



Designation: D 2856 – 94 (Reapproved 1998)

Standard Test Method for Open-Cell Content of Rigid Cellular Plastics by the Air Pycnometer¹

This standard is issued under the fixed designation D 2856; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 Cellular plastics are composed of the membranes or walls of polymer separating small cavities or cells. These cells may be interconnecting (open cell), non-connecting (closed cell), or any combination of these types. This test method determines numerical values for open cells. It is a porosity determination, measuring the accessible cellular volume of a material. The volume occupied by closed cells is considered to include cell walls. Since any conveniently sized specimen can only be obtained by some cutting operation, a fraction of the closed cells will be opened during sample preparation and will be included as open cells.

1.2 This test method consists of three procedures:

1.2.1 *Procedure A*, designed to correct for cells opened during sample preparation, by measuring cell diameter, calculating, and allowing for surface volume;

1.2.2 *Procedure B*, designed to correct for cells opened in sample preparation, by cutting and exposing new surface area equal to the surface area of the original sample dimension, and

1.2.3 *Procedure C*, which does not correct for cells opened during sample preparation and gives good accuracy on predominantly highly open-celled materials. The accuracy decreases as the closed cell content increases and as the cell size increases.

1.3 The values as stated in SI units are to be regarded as the standard. The values in parentheses are given 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.* Specific precautionary statements are given in Note 2, Note 4, and Note 8.

NOTE 1—This test method and ISO 4590-1981 use the same basic principles but are significantly different in experimental detail.

¹ This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D 20.22 on Cellular Plastics.

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2. Referenced Documents

2.1 *ASTM Standards*:²

D 618 Practice for Conditioning Plastics and Electrical Insulation Materials for Testing

D 883 Terminology Relating to Plastics

D 3576 Test Method for Cell Size of Rigid Cellular Plastics

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

2.2 *ISO Standard*:

ISO 4590-1981 Cellular Plastics—Determination of Volume Percentage of Open and Closed Cells of Rigid Materials³

3. Terminology

3.1 *Definition*:

3.1.1 *closed cell*—a cell totally enclosed by its walls and hence not interconnecting with other cells.

3.1.2 Terms relating to plastics as given in Terminology D 883 shall be used where applicable.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *open cell*—a cell not totally enclosed by its walls and hence interconnecting with other cells.

3.2.2 *volume of closed cells*—inaccessible internal volume, consisting of an aggregate of solid polymer volume (cell walls, struts), filler volume, when applicable (solid particles or fibers), the volume of individual closed cells, and the volume of small cell groups interconnected by ruptured cell walls but otherwise inaccessible.

3.2.3 *corrected volume of open cells*—the internal porous volume.

3.2.4 *uncorrected volume of open cells*—the aggregate measurement of both the internal porous volume of the material and the various irregular volumes accessible at the cut-cell surface of the test specimen.

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 Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.



3.3 Symbols:

- A = total geometric surface area of specimen, cm^2 ,
 h = specimen height, cm,
 l = specimen length, cm,
 O_c = volume, percent open cells,
 t = average chord length found in cell size determination, cm,
 V = geometric volume of specimen, cm^3 ,
 V_s = volume of the surface cells opened by sample preparation, cm^3 ,
 V_1 = displacement volume of the specimen, cm^3 ,
 V_2 = displacement volume after trisection, cm^3 , and
 w = specimen width, cm.

4. Summary of Test Method

4.1 This test method is based on a determination of porosity in which the accessible cellular volume of a cellular plastic is determined by application of Boyle's Law, which states that the decrease in volume of a confined gas results in a proportionate increase in pressure. The apparatus consists of two cylinders of equal volume with an accessible chamber provided in one of the cylinders for insertion of the test specimen. Pistons in both cylinders permit volume changes. The pressures are increased equally by decreasing both volumes when a specimen is present in the specimen chamber. The volume change for the specimen cylinder is smaller than for the empty reference chamber, and corresponds to the displacement volume of the specimen. The difference between this volume and the geometric volume of the specimen is a measure of the open-cell volume.

