Designation: D 543 – 95 (Reapproved 2001)

Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents[1]

This standard is issued under the fixed designation D 543; 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 practices cover the evaluation of all plastic materials including cast, hot-molded, cold-molded, laminated resinous products, and sheet materials for resistance to chemical reagents. These practices include provisions for reporting changes in weight, dimensions, appearance, and strength properties. Standard reagents are specified to establish results on a comparable basis. Provisions are made for various exposure times, stress conditions, and exposure to reagents at elevated temperatures. The type of conditioning (immersion or wet patch) depends upon the end-use of the material. If used as a container or transfer line, specimens should be immersed. If the material will only see short exposures or will be used in close proximity and reagent may splash or spill on the material, the wet patch method of applying reagent should be used.

NOTE 1—These practices are related to ISO 175. Method B is similar to ISO 4599-1986(E). An ISO standard is under development that requires specific procedures for reporting the change in mechanical properties after chemical exposure.

1.2 The effect of chemical reagents on other properties shall be determined by making measurements on standard specimens for such tests before and after immersion or stress, or both, if so tested.

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

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.* Specific hazards statements are given in Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

D 13 Specification for Spirits of Turpentine[2]
D 396 Specification for Fuel Oils[3]
D 618 Practice for Conditioning Plastics for Testing[4]
D 883 Terminology Relating to Plastics[4]
D 1040 Specification for Uninhibited Mineral Insulating Oil for Use in Transformers and in Oil Circuit Breakers[5]
D 1898 Practice for Sampling of Plastics[6]
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[7]

2.2 *Military Specifications:*[8]

MIL-A-11755 Antifreeze, Arctic-Type
MIL-A-46153 Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package
MIL-C-372 Cleaning Compound, Solvent (For Bore of Small Arms and Automatic Aircraft Weapons)
MIL-D-12468 Decontaminating Agent, STB
MIL-D-50030 Decontaminating Agent, DS2
MIL-F-46162 Fuel, Diesel, Referee Grade
MIL-G-5572 Gasoline, Aviation, Grades 80/87, 100/130, 115/145
MIL-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missiles, and Ordinance
MIL-H-6083 Hydraulic Fluid, Petroleum Base, for Preservation and Operation
MIL-H-83283 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft
MIL-L-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0–148
MIL-L-14107 Lubricating Oil, Weapons, Low Temperature

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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 D20.50 on Permanence Properties.

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[2] *Annual Book of ASTM Standards*, Vol 06.03.

[3] *Annual Book of ASTM Standards*, Vol 05.01.

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

[5] *Discontinued. See 1980 Annual Book of ASTM Standards, Part 40.*

[6] Discontinued; see *1997 Annual Book of ASTM Standards*, Vol 08.01.

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

[8] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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MIL-L-23699 Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-L-46000 Lubricant, Semi-Fluid (Automatic Weapons)
MIL-T-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-T-83133 Turbine Fuel, Aviation, Kerosene Type, Grade JP-8

2.3 *U.S. Army Regulation:*[8]

AR 70-71 Nuclear, Biological, and Chemical Contamination Survivability of Army Material

2.4 *ISO Standards:*[9]

ISO 175 Plastics—Determination of Resistance to Liquid Chemicals
ISO 4599-1986(E) Plastics—Determination of Resistance to Environmental Stress Cracking (ESC)—Bent Strip Method

3. Terminology

3.1 *Definitions*—Definitions of terms applying to these practices appear in Terminology D 883.

4. Significance and Use

4.1 The limitations of the results obtained from these practices should be recognized. The choice of types and concentrations of reagents, duration of immersion or stress, or both, temperature of the test, and properties to be reported is necessarily arbitrary. The specification of these conditions provides a basis for standardization and serves as a guide to investigators wishing to compare the relative resistance of various plastics to typical chemical reagents.

