



Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 These test methods are intended to evaluate the chemical resistance of resin, silica, silicate, sulfur, and hydraulic materials, grouts, monolithic surfacings, and polymer concretes under anticipated service conditions. These test methods provide for the determination of changes in the following properties of the test specimens and test medium after exposure of the specimens to the medium:

- 1.1.1 Weight of specimen,
- 1.1.2 Appearance of specimen,
- 1.1.3 Appearance of test medium, and
- 1.1.4 Compressive strength of specimens.

1.2 Test Method A outlines the testing procedure generally used for systems containing aggregate less than 0.0625 in. (1.6 mm) in size. Test Method B covers the testing procedure generally used for systems containing aggregate from 0.0625 to 0.4 in. (1.6 to 1.0 mm) in size. Test Method C is used for systems containing aggregate larger than 0.4 in.

1.3 The units stated are to be regarded as 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.*

2. Referenced Documents

2.1 ASTM Standards:

- C 470/C 470M Specifications for Molds for Forming Concrete Test Cylinders Vertically²
- C 579 Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes³
- C 904 Terminology Relating to Chemical-Resistant Non-metallic Materials³

¹ These test methods are under the jurisdiction of ASTM Committee C03 on Chemical-Resistant Nonmetallic Materials and are the direct responsibility of Subcommittee C03.01 on Test Methods.

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² *Annual Book of ASTM Standards*, Vol 04.02.

³ *Annual Book of ASTM Standards*, Vol 04.05.

C 1312 Practice for Making and Conditioning Chemical-Resistant Sulfur Polymer Cement Concrete Test Specimens in the Laboratory³

E 4 Practices for Force Verification of Testing Machines⁴

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods, see Terminology C 904.

4. Significance and Use

4.1 The results obtained by these test methods should serve as a guide in, but not as the sole basis for, selection of a chemical-resistant material for a particular application. No attempt has been made to incorporate into these test methods all the various factors that may affect the performance of a material when subjected to actual service. The strength values obtained by these test methods should not be used to evaluate the compressive strength of chemical-resistant materials. The appropriate ASTM test method for the specific material should be used for determining and evaluating the compressive strength.

5. Apparatus

5.1 *Equipment*, capable of weighing materials or specimens to ± 0.3 % accuracy.

5.2 *Equipment for Mixing*, consisting of a container of suitable size, preferably made of corrosion-resistant metal, or a porcelain pan, and a strong, sturdy spatula or trowel.

5.3 Specimen Molds:

5.3.1 *Test Method A*—These molds shall be right cylinder $1 \pm \frac{1}{32}$ in. (25 ± 0.8 mm) in diameter by $1 \pm \frac{1}{32}$ in. high. The molds may be constructed in any manner that will allow formation of a test specimen of the desired size. Typical molds consist of a 1-in. thick, flat plastic sheet in which 1-in. diameter, smooth-sided holes have been cut, and to the bottom of which a $\frac{1}{4}$ -in. (6-mm) thick, flat plastic sheet (without matching holes) is attached by means of screws or bolts. Alternately, the molds may consist of sections of round plastic tubing or pipe, 1 in. in inside diameter and 1 in. long, having sufficient wall thickness to be rigid and retain dimensional

⁴ *Annual Book of ASTM Standards*, Vol 03.01.

stability during the molding operation, and a 1/4-in. thick, flat plastic sheet on which one open end of each section can be rested. With the latter style of mold, the tubing segment may be sealed with a material, such as caulking compound or stopcock grease. For most types of specimens it is satisfactory to simply seal one end of the tubing segment with masking tape.

NOTE 1—For use with sulfur mortars an additional piece of flat plastic sheet at least 1/8 in. (3 mm) thick containing a 1/4-in. (6-mm) hole and a section of plastic tubing or pipe 1 in. (25 mm) in diameter by 1 in. high are required. They are used to form a pouring gate and reservoir in the preparation of sulfur mortar specimens.

