Designation: D7710 – 14

Standard Test Method for Determination of Volume and Density of Rigid and Irregularly Shaped Molded Cellular Materials[1]

This standard is issued under the fixed designation D7710; 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 is used to determine the volume and density of irregularly shaped molded products.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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 to determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Summary of Test Method

3.1 This test method is used to determine the volume of irregular shaped materials. It uses displacement volume testing to determine the volume occupied by a specimen. This test method is used on materials that do not compress easily. Molded flexible and semi-rigid polyurethane foam are the primary application for this test method although it is possible there will be other uses for this test method.

4. Significance and Use

4.1 The test procedure provides a standard method of obtaining data for research and development, quality control, acceptance and rejection under specifications and for special purposes.

4.2 The data obtained by this test method is applicable to the material under the conditions of this particular test and are not necessarily the same as obtained under other environments in use.

5. Interferences

5.1 Successful application of this test method is dependent on the ability of the media to surround the test sample positioned in the test vessel and fill in all the open space.

6. Apparatus

6.1 Test vessel constructed as outlined in Section 10.

7. Reagents and Materials

7.1 Low-density polyethylene (LDPE) media (unfoamed) approximately 4 mm in diameter. Media shall be uniform in size and appearance.

7.1.1 The precision and bias statement was made using data from an interlaboratory study (ILS) using LDPE media. Other materials are potentially suitable for use but are not addressed in this test method.

7.1.2 The polyethylene media shall hereafter be referred to as "media" to accommodate other material as outlined in 7.1.1.

8. Hazards

8.1 No hazards have been identified with this test method.

9. Sampling, Test Specimens, and Test Units

9.1 One specimen from a mold or cavity is to be tested at a time.

9.2 Test units are SI units.

10. Preparation of Apparatus

10.1 *Test Vessel Construction:*

10.1.1 Test vessel shall allow at least 25 mm on each side of the specimen.

10.1.2 Test vessel is a square or rectangular box made of a rigid transparent plastic such as an acrylic or polycarbonate. This is to allow for visual inspection of the media during the filling process, ensuring that the media has minimal spacing between particles, between the part and the vessel walls, and is properly settled.

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[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 Aug. 1, 2014. Published September 2014. DOI: 10.1520/D7710-14

[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.

10.1.3 Top of vessel has a hinged lid that is firmly secured with a latch on the side opposite the hinges. Reinforce the lid to ensure that the lid remains flat.

10.2 Center of test vessel lid has a 76 ± 3 mm diameter hole in the center for filling of the media

10.3 For vessels greater than 750 cm^2 additional holes shall be evenly spaced in the lid. Use one hole for every 400 cm^2 (overlapping is permitted).

10.4 Small vessels are to be turned upside down to pour out the media. Large boxes are to have a plug installed on the side of the box to pour out the media.

11. Calibration and Standardization

11.1 *Calibration of Test Vessel: Method A (Displacement Method)*

11.1.1 Pour media into a graduated cylinder. Gently tap the cylinder three times to settle the media in the cylinder. It is important to fill the vessel consistently. When filling the vessel, the media shall be poured to overflowing and a straight edge larger than the opening dragged over the opening to provide a level and consistent surface. Repeat after any action that would cause the material to settle.

11.1.1.1 Record volume and place media into test vessel.

11.1.1.2 Continue filling the test vessel through hole in the lid using the method in 11.1.1. Periodically lift box 25 mm from surface and drop three times to settle the media. (Very large vessels shall be shaken instead of dropped if the weight of the apparatus is too great to be safely picked up and dropped.)

11.1.1.3 Repeat 11.1.1.2 until the vessel is full.

11.1.1.4 Record the volume (V_a) of media needed to completely fill the vessel, to the nearest millilitre.

11.1.1.5 Conduct the test five times and record the average volume of the vessel (V_0).

11.1.1.6 Calculate theoretical volume by measuring the length, width, and height of the box's interior in centimetres. Multiply these values together and compare to the average volume (V_0). If the difference is more than 2 mL, repeat calibration (11.1).