4.2 Correlation of test results with the actual performance or serviceability of plastics is necessarily dependent upon the similarity between the testing and the end-use conditions. For applications involving continuous immersion, the data obtained in short-time tests are of interest only in eliminating the most unsuitable materials or indicating a probable relative order of resistance to chemical reagents.

4.3 Evaluation of plastics for special applications involving corrosive conditions should be based upon the particular reagents and concentrations to be encountered. The selection of test conditions should take into account the manner and duration of contact with reagents, the temperature of the system, applied stress, and other performance factors involved in the particular application.

5. Apparatus

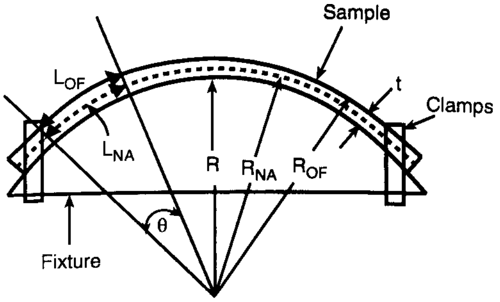
5.1 *Balance*—A balance capable of weighing accurately to 0.05 % for a test specimen weighing 100 g or less, and to 0.1 % for a test specimen weighing over 100 g. Assurance that the balance meets the performance requirements should be provided by frequent checks on adjustments of zero points and sensitivity and by periodic calibration for absolute accuracy, using standard masses.

5.2 *Micrometers*—Use a suitable micrometer for measuring the dimensions of test specimens similar to that described in Test Method D 374. The micrometer should have an incremental discrimination of at least 0.025 mm (0.001 in.). For specimens 0.100 in. thick or less, the micrometer used shall have an incremental discrimination of at least 0.0025 mm (0.0001 in.). The micrometer must be verified using gage blocks traceable to National Institute of Standards and Technology (NIST) every 30 days minimum.

5.3 *Room*, or enclosed space capable of being maintained at the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity in accordance with Practice D 618.

5.4 *Containers*—Suitable containers for submerging specimens in chemical reagents. They must be resistant to the corrosive effects of the reagents being used. Venting should be provided, especially when using volatile reagents at elevated temperatures. Tightly sealed containers are preferred for room temperature testing to minimize loss.

5.5 *Strain Jigs*—Jigs are to be capable of supplying known amounts of strain to test specimens. Fig. 1 is a side view drawing of a typical strain jig used to obtain 1.0 % strain in a 3.2 mm (0.125 in.) thick test specimen. Shown in Fig. 1 is an equation that can be used to calculate strain from known dimensions or back-calculate jig dimensions for a desired specimen strain.



R = radius of jig
R_{NA} = radius of neutral axis
R_{OF} = radius of outer fiber
t = thickness of specimen
θ = arbitrary angle
L_{OF} = length of outer fiber
L_{NA} = length of neutral axi

considering a portion of test bar determined by angle θ

$$L_{NA} = R_{NA}\,\theta = (R + \tfrac{1}{2}t)\,\theta \qquad R_{NA} = R + \tfrac{1}{2}t$$

$$L_{OF} = R_{OF}\,\theta = (R + t)\,\theta \qquad R_{OF} = R + t$$

$$\Delta L = L_{OF} - L_{NA} = (R + t)\,\theta - (R + \tfrac{1}{2}t)\,\theta$$

$$\Sigma = \frac{\Delta L}{L} = \frac{(R + t)\,\theta - (R + \frac{1}{2}t)\,\theta}{(R + \frac{1}{2}t)\,\theta}$$

$$\Sigma = \frac{(R + t) - R + \frac{1}{2}t}{R + \frac{1}{2}t} = \frac{\frac{1}{2}t}{R + \frac{1}{2}t}$$

$$\boxed{\Sigma = \frac{1}{\frac{2R}{t} + 1}} \qquad \boxed{R = \frac{(\frac{1}{\Sigma} - 1)\,t}{2}}$$

FIG. 1 Determination of Strain Level of ESCR Fixtures

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

5.6 *Oven or Constant Temperature Bath*, capable of maintaining temperatures within ±2°C of the specified test temperatures.

