Designation: D 1622 – 98

Standard Test Method for Apparent Density of Rigid Cellular Plastics[1]

This standard is issued under the fixed designation D 1622; 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 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.2 *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—ISO 845 is technically equivalent to this test method.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[3]

2.2 *ISO Standard:*

ISO 845 Cellular Plastics and Rubbers—Determination of Apparent (Bulk) Density[4]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard:*

3.1.1 *apparent core density (of a cellular plastic)*—the weight in air per unit volume of a sample, after all forming skins have been removed.

3.1.2 *apparent overall density (of a cellular plastic)*—the weight in air per unit volume of a sample, including all forming skins.

3.1.3 When density or apparent density is used in reference to a cellular plastic, without further qualification, it shall be interpreted as follows:

3.1.3.1 *density*—shall be interpreted as being the *apparent overall density* if the material is to be used with forming skins intact.

3.1.3.2 *density*—shall be interpreted as the *apparent core density* if the forming skins have been, or will be, removed before the material is used.

4. Significance and Use

4.1 If the material to be tested includes forming skins, the apparent overall density, or the apparent core density, or both, may be determined. If the material does not have forming skins, the term overall density is not applicable.

4.2 This test method is also applicable to spray foam materials.

4.3 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 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.

5. Apparatus

5.1 *Analytical Balance or Scale,* capable of weighing the specimens to the nearest ±0.1 %.

5.2 *Micrometer Dial Gage, Caliper, or Steel Rule,* suitable for measuring dimensions of the specimen to ±0.1 %.

5.3 *Dual Component Spray Equipment,* designed to meter the materials.

6. Test Specimen

6.1 The specimen shall be of a shape whose volume can be readily calculated, and not less than 16.4 cm^3 (1.0 $in.^3$) in volume.

6.2 If the sample is a single object whose weight and volume can be measured accurately, the total weight and total volume may be used to determine the sample density. In this case, the test specimen is the entire sample.

6.3 When testing spray foam materials, specimens shall be prepared as follows:

6.3.1 Test specimens shall be taken from finished foam samples that have been sprayed from compounds in accordance with 6.3.2.

6.3.2 The sample compounds should be sprayed at room temperature of between 20 to 24°C. Spray equipment should be adjusted to the best spray pattern and optimum performance.

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[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.22 on Cellular Plastics.

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[2] *Annual Book of ASTM Standards,* Vol 08.01.

[3] *Annual Book of ASTM Standards,* Vol 14.02.

[4] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

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

Spray apply a minimum 1.27-cm (½-in.) layer of foam to a 0.95-cm by 63.5-cm by 63.5-cm (⅜-in. by 24-in. by 24-in.) primed plywood base. After a minimum of 5 min, spray apply a second layer of 3.8 cm (1½ in.).

6.3.3 Cut a 2.54-cm (1-in.) thick specimen from the second layer. For calculation of core density, remove the bottom layer and the top skin. For calculation of the apparent overall density, cut a specimen that includes the forming skin.

6.4 If separate test specimens are cut from the sample, a minimum of five shall be used. The specimens shall be taken from locations distributed throughout the sample.

6.5 When apparent overall density is determined using specimens cut from a larger sample, the ratio of forming skin area to total volume shall be the same for the test specimens as for the sample.

7. Conditioning

7.1 Unless specified by the contract or relevant material specification, 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 the test in accordance with Procedure A of Practice D 618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

7.2 *Test Conditions*—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 the material specification or in this test method. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

8. Number of Specimens

8.1 A minimum of five specimens shall be tested, unless the entire sample is measured as a single specimen (see Section 6).

9. Procedure

9.1 Weigh the test specimen on a balance or scale to a precision of ±0.1 %.

9.2 Measure specimens having dimensions up to and including 25.4 mm (1 in.) with a dial-type gage having a foot with a minimum area of 6.5 cm^2 (1 $in.^2$). Hold the pressure of the dial foot to 0.175 ± 0.035 kN/m^2 (0.025 ± 0.005 psi). Measure dimensions over 25.4 mm (1 in.) with a dial gage, sliding caliper gage, or steel scale of tape. When a sliding caliper gage is used, the proper setting shall be that point at which the measuring faces of the gage contact the surfaces of the specimen without compressing them. Measure all dimensions to a precision of ±0.1 %. In general, three measurements shall be made of each dimension. A lesser number may be made when the following conditions apply:

Measurements per Dimension	Maximum Allowed Cross-Sectional Area Perpendicular to Measured Dimension	Maximum Allowed Length of Longest Perpendicular Dimension
1	25 cm^2(4 $in.^2$)	10 cm (4 in.)
2	100 cm^2(16 $in.^2$)	30 cm (12 in.)

10. Calculation

10.1 Calculate the density to three significant figures as follows:

$$D = \frac{W_s}{V}$$

where:

D = density of specimen, kg/m^3,
W_s = weight of specimen, kg, and
V = volume of specimen, m^3.

NOTE 2—To obtain density in g/cm^3, divide D by 1000. To obtain density in lb/ft^3, divide D by 16.

10.2 See Appendix X1 for a density calculation that corrects for the buoyant effect of air.

NOTE 3—The air buoyancy effect will vary with time and depends on the open-cell content of the foam. Highly open-celled materials are essentially air-filled and will not exhibit the buoyant effects of air. However, freshly produced closed-cell materials are essentially air-void and will exhibit maximum buoyant effects of air. An additional 1.22 kg/m^3 (0.076 lb/ft^3) would be added to the density of an air-void specimen if the correction is used.

