Designation: ~~D3576 – 15~~ D3576 – 20

Standard Test Method for Cell Size of Rigid Cellular Plastics[1]

This standard is issued under the fixed designation D3576; 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 apparent cell size of rigid cellular plastics by counting the number of cell-wall intersections in a specified distance.

1.2 Procedure A requires the preparation of a thin slice, not more than one half the average cell diameter in thickness, that is mechanically stable. For most rigid cellular plastics this limits the test method to materials with an average cell size of at least 0.2 mm.

1.3 Procedure B is intended for use with materials whose friable nature makes it difficult to obtain a thin slice for viewing.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.5 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

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1.6 *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]

D883 Terminology Relating to Plastics
D2842 Test Method for Water Absorption of Rigid Cellular Plastics
D6226 Test Method for Open Cell Content of Rigid Cellular Plastics
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.22 on Cellular Materials - Plastics and Elastomers.

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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.

***A Summary of Changes section appears at the end of this standard**

2.2 *ISO Standard:*
ISO 2896 Cellular Plastics, Rigid—Determination of Water Absorption[3]

3. Terminology

3.1 ~~Definitions of terms applicable to this test method are given in~~ Terms used in this standard are defined in accordance with Terminology D883, unless otherwise specified. For terms relating to precision and bias and associated issues, the terms used in this standard are defined in accordance with Terminology E456.

4. Summary of Test Method

4.1 *Procedure A*—The cellular plastic specimen is cut to not more than one half the average cell diameter in thickness on a slicer and the shadowgraph is projected on a screen by the use of a cell-size scale slide assembly and a projector. The average chord length is obtained by counting the cells on cell-wall intersections and converting this value to average cell size by mathematical derivation.

4.2 *Procedure B*—The cellular plastic specimen is sliced to provide a smooth surface. The cell walls are accented by the use of a marking pen or marking ink. The average chord length is obtained by counting the cell wall intersections and converting this value to average cell size by mathematical derivation.

5. Significance and Use

5.1 Several physical properties of rigid cellular plastics are dependent on cell size and cell orientation. Measuring water absorption and open-cell content in accordance with Test Method D2842 and Test Method D6226 requires knowledge of surface cell volume, which uses cell size values in the calculations.

5.2 This test method provides an apparent cell size because it assumes that there is no measurable edge to edge or top to bottom variation in average cell size and that the cell size distribution about the average cell size is normal. If the analyst is concerned there may be significant variation in either the average cell size or the cell size distribution more detailed analysis may be required.

5.3 Before proceeding with this test method, reference should be made to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters, or a combination thereof, covered in the materials specification shall take precedence over those mentioned in this test method. If there are no material specifications, then the default conditions apply.

6. Apparatus

6.1 The apparatus required to perform the test as defined by Procedure A is listed as follows:

6.1.1 *Cell Size Specimen Slicer*—Cutting blade apparatus capable of slicing thin specimens (0.02 mm) for cell size viewing. Fig. 1 shows an acceptable alternative slicing apparatus.

6.1.2 *Cell Size Projector*—Conventional 35-mm slide projector that accepts standard 50 by 50-mm (2 by 2-in.) slides.

6.1.3 *Cell Size Scale Slide Assembly,* consisting of two pieces of slide glass hinged by tape along one edge, between which a calibrated scale (30 mm in length) printed on a thin plastic sheet is placed (see Fig. 2).

6.2 The apparatus required to perform the test as defined by Procedure B is listed as follows:

6.2.1 *Cell Size Specimen Slicer*—Cutting blade apparatus capable of providing a smooth surface.

6.2.2 *Optical Magnification System,* capable of 5 to 25× magnification with a calibrated scale of the appropriate length.

6.2.3 *Highlighting Marker/Ink,* that does not contain a solvent which will attack the polymer system. The ink used should contrast with the color of the foam.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