5.7 *Testing Devices*—Testing devices for determining specific strength properties of specimens before and after submersion or strain, or both, conforming to the requirements prescribed in the ASTM test methods for the specific properties being determined.

5.8 *Laboratory Hood*, or other system adequate for vapor ventilation.

6. Reagents and Materials

6.1 The following list of standard reagents is intended to be representative of the main categories of pure chemical compounds, solutions, and common industrial products. Chemicals used in this practice shall be of technical grade or greater purity. All solutions shall be made with freshly prepared distilled water. Specific concentrations are on a weight percent or specific gravity basis. Mixing instructions are based on amounts of ingredients calculated to produce 1000 mL of solution of the specified concentration.

6.2 The following list of standard reagents is not intended to preclude the use of other reagents pertinent to particular chemical resistance requirements. It is intended to standardize typical reagents, solution concentrations, and industrial products for general testing of the resistance of plastics to chemical reagents. Material specifications in which chemical resistance is indicated shall be based upon reagents and conditions selected from those listed herein except by mutual agreement between the seller and the purchaser.

6.3 *Standard Reagents*:

6.3.1 *Acetic Acid* (sp gr 1.05)—Glacial acetic acid.

6.3.2 *Acetic Acid* (5 %)—Add 48 mL (50.5 g) of glacial acetic acid (sp gr 1.05) to 955 mL of water.

6.3.3 *Acetone*.

6.3.4 *Ammonium Hydroxide* (sp gr 0.90)—Concentrated ammonium hydroxide (NH_4OH).

6.3.5 *Ammonium Hydroxide* (10 %)—Add 375 mL (336 g) of (NH_4OH) (sp gr 0.90) to 622 mL of water.

6.3.6 *Aniline*.

6.3.7 *Benzene*.

6.3.8 *Carbon Tetrachloride*.

6.3.9 *Chromic Acid* (40 %)—Dissolve 549 g of chromic anhydride (C_rO_2) in 822 mL of water.

6.3.10 *Citric Acid* (1 %)—Dissolve 104 g of citric acid crystals in 935 mL of water.

6.3.11 *Cottonseed Oil*, edible grade.

6.3.12 *Detergent Solution, Heavy Duty* (0.025 %)—Dissolve 0.05 g of alkyl aryl sulfonate and 0.20 g of trisodium phosphate in 1000 mL of water.

6.3.13 *Diethyl Ether*.

6.3.14 *Dimethyl Formamide*.

6.3.15 *Distilled Water*, freshly prepared.

6.3.16 *Ethyl Acetate*.

6.3.17 *Ethyl Alcohol* (95 %)—Undenatured ethyl alcohol.

6.3.18 *Ethyl Alcohol* (50 %)—Add 598 mL (482 g) of 95 % undenatured ethyl alcohol to 435 mL of water.

6.3.19 *Ethylene Dichloride*.

6.3.20 *2-Ethylhexyl Sebacate*.

6.3.21 *Heptane*, commercial grade, boiling range from 90 to 100°C.

6.3.22 *Hydrochloric Acid* (sp gr 1.19)—Concentrated hydrochloric acid (HCl).

6.3.23 *Hydrochloric Acid* (10 %)—Add 239 mL (283 g) of HCl (sp gr 1.19) to 764 mL of water.

6.3.24 *Hydrofluoric Acid* (40 %)—Slowly add 748 mL (866 g) of hydrofluoric acid (52 to 55 % HF) to 293 mL of water.

6.3.25 *Hydrogen Peroxide Solution*, 28 % or USP 100 volume.

6.3.26 *Hydrogen Peroxide Solution* (3 % or USP 10 volume)—Add 98 mL (108 g) of commercial grade (100 volume or 28 %) hydrogen peroxide (H_2O_2) to 901 mL of water.

