Designation: D 2842 – 01

Standard Test Method for Water Absorption of Rigid Cellular Plastics[1]

This standard is issued under the fixed designation D 2842; 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 water absorption of rigid cellular plastics by measuring the change in buoyant force resulting from immersion under a 5.1-cm (2-in.) head of water for the specified immersion period of 96 h.

1.2 This test method describes two procedures that may be used to measure the change in buoyant force. Procedure A should be used for materials that either experience rapid water absorption or that show an increase in volume during the exposure period, or both. Materials that do not exhibit either of these characteristics should be evaluated by Procedure B.

1.3 For specific applications, immersion periods varying from the normal 96-h test requirement shall be agreed upon between the manufacturer and the purchaser.

1.4 The values stated in SI units are to be regarded as the standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—This test method and ISO 2896 are technically equivalent.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 3576 Test Method for Cell Size of Rigid Cellular Plastics

E 96 Test Methods for Water Vapor Transmission of Materials

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

2.2 *ISO Standard:*

ISO 2896 Cellular Plastics, Rigid—Determination of Water Absorption[3]

3. Terminology

3.1 *Definitions*—There are no terms in this test method that are new or other than dictionary definitions.

4. Summary of Test Method

4.1 The buoyant force of an object less dense than water is equal to the weight of water it displaces when submerged, less the dry weight of the object. Water absorbed into the object lowers the buoyant force by increasing the weight of the sample. By knowing the volume and initial dry weight of the sample, the initial buoyant force can be calculated or the initial buoyant force can be determined by direct measurement. The final buoyant force at the end of the immersion period is measured with an underwater weighing assembly. The difference between the initial and final buoyant force is the weight of the water absorbed per unit of specimen volume.

5. Significance and Use

5.1 The purpose of this test method is to provide a means for comparing relative water absorption tendencies between different cellular plastics. It is intended for use in specifications, product evaluation, and quality control. It is applicable to specific end-use design requirements only to the extent that the end-use conditions are similar to the immersion period (normally 96 h) and 5.1-cm (2-in.) head requirements of the test method.

NOTE 2—Studies by ASTM Subcommittee D20.22 show that some cellular plastics, particularly those with open cells or natural interstices, continue to absorb additional significant amounts of water beyond the 96-h immersion period. It was also found that water absorption of some cellular plastics is significantly higher when exposed to a greater pressure head, as might be encountered in certain underwater installations.

5.2 This test method provides a means for measuring absorption as a result of direct contact exposure to free water. Results by this test method cannot be used to compare the resistance of cellular plastics to water vapor transmission and subsequent condensation within the cells. To determine resistance to water vapor transmission, see Test Methods E 96.

5.3 Water absorption testing is subject to several important variables, which if not considered, prohibit sufficient agreement among testing laboratories. Development of this test method has taken into account the most serious of the possible sources of error.

[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.

Current edition approved November 10, 2001. Published January 2002. Originally published as D 2842 – 69. Last previous edition D 2842 – 97.

[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.

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

NOTE 3—In some methods, an error is encountered due to a rapid absorption of water before an accurate initial weight can be obtained. This test method accounts for that potential error by providing Procedure A for use with materials that behave in this manner. In this procedure the only submerged measurement required is a final weighing taken after the 96-h immersion period.

NOTE 4—The increase in volume that occurs with some foams when immersed is accounted for in Procedure A. This procedure should be used for materials that exhibit this type of behavior. This is accounted for by basing all buoyant force calculations on the volume of the wet specimen at the conclusion of the immersion period.

NOTE 5—The problem of air bubbles clinging to the submerged specimen and affecting the end result is minimized by specifying deaerated distilled water.

NOTE 6—Surface cells opened during specimen preparation result in an error when calculating the apparent volume of the test specimen. The degree of this error is a function of cell size. This test method accounts for this error in that all calculations are based on the true specimen volume. The true specimen volume is determined in Procedure A as the measured volume minus the volume of surface cells opened by cutting. This correction is not required in Procedure B since the true specimen volume is determined by direct measurement.

