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Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[1]

This standard is issued under the fixed designation D 792; 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 These test methods describe the determination of the specific gravity (relative density) and density of solid plastics in forms such as sheets, rods, tubes, or molded items.

1.2 Two test methods are described:

1.2.1 *Test Method A*— For testing solid plastics in water, and

1.2.2 *Test Method B*— For testing solid plastics in liquids other than water. ~~Note1—Alternatively, Test Method D1505 may be applied to many such forms, as well as to films and sheeting.~~

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

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.*

NOTE ~~2—This standard is not equivalent to ISO 1183 Method A.~~ 1—This standard is not equivalent to ISO 1183–1 Method A. This test method provides more guidelines on sample weight and dimension. ISO 1183-1 allows testing at an additional temperature of 27 ± 2°C.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 618~~Practice for Conditioning Plastics and Electrical Insulating Materials for Testing~~ Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range

D 891~~Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals~~ Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range

D 4968 Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range

~~D1505Test Method for Density of Plastics by the Density-Gradient Technique[2]~~

~~D1622Test Method for Apparent Density of Rigid Cellular Plastics[2]~~

~~D1898Practice for Sampling of Plastics~~

~~D4968Guide for Annual Review of Test Methods and Specifications for Plastics[2]~~ 6436 Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range

E 1~~Specification for ASTM Thermometers~~ Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range

E 12~~Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases~~

~~E380Practice for Use of the International System of Units (SI) (the Modernized Metric System)~~ Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases[3]

E 691~~Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method~~ Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range

IEEE/ASTM SI-10 Practice for Use of the International System of Units (SI) (the Modernized Metric System)

[1] These test methods are under the jurisdiction of ASTM Committee D20 on Plastics and are the direct responsibility of Subcommittee D20.70 on Analytical Methods (Section D20.70.01).

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

[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] Withdrawn.

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

3. Terminology

3.1 *General*—The units, symbols, and abbreviations used in these test methods are in accordance with ~~Practice E380~~IEEE/ASTM SI-10.

3.2 *Definitions:*

3.2.1 *specific gravity (relative density)*—the ratio of the mass ~~in air~~ of a ~~unit~~given volume of the impermeable portion of the material at 23°C to the mass ~~in air~~ of ~~equal density of~~ an equal volume of gas-free distilled or de-mineralized water at the same temperature; the form of expression shall be:

Specific gravity (relative density) 23/23°C
(or sp gr 23/23°C)

NOTE ~~3—This~~ 2—This definition is essentially equivalent to the definition for apparent specific gravity and apparent density in Terminology E 12, because the small percentage difference introduced by not correcting for the buoyancy of air is insignificant for most purposes.

3.2.2 *density*~~—the mass in air in kilograms per cubic metre of impermeable portion of the material at 23°C. The form of expression shall be:~~ —cubic metre of impermeable portion of the material at 23°C. The form of expression shall be:

~~D^{23},kg/m^3(Notes3-5)~~

D^{23}, kg/m^3 (Notes 2-4)

NOTE ~~4—The~~ 3—The SI unit of density, as defined in ~~Practice E380~~IEEE/ASTM SI-10, is kg/m^3. To convert density in g/cm^3 to density in kg/m^3, multiply by 1000.

NOTE ~~5—Specific gravity 23/23°C can be converted to density 23°C, kg/m~~ 4—To convert specific gravity 23/23°C to density 23°C, kg/m^3, ~~by~~ use ~~of~~ the following equation:

$D^{23\,C}$, kg/m^3 ~~= spgr23/23°C×997.5~~

= sp gr 23/23°C × 997.5

Where 997.5 kg/m^3 is the density of water at 23°C.

4. Summary of Test Method

4.1 Determine the mass of a specimen of the solid plastic in air. It is then immersed in a liquid, its apparent mass upon immersion is determined, and its specific gravity (relative density) calculated.