6.3.27 *Isooctane*, 2,2,4-trimethyl pentane.

6.3.28 *Kerosine*—No. 2 fuel oil, Specification D 396.

6.3.29 *Methyl Alcohol*.

6.3.30 *Mineral Oil, White, USP*, sp gr 0.830 to 0.860; Saybolt at 100°F: 125 to 135 s.

6.3.31 *Nitric Acid* (sp gr 1.42)—Concentrated nitric acid (HNO_3).

6.3.32 *Nitric Acid* (40 %)—Add 500 mL (710 g) of HNO_3(sp gr 1.42) to 535 mL of water.

6.3.33 *Nitric Acid* (10 %)—Add 108 mL (153 g) of HNO_3(sp gr 1.42) to 901 mL of water.

6.3.34 *Oleic Acid, cP*.

6.3.35 *Olive Oil*, edible grade.

6.3.36 *Phenol Solution* (5 %)—Dissolve 47 g of carbonic acid crystals, USP, in 950 mL of water.

6.3.37 *Soap Solution* (1 %)—Dissolve dehydrated pure white soap flakes (dried 1 h at 105°C) in water.

6.3.38 *Sodium Carbonate Solution* (20 %)—Add 660 g of sodium carbonate ($Na_2 \cdot CO_3 \cdot 10H_2O$) to 555 mL of water.

6.3.39 *Sodium Carbonate Solution* (2 %)—Add 55 g of $Na_2 \cdot CO_3 \cdot 10H_2O$ to 964 mL of water.

6.3.40 *Sodium Chloride Solution* (10 %)—Add 107 g of sodium chloride (NaCl) to 964 mL of water.

6.3.41 *Sodium Hydroxide Solution* (60 %)—Slowly dissolve 971 g of sodium hydroxide (NaOH) in 649 mL of water.

6.3.42 *Sodium Hydroxide Solution* (10 %)—Dissolve 111 g of NaOH in 988 mL of water.

6.3.43 *Sodium Hydroxide Solution* (1 %)—Dissolve 10.1 g of NaOH in 999 mL of water.

6.3.44 *Sodium Hypochlorite Solution, National Formulary*, (4 to 6 %)—The concentration of this solution can be determined as follows: Weigh accurately in a glass-stoppered flask about 3 mL of the solution and dilute with 50 mL of water. Add 2 g of potassium iodide (KI) and 10 mL of acetic acid, and titrate the liberated iodine with 0.1 N sodium thiosulfate ($Na_2S_2O_3$), adding starch solution as the indicator. Each millilitre of 0.1 N $Na_2S_2O_3$ solution is equivalent to 3.7222 mg of sodium hypochlorite.

6.3.45 *Sulfuric Acid* (sp gr 1.84)—Concentrated sulfuric acid (H_2SO_4).

6.3.46 *Sulfuric Acid* (30 %)—Slowly add 199 mL (366 g) of H_2SO_4(sp gr 1.84) to 853 mL of water.

6.3.47 *Sulfuric Acid* (3 %)—Slowly add 16.6 mL (30.6 g) of H_2SO_4 (sp gr 1.84) to 988 mL of water.

6.3.48 *Toluene*.

6.3.49 *Transformer Oil*, in accordance with the requirements of Specification D 1040.

6.3.50 *Turpentine*—Gum spirits or steam distilled wood turpentine in accordance with Specification D 13.

6.4 Table 1 contains a list of military specifications for various liquids intended to be representative of the main types of liquids that may be encountered in a military service environment. Plastics that are intended for use in such environments shall be tested for chemical resistance to the liquids in Table 1 as applicable.

6.4.1 Army Regulation 70-71 establishes the requirement for chemical contamination survivability of Army material intended to withstand the hazards of a chemical warfare (CW) environment. Decontaminating agents STB and DS2 are included in Table 1. In addition, selected CW agents (or suitable simulants) are liquids against which it may be appropriate to test the resistance of certain plastics.