11.2 *Calibration of Vessel: Method B (Bulk Density Method)*

11.2.1 Weigh a one litre graduated cylinder to the nearest 0.1 g and record as (W_1).

11.2.2 Pour media into a graduated cylinder. Gently tap the cylinder three times to settle the media in the cylinder.

11.2.3 Add more media if needed. Repeat 11.2.2 until the cylinder is full.

11.2.4 When the cylinder is full, weigh the cylinder or volumetric flask to nearest 0.1 g and record as (W_2).

11.2.5 Determine weight of one litre of media by subtracting (W_1) from (W_2).

11.2.6 Conduct weight test five times and record the average weight in grams per litre (W_F).

12. Conditioning

12.1 Test specimen to be conditioned at 23 ± 2°C and 50 ± 10 % relative humidity for 24 hours prior to testing.

12.2 Testing to be conducted in an environment of 23 ± 2°C and 50 ± 10 % relative humidity.

13. Procedure

13.1 *Test Method A: Determination of Volume by Measuring Displacement*

13.1.1 Fill vessel approximately ½ way full with media.

13.1.2 Place test piece in the vessel and submerge so that it is at least 25 mm below the top of the vessel.

13.1.3 Fill the vessel with media until the entire vessel is occupied, free of voids. When the vessel appears full, settle the media by dropping vessel 25 mm to a flat surface three times. Continue this process until the container is full. (Very large vessels shall be shaken instead of dropped if the weight of the apparatus is too great to be safely picked up and dropped.) It is important to fill the vessel consistently. When filling the vessel, the media shall be poured to overflowing and a straight edge larger than the opening dragged over the opening to provide a level and consistent surface. Repeat after any action that would cause the material to settle.

13.1.4 Carefully remove the media and measure the total volume of media (V_1) with a graduated cylinder as it is being removed.

13.1.5 Calculate volume of the specimen (V_2) by subtracting litres of media (V_1) (13.1.6) from initial volume (V_0) (13.1.5).

13.1.6 Conduct test three times and record the average of the readings.

13.1.7 Report volume in litres to nearest 0.01 litre.

13.1.8 *Density Calculation:*

13.1.8.1 Weigh specimen to the nearest gram (W_A).

13.1.8.2 Calculate density (D_A) in kg/m^3 by dividing the mass of the specimen (W_A) in g by its volume (V_2) in litres: (W_A) / (V_2) = (D_A) in g/mL to nearest 0.1. This is equivalent to kg/m^3.

13.2 *Test Method B: Determination of Volume by Measuring Weight Differential*

13.2.1 Weigh the specimen to the nearest 0.1 g and record as (W_3).

13.2.2 Place the vessel on a balance capable of weighing to the nearest 0.1 g and tare balance.

13.2.3 Remove the vessel from the balance and fill vessel approximately ½ way full with media.

13.2.4 Place specimen in the vessel and submerge so that it is at least 25 mm below the top of the vessel.

13.2.5 Fill the vessel the rest of the way with the media.

13.2.6 When the vessel appears full, settle the media by dropping vessel 25 mm to a flat surface three times. Continue filling and settling until the container is full. (Very large vessels shall be shaken.)

13.2.7 Place filled vessel on balance and record final weight of vessel (W_4).

14. Calculation or Interpretation of Results

14.1 Calculate volume (V by determining the weight of the media (W_4 (13.2.7) – W_3 (13.2.1)) and dividing the weight of the media by weight of one litre of media (W_F) (13.2.6). This is the volume (V_B) of the part in litres [(W_4 – W_3)/W_F].

14.2 Calculate the density (D_B) of the specimen by dividing its mass (W_3) by its volume (V_B). $D_B = (W_3) / (V_B)$ in g/L which is equivalent to kg/m^3. Report to nearest 0.1 kg/m^3.

15. Report

15.1 Report volume of test specimen in litres.

15.2 Report density in kg/m^3 as required.

16. Precision and Bias

16.1 Precision and bias for tests methods in this standard are based on round robin studies conducted by the ASTM D20.22 committee in accordance with Practice E691. For this study, four materials were selected to cover a range of properties expected in commercially available products. Two labs participated. The samples and tests vessel were used by both labs that performed the test. Each laboratory obtained five test results for each material. Precision, characterized by repeatability (S_r and r) and reproducibility (S_R and R) have been determined as shown in the individual tables. (See Table 1.)

16.2 *Bias*—There are no recognized standards by which to estimate bias for these test methods. (**Warning—**The explanation of r and R are only intended to present a meaningful way of considering the approximate precision of these test methods.

TABLE 1 Irregular Volume / Density Test

(2 Laboratories)					
Material	Avg.	S_r	S_R	r	R
1	56.227	1.782	1.881	4.989	5.266
2	126.268	14.157	40.260	39.640	112.727
3	115.318	4.235	10.891	11.858	30.496
4	53.877	0.664	3.415	1.860	9.562

The data in the tables should not be applied to acceptance or rejection of materials, as these data apply only to the materials tested in the round robins and are unlikely to be rigorously representative of other lots, formulations, conditions, materials, or laboratories. Users of these test methods should apply the principles outlined in Practice E691 to generate data specific to their materials and laboratory.)

16.3 The study shown is presented as a repeatability study for reference only. The round robin study is ongoing. This standard will be updated with data from six labs when the study is complete.

17. Keywords

17.1 volume; density; molded; polyurethane; irregularly shaped; cellular materials