5. Significance and Use

5.1 The specific gravity or density of a solid is a property that ~~can be~~is conveniently measured ~~conveniently~~ to identify a material, to follow physical changes in a sample, to indicate degree of uniformity among different sampling units or specimens, or to indicate the average density of a large item.

5.2 Changes in density of a single ~~specimen may be~~ material are due to ~~changes~~ localized differences in crystallinity, loss of plasticizer, absorption of solvent, or to other causes. ~~Portions~~ It is possible that portions of a sample ~~may~~ differ in density because of their differences in crystallinity, thermal history, porosity, and composition (types or proportions of resin, plasticizer, pigment, or filler).

~~NOTE 6—Reference is made to Test Method D1622.~~

5.3 Density is useful for calculating strength-weight and cost-weight ratios.

6. Sampling

6.1 The sampling units used for the determination of specific gravity (relative density) shall be representative of the quantity of product for which the data are ~~required, in accordance with Practice D1898.~~ required.

6.1.1 If it is known or suspected that the sample consists of two or more layers or sections having different specific gravities, either complete finished parts or complete cross sections of the parts or shapes shall be used as the specimens, or separate specimens shall be taken and tested from each layer. The specific gravity (relative density) of the total part ~~cannot~~shall not be obtained by adding the specific gravity of the layers, unless relative percentages of the layers are taken into account.

7. Conditioning

7.1 *Conditioning*— Condition the test specimens at 23 ± 2°C and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618, unless otherwise specified by the contract or relevant material specifications. In cases of disagreement, the tolerances shall be ±1°C and ±2 % relative humidity.

7.2 *Test Conditions*— Conduct tests in the standard laboratory atmosphere of 23 ± 2°C and 50 ± 5 % relative humidity, unless otherwise specified in this specification or by the contract or relevant material specification. In cases of disagreement, the tolerances shall be ±1°C and ±2 % relative humidity.

TEST METHOD A FOR TESTING SOLID PLASTICS IN WATER (SPECIMENS 1 TO 50 g)

8. Scope

8.1 This test method involves weighing a one-piece specimen of 1 to 50 g in water, using a sinker with plastics that are lighter

than water. This test method is suitable for plastics that are wet by, but otherwise not affected by water.

9. Apparatus

9.1 *Analytical Balance*—A balance with a precision within 0.1 mg, accuracy within 0.05% relative (that is, 0.05% of the mass of the specimen in air), and equipped with a stationary support for the immersion vessel above the balance pan ("pan straddle"). —A balance with a precision of 0.1 mg or better is required for materials having densities less than 1.00 g/cm^3 and sample weights less than 10 grams. For all other materials and sample weights, a balance with precision of 1 mg or better is acceptable (see Note 5). The balance shall be equipped with a stationary support for the immersion vessel above the balance pan ("pan straddle").

NOTE 7—Assurance that the balance meets the performance requirements should be provided by frequent checks on adjustments of zero point and sensitivity and by periodic calibration for absolute accuracy, using standard masses.

9.2 *5—The balance shall provide the precision that all materials tested have three significant figures on density. In case that materials with different densities are tested on one single balance, use the balance that provides at least three significant figures for all materials concerned.*

NOTE 6—To assure that the balance meets the performance requirements, check on zero point and sensitivity frequently and perform periodic calibration.

9.2 *Sample Holder*, corrosion-resistant (for example, wire, gemholder, etc.).

9.3 *Sinker*—A sinker for use with specimens of plastics that have specific gravities less than 1.000.1.00. The sinker shall: (*1*) be corrosion-resistant; (*2*) have a specific gravity of not less than 7.0; (*3*) have smooth surfaces and a regular shape; and (*4*) be slightly heavier than necessary to sink the specimen. The sinker shouldshall have an opening to facilitate attachment to the specimen and sample holder.

9.4 *Immersion Vessel*— A beaker or other wide-mouthed vessel for holding the water and immersed specimen.