5.4 The volume error associated with surface cells opened during specimen preparation decreases as the cell size decreases. This test method provides the option to ignore this variable with cellular plastics estimated to have an average cell diameter of 0.03 cm or less. For cellular plastics having greater than 0.03-cm average cell diameter and in all cases of dispute, measurement of cell size shall be mandatory in determining the specimen volume.

5.5 For most materials the size of the test specimens is small compared with the size of the products actually installed in the field. If the surface-to-volume ratios for the test specimens and the corresponding products are different, the test results may be misleading.

5.6 In most cases water retention is a secondary performance characteristic that has an influence on a primary characteristic, such as thermal performance, surface accumulation of moisture, localized collection of electrolytes, etc.

5.7 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 covered in the materials specification, or both, 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 *Balance*—A balance capable of weighing up to 2500 g with a sensitivity of 0.1 g. Balance must have provision for attaching wire sling below balance platform for making submerged weighings.

6.2 *Underwater Weighing Jig*, constructed so that specimen floats against jig ceiling with 15.2 by 15.2-cm (6 by 6-in.) specimen face in the horizontal position. The jig should trap no air when submerged. The approximate dry weight is to be 2500 g. Fig. 1 shows two recommended styles of jig construction.

6.3 *Immersion Tank*—An open-top tank or aquarium of sufficient size to accommodate at least three specimens with the top 15.2 by 15.2-cm (6 by 6-in.) faces in the horizontal position and additional space for the weighing jig. (A 75.8-dm[4] (20-gal) glass aquarium, 76.2 by 33.0 by 30.4 cm (30 by 13 by 12 in.) high is of sufficient size for testing up to six specimens.)

6.4 *Balance Platform*—A mounting platform to be placed across the top of the immersion tank to support the balance. A hole in the platform must be provided at an appropriate location to accommodate wire sling from balance to jig.

6.5 *Conditioning Oven*—Forced-air circulating oven capable of maintaining 50 ± 3°C (122 ± 5°F) for 24 h.

6.6 *Desiccator*, containing desiccant with high affinity for water vapor (anhydrous calcium chloride or equivalent) for maintaining dryness of test specimens upon removal from conditioning oven.

6.7 *Vernier Calipers or Dial Micrometer*—Measuring device capable of measuring specimen to nearest 0.002 cm (0.001 in.). Fig. 2 shows a recommended measuring device.

6.8 *Cell-Size Specimen Slicer*[5]—Cutting blade apparatus capable of slicing thin specimens (0.01 to 0.04 cm) for cellsize viewing. Fig. 3 shows an acceptable alternative slicing apparatus.

6.9 *Cell-Size Projector*—Conventional 35-mm slide projector that accepts standard 5.1 by 5.1-cm (2 by 2-in.) slides.

6.10 *Cell-Size Scale Slide Assembly*, consisting of two pieces of slide glass[5] hinged by tape along one edge, between which a calibrated scale (3.0 mm in length) printed on a thin plastic sheet is placed. See Fig. 4.

7. Reagents and Materials

7.1 *Distilled Water*—Sufficient amount of freshly distilled water to maintain a 5.08-cm (2-in.) head over specimens and jig at all times.

7.2 *Gas Barrier Film*—Layer of low permeance (polyethylene, saran, or equivalent) plastic film covering surface of water to retard air pick up by deaerated water.

8. Test Specimens

8.1 Three test specimens shall be tested from each sample.

8.2 *Test Specimen Size*:

8.2.1 The recommended test specimen size shall be 15 cm (6 in.) in width by 15 cm in length by 7.5 cm (3 in.) in thickness for any material which can be cut to this size from larger stock without substantially changing its original character.

8.2.2 Test specimen size shall be 15 cm (6 in.) in width by 15 cm in length by the actual thicknesses for materials having less than 7.5 cm (3 in.) overall thickness. This is intended for materials normally produced and sold with natural or laminated skin surfaces and for other materials in which the sample stock available for testing is less than 7.5 cm in thickness.