5.3.2 *Test Method B*—Molds for the 2-in. (50-mm) cube specimens shall be tight fitting and leakproof. The sides of the molds shall be sufficiently rigid to prevent spreading or warping. The interior faces of the molds shall be manufactured to ensure plane surfaces with a permissible variation of 0.002 in. (0.05 mm). The distances between opposite faces shall be $2 \pm 1/16$ in. (50 ± 0.8 mm). The height of the molds shall be $2 \pm 1/16$ in. The angle between adjacent interior faces and between interior faces and the bottom of the mold shall be $90 \pm 0.5^\circ$.

5.3.3 *Test Method C*:

5.3.3.1 For polymer concretes other than sulfur polymer cement concretes, molds shall be right cylinders made of heavy gage metal or other rigid nonabsorbent material. The cylinder diameter shall be at least four times the nominal maximum aggregate size in the mix. The minimum cylinder diameter shall be 2 in. (50 mm). The cylinder height shall be two times the diameter. The plane of the rim of the mold shall be at right angles to the axis within 0.5° . The mold shall be at right angles to the axis within 0.5° . The mold shall not vary from the prescribed diameter by more than 1/16 in. (1.5 mm) nor from the prescribed height by more than 1/8 in. (3 mm). Molds shall be provided with a flat base plate with a means for securing it to the mold at a right angle to the axis of the cylinder in the instance of reusable metal molds. For molds other than metal, a mechanically attached smooth flat metal or integrally molded flat bottom of the same material as the sides shall be used. Single-use molds shall conform to Specifications C 470/ C 470M.

5.3.3.2 For molds to be used for preparing sulfur polymer cement concrete specimens, refer to Practice C 1312.

NOTE 2—The material from which the mold is constructed must be chemically inert and have antistick properties. Polyethylene, polypropylene, polytetrafluoroethylene, and metal forms having either a sintered coating of tetrafluoroethylene or a suitable release agent compatible with the material being tested are satisfactory. Because of their superior heat resistance, only trifluorochloroethylene and tetrafluoroethylene mold release agents should be used with sulfur materials.

5.4 *Weighing Equipment*, of adequate capacity. For Method A, suitable for accurate weighing to 0.001 g.

5.5 *Micrometer*, suitable for accurate measurement to 0.001 in. (0.03 mm).

5.6 *Containers*:

5.6.1 *Wide-Mouth Glass Jars*, of sufficient capacity, fitted with plastic or plastic-lined metal screw caps for low-temperature tests involving media of low volatility.

5.6.2 *Erlenmeyer Flasks*, of sufficient capacity, each fitted with standard-taper joints and a reflux condenser attachment for use with volatile media.

5.6.3 *Containers*, as described in 5.6.1 and 5.6.2 having an inert coating on their inner surfaces, or containers of a suitable inert material for use with media which attack glass.

5.7 *Constant-Temperature Oven or Liquid Bath*, capable of maintaining temperature within a range of $\pm 4^\circ\text{F}$ ($\pm 2^\circ\text{C}$).

5.8 *Testing Machine*, may be of any type of sufficient capacity which will provide the rates of loading prescribed. It shall have been verified to have an accuracy of 1.0 %, or better, within twelve months of the time of use in accordance with Practices E 4. The testing machine shall be equipped with two steel bearing blocks with hardened faces, one of which is a spherically seated block that will bear on the top of the specimen, and the other a plain block that will support the bottom. The size of the bearing block shall be of sufficient size to contact the entire bearing surface of the specimen. The bearing faces shall not depart from a plane by more than 0.001 in. (0.025 mm) in any 6-in. (150-mm) diameter circle.

6. Test Media

6.1 The test media shall consist of the media to which the chemical-resistant materials are to be exposed in service.

7. Test Specimens

7.1 The number of specimens required is dependent upon the number of test media to be employed, the number of different temperatures at which testing is performed, and the frequency of test intervals. The test specimens shall consist of sets of a minimum of three cylinders for one medium at a single temperature and for each test interval. In addition one set of at least three specimens shall be available for test immediately following the conditioning period, and other sets of at least three, equivalent to the number of test temperatures, for the total test period. Calculate the total number of specimens required as follows:

$$N = n(M \times T \times I) + nT + n \quad (1)$$

where:

N = number of specimens,

n = number of specimens for a single test,

M = number of media,

T = number of test temperatures, and

I = number of test intervals.

