Designation: D570 – 22

Standard Test Method for Water Absorption of Plastics[1]

This standard is issued under the fixed designation D570; 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 U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of the relative rate of absorption of water by plastics when immersed. This test method is intended to apply to the testing of all types of plastics, including cast, hot-molded, and cold-molded resinous products, and both homogeneous and laminated plastics in rod and tube form and in sheets 0.13 mm (0.005 in.) or greater in thickness.

1.2 The values given in SI units are to be regarded as standard. The values stated in parentheses are for information only.

NOTE 1—This test method and ISO 62 are technically equivalent when the test specimen described in 6.2 is used.

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

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics

E456 Terminology Relating to Quality and Statistics

2.2 *ISO Standard:*

ISO 62 Plastics—Determination of Water Absorption[3]

3. Terminology

3.1 For definitions of terms that appear in this practice relating to plastics, refer to Terminology D883.

3.2 For definitions of terms that appear in this practice relating to quality and statistics (such as precision and bias), refer to Terminology E456.

4. Significance and Use

4.1 This test method for rate of water absorption has two chief functions: first, as a guide to the proportion of water absorbed by a material and consequently, in those cases where the relationships between moisture and electrical or mechanical properties, dimensions, or appearance have been determined, as a guide to the effects of exposure to water or humid conditions on such properties; and second, as a control test on the uniformity of a product. This second function is particularly applicable to sheet, rod, and tube arms when the test is made on the finished product.

4.2 Comparison of water absorption values of various plastics made on the basis of values obtained in accordance with 8.1 and 8.4 have been found useful.

4.3 Ideal diffusion of liquids[4] into polymers is a function of the square root of immersion time. Time to saturation is strongly dependent on specimen thickness. For example, Table 1 shows the time to approximate time saturation for various thickness of nylon-6.

4.4 The moisture content of a plastic is very intimately related to such properties as electrical insulation resistance, dielectric losses, mechanical strength, appearance, and dimensions. The effect upon these properties of change in moisture content due to water absorption depends largely on the type of exposure (by immersion in water or by exposure to high humidity), shape of the part, and inherent properties of the plastic. With nonhomogeneous materials, such as laminated

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[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, http://www.ansi.org.

[4] Additional information regarding diffusion of liquids in polymers can be found in the following references: (*1*) *Diffusion, Mass Transfer in Fluid Systems*, E. L. Cussler, Cambridge University Press, 1985, ISBN 0-521-29846-6, (*2*) *Diffusion in Polymers,* J. Crank and G. S. Park, Academic Press, 1968, and (*3*) "Permeation, Diffusion, and Sorption of Gases and Vapors," R. M. Felder and G. S. Huvard, in *Methods of Experimental Physics*, Vol 16C, 1980, Academic Press.

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

TABLE 1 Time to Saturation for Various Thickness of Nylon-6

Thickness, mm	Typical Time to 95 % Saturation, h
1	100
2	400
3.2	1 000
10	10 000
25	62 000

forms, the rate of water absorption is sometimes known to be widely different through each edge and surface. Even for otherwise homogeneous materials, it has been observed to be slightly greater through cut edges than through molded surfaces. Consequently, attempts to correlate water absorption with the surface area must generally be limited to closely related materials and to similarly shaped specimens: For materials of widely varying density, relation between water-absorption values on a volume as well as a weight basis needs to be considered.

5. Apparatus

5.1 *Balance*—An analytical balance capable of reading 0.0001 g.

5.2 *Oven,* capable of maintaining uniform temperatures of 50 ± 3°C (122 ± 5.4°F) and of 105 to 110°C (221 to 230°F).

6. Test Specimen

6.1 The test specimen for molded plastics shall be in the form of a disk 50.8 mm (2 in.) in diameter and 3.2 mm (0.125 in.) in thickness. Permissible variations in thickness are ±0.18 mm (±0.007 in.) for hot-molded and ±0.30 mm (±0.012 in.) for cold-molded or cast materials.

6.2 *ISO Standard Specimen*—The test specimen for homogeneous plastics shall be 60 by 60 by 1 mm. Tolerance for the 60-mm dimension is ±2 mm and ±0.05 mm for the 1-mm thickness.