8.2.3 For materials produced and sold with natural or laminated skin surfaces having an overall thickness greater than 7.5 cm (3 in.), the test specimen thickness shall be the

[4] Hobart Model 411, an electrically operated slicer available from the Hobart Manufacturing Co., 12750 North End, Oak Park, MI 48237, has been found satisfactory for this purpose.

[5] Cell-size grid decals can be obtained from ASTM Headquarters, Reference Test Method D 3576.

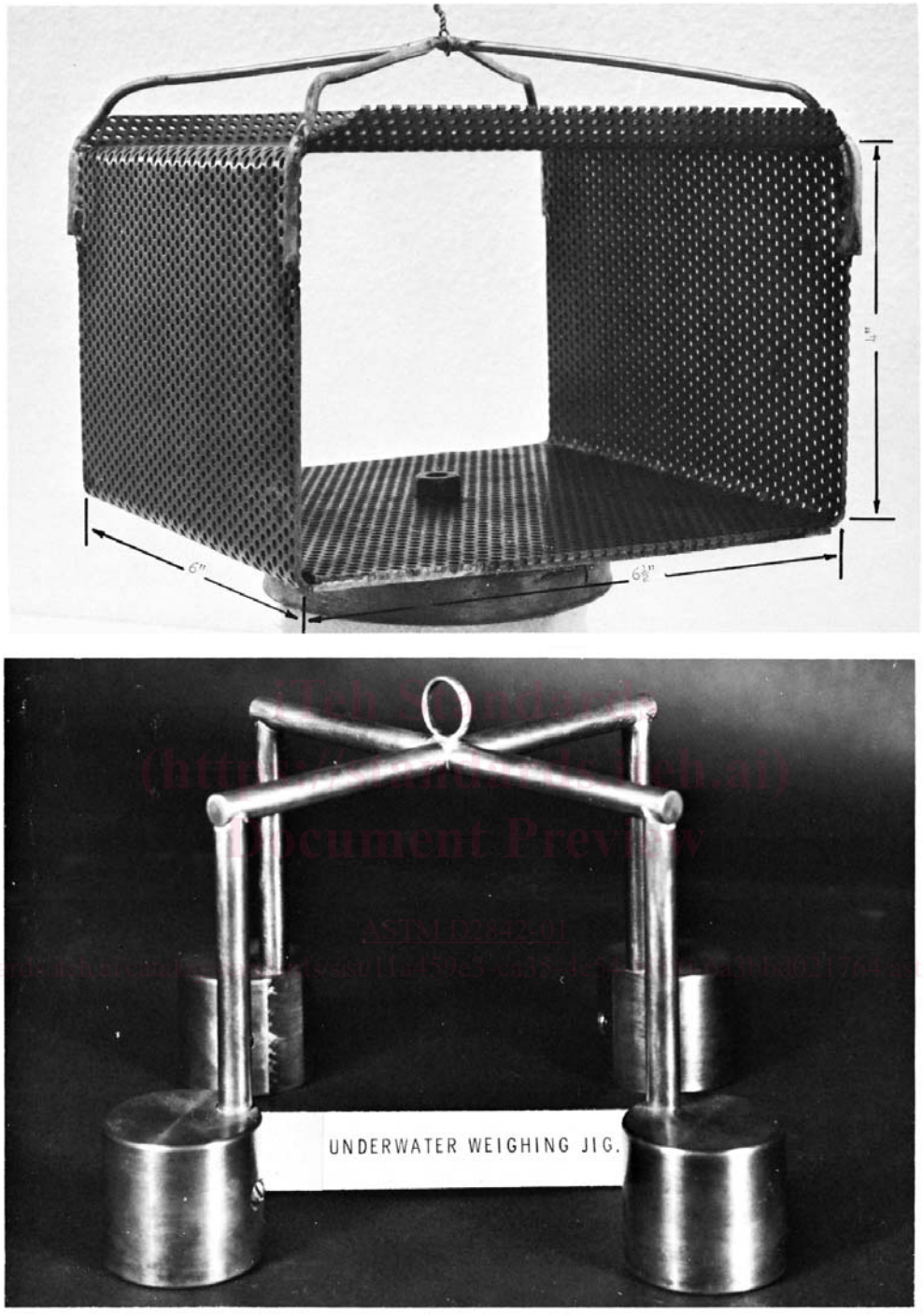

FIG. 1 Underwater Weighing Jigs

actual thickness with the length and width dimensions increased to no less than two times the thickness dimension. To accommodate these larger specimens, the test equipment specified previously must be modified accordingly.