NOTE 3—For calcium aluminate cements, strength and weight changes are a natural phenomena, with the degree of change being dependent upon the test conditions involved. Therefore, when conducting chemical resistance tests on these products, additional sets of control samples should be prepared for testing at each test temperature and each test interval. The immersion medium for these control samples will be potable water.

7.2 Make all specimens for a single determination from a single mix.

7.3 *Test Method A*—Prepare test specimens to be used in accordance with Test Method A as described in 8.1. Test specimens shall be right cylinders $1 + 1/32$ in., $- 1/16$ in. ($25 + 0.8$, $- 1.6$ mm) in diameter by $1 \pm 1/16$ in. (25 ± 1.6 mm) high. If the faces of the specimen are not flat, smooth, and normal to the cylinder axis, they may be sanded, ground, or machined to specification. Exercise care that the frictional heat developed during such operations does not damage the specimens.

7.4 *Test Method B*—Prepare test specimens to be used in accordance with Test Method B as described in 8.1. Test specimens shall be cubes with dimensions of $2 + \frac{1}{16}$ in., $- \frac{1}{8}$ in. ($50 + 1.5$, $- 3.0$ mm).

7.5 *Test Method C:*

7.5.1 For polymer concretes other than sulfur concretes, prepare the test specimens to be used in accordance with 8.2.

7.5.1.1 Do not test specimens if any individual diameter of a cylinder differs from any other diameter of the same cylinder by more than 2 %.

7.5.1.2 Neither end of compressive test specimens, when tested, shall depart from perpendicular to the axis by more than 0.5° (approximately equivalent to $\frac{1}{8}$ in. in 12 in. (3 mm in 300 mm). Compression test specimens that are not flat within 0.01 in. (0.25 mm) shall be sawed, ground, or capped in accordance with 8.2.1.2. Determine the diameter used for calculating the cross-sectional area of the test specimen to the nearest 0.01 in. (0.25 mm) by averaging two diameters measured at right angles to each other at about mid-height of the specimen.

7.5.2 For preparing sulfur polymer cement concrete test specimens, refer to Practice C 1312.

8. Preparation of Specimens

8.1 *Specimen Preparation for Test Methods A and B:*

8.1.1 *Resin, Silicate, and Silica Materials*—Mix a sufficient amount of the components in the proportions and in the manner specified by the manufacturer of the materials. Fill the molds one-half full. Remove any entrapped air by using a cutting and stabbing motion with a spatula or rounded-end rod. Fill the remainder of the mold, working down into the previously placed portion. Upon completion of the filling operation, the tops of the specimens should extend slightly above the tops of the molds. When the molds have been filled, strike off the excess material, even with the top of the mold. Permit the material to remain in the mold until it has set sufficiently to allow removal without danger of deformation or breakage.

8.1.1.1 *Silicate Materials*—Some silicates may require covering during the curing period. After removal from the molds, acid-treat the specimens, if required, in accordance with the recommendations given by the manufacturer. No other treatment shall be permitted. Record the method of treatment in 13.1.3.

8.1.2 *Sulfur Materials:*

8.1.2.1 *Sulfur Mortars*—Slowly melt a minimum of 2 lb (900 g) of the material in a suitable container at a temperature of 265 to 290°F (130 to 145°C) with constant agitation. Stir to lift and blend the aggregate without beating air into the melt. Place the piece of plastic sheet containing the $\frac{1}{4}$ -in. (6-mm) round hole over the open face of the mold with the hole centered on the face. On top of the piece of plastic sheet and surrounding the hole, place a section of plastic tubing or pipe 1 in. (25 mm) in diameter by 1 in. high. Pour the melted material through the hole into the mold and continue to pour until the section of tubing or pipe is completely filled. The excess material contained in the hole in the plastic sheet acts as a reservoir to compensate for shrinkage of the material during cooling. Allow the specimen to remain in the mold until it has completely solidified. Upon removal, file, grind, or sand the

surface flush, removing the excess material remaining at the pouring gate.

