe.

4. Significance and Use

4.1 Penetration resistance is an important end-use performance of thin flexible materials where a sharp-edged product can destroy the integrity of a barrier wrap. This will permit package entry/exit of gases, odors, and unwanted contaminates, causing potential harm to the product and reducing shelf-life. Material response to penetration will vary with numerous factors, such as film thickness, elastic modulus, rate of penetration, temperature, shape and type of probe. Consequently, material responses from

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puncture to stretch may be observed and quantified using this method. Although numerous combinations of experimental factors can be devised and used to simulate specific end-use applications, the recommended conditions in this method should be followed for standard comparisons of materials.

5. Apparatus

5.1 *Universal Testing* ~~*Apparatus ,*~~ *Apparatus,* with a recording device.

5.2 *Compression Load Cell(s).*

5.3 *Penetration Probe,* as per Fig. 1.

5.3.1 A 3.2 mm (0.125 in.) diameter hemispherical (biaxial stress) probe is recommended for general application and standard comparison of materials and interlaboratory results.

5.4 *Specimen Clamping Fixture,* as per Fig. 2 or equivalent.

5.4.1 A sample test diameter of 34.9 mm (1.375 in.) is required for interlaboratory comparison of results. (If other probes are used, a minimum clamp to probe diameter ratio of 10 to 1 is required.)

5.5 *Specimen Cutter.*

6. Test Specimen

6.1 The test specimen shall be of uniform thickness (±2 % or 0.0025 mm (0.0001 in.), whichever is larger).

6.2 The dimensions of the test specimen shall be 76 mm by 76 mm (3 in. by 3 in.).

7. Preparation of Apparatus

7.1 Consult the equipment operations manual for instructions to set up and operate the equipment.

7.2 Install probe apparatus.

7.3 Center probe over the fixture.

8. Number of Test Specimens

8.1 Test at least five specimens for each sample.

9. Conditioning

9.1 Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618 for those tests where conditioning is required.
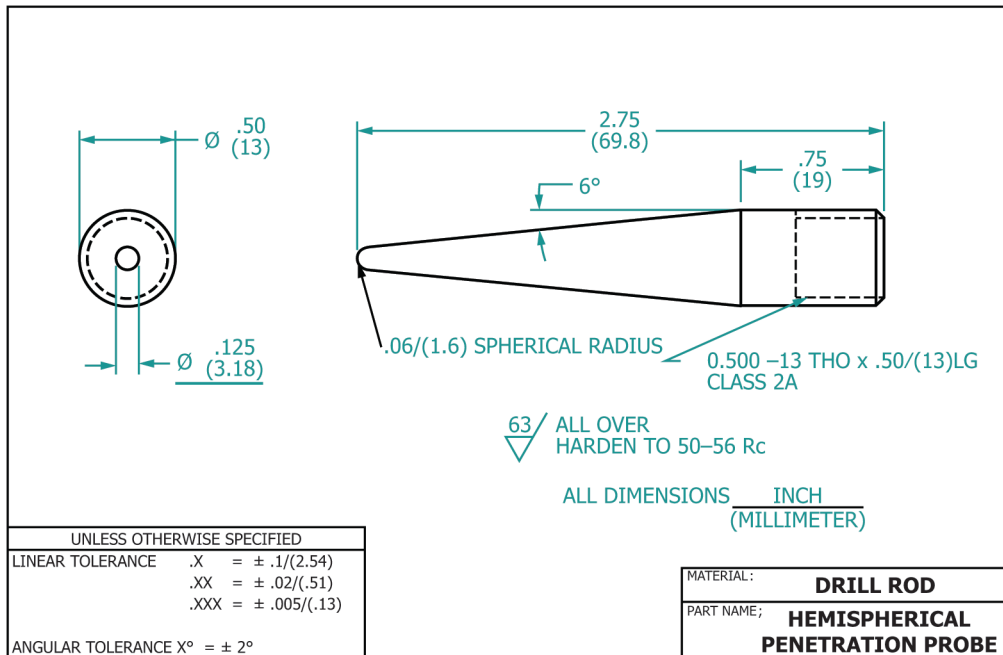