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

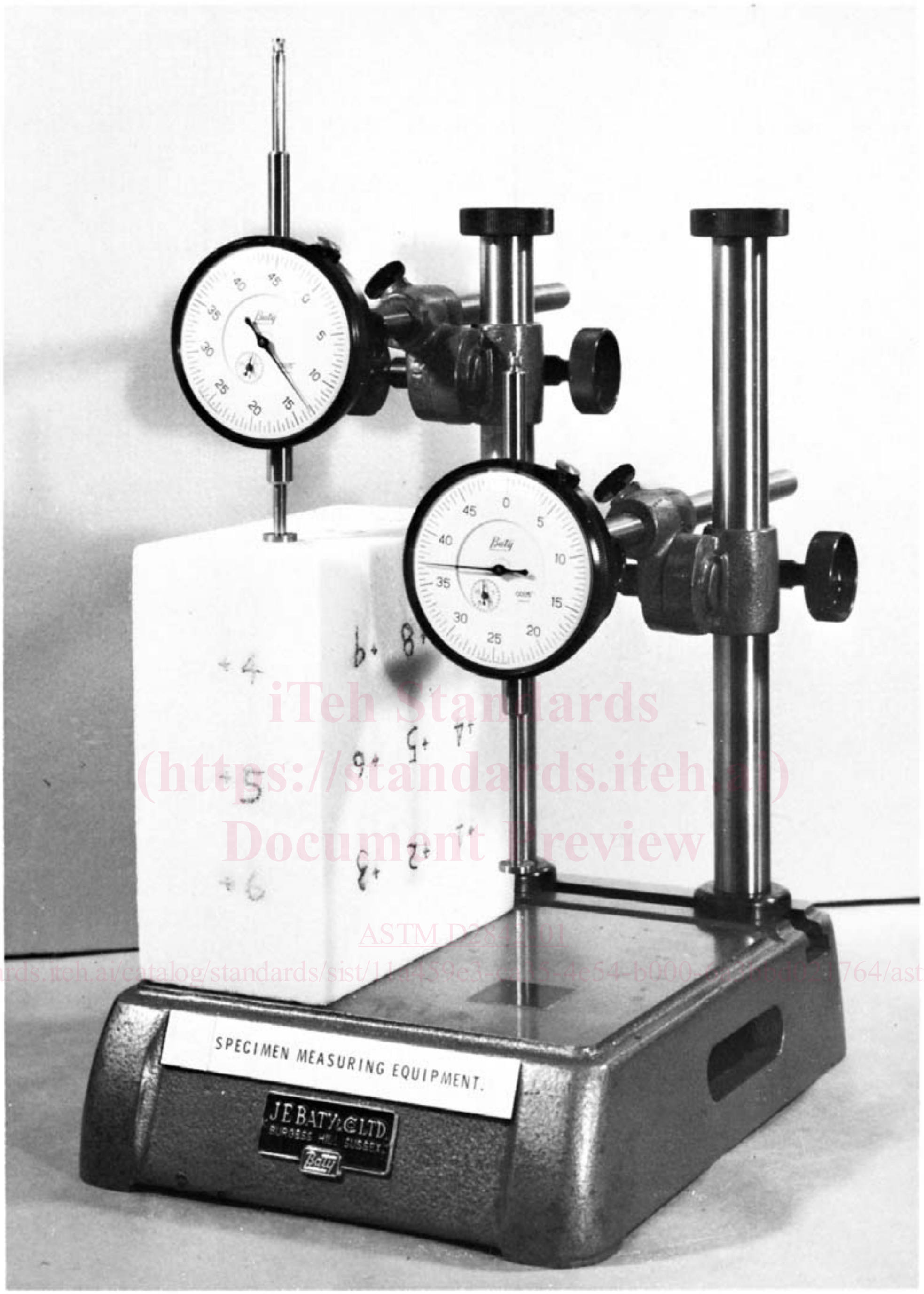

FIG. 2 Dual-Dial Micrometer Measuring Device

sanding with No. 0 or finer sandpaper. Resulting dust shall be blown from the specimen.

9. Conditioning

9.1 Unless specified by the contract or relevant material specification, after cutting specimens, condition them in a forced-air circulating oven for 24 h or more at 50 ± 3°C (122 ± 5°F).

9.2 Allow specimens to cool to room temperature in a desiccator and then weigh to the nearest 0.1 g.

9.3 Return specimens to conditioning oven for 4 additional hours at 50 ± 3°C (122 ± 5°F), cool in desiccator, and weigh to the nearest 0.1 g. Repeat 4-h conditioning intervals until specimens reach constant weight as indicated by less than 0.2-g weight change between successive weighings.

