
Standard Method of Test for

**Protective Sealers for Portland
Cement Concrete**

AASHTO Designation: TP 96-13 (2018)¹

Technical Section: 4c, Markings and Coatings

Release: Group 2 (June)



**American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001**

Standard Method of Test for

Protective Sealers for Portland Cement Concrete

AASHTO Designation: TP 96-13 (2018)¹



Technical Section: 4c, Markings and Coatings

Release: Group 1 (June)

1. SCOPE

- 1.1. This method covers test methods and selection criteria for prequalification of sealers for protecting new concrete or prolonging the life of sound in-service concrete used in highway structures. Sealer testing and evaluation for routine and job site product quality assurance, field performance, and re-application are provided in the “Guideline for Quality Assurance, Job Site Quality Control, and Reapplication of Protective Sealers for Portland Cement Concrete.”
 - 1.2. Sealers are divided into two basic types: coatings, which remain on the surface; and penetrants, which penetrate into the concrete to some measurable depth and do not substantially change the appearance of the concrete.
 - 1.3. The values stated in SI units are to be regarded as the standard.
-

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
 - [M 6](#), Fine Aggregate for Hydraulic Cement Concrete
 - [M 80](#), Coarse Aggregate for Hydraulic Cement Concrete
 - [M 233](#), Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete
 - [T 22](#), Compressive Strength of Cylindrical Concrete Specimens
 - [T 160](#), Length Change of Hardened Hydraulic Cement Mortar and Concrete
 - [T 260](#), Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials
 - [T 278](#), Surface Frictional Properties Using the British Pendulum Tester
- 2.2. *ASTM Standards:*
 - [C33/C33M](#), Standard Specification for Concrete Aggregates
 - [C138/C138M](#), Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
 - [C143/C143M](#), Standard Test Method for Slump of Hydraulic-Cement Concrete
 - [C157/C157M](#), Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
 - [C192/C192M](#), Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory

- [C231/C231M](#), Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- [C494/C494M](#), Standard Specification for Chemical Admixtures for Concrete
- [C496/C496M](#), Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
- [C511](#), Standard Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
- [C642](#), Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
- [C666/C666M](#), Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
- [C672/C672M](#), Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals
- [C1064/C1064M](#), Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
- [C1152/C1152M](#), Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete
- [C1315](#), Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
- [C1583/C1583M](#), Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)
- [D891](#), Standard Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals
- [D2369](#), Standard Test Method for Volatile Content of Coatings
- [D4138](#), Standard Practices for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive, Cross-Sectioning Means
- [D4541](#), Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
- [D5095](#), Standard Test Method for Determination of the Nonvolatile Content in Silanes, Siloxanes and Silane-Siloxane Blends Used in Masonry Water Repellent Treatments
- [D6132](#), Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Coating Thickness Gage
- [D6762](#), Standard Test Method for Determining the Hiding Power of Paint by Visual Evaluation of Spray Applied Coatings
- [D7089](#), Standard Practice for Determination of the Effectiveness of Anti-Graffiti Coating for Use on Concrete, Masonry and Natural Stone Surfaces by Pressure Washing
- [E274/E274M](#), Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire
- [E355](#), Standard Practice for Gas Chromatography Terms and Relationships
- [E573](#), Standard Practices for Internal Reflection Spectroscopy
- [E1252](#), Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis

2.3.

Other Reference:

- Pfeifer, D. W., and M. J. Scali. *National Cooperative Highway Research Program Report 244: Concrete Sealers for Protection of Bridge Structures*. National Academy Press, Washington, DC, 1981, 138 pp.