9.5 *Thermometer*— A thermometer with an accuracy of ±0.1°C is required. — A thermometer readable to 0.1°C or better.

10. Materials

10.1 *Water*—The water shall be substantially air-free and distilled or de-mineralized water.

NOTE 8—Water may be rendered substantially air-free 7—Air in water can be removed by boiling and cooling the water, or by shaking the water under vacuum in a heavy-walled vacuum flask. (Precaution: **Warning—** Use gloves and shielding.) If the water does not wet the specimen, add a few drops of a wetting agent shall be added.into the water. If this solution does not wet the specimen, Method B shall be used.

11. Test Specimen

11.1The test specimen shall be a single piece of the material under test of any size and shape that can conveniently be prepared and tested, provided that its volume shall be not less than 1 cm

11.1 The test specimen shall be a single piece of material with a size and shape suitable for the testing apparatus, provided that its volume shall be not less than 1 cm^3 and its surface and edges shall be made smooth. The thickness of the specimen shouldshall be at least 1 mm for each 1 g of weight. A specimen weighing 1 to 5 g usually will was found to be found convenient, but specimens up to approximately 50 g may be used (are also acceptable (see Note 98). Care shouldshall be taken in cutting specimens to avoid changes in density resulting from compressive stresses or frictional heating.

NOTE 98—Specifications for certain plastics require a particular method of specimen preparation and should be consulted if applicable.

11.2 The specimen shall be free from oil, grease, and other foreign matter.

12. Procedure

12.1Measure12.1 Measure and record the water temperature.

12.2 Weigh the specimen in air to the nearest 0.1 mg for specimens of mass 1 to 10 g or to the nearest mg for specimens of mass more than 10 to 50 g. Weigh the specimen in air. Weigh to the nearest 0.1 mg for specimens of mass 1 to 10 g and density less than 1.00 g/cm ^{3}. Weigh to the nearest 1 mg for other specimens.

12.3 If necessary, attach to the balance a piece of fine wire sufficiently long to reach from the hook above the pan to the support for the immersion vessel. In this case attach the specimen to the wire such that it is suspended about 25 mm above the vessel support.

NOTE 10—If 9—If a wire is used, weigh the specimen may be weighed in air after hanging from the wire. In this case, record the mass of the specimen, a = (mass of specimen + wire, in air) – (mass of wire in air).

12.4Mount12.4 Mount the immersion vessel on the support, and completely immerse the suspended specimen (and sinkers, if used) in water (see 10.1) at a temperature of 23 ± 2°C. The vessel must not touch sample holder or specimen. Remove any bubbles adhering to the specimen, sample holder, or sinker, paying by rubbing them with a wire. Pay particular attention to holes in the specimen and sinker. Usually these bubbles can be removed by rubbing them with a wire. If the bubbles cannot beare not removed by this method or if bubbles are continuously formed (as from dissolved gases), the use of vacuum is recommended (see Note 1210). Determine the mass of the suspended specimen to the required precision (see 12.2)) (see Note 11). Record this apparent

mass as *b* (the mass of the specimen, sinker, if used, and the partially immersed wire in liquid). Unless otherwise specified, weigh rapidly in order to minimize absorption of water by the specimen.

NOTE~~11—It may be necessary to change the sensitivity adjustment of the balance to overcome the damping effect of the immersed specimen.~~ 10—Some specimens may contain absorbed or dissolved gases, or irregularities which tend to trap air bubbles; any of these may affect the density values obtained. In such cases, the immersed specimen may be subjected to vacuum in a separate vessel until evolution of bubbles has substantially ceased before weighing (see Test Method B). It must also be demonstrated that the use of this technique leads to results of the required degree of precision.