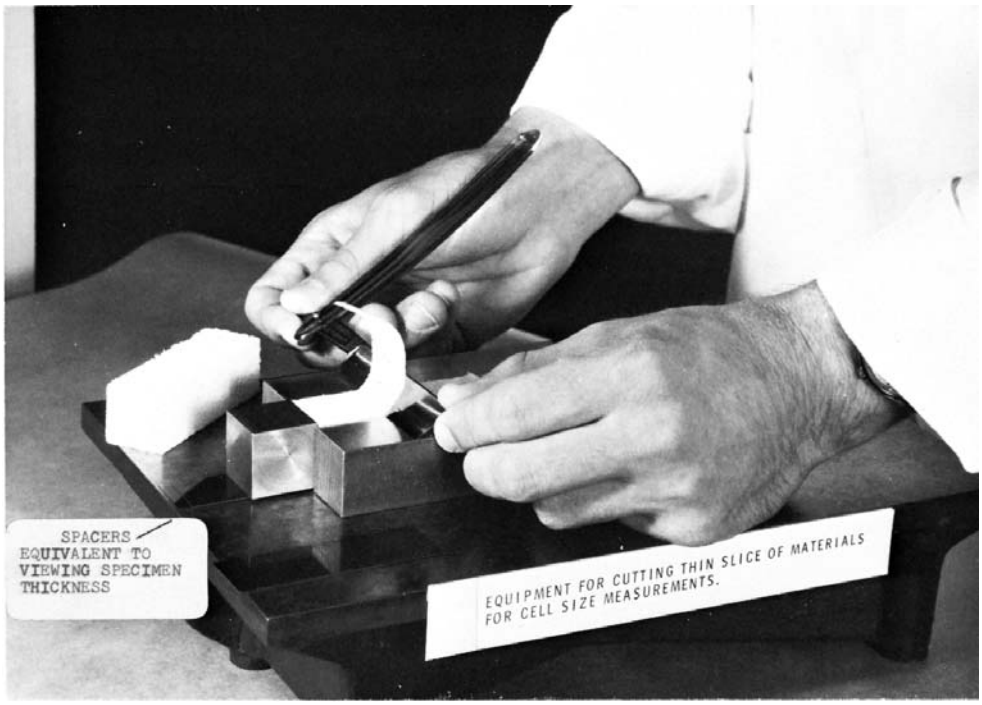

FIG. 3 Razor Blade Cell-Size Specimen Slicer

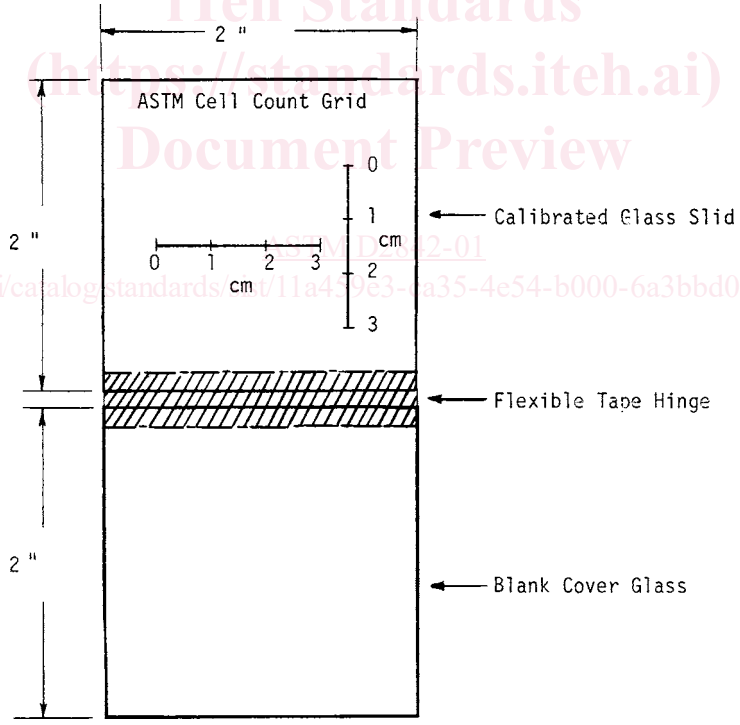

FIG. 4 Cell-Size Scale Slide Assembly

9.4 Record final dry weight of each specimen to nearest 0.1 g (W_1).

10. Procedure

10.1 *Procedure A*:

10.1.1 Place underwater weighing jig in immersion tank.

10.1.2 Immerse specimens by suitable weighted rack in open-top immersion tank filled with freshly distilled water at 23 ± 2°C (73.4 ± 3.6°F). Adjust the water level to maintain a 5.1-cm (2-in.) head of water over the top of specimens with 15.2 by 15.2-cm (6 by 6-in.) faces in the horizontal position.

10.1.3 Remove obvious air bubbles clinging to the specimen with a soft-bristle brush.

10.1.4 Cover entire surface of water with low-permeance plastic film.

10.1.5 Leave specimens immersed for 96 h while maintaining 5.1-cm (2-in.) head of water at 23 ± 2°C (73.4 ± 3.6°F).

10.1.6 At the end of 96-h immersion time, assemble balance platform and balance on the top of the tank, remove the plastic film from water, and zero balance.

10.1.7 Attach the underwater weighing jig to the balance with wire sling such that the top horizontal surface of the jig is 5.1 cm (2 in.) below the surface of the water. Be sure that the submerged jig is free of trapped air bubbles.

10.1.8 Weigh the empty submerged jig to the nearest 0.1 g (W_2).

10.1.9 Insert the test specimen into submerged underwater weighing jig without removing the specimen from the water. Weigh to the nearest 0.1 g (W_3). Do not remove any specimens from the water until all have been weighed, as removing the specimens reduces the 5.1-cm (2-in.) head.

10.1.10 Remove specimens from water and immediately measure the specimen dimensions (length, width, and thickness) to the nearest 0.002 cm (0.001 in.). For convenience, remove the surface water from the specimen with a towel before measuring.

10.1.11 In accordance with the provisions of 4.4, the following procedure (10.1.12-10.1.15) can be omitted for cellular plastics estimated to have an average cell diameter of 0.03 cm or less. An average cell diameter of 0.03 cm is equivalent to 0.018-cm average chord length, t, as measured in 10.1.15. In this case $V_1 = V_2$ in the calculation.