7. Hazards

7.1 Safety precautions should be taken to avoid personal contact, to eliminate toxic vapors, and to guard against explosion hazards in accordance with the hazardous nature of the particular reagents being used.

8. Sampling

8.1 For Practices A and B, Procedure I, sample in accordance with the pertinent considerations outlined in Practice D 1898.

8.2 For Practices A and B, Procedure II, sample in accordance with the ASTM test methods for the specific properties to be determined.

9. Test Specimens

9.1 The type and dimensions of test specimens to be used depend upon the form of the material and the tests to be performed (see Note 2). At least three specimens shall be used for each material being tested, for each reagent involved, for each length of conditioning, and for each strain level. The test specimens shall be as follows:

9.1.1 *Molding and Extrusion Materials*—Specimens shall be molded to shape or cut from molded slabs as required in 9.1.1.1 and 9.1.1.2. The cut edges of specimens shall be made smooth by sharp cutting, machining, or by finishing with No. 0 or finer sandpaper or emery cloth. Molding shall conform to conditions recommended by the manufacturer of the material (see Note 2). The shape and dimensions of specimens shall depend upon the test to be performed and shall conform to the following:

9.1.1.1 *Weight and Dimension Changes*—Standard specimens shall be in the form of disks 50.80 mm (2 in.) in diameter and 3.175 mm (0.125 in.) in thickness molded or cut from molded slabs. The nominal surface area of this standard disk is 45.60 cm^2 (7.1 $in.^2$).

9.1.1.2 *Mechanical Property Changes*—Standard tensile specimens shall be used in accordance with the test method prescribed in the appropriate specification for the material being tested or by agreement among those concerned. Where the determination of other mechanical properties is agreed upon between the seller and the purchaser, standard specimens prescribed in the appropriate test methods shall be used.

9.1.2 *Sheet Materials*—Specimens from sheet materials shall be cut from a representative sample of the material (see Note 3) in a manner depending upon the tests to be performed and the thickness of the sheet, as follows (see 9.1.1 regarding preparation of cut edges):

9.1.2.1 *Weight and Dimension Changes*—Standard specimens shall be in the form of bars 76.20 mm (3 in.) in length by 25.40 mm (1 in.) in width by the thickness of the material. The nominal surface area of the standard bar, having a thickness of 3.175 mm (0.125 in.), is 45.16 cm^2 (7.0 $in.^2$). Circular disk specimens 50.80 mm (2 in.) in diameter by the thickness of the material are permissible under mutual agreement between the seller and the purchaser. Permissible variations in thickness of both types of specimens are ±0.18 mm (±0.007 in.) for hot molded and ±0.30 mm (±0.012 in.) for cold molded or cast materials.

9.1.2.2 *Mechanical Property Changes*—Standard machined, sheared, or cut tensile specimens shall be used in accordance with the test methods prescribed in the appropriate specifications of the material to be tested, or by agreement among those concerned (see 9.1.1.2).

NOTE 2—Specimen surface area greatly affects the weight change due to immersion in chemical reagents. Thickness influences percentage dimension change as well as percentage change in mechanical properties. In addition, molded specimens may not agree with specimens cut from molded or otherwise formed sheet of a given material. Consequently, comparison of materials should be made only on the basis of results obtained from specimens of identical dimensions and like methods of specimen preparation.

NOTE 3—Molding conditions can affect the resistance of plastics to chemical reagents. Compression moldings should be prepared in a manner that will disburse external lubricants and result in complete fusion of the particles. Injection molding should be accomplished in a manner that results in a minimum of molecular orientation and thermal stress or a controlled level of both, depending upon the condition being simulated.