6.3 The test specimen for sheets shall be in the form of a bar 76.2 mm (3 in.) long by 25.4 mm (1 in.) wide by the thickness of the material. When comparison of absorption values with molded plastics is desired, specimens 3.2-mm (0.125-in.) thick shall be used. Permissible variations in thickness shall be 0.20 mm (±0.008 in.) except for materials which have greater standard commercial tolerances.

6.4 The test specimen for rods shall be 25.4-mm (1-in.) long for rods 25.4 mm in diameter or under and 12.7-mm (0.50-in.) long for larger-diameter rods. The diameter of the specimen shall be the diameter of the finished rod.

6.5 The test specimen for tubes less than 76 mm (3 in.) in inside diameter shall be the full section of the tube and 25.4-mm (1-in.) long. For tubes 76 mm (3 in.) or more in inside diameter, a rectangular specimen shall be cut 76 mm in length in the circumferential direction of the tube and 25.4 mm in width lengthwise of the tube.

6.6 The test specimens for sheets, rods, and tubes shall be machined, sawed, or sheared from the sample so as to have smooth edges free from cracks. The cut edges shall be made smooth by finishing with No. 0 or finer sandpaper or emery cloth. Sawing, machining, and sandpapering operations shall be slow enough so that the material is not heated appreciably.

NOTE 2—If there is any oil on the surface of the specimen when received or as a result of machining operations, wash the specimen with a cloth wet with gasoline to remove oil, wipe with a dry cloth, and allow to stand in air for 2 h to permit evaporation of the gasoline. If gasoline attacks the plastic, use some suitable solvent or detergent that will evaporate within the 2-h period.

6.7 The dimensions listed in Table 2 for the various specimens shall be measured to the nearest 0.025 mm (0.001 in.). Dimensions not listed shall be measured within 0.8 mm (±0.031 in.).

7. Conditioning

7.1 Three specimens shall be conditioned as follows:

7.1.1 Specimens of materials whose water-absorption value would be appreciably affected by temperatures in the neighborhood of 110°C (230°F), shall be dried in an oven for 24 h at 50 ± 3°C (122 ± 5.4°F), cooled in a desiccator, and immediately weighed to the nearest 0.001 g.

NOTE 3—If a static charge interferes with the weighing, lightly rub the surface of the specimens with a grounded conductor.

7.1.2 Specimens of materials, such as phenolic laminated plastics and other products whose water-absorption value has been shown not to be appreciably affected by temperatures up to 110°C (230°F), shall be dried in an oven for 1 h at 105 to 110°C (221 to 230°F).

7.1.3 When data for comparison with absorption values for other plastics are desired, the specimens shall be dried in an oven for 24 h at 50 ± 3°C (122 ± 5.4°F), cooled in a desiccator, and immediately weighed to the nearest 0.001 g.

8. Procedure

8.1 *Twenty-Four Hour Immersion*—The conditioned specimens shall be placed in a container of distilled water maintained at a temperature of 23 ± 1°C (73.4 ± 1.8°F), and shall rest on edge and be entirely immersed. At the end of 24, +½, –0 h, the specimens shall be removed from the water one at a time, all surface water wiped off with a dry cloth, and weighed to the nearest 0.001 g immediately. If the specimen is 1⁄16 in. or less in thickness, it shall be put in a weighing bottle immediately after wiping and weighed in the bottle.

8.2 *Two-Hour Immersion*—For all thicknesses of materials having a relatively high rate of absorption, and for thin specimens of other materials which may show a significant weight increase in 2 h, the specimens shall be tested as described in 8.1 except that the time of immersion shall be reduced to 120 ± 4 min.

TABLE 2 Critical Specimen Dimension Measurements

Type of Specimen	Dimensions
Molded disk	thickness
Sheet	thickness
Rod	length and diameter
Tube	inside and outside diameter, and wall thickness

8.3 *Repeated Immersion*—A specimen may be weighed to the nearest 0.001 g after 2-h immersion, replaced in the water, and weighed again after 24 h.

NOTE 4—In using this test method the amount of water absorbed in 24 h may be less than it would have been had the immersion not been interrupted.