8.1.2.2 *Sulfur Polymer Cement Concretes*—Prepare specimens in accordance with Practice C 1312.

8.2 *Specimen Preparation for Test Method C:*

8.2.1 *Polymer Concretes Other than Sulfur Polymer Cement Concretes*—Prepare specimens in accordance with 8.1 with the following additional considerations:

8.2.1.1 The use of vibrators may be required. The type and method of vibrating will be as recommended by the manufacturer and shall be specified in the test report.

8.2.1.2 *Filling and Capping for Cylindrical Resin, Silicate, and Silica Specimens*—The top layer may be filled to slightly below the top edge of the mold. The top surface of the specimen shall be finished as much as practicable to a plane perpendicular to the axis of the specimen. The flatness of the finished specimen shall be within 0.010 in. (0.25 mm). Specimens exceeding this tolerance shall be machined flat or a capping compound shall be applied.

8.2.1.3 Capping, if used, shall be made as thin as practicable and shall be applied before removal of the polymer concrete from the molds.

8.2.1.4 If a polymer paste or mortar is used for capping, it is preferable that the polymer used be the same as the one used to make the specimen. Fillers used may be the fine portion used in the polymer concrete or another mineral powder.

8.2.1.5 For capping in the mold, a suitable capping compound may be made from a polymer mortar. The surface of the polymer concrete shall be wiped off after hardening, and a polymer mortar or polymer paste with suitable fillers shall be deposited and pressed down uniformly to the top edge of the mold with a capping plate. In order to prevent the capping plate from bonding to the paste or mortar, the underside of the capping plate shall be covered with a release agent.

8.2.1.6 For capping after mold removal, stiff polymer paste or mortar or a low-melting-point alloy for capping shall be used. A suitable apparatus to maintain parallel ends on the specimen shall be used.

NOTE 4—Any capping compound to be used with polymer concrete should be tested to ascertain that its strength is high enough to prevent premature failure in the cap when testing in high compressive strength polymer concretes. Cap failure may result in substantially lower compressive strength results.

8.2.2 *Sulfur Concretes*—Prepare specimens in accordance with Practice C 1312.

8.2.3 *Hydraulic Materials*—Mix the material, employing the same proportions of water, cement, and aggregates as are to be used in service. The aggregates shall be of the type and origin of the aggregates to be used in service. Depending upon the aggregate sizing, select specimen molds from either 5.3.2 or 5.3.3.1. Cast the specimens in accordance with the procedure described in 8.2.1.

9. Conditioning

9.1 *Resin and Silica Materials*—Age the test specimens for a period of seven days, including the cure period in the mold, at $73 \pm 4^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) before testing.

9.2 *Silicate Materials*—Follow the same procedure as given in 9.1, the only exception being that the relative humidity of the

surrounding air must be kept below 80 %.

9.3 *Sulfur Materials*—Before testing, condition the specimens to $73 \pm 4^\circ\text{F}$ for at least 24 h, including the time in the mold.

9.4 *Hydraulic Materials*—When calcium aluminate materials are used, cure the specimens in the mold in a moist cabinet maintained at a temperature of $73 \pm 4^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$), and a relative humidity of not less than 98 % or under wet mats, for 24 h. When portland cements are used, extend this curing period to 28 days, with the specimens being removed from the molds at the age of 24 h.

10. Test Conditions

10.1 The test conditions (test medium, temperature, etc.) shall simulate the anticipated service conditions as closely as possible.

11. Procedure

11.1 Measurement of Specimens:

11.1.1 *Test Method A and Test Method C Including Sulfur Polymer Cement Concretes*—Immediately following the conditioning period, measure the diameter of all test specimens to the nearest 0.001 in. (0.0254 mm), using a micrometer. Make two measurements at right angles to each other at mid-height and record the diameter as the average of the two.