TABLE 1 Military Specifications for Liquids Encountered in Military Service Environments

Specification	Title
MIL-C-372	Cleaning Compound, Solvent (for Bore of Small Arms and Automatic Aircraft Weapons)
MIL-G-5572	Gasoline, Aviation, Grades 80/87, 100/130, 115/145
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missiles, and Ordinance
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-H-6083	Hydraulic Fluid, Petroleum Base, for Preservation and Operation
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, Nato Code Number 0–148
MIL-A-11755	Antifreeze, Artic-Type
MIL-D-12468	Decontaminating Agent, STB
MIL-L-14107	Lubricating Oil, Weapons, Low Temperature
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-L-46000	Lubricant, Semi-Fluid (Automatic Weapons)
MIL-A-46153	Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package
MIL-F-46162	Fuel, Diesel, Referee Grade
MIL-D-50030	Decontaminating Agent, DS2
MIL-T-83133	Turbine Fuel, Aviation, Kerosene Type, Grade JP-8
MIL-H-83283	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft

NOTE 4—For certain products, such as laminates, in which edge effects are pronounced, larger coupons may be exposed from which standard specimens can be cut after immersion for determining the effects of reagents on mechanical properties. This may be allowed in provisions of material specifications by mutual agreement between the seller and the purchaser and should be reported as such.

10. Conditioning

10.1 *Conditioning*—Condition the test specimen 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 case of disagreement, the tolerances shall be 1°C (1.8°F) and ±2 % relative humidity.

10.2 *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 these practices. In case of disagreement, the tolerances shall be 1°C (1.8°F) and ±2 % relative humidity.

PRACTICE A—IMMERSION TEST

11. Procedure I—Weight and Dimension Changes (See Note 4 and 6.2)

11.1 Weigh each conditioned specimen separately and measure thickness at the center, length, and width, or two diameters at right angles to each other, to the nearest 0.025 mm (0.001 in.). In the case of laminates, edge swelling is not uncommon under certain conditions. Consequently, it may be necessary to measure thickness both at the center and at the edges and report the percentage change separately for each position.

11.2 Place the specimens in appropriate containers for the reagents being used and allow the specimens to be totally immersed in fresh reagent for seven days in the standard laboratory atmosphere. Suspend the specimens to avoid any contact with the walls or bottom of the container. For specimens of thin sheeting or those having a lower density than the reagent, it may be necessary to attach small weights such as nichrome to prevent floating or curling. Several specimens of a given material may be immersed in the same container provided sufficient reagent is allowed for the total surface area exposed and the specimens do not touch each other. For specimens of nonextractable and relatively insoluble materials, the quantity of reagent shall be approximately 10 mL/in.^{2} of specimen surface area. For specimens that tend to dissolve or which involve extraction of plasticizers, the quantity of reagent shall be approximately 40 mL/in.^{2} of specimen surface area. Where there is any doubt in these matters, use the higher solvent ratio. For tests at other than room temperatures, it is recommended that the test temperature be 50°C, 70°C, or other temperatures recommended in Practice D 618. It is important that the reagent be at the elevated test temperature before the specimens are immersed.

11.3 Stir the reagents every 24 h by moderate manual rotation of the containers or other suitable means (see Note 5).

11.4 After 168 h, or other agreed upon period of time, individually remove each specimen from the reagent, immediately weigh, and remeasure its dimensions. Wash with running water specimens removed from acid, alkali, or other aqueous solutions, wipe them dry with a cloth or tissue, and immediately weigh. Hygroscopic reagents such as concentrated sulfuric acid may remain absorbed on the surface of the specimens even after rinsing, requiring immediate special handling to avoid moisture pickup before and during weighing. Rinse specimens removed from nonvolatile, nonwater-soluble organic liquids with a nonaggressive but volatile solvent, such as ligroin, before wiping dry. Specimens removed from volatile solvents such as acetone, alcohol, etc., need no rinsing before wiping dry. Some specimens may become tacky due to dissolved material on the surface or solvent absorbed throughout the specimen. Take care in wiping such specimens not to disturb or contaminate the surface.