8.4 *Long-Term Immersion*—To determine the total water absorbed when substantially saturated, the conditioned specimens shall be tested as described in 8.1 except that at the end of 24 h they shall be removed from the water, wiped free of surface moisture with a dry cloth, weighed to the nearest 0.001 g immediately, and then replaced in the water. The weighings shall be repeated at the end of the first week and every two weeks thereafter until the increase in weight per two-week period, as shown by three consecutive weighings, averages less than 1 % of the total increase in weight or 5 mg, whichever is greater; the specimen shall then be considered substantially saturated. The difference between the substantially saturated weight and the dry weight shall be considered as the water absorbed when substantially saturated.

8.5 *Two-Hour Boiling Water Immersion*—The conditioned specimens shall be placed in a container of boiling distilled water, and shall be supported on edge and be entirely immersed. At the end of 120 ± 4 min, the specimens shall be removed from the water and cooled in distilled water maintained at room temperature. After 15 ± 1 min, the specimens shall be removed from the water, one at a time, all surface water removed with a dry cloth, and the specimens weighed to the nearest 0.001 g immediately. If the specimen is 1⁄16 in. or less in thickness, it shall be weighed in a weighing bottle.

8.6 *One-Half-Hour Boiling Water Immersion*—For all thicknesses of materials having a relatively high rate of absorption and for thin specimens of other materials which may show a significant weight increase in ½ h, the specimens shall be tested as described in 8.5, except that the time of immersion shall be reduced to 30 ± 1 min.

8.7 *Immersion at 50°C*—The conditioned specimens shall be tested as described in 8.5, except that the time and temperature of immersion shall be 48 ± 1 h and 50 ± 1°C (122.0 ± 1.8°F), respectively, and cooling in water before weighing shall be omitted.

8.8 When data for comparison with absorption values for other plastics are desired, the 24-h immersion procedure described in 8.1 and the equilibrium value determined in 8.4 shall be used.

9. Reconditioning

9.1 When materials are known or suspected to contain any appreciable amount of water-soluble ingredients, the specimens, after immersion, shall be weighed, and then reconditioned for the same time and temperature as used in the original drying period. They shall then be cooled in a desiccator and immediately reweighed. If the reconditioned weight is lower than the conditioned weight, the difference shall be considered as water-soluble matter lost during the immersion test. For such materials, the water-absorption value shall be taken as the sum of the increase in weight on immersion and of the weight of the water-soluble matter.

10. Calculation and Report

10.1 The report shall include the values for each specimen and the average for the three specimens as follows:

10.1.1 Dimensions of the specimens before test, measured in accordance with 6.6, and reported to the nearest 0.025 mm (0.001 in.),

10.1.2 Conditioning time and temperature,

10.1.3 Immersion procedure used,

10.1.4 Time of immersion (long-term immersion procedure only),

10.1.5 Percentage increase in weight during immersion, calculated to the nearest 0.01 % as follows:

$$\text{Increase in weight, \%} = \frac{\text{wet weight} - \text{conditioned weight}}{\text{conditioned weight}} \times 100$$

10.1.6 Percentage of soluble matter lost during immersion, if determined, calculated to the nearest 0.01 % as follows (see Note 5):

$$\text{Soluble matter lost, \%} = \frac{\text{conditioned weight} - \text{reconditioned weight}}{\text{conditioned weight}} \times 100$$

NOTE 5—When the weight on reconditioning the specimen after immersion in water exceeds the conditioned weight prior to immersion, report "none" under 10.1.6.

10.1.7 For long-term immersion procedure only, prepare a graph of the increase in weight as a function of the square root of each immersion time. The initial slope of this graph is proportional to the diffusion constant of water in the plastic. The plateau region with little or no change in weight as a function of the square root of immersion time represents the saturation water content of the plastic.

NOTE 6—Deviation from the initial slope and plateau model indicates that simple diffusion may be a poor model for determining water content. In such cases, additional studies are suggested to determine a better model for water absorption.

10.1.8 The percentage of water absorbed, which is the sum of the values in 10.1.5 and 10.1.6, and

10.1.9 Any observations as to warping, cracking, or change in appearance of the specimens.

11. Precision and Bias[5]

11.1 *Precision*—The 95 % repeatability limit and 95% reproducibility limit have been determined as shown in Table 3.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D20-1064.

TABLE 3 Precision and Bias

	Repeatability	Reproducibility
Average absorption above 1 % (2 materials)	2.33 %	4.89 %
Average absorption below 0.2 % (1 material)	9.01 %	16.63 %