NOTE~~12—Some specimens may contain absorbed or dissolved gases, or irregularities which tend to trap air bubbles; any of these may affect the density values obtained. In such cases, the immersed specimen may be subjected to vacuum in a separate vessel until evolution of bubbles has substantially ceased before weighing (see Test Method B). It must also be demonstrated that the use of this technique leads to results of the required degree of precision.~~

~~12.5Weigh the sample holder (and sinker, if used) in water with immersion to the same depth as used in the previous step (Notes 13 and 14~~ 11—It may be necessary to change the sensitivity adjustment of the balance to overcome the damping effect of the immersed specimen.

12.5 Weigh the sample holder (and sinker, if used) in water with immersion to the same depth as used in the previous step (Notes 12 and 13). Record this weight as *w* (mass of the sample holder in liquid).

NOTE~~13—If~~ 12—If a wire is used, it is convenient to mark the level of immersion by means of a shallow notch filed in the wire. The finer the wire, the greater the tolerance ~~which may be~~ is permitted in adjusting the level of immersion between weighings. With wire Awg No. 36 or finer, disregard its degrees of immersion and, if no sinker is used, use the mass of the wire in air as *w*.

NOTE~~14—If~~ 13—If the wire is used and is left attached to the balance arm during a series of determinations, determine the mass *a* ~~may be determined either~~ with the aid of a tare on the other arm of the balance or as in Note ~~12~~9. In such cases, care must be taken that the change of mass of the wire (for example, from visible water) between readings does not exceed the desired precision.

12.6 Repeat the procedure for the required number of specimens. Two specimens per sample are recommended. Determine acceptability of number of replicate test specimens by comparing results with precision data given in Tables 1 and 2~~. Additional specimens may be required to give the desired precision.~~ . Use additional specimens if desired.

13. Calculation

13.1 Calculate the specific gravity of the plastic as follows:

$$\text{sp gr } 23/23°\text{C} = a/(a + w - b)$$

where:

a = apparent mass of specimen, without wire or sinker, in air,
b = apparent mass of specimen (and of sinker, if used) completely immersed and of the wire partially immersed in liquid, and
w = apparent mass of totally immersed sinker (if used) and of partially immersed wire.

~~13.2Calculate~~13.2 Calculate the density of the plastic as follows:

$$D^{23C}, \text{kg/m}^3 = \text{sp gr } 23/23°\text{C} \times 997.5$$

13.3 ~~If the temperature of the water is different than 23°C, the following equations will be used:~~ If the temperature of the water is different than 23°C, use the density of water listed in Table 3 directly, or use the following equations to calculate the density of water at testing temperature:

$$M = \Delta D/\Delta t \quad (1)$$

~~D (conversion to 23°C), kg/m^3~~

$$= \text{sp gr } t_a/t_w \times [997.5 + (t_w - 23) \times M] \quad (2)$$

D(conversion to 23°C), kg/m^3

$$= \text{sp gr } t_a/t_w \times [997.5 + (t_w - 23) \times M] \quad (2)$$

– 23) × M]

and

TABLE 1 Test Method A Specific Gravity Tested in Water

Material	Mean	S_r[A]	S_R[B]	r[C]	R[D]
Polypropylene	0.9007	0.00196	0.00297	0.00555	0.00841
Cellulose Acetate Butyrate	1.1973	0.00232	0.00304	0.00657	0.00860
Polyphenylene Sulfide	1.1708	0.00540	0.00738	0.01528	0.02089
Thermoset	1.3136	0.00271	0.00313	0.00767	0.02171
Polyvinyl Chloride	1.3396	0.00243	0.00615	0.00688	0.01947

[A] S_r = within laboratory standard deviation for the individual material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories:

$$S_r = [[(s_1)^2 + (s_2)^2 \ldots + (s_n)^2]/n]^{1/2}$$

[B] S_R = between-laboratories reproducibility, expressed as standard deviation: $S_R = [S_r^2 + S_L^2]^{1/2}$ where S_L is the standard deviation of laboratory means.
[C] r = within-laboratory critical interval between two test results = 2.8 × S_r.
[D] R = between-laboratories critical interval between two test results = 2.8 × S_R.