11.1.2 *Test Method B*—Immediately following the conditioning period, measure the cross-sectional dimensions of all test specimens to the nearest 0.001 in. (25 μm) using a micrometer. Take two measurements for each dimension at mid-height and perpendicular to the load axis and average them.

11.2 *Exposure, Weighing, and Visual Inspection of Test Specimens*—Following the conditioning period, weigh all the specimens to the nearest 0.001 g on an analytical balance and record the values. Prior to immersion, record a brief description of the color and surface appearance of the specimens and the color and clarity of the test medium. For test specimens prepared by 5.3.1, place the weighed specimens, to be immersed on their curved sides in a suitable container or containers, taking care to prevent the cylinder faces from coming in contact with each other. The total number of specimens per container is not limited except by the ability of the container to hold the specimens, plus the required amount of test medium per specimen. Add sufficient quantity of the test medium to completely immerse each specimen, and place the closed container in a constant-temperature oven adjusted to the required temperature or in a suitably adjusted liquid bath. Examine the specimens after 1, 7, 14, 28, 56, and 84 days of immersion to determine the rate of attack.

NOTE 5—Other inspection periods may be employed and the test method may be terminated prior to 84 days if desired.

11.2.1 Clean the specimens by three quick rinses in running cold tap water and quick dry by blotting with a paper towel between each rinse. For each test specimen prepared by 5.3.1, after the final blotting, allow the specimen to dry for $\frac{1}{2}$ h resting on its curved surface before weighing. For each test specimen prepared by 5.3.2 and 5.3.3, after final blotting, allow the specimen to dry for $\frac{1}{2}$ h before weighing. Weigh all specimens to the nearest 0.001 g.

11.2.2 Note any indication of surface attack on the specimen, any discoloration of the test medium, and the formation of any sediment.

11.3 *Changing of Test Medium*—Discard and replace the test medium with fresh material after each inspection period. Replace media that are known to be unstable, for example, aqueous sodium hypochlorite, as often as necessary in order to maintain the original chemical composition and concentration.

11.4 Compression Testing of Specimens:

11.4.1 Determine the compressive strength for one set of specimens immediately following the conditioning period; for one set of specimens after each inspection period for each medium and each test temperature; and for one set of specimens after aging in air for the total test period at the test temperature. The elapsed time between the removal of the specimens from the test medium and the compressive tests should be uniform for all specimens.

11.4.2 Perform the compression tests at $73 \pm 4^\circ\text{F}$.

11.4.3 *Placing the Specimen*—Place the bearing block, with its hardened face up, on the platen of the testing machine directly under the spherically seated (upper) bearing block. Wipe clean the bearing faces of the upper and lower bearing blocks and of the test specimen and place the test specimen on the lower bearing block. As the spherically seated block is brought to bear on the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

11.4.4 *Rate of Loading*—Apply the load continuously and without shock. Test at a rate of 6000 psi/min or at a crosshead movement of 0.1 to 0.125 in./min times the specimen height in inches when the machine is running without load. Make no adjustment in the controls of the testing machine while a specimen is rapidly yielding, immediately before failure.

NOTE 6—The above methods of controlling machine crosshead rate are not identical and may produce different compressive strength values.

11.4.5 Load the test specimen to failure and record the maximum load (W).

11.5 Calculations:

11.5.1 Test Method A and C:

11.5.1.1 Calculate compressive strength(s) as follows:

$$S = (4W)/(\pi \times D^2) \quad (2)$$

where:

S = compressive strength, psi (MPa),

W = maximum load, lb (N), and

D = diameter measured in 11.1.1, in. (mm).

11.5.2 Test Method B:

11.5.2.1 Calculate compressive strength(s) as follows:

$$S = (W)/(L_1 \times L_2) \quad (3)$$

where:

S = compressive strength, psi (MPa),

W = maximum load, lb (N), and

L_1 and L_2 = cross-section dimensions of cube measured in 11.1.2, in. (mm).