11.5 Observe the surface of each specimen after exposure to the chemical reagent. Observe and report appearance on the basis of examination for evidence of loss of gloss, developed texture, decomposition, discoloration, swelling, clouding, tackiness, rubberiness, crazing, bubbling, cracking, solubility, etc. See Terminology D 883 for proper descriptive terminology.

NOTE 5—For some materials, absorption of the reagent over the 168 h immersion period is nearly balanced by the removal of soluble constituents from the plastic. This type of behavior may be revealed by comparing the initial conditioned weight of the specimen with its weight when dried for 168 h at 23°C and 50 % relative humidity, after removal from the chemical reagent. A final weight lower than the initial weight may indicate removal of soluble constituents. However, only for particular combinations of reagent and test specimen can this weight difference be considered as due strictly to the removal of soluble constituents.

NOTE 6—In making tests for shorter or longer periods of time than 168 h, it is recommended that the tests be run at 24 and 72 h for times that are made up of increments of 4 weeks, respectively. The containers should be stirred once each day during the first week, and once each week thereafter.

12. Procedure II—Mechanical Property Changes

12.1 Immerse and handle the mechanical test specimens in accordance with instructions given in Procedure I (Section 11).

12.2 Determine the mechanical properties of identical nonimmersed and immersed specimens in accordance with the standard methods for tensile tests prescribed in the specifications for the materials being tested (see Note 7). Make mechanical properties tests on nonimmersed and immersed specimens prepared from the same sample or lot of material in the same manner, and run under identical conditions. Test immersed specimens immediately after they are removed from the chemical reagent. Where specimens are exposed to reagents at elevated temperature, unless they are to be tested at the elevated temperature, they shall be placed in another container of the reagent at the standard laboratory temperature for approximately 1 h to effect cooling prior to testing (see Note 7).

NOTE 7—While tensile tests are generally more applicable and preferred for assessing mechanical property changes due to the effects of chemical reagents, other mechanical properties may be more significant in special cases (for example, flexural properties of rigid materials that are not appreciably softened by the reagents under study but may be extremely sensitive to surface attack such as crazing). Consequently, in the use of these practices for establishing chemical resistance levels in material or product specifications, consideration should be given to the choice of mechanical properties that properly characterize the effects of exposure to chemical reagents.

NOTE 8—To isolate the effects of certain chemical reagents on the mechanical properties of some plastics, it is necessary to test identical specimens that have been immersed in water. This is especially true of tests for determining the effects of aqueous solutions, where these may not differ greatly from the effects of immersion in water alone. When tests are run with a variety of aqueous solution reagents, the effects due to water alone should be established for better comparison of results. Similar behavior may result when tests are run at elevated temperatures, requiring knowledge of the effects of temperature alone to properly assess the effects due to the chemical reagents.

PRACTICE B—MECHANICAL STRESS AND REAGENT EXPOSURE

13. Scope

13.1 This practice consists of exposing standard ASTM test specimens to the reagents being evaluated under standardized conditions of applied strain. After exposure, the specimens are visually evaluated and mechanically tested to determine the effects of reagents on the stressed chemically exposed plastics.

14. Apparatus

14.1 *Micrometers* (see 5.2).

14.2 *Room* (see 5.3).

14.3 *Containers* (see 5.4).

14.4 *Strain Fixtures*—Use three point flexural strain devices capable of applying known amounts of strain to the test specimen. The fixtures are to be made of stainless steel with stainless steel tabs at each end capable of affixing the test specimen to the fixtures in such a way that intimate contact is maintained between the test specimen and the fixture along the entire length of the test specimen. The clamping system should allow for thermal expansion of the material when exposure to elevated temperature is specified. The stainless steel is to be of Type 304 with a surface finish of 64. Fig. 1 provides a drawing of a typical strain fixture along with calculations for determining the radius of curvature required for a specified percent strain.

14.5 *Oven or Constant Temperature Bath* (see 5.6).

14.6 *Testing Devices* (see 5.7).

14.7 *Laboratory Hood* (see 5.8).