3. SEALER PROPERTIES

- 3.1. A number of performance categories must be considered when choosing a sealer. There are basic properties that are universally significant for all sealers and other special properties that depend on the intended application. The performance categories include the following:
- 3.2. *Universal Properties*—All sealers, by definition, are intended to reduce water penetration into concrete and to extend the service life of the concrete. Most sealers for highway structures are used to reduce the ingress of chlorides from deicers or seawater to protect the embedded reinforcing steel from corrosion. Therefore, improving the resistances, in concrete, to both water and chloride penetration is a basic property of all sealers.
- Highway structures are exposed to their environments, so all sealers must work under a variety of environmental conditions (temperature and moisture) and be durable to weathering and alkalis present in the concrete. Reasonable curing or drying time is also needed, so that the sealers are not damaged by rain shortly after treatment and to avoid lengthy lane closures of decks when sealers are installed.
- Good vapor transmission of sealed surfaces is a preferred property of most sealers, since this property allows moisture that is present or able to penetrate into the treated structure to dry as environmental conditions permit. Nonbreathable sealers have limited applications in highway structures, since preventing concrete from drying between rain events limits the sealer effectiveness at slowing moisture-driven deterioration mechanisms. Improperly applied, non-breathable sealers can trap water in concrete and increase moisture-drive deterioration.
- Sealers should be effective on both new and older concrete, but specific materials can be tested and specified for each condition.
- 3.3. *Traffic Exposure Resistance*—Sealers on traveled surfaces must not reduce the frictional properties of the concrete and must be effective after traffic wear. Penetrants require good penetration to remain effective after surface wear, and coatings must be wear resistant. Rapid curing may also be needed if applied during short lane closure periods.
- 3.4. *Freeze-Thaw, Scaling, and Concrete Durability*—Sealers can be used to improve the concrete's resistance to cyclic freezing damage or surface scaling. Special tests recreating cyclic freezing conditions are presented to evaluate these properties. Sealers have also been used to extend the service life of structures with other concrete distress. Such deleterious reactions are highly dependent on site conditions and materials, and no widely useful test can be proposed to characterize the ability of sealer to slow or stop all types of concrete deterioration. However, in a general sense, the ability of sealer to retard moisture ingress will be a determining factor in the likelihood that such reactions will be affected.
- 3.5. *Adverse Conditions*—It may be necessary to apply the sealer under adverse conditions, such as very low ambient temperatures or very high moisture conditions. In these cases, a sealer must be chosen that can be installed and offer protection under these adverse conditions.
- 3.6. *Other Considerations:*
- 3.6.1. *Color*—Color and final appearance may be important for some structures. If the color of the treated concrete is important, test blocks or mock-ups should be treated with candidate materials for evaluation prior to use.
- 3.6.2. *Safety*—Sealers must be safe to store, handle, and apply. Several sealer types involve toxic or hazardous components and may not meet local air quality regulations.

- 3.6.3. *Economy*—It is desirable that the chosen sealer have a low initial cost; however, this should not take precedence over life-cycle costs. Cost-based decision making should include consideration of the sealer effectiveness and the frequency of reapplication necessary to maintain effectiveness.

4. GENERAL SEALER TYPES

- 4.1. Sealers commonly used for concrete vary widely in chemistry and application rates. The following discusses the most common types of sealers used and provides some general precautions. Review of manufacturer data sheets and recommendations as well as MSDS safety sheets is essential before using any sealer.
- 4.2. *Linseed Oil*—Linseed oil (as specified in [M 233](#)) is one of the earliest materials to be used to protect concrete. It penetrates the surface and forms a partial barrier to water. It has been used on decks and does not materially change the original frictional properties of the concrete if applied at the proper rate. Compared to solutions, emulsions of linseed oil may be less effective and have a reduced service life. Linseed oil is easily applied and safety hazards are minimal; only routine precautions for handling and using flammable liquids are necessary.
- Application of linseed oil may be readily accomplished by brush, squeegee, roller, hand sprayer, or power sprayer. For the best results on new concrete surfaces, the concrete should be allowed to cure for about 30 days prior to the application of the compound. The concrete surface should be dry and at a temperature of not less than 10°C (50°F) at the time of application. Two approximately equal applications are best with a 24-h minimum drying time between applications. To remain effective, concrete surfaces should be recoated annually for 2 years followed by a biannual or triannual schedule of treatment. Cleaning of tools and equipment is accomplished by use of kerosene or other petroleum solvents. Use appropriate safety precautions when using these solvents.
- 4.3. *Epoxy Resins*—Epoxy is usually considered a coating but may penetrate the concrete slightly depending on the formulation. The two-component epoxy resin system forms a sealer that is tough, hard, and resistant to chemicals and weathering. Coating pinholes (small breaks in the coating that develop during curing) can be a problem but can be avoided by use of a suitable primer or by applying two coats. Also, application when the concrete is cooling helps prevent pinholes. Thick coatings can flake or peel due to a difference in thermal expansion of the coating and the concrete or due to improper surface preparation. They can also reduce frictional properties and may polish with time. The use of a suitable aggregate spread over the freshly applied coating greatly improves frictional properties. It is essential that the recommendations of the manufacturer be followed precisely for mixing, application procedures, and equipment use. Recommended safety practices must be followed carefully.
- All materials should be within acceptable temperature ranges before mixing. Thorough mixing of the components in the specified proportions is essential. No more should be mixed than will be used within the pot life of the materials. Small-batch mixing can best be done in clean, dry pails or disposable containers using a mechanical stirrer, although hand mixing is acceptable if sufficient care is exercised. For large jobs, specialized continuous mixing equipment should be used.
- Application on small areas can readily be made by brush, roller, squeegee, hand sprayer, or other means. Power spray equipment is most effective for covering large areas. For most epoxy formulations, the temperature of the concrete surface should not be less than 15°C (60°F); however, special formulations can be used at lower temperatures.
- Equipment used in application must be cleaned using solvent washes before the epoxy sets, as recommended by the manufacturer. Use appropriate safety precautions when using these solvents.
- 4.4. *Silanes and Siloxanes*—These penetrant materials are widely used. They penetrate into the concrete matrix and react chemically with the concrete to form a hydrophobic surface layer. The effectiveness and depth of penetration is usually related to the amount of active solids content and

the amount of material applied. They can be applied in one coat, but usually two or more coats provide better performance.