FIG. 1 Penetration Probe
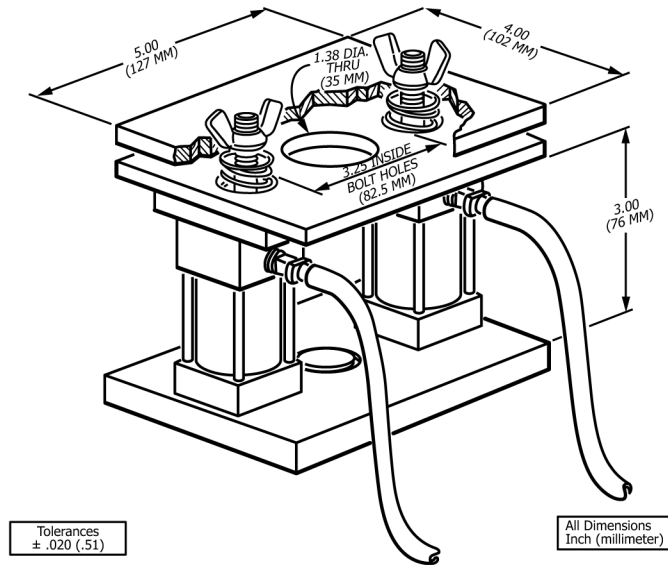
FIG. 2 Specimen Clamping Fixture

9.2 Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity unless otherwise specified in this test method.

10. Procedure

10.1 Following the instrument manufacturer's instructions, calibrate the test equipment.

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

10.3 Using the specimen cutter, cut each sample material into a minimum of five 3 in. by 3 in. pieces.

10.4 Measure the caliper (average of 3 readings) in the center of a film specimen.

10.5 Adjust the universal tester cross head speed to 25 mm/min (1.0 in./min). (Set chart speed recorder to 500 mm/min (20 in./min), if applicable.) Select a data acquisition rate to give a minimum resolution of 0.1 mm/point of penetration.

10.6 Clamp the film specimen in the holder, place sample holder directly under crosshead probe, center and lower it as close as possible to the film specimen without making contact.

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

10.8 Activate universal tester. At the first sign of a perforation through the film, return the crosshead to origination point. (A perforation is any size hole in the film specimen visible to the naked eye, or a point where an instantaneous drop in load to near zero occurs.) See Fig. 3.

NOTE 1—In case of laminate materials, multiple drops in load may be observed as discrete layers fail. Under this condition the last instantaneous drop to near zero would be considered a failure.
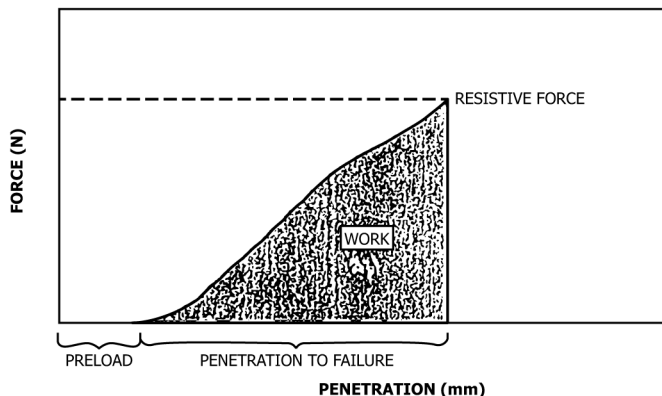

FIG. 3 Graphical Output of Slow Rate Penetration Test

10.9 Record specimen identification, force (peak) to break, energy (work) to break, and probe penetration (at first break) from mechanical testing software output (Fig. 3). (If using chart recording instruments, record specimen identification on chart and integrator reading if used.)

10.10 Repeat test sequence (~~10.1~~(10.1 to 10.9) for the remaining samples.

11. Calculation

11.1 Compute the values of peak force, probe penetration to break, and energy to break.

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 *Force to Break*—Peak force to achieve break (Newtons):

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

where:

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

11.2.2 *Probe Penetration*—Depth probe traveled in penetrating film specimen (mm), from initial probe contact with sample, to penetration at break:

$$P = \frac{D \times S}{C} \tag{2}$$

where:

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

11.2.3 *Energy*—Work to break (Joules):

TABLE 1 Puncture Force (6 Laboratories)

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| Material | Material Orientation | Values expressed in units of Newtons | | | | |
		Average	S_r	S_R	r	R
BW 010	Inside	6.63	0.187	0.676	0.525	1.891
BW 010	Outside	6.72	0.360	0.903	1.015	2.528
BW 82	Inside	9.47	1.94	2.034	5.429	5.696
BW 82	Outside	9.08	2.23	2.416	6.226	6.773
BW 117	Inside	12.10	1.615	2.238	4.521	6.608
BW 117	Outside	12.37	1.798	2.852	5.029	7.983
BW 295	Inside	42.54	1.776	2.078	4.966	5.816
BW 295	Outside	36.49	0.983	3.066	2.756	8.580
BW 341	Inside	41.83	2.697	3.502	7.547	9.803
BW 341	Outside	42.94	3.400	4.971	9.514	13.920
BW 234	Inside	72.31	11.080	14.285	31.061	39.961
BW 234	Outside	65.64	16.421	17.266	45.969	48.372