15. Reagents and Materials

15.1 See Section 6.

16. Hazards

16.1 See Section 7.

17. Test Specimens

17.1 Same as 9.1 except a minimum of five test specimens shall be tested.

17.1.1 *Molding and Extrusion Materials*—Same as 9.1.1.

17.1.1.1 Same as 9.1.1.2.

17.1.2 *Sheet Materials*—Same as 9.1.2.

17.1.2.1 Same as 9.1.2.2.

18. Conditioning

18.1 *Conditioning*—See 10.1.

18.2 *Test Conditions*—See 10.2.

19. Procedure

19.1 Mount the appropriate test specimens, as specified by the mechanical test being performed, onto strain fixtures that have the radius of curvature necessary to provide the specified strain. Ensure that intimate contact of the specimens and fixtures is maintained along the entire length of the gage area or specimen area to be tested.

19.2 Expose the strained test specimens, along with one set of 0.0 % strain (unstrained) specimens, to the reagent being evaluated for compatibility. The test specimens can be immersed in liquid reagents, or alternately, a wet patch method can be used. The wet patch method involves applying a cotton patch (cheesecloth) over the test specimens and saturating the patch with liquid. For volatile reagents, the liquid should be reapplied daily to provide continuous saturation. Greases can be wiped directly onto the specimen surface.

19.3 Exposure times for chemically exposed and unexposed test specimens shall be 7 days for room temperature exposure and 3 days for elevated temperature exposure unless other exposure times are agreed upon between those concerned. Test temperatures other than room temperature shall be as recommended in Practice D 618, unless specified otherwise.

19.4 Maintain one set of test specimens strained identically to the specimens being exposed (including 0.0 %) but with no reagent, to act as a control. If exposure includes elevated temperatures, a set of chemically unexposed controls shall be conditioned at the same temperature and times as the exposed specimen. Control test specimens shall be tested for the specified mechanical properties at the same time as the exposed test specimens.

19.5 After the specified exposure period, determine the mechanical properties of the unexposed control and exposed specimens in accordance with the standard methods for tensile, flexural, or other properties as prescribed in the specifications for the materials being tested (see Note 9). Test mechanical properties of unexposed and exposed specimens prepared from the same sample or lot of material in the same manner, and run under identical conditions. Test specimens within 24 h after removal from chemical agent and removal from strain fixtures unless specified otherwise as agreed upon between those concerned.

NOTE 9—In some cases deviations from standardized test methods may occur, for example, it may not be feasible to use extensometers when measuring strain during tensile testing due to the curvature of the test specimen resulting from the applied strain. Also, after exposure to some reagents, some materials may soften, in which case, contact extensometers could induce flaws resulting in premature failure. In all cases modifications to standard test methods shall be noted on test reports.

20. Report

20.1 Report the following information:

20.1.1 Complete identification of the material tested including type, source, manufacturer's code, form, and previous history,

20.1.2 Method of preparing test specimen,

20.1.3 Specimen type and dimensions,

20.1.4 Method of test,

20.1.5 Conditioning procedure used,

20.1.6 Chemical reagents,

20.1.7 Stress level used,

20.1.8 Chemical agent application type (for example, immersion or wet patch),

20.1.9 Exposure temperatures,

20.1.10 Duration of exposure,

20.1.11 Mechanical properties of identical unexposed/unstressed specimens and exposed/stressed specimens,

20.1.12 Average percentage increase or decrease in mechanical properties taking the properties of the unexposed/unstressed specimens as 100 %,

20.1.13 Mean of the changes for the mechanical property,

20.1.14 Standard deviation of the changes for the mechanical property, and

20.1.15 Appearance changes.

21. Precision and Bias

21.1 *Precision*—It is not practical to specify precision for these practices because of the wide differences possible in the effects of specific reagents to different plastics.

22. Keywords

22.1 chemical reagent; dimensional changes; exposure; mechanical property changes; plastics; stress

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