10.1.12 Prepare the cell size viewing specimen by cutting a thin slice (0.01 to 0.04 cm) from one of the cut surfaces of the specimen (Note 8). Slice thickness should be as thin as practical so that shadowgraph will not be occluded by overlapping cell walls. Optimum slice thickness will vary with the average cell size of the foam with larger cell foams requiring thicker slices.

NOTE 7—One cell-size measurement will provide a representative average cell size for cellular plastics having symmetric cells of relatively uniform size. However, cellular plastics known to be significantly anisotropic will require measurement of cell size in three normal directions for maximum accuracy. An acceptable procedure, in this case, is to take cell-size slices from two perpendicular planes of the test specimen. The size of the cells in the three normal directions can then be measured to fully represent the cell.

10.1.13 Insert the thin-sliced foam specimen into the cell-size slide sandwich. Reassemble the slide.

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

10.1.15 Determine the average cell chord length, t, from the projected shadowgraph. First count the number of cells (or cell walls) which intersect the 3.0-cm straight line projected with the specimen. Then divide the length of the line (3.0 cm) by the number of cells counted to obtain the average chord length, t.

10.2 *Procedure B*:

10.2.1 Place the underwater weighing jig in the immersion tank.

10.2.2 Immerse specimens by suitable weighted rack in the open-top immersion tank filled with freshly distilled water at 23 ± 2°C (73.4 ± 3.6°F). Adjust the water level to maintain a 5.1-cm (2-in.) head of water over the top of the specimens with 15.2 by 15.2-cm (6 by 6-in.) faces in the horizontal position.

10.2.3 Remove obvious air bubbles clinging to the specimen with a soft-bristle brush.

10.2.4 Assemble the balance on top of the tank, and zero the balance.

10.2.5 Attach the underwater weighing jig to the balance with a wire sling such that the top horizontal surface of the jig is 5.1 cm (2 in.) below the surface of the water. Be sure the submerged jig is free of trapped air bubbles.

10.2.6 Weigh the empty submerged jig to the nearest 0.1 g (W_{2i}).

10.2.7 Insert the test specimen into the submerged underwater weighing jig without removing the specimen from the water. Weigh to the nearest 0.1 g (W_{3i}).

10.2.8 Repeat 10.2.7 until W_3 has been measured on all specimens.

10.2.9 Cover the entire surface of the water with a low permeance plastic film.

10.2.10 Leave specimens immersed for the agreed upon immersion period (96 h is standard) while maintaining a 5.1-cm (2-in.) head of water at 23 ± 2°C (73.4 ± 3.6°F).

10.2.11 At the end of the immersion period, remove the plastic film from the water, and zero the balance.

10.2.12 Verify that the top horizontal surface of the jig is 5.1 cm (2 in.) below the surface of the water. Be sure the submerged jig is free of trapped air bubbles.

10.2.13 Weigh the empty submerged jig to the nearest 0.1 g (W_{2f}).

10.2.14 Insert the test specimen into the submerged underwater weighing jig without removing the specimen from the water. Weigh to the nearest 0.1 g (W_{3f}).

11. Calculation

11.1 *Calculation for Procedure A*:

11.1.1 See appendix for derivation of open-celled surface volume from measured cell size.

11.1.2 *Definitions of symbols*:

A = specimen total surface area, cm^2,
h = specimen height (or thickness), cm,
l = specimen length, cm,
w = specimen width, cm,
t = average chord length of surface cells, cm,
V_1 = apparent specimen volume, cm^3,
V_2 = true specimen volume, cm^3,
W_1 = dry weight of specimen, g,
W_2 = weight of empty submerged jig, g, and
W_3 = submerged weight of jig and specimen after immersion period, g.

11.1.3 Calculate apparent specimen volume (V_1) from measured specimen dimensions as follows:

$$V_1 = lwh \quad (1)$$

11.1.4 Calculate surface area, A, as follows:

$$A = 2(l \cdot w) + 2(l \cdot h) + 2(w \cdot h) \quad (2)$$