11.5.3 *Change in Compressive Strength*—Calculate to the nearest 0.01 % the percentage decrease or increase in compressive strength of the specimen during immersion for each

examination period, taking the compressive strength after conditioning as 100 %.

$$\text{Change in compressive strength, \%} = [(S_2 - S_1)/S_1] \times 100 \quad (4)$$

where:

S_1 = average compressive strength of a set of specimens following the conditioning period. The compressive strength of each specimen in the set shall be the maximum applied load per cross-sectional area of the specimen, psi (MPa), and

S_2 = average compressive strength of a set of specimens following the test period. The compressive strength of each specimen in the set shall be the maximum applied load per cross-sectional area of the specimen, psi (MPa).

11.5.3.1 Construct a graph employing the percentage of change in average compressive strength of the specimens broken at a given examination period after immersion in a particular test medium at a given temperature, plotting the percentage of change in compressive strength as the ordinate and the test period, in days, as the abscissa.

11.5.3.2 The absolute compressive strength in pounds-force per square inch (or pascals) should be shown for the initial specimen (100 % value) and the final specimen. These values should be noted parenthetically near the plot point of each value.

11.6 Weight Change of Tested Specimens:

11.6.1 *Weight Change*—Calculate to the nearest 0.01 % the percentage loss or gain in weight of the specimens during immersion for each examination period, taking the conditioned weight as 100 % as follows:

$$\text{Weight change, \%} = [(W - C)/C] \times 100 \quad (5)$$

where:

C = conditioned weight of specimen, g, and
 W = weight of specimen after immersion, g.

NOTE 7—A result showing a plus (+) sign shall indicate a gain in weight and a minus (−) sign shall indicate a loss.

11.6.1.1 Construct a graph employing the average percentage of weight change of all the specimens at a given examination period after immersion in a particular test medium at a given temperature, plotting the percentage of weight change as the ordinate and the test period, in days, as the abscissa.

12. Interpretation of Results

12.1 *Weight Change*—Because of the chemical nature of certain types of materials, the rate of weight change with time is of more significance than the actual value at any time. A plot of the test results will indicate whether a particular material will approach constant weight in time or will continue to change in weight as the test progresses.

12.2 *Appearance of Specimen*—Visual inspection of the

exposed specimen for surface cracks, loss of gloss, etching, pitting, softening, etc., is very important in cases where initial weight changes are high.

12.3 *Appearance of Test Medium*—Discoloration of the test medium and the formation of sediment are significant factors. An initial discoloration coupled with a high weight loss may indicate extraction of soluble components. Continuation of the test with fresh medium will indicate whether or not the attack is progressive.

12.4 *Change in Compressive Strength*—The same considerations hold true as mentioned in 12.1, and, therefore, the rate of change in compressive strength is the important characteristic to be determined.

13. Report

13.1 Report the following information:

13.1.1 Manufacturer's name of material and generic type.

13.1.2 Mixing ratio.

13.1.3 Conditioning procedure.

13.1.4 Test conditions, that is, test medium, frequency of change of test medium, temperature, etc.

13.1.5 Color and surface appearance of specimen before testing.

13.1.6 Total duration of the test and the examination periods, in days. For each examination period the following data are required:

13.1.6.1 Average percentage of weight change of the specimens,

13.1.6.2 Appearance of the specimens after immersion (surface cracks, loss of gloss, etching, pitting, softening, etc.),

13.1.6.3 Appearance of the test medium (discoloration, sediment, etc.), and,

13.1.6.4 Average percent change in the compressive strength of specimens.

13.1.7 Graph showing percent weight change plotted against the test period (11.6.1.1).

13.1.8 Graph showing percent change in compressive strength plotted against the test period (11.5.3.1).

14. Precision and Bias

14.1 Test specimens that give weight change or compressive strength values differing by more than 15 % from the average value of all specimens made from the same material sample and tested at the same period shall not be considered in determining the average values for that test. If, after discarding nonconforming values, there are less than two acceptable values for each determination for any given period, the results shall be discarded and a retest shall be made.

15. Keywords

15.1 brick mortars; chemical-resistant; machinery grouts; monolithic surfacings; polymer concrete; resin materials; silica materials; silicate materials; tile grouts

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