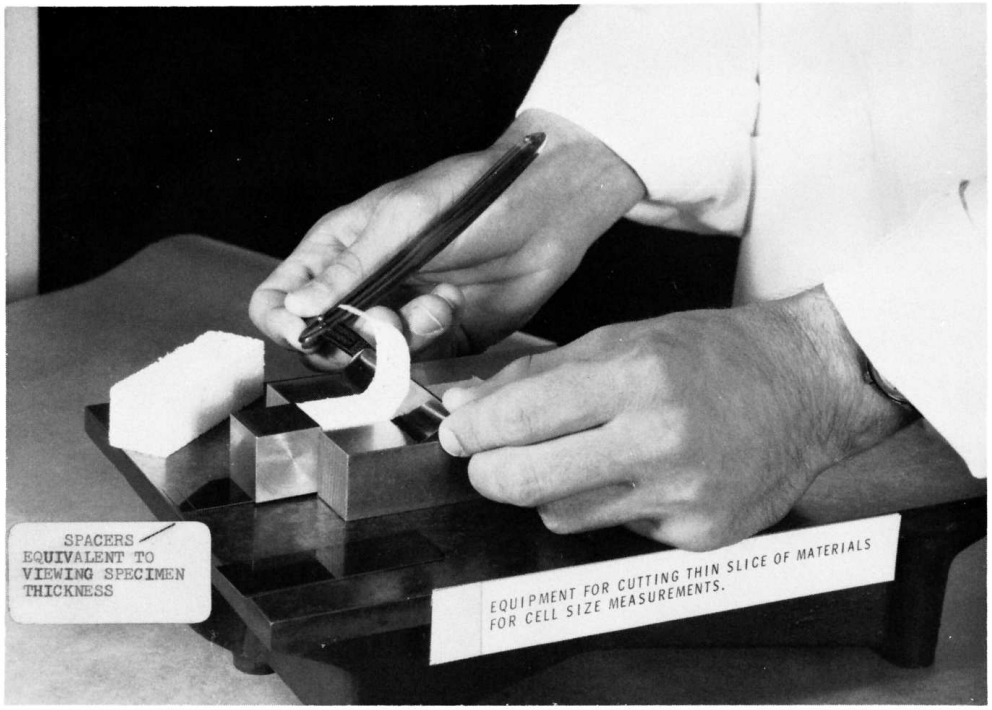

FIG. 1 Razor Blade Cell Size Specimen Slicer

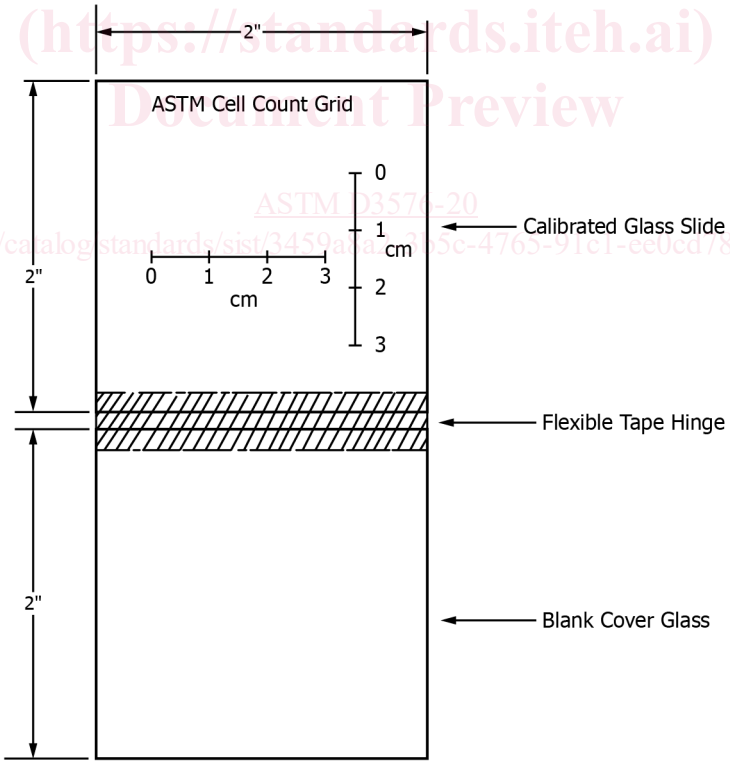

FIG. 2 Cell Size Scale Slide Assembly

7. Sampling

7.1 Generally one specimen is sufficient to determine the apparent cell size of a sample.

7.2 The number of samples may be dictated by the end-use data needed.

8. Procedures

8.1 *Procedure A:*

8.1.1 Cut a specimen 50 by 50 mm by thickness (2 by 2 in. by thickness) from the sample in the area to be tested.

8.1.2 Prepare the cell size viewing specimen by cutting a thin slice (less than monocellular) from one of the cut surfaces of the specimen. (Slice thickness should be as thin as practicable; so that a shadowgraph will not be occluded by overlapping cell walls. Optimum slice thickness will vary with the average cell size of the foam, with smaller cell foams requiring thinner slices.)

NOTE 2—One cell size measurement will provide a representative apparent cell size for cellular plastics having symmetric cells of relatively uniform size. However, if the cell size in the three normal directions is suspected of varying by a value greater than the precision of this test method, all three directions should be measured and reported for maximum accuracy. An acceptable procedure, in this case, is to determine the cell size in two planes perpendicular to each other. The size of the cells in the three normal directions can then be compared and reported separately if desired.

8.1.3 Insert the thin-sliced foam specimen into the cell size slide assembly. Position the zero on the grid line at the top of the area to be measured. Reassemble the slide.

8.1.4 Insert the slide assembly into the projector. Focus the projector on the wall or screen so that a sharp image shadowgraph results.