10.3 Calculate the standard deviation (estimated) as follows and report it to two significant figures:

$$s = \sqrt{\frac{\Sigma X^2 - nX^2}{n-1}} \text{ or } s = [\Sigma X^2 - n\bar{X}^2)/(n-1)]^{1/2}$$

where:

s = estimated standard deviation,
X = value of a single observation,
n = number of observations, and
$\bar{X}$ = arithmetic mean of the set of observations.

11. Report

11.1 Report the following information:

11.1.1 Complete description of material tested, including type, source, code numbers, form, etc.,

11.1.2 Conditioning procedure used if different from that specified in Section 7,

11.1.3 Number of specimens tested if different from that specified in Section 8,

11.1.4 Density, average value, and standard deviation, and

11.1.5 Date of test.

11.2 Unless otherwise stated, the density is assumed to be the density calculated as defined in 10.1.

TABLE 1 Within-Laboratory and Between-Laboratory Estimate of Precision Based on Round-Robin Testing Data for D 1622 – 83

Material	Nominal Density	Average	Values, kg/m^3			
			S_r[A]	S_R[B]	I_r[C]	I_R[D]
M1	38	37.51	0.42	0.56	1.18	1.58
M2	50	49.63	0.30	0.46	0.86	1.31
M3	24	26.03	0.14	0.66	0.40	1.88
M4	21	20.79	0.59	1.11	1.58	3.14

[A] S_r is the within-laboratory standard deviation of the average.
[B] S_R is the between-laboratories standard deviation of the average.
[C] $I_r = 2.83\ S_r$.
[D] $I_R = 2.83\ S_R$.

TABLE 2 Within-Laboratory and Between-Laboratory Relative Precision Based on Round-Robin Testing Data for D 1622 – 83

Material	Nominal Density, kg/m^3	Average, kg/m^3	Values Expressed as Percent of the Average			
			V_r[A]	V_R[B]	VI_r[C]	VI_R[D]
M1	38	37.51	1.12	1.49	3.17	4.22
M2	50	49.63	0.60	0.93	1.70	2.53
M3	24	38.03	0.50	2.35	1.42	6.65
M4	21	20.79	2.84	5.34	8.04	15.11

[A] V_r is the within-laboratory coefficient of variation of the average.
[B] V_R is the between-laboratories coefficient of variation of the average.
[C] $VI_r = 2.83\ V_r$.
[D] $VI_R = 2.83\ V_R$.

12. Precision and Bias[5]

12.1 *Precision:*

12.1.1 Tables 1 and 2 are based on a round-robin conducted in 1982 in accordance with Practice E 691, involving four materials tested by five laboratories. For each material, all 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 five individual determinations. Each laboratory obtained one test result for each material.

NOTE 4—**Caution:** The following explanations of I_r and I_R (12.1.2-12.1.5) are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Tables 1 and 2 should not be rigorously applied to the acceptance or rejection of material, as those data are specific to the round-robin and may not be representative of other lots, conditions, materials or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 12.1.2-12.1.5 would then be valid for such data.

12.1.2 *Concept of I_r and I_R*—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages (medians/other function) from testing five specimens:

12.1.3 *Repeatability (I_r)*—Comparing two test results for the same material, obtained by the same operator using the same equipment on the same day, the two test results should be judged not equivalent if they differ by more than the I_r for that material.

12.1.4 *Reproducibility (I_R)*—Comparing two test results for the same material, obtained by different operators using different equipment on different days, the two test results should be judged not equivalent if they differ by more than the I_R value for that material.

12.1.5 Any judgment made in accordance with 12.1.3 and 12.1.4 would have an approximate 95 % (0.95) probability of being correct.

12.2 The precision has not been determined for the test method specific to spray foam materials.

12.3 *Bias*—Bias is systematic error that contributes to the difference between a test result and a true (or reference) value. There are no recognized standards on which to base an estimate of bias for this test method.

13. Keywords

13.1 apparent core density; apparent density; apparent overall density; density; rigid cellular plastics; spray foam

[5] Supporting data are available from ASTM Headquarters. Request RR: D20-1105.

APPENDIX

(Nonmandatory Information)

X1. DENSITY CALCULATION USING A CORRECTION FOR THE BUOYANT EFFECT OF AIR

X1.1 Calculate the density to three significant figures as follows:

$$D = \{W_s + W_a)/V\}$$

where:

D = density of specimen, kg/m^3,
W_s = weight of specimen, kg,
W_a = weight of displaced air, kg, calculated by multiplying the volume of the specimen in cubic metres by the density of air at atmospheric temperature and pressure. (The density of air at 23°C and 760 mm Hg of pressure = 1.22 kg/m^3 (0.076 lb/ft^3)), and
V = volume of specimen, m^3 .

X1.2 The error associated with the density not using the correction for the buoyant effect of air is dynamic and approaches zero as air infiltrates into a sample. Thus, the value of W_a is zero in the above calculation when the sample is at equilibrium with the air. In this case the calculation for density is identical to the calculation in 10.1.

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SUMMARY OF CHANGES

Committee D-20 has identified the location of selected changes to this test method since the last issue that may impact the use of this test method:

D 1622 – 98:

(*1*) The health and safety caveat was updated.

(*2*) Significance and Use section was revised to reference material specifications.

(*3*) Conditioning section wording was revised.