5. Significance and Use

5.1 This test method is intended to be used in specifications where porosity of cellular plastics has a direct bearing on their end use. For example, for thermal insulation applications, a high percentage of closed cells is necessary to prevent escape of gases and to promote low thermal conductivity. In flotation applications, high closed-cell content generally reduces water absorption.

6. Apparatus

6.1 Air Pycnometer.

NOTE 2—**Warning:** Beckman no longer manufactures or services the Beckman Pycnometer around which this test method was written. It is imperative that alternate equipment be investigated and data made available.

6.2 *Cutting Device*, for sample preparation, such as a bandsaw or hobby jigsaw, the blade of which must be capable of producing a smooth cut. This will require a blade with at least four teeth/centimetre (10 teeth/inch).

6.3 *Vernier Calipers*, or dial micrometer measuring device, capable of measuring specimens to the nearest 0.1 cm (0.04 in.).

6.4 *Razor Blades*, single-edge, new.

7. Principle of Operation of the Air Pycnometer

NOTE 3—The "half-atmosphere" method for operation of the air pycnometer is described in this test method. It subjects the specimen to a

minimum pressure of approximately 0.05 MPa (7.4 psi). This rarely distorts the specimen, although occasional drifting of the pressure may be evidence that some gas is being withdrawn from the specimen, or that cells are rupturing. This is a modification of the "two-atmosphere" method described in the instruction manual for the air pycnometer instrument.

7.1 Fig. 1 depicts two chambers assumed (for illustrative purposes) to be of equal volume, with no specimen in the specimen chamber. In order to maintain equal pressure on both sides of the differential pressure indicator, any movement of one piston from Position 1 must be duplicated by a similar movement of the second piston. If both pistons are advanced to Position 2, with a specimen, V_x ; inserted in Chamber B, and the coupling valve closed, the pressure on both chambers will not be equal. However, the pressure can be equalized by withdrawing Piston B an amount proportional in volume to V_x (from Position 2 to Position 3). The distance, d_x , from Position 2 to Position 3 is calibrated to read directly in cubic centimetres, and a digital counter is employed to indicate this distance.

8. Sampling and Test Specimen Preparation

8.1 The test specimen shall be a cube having a nominal dimension of 2.50 by 2.50 by 2.50 cm (0.984 by 0.984 by 0.984 in.). Unless otherwise agreed upon, at least five specimens, selected at random, shall be tested. All specimens having obvious defects shall be eliminated.

NOTE 4—**Caution:** Cylindrical-shaped specimens will give erroneous results by Procedure A or B of this test method.

8.2 Sample selection on commercially available materials shall be by agreement between the supplier and the user.

8.3 Test specimens shall be machined or sawed from the sample so as to have smooth surfaces. All machined or sawed surfaces may be further smoothed by slicing techniques or sanding with Number 0 or finer sandpaper. Resulting dust shall be blown from the specimen.

9. Conditioning

9.1 Condition specimens at standard laboratory atmosphere, $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and $50 \pm 5\%$ relative humidity for a minimum of 24 h.

9.2 Since this test method depends on very accurate measurement of air volumes, the temperature of the environment, the apparatus, the specimen, and the specimen cup must be kept constant within 2°C and the relative humidity controlled within 5% during the entire test.

PROCEDURE A—DETERMINATION OF OPEN-CELL CONTENT USING CELL DIMENSIONS TO CORRECT FOR CELLS CUT BY SPECIMEN PREPARATION

10. Procedure

10.1 Calibrate the air pycnometer by the procedure outlined in Annex A1.

10.2 Measure and record the length, l , height, h , and width, w , of the specimen to the nearest 0.003 cm (0.001 in.).

NOTE 5—Some pycnometers are equipped with a purge valve, as well as a coupling valve; others have no purge valve. In the following instructions, ignore any references to the purge valve if the pycnometer has none.