8.1.5 Count the number of cell walls that intersect the reference line.[4]

8.1.6 Determine the average cell chord length, *t*. Divide the length of the reference line by the number of cells counted to obtain the average chord length, *t*. The length of the reference line is expressed in millimetres.

8.2 *Procedure B:*

8.2.1 Cut a 25-mm (1-in.) section across the width of the sample.

8.2.2 Identify the length *(L)* and width *(W)* direction in the middle of the strip.

8.2.3 Cut a 25-mm (1-in.) section with the *L* and *W* marking from the center of the strip giving a specimen of 25 by 25 mm by thickness (1 by 1 in. by thickness).

8.2.4 Shave adjacent planes of the sample giving exposed cut cells in the *L, W*, and thickness *(T)* directions (see Note 2).

8.2.5 Coat the shaved planes with the marker/ink with a uniform coating in such a manner that additional cell walls are not broken.

8.2.6 Place the sample in a manner to observe cells in the *T* direction. The sample holder should be of sufficient size and integrity so as to hold the sample steady during measurement (see Note 3).

NOTE 3—For samples with an apparent cell size of 0.3 mm or smaller the cell size may be measured by the use of a scope with a 10-mm calibrated reference line. For samples with an apparent cell size of 1.0 mm or greater a handheld eyepiece with a calibrated scale of 30-mm length can be used.

8.2.7 Count the number of cell walls which intersect the reference line.[4]

8.2.8 The cells counted must be a random selection, however, the specific placement of the line should be adjusted to start the count to include a full cell at the beginning of the line.

8.2.9 Determine the average cell chord length, *t*. Divide the length of the reference line by the number of cells counted to obtain the average chord length, *t*. The length of the reference line is expressed in millimetres.

[4] The reference line length should be suitable to the cell size being measured. A minimum cell count of 20 should be adequate.

TABLE 1 Precision Data Summary, Procedure A

Material	Nominal Thickness, in.	Average Cell Size, mm	% γ_r [A]	% γ_R [B]	r [C]	R [D]	Number of Laboratories in Research Report
Extruded Polystyrene Foam	0.75	0.36	5.7	9.3	16.3	26.4	4
Extruded Polystyrene Foam	2	0.79	7.3	12.3	20.7	34.7	4
Extruded Polystyrene Foam	6.5	1.6	5.3	15.1	14.9	42.8	4
Polyisocyanurate Foam (Glass Fibers Reinforced)	2	0.33	9.4	18.3	26.6	51.8	3
Phenolic Foam	1	0.37	17.2	17.4	48.7	49.2	3

[A] γ_r is the within-laboratory coefficient of variation of the average.
[B] γ_R is the between-laboratories coefficient of variation of the average.
[C] r is the within-laboratory repeatability limit = 2.8 γ_r.
[D] R is the between-laboratories reproducibility limit = 2.8 γ_R.

9. Calculation

9.1 Calculate the cell size for each direction measured as follows:

$$d = t(1.623)$$

where:

d = cell size, mm, and
t = average cell chord length, mm.

See Appendix X1 for the derivation of the equation.

10. Report

10.1 Report the following information:

10.1.1 Material type and manufacturer,

10.1.2 Lot number/production date of the material evaluated,

10.1.3 Procedure used (A or B),

10.1.4 The number of specimens evaluated, and

10.1.5 The average cell size in millimetres for each direction measured. For those foams having a cell size larger than 1.0 mm, report the value to the nearest 0.1 mm. For those smaller than 1.0 mm, report the value to the nearest 0.01 mm.

11. Precision and Bias[5]

11.1 ~~Tables 1 and 2 are based on a round robin~~ The precision of this test method is based on an interlaboratory study of D3576~~conducted in 1989 in accordance with Practice~~ , Standard Test Method for Cell Size of Rigid Cellular Plastics, conducted in 1989. Seven laboratories tested ~~E691 involving~~ six different materials for Procedures A and B. Due to equipment limitations, only four of the participants were able to obtain data with Procedure A. All seven participants obtained data using Procedure B. All of the samples were prepared at one source but the individual specimens were prepared at the laboratories that tested them. Each test result was the average of three determinations. Each laboratory obtained one test result for each material. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. RR:D20-1185. (**Warning—**~~Sections~~ The data in ~~11.2 – Tables 1 and 2~~11.2.3 ~~are intended only to give an approximate precision of this test method. When data is obtained from less than six laboratories, it should be viewed with extreme caution. The data should~~ shall not be rigorously applied to acceptance or rejection of ~~material. The data is~~material, as those data are specific to the ~~round robin~~interlaboratory study and ~~may~~are not ~~be~~necessarily representative of other lots, conditions, materials, or laboratories. Users of this test method ~~should~~shall apply the principles outlined in Practice E691 to generate data specific to their laboratory and materials, or between specific laboratories. ~~The principles of 11.2 – 11.2.3 a would then be valid for such data.~~)

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D20-1185.