Normally, these materials should not be applied at temperatures below 0°C (32°F) or when the temperature is expected to fall below 0°C (32°F) within 12 h of application. They penetrate thoroughly dry concrete best. Application rates range between 2.45 and 9.82 m²/L (100 to 400 ft²/gal) depending on surface texture and absorption. Low-pressure airless sprayers, brushes and rollers are commonly used to apply these sealers with enough material to sufficiently saturate the surface of the concrete.

- 4.5. *Methacrylates*—These materials may be described as a coating or penetrant depending on the formulation. Two coats are usually required. The surface to be treated must be dry and clean. The time needed between coats will vary according to temperature and moisture conditions.

Typically, these materials are not to be applied when the temperature is below 10°C (50°F), although some methacrylate formulations can be placed at very cold temperatures. A primer is required for some formulations. The concrete surface must be dry. Application rates range from 2.45 to 9.82 m²/L (100 to 400 ft²/gal). Common methods of application include sprayer, roller, brush, and squeegee. Always check safe handling and application procedures.

- 4.6. *Sodium Silicate*—This material is a penetrant in the form of aqueous solution but is sometimes part of a cementitious coating formulation. Concrete surfaces must be clean and dry at the time of application. The material should not be applied at temperatures below 4°C (40°F).

The material is usually applied by brush, squeegee, or spraying. Some manufacturers recommend that the surface should be flushed with water 3 to 6 h after material application and the flushing be repeated at 24-h intervals for 72 h. The recommended coverage rate is typically 4.91 to 7.36 m²/L (200 to 300 ft²/gal).

- 4.7. *Urethane*—This material is classified as a penetrant or a coating depending on formulation. Two coats are often required. The concrete surface should be free of loose material, clean, and dry. Some formulations should not be applied under high humidity conditions. (See manufacturer's recommendations for application and safety information.)

Urethane materials can be applied in the temperature range of 4 to 38°C (40 to 100°F) with some formulations having allowable application temperatures below freezing. Typical coverage rates include 4.91 to 9.82 m²/L (200 to 400 ft²/gal). Urethane sealers are best applied with either an air-atomized or conventional airless sprayer, although brush, roller, or squeegee may be used.

- 4.8. *Others:*

- 4.8.1. *Coal Tar Epoxy*—Coal tar resins form surface coatings that are hard and durable. They are relatively resistant to many corrosive and abrasive environments. They are more wear resistant when filled with sand and other suitable aggregate. These materials contain curing agents and strong solvents that may cause allergic reactions. They must be handled with caution; recommended safety precautions must be followed. These materials are naturally dark to black in color and may not be desirable in some locations.

- 4.8.2. *Tar Primer and Seal*—Tars applied to concrete surfaces form a coating that is an effective surface barrier to water. Usually a primer must be used because of wetting difficulties on concrete. These materials may be applied in solution or softened by heat. Due to relatively poor resistance to sunlight, weather, and abrasion, these materials should be covered by a suitable bituminous mix. Tars may be applied by power or hand sprayer, by brush, or by squeegee. The concrete surface to be treated should be dry and clean. The prime coat should be permitted to cure thoroughly before applying subsequent coats. The viscosity will vary with application temperature and the grade of tar, so proper application may require adjustments in the grade selected or constrain the application conditions.

5. PREQUALIFICATION TESTS FOR UNIVERSAL PROPERTIES

- 5.1. *Test Overview*—This test procedure outlines the methods and requirements used for the testing of the universal properties of concrete sealers and includes batching, casting, and storing concrete test cubes for use in the testing of penetrating and film-forming sealers for use on concrete surfaces. These tests are used to prequalify all sealers to be used on highway structures. The properties evaluated include:

- water vapor transmission,
- saltwater absorption,
- chloride permeability,
- sealer penetration depth or coating thickness,
- UV weathering and cyclic saltwater ponding, and
- resistance to alkali.

Methods to characterize the sealer material are also provided and are used to ensure materials provided for project use are the same as the materials submitted and tested for prequalification. Figure A1.1 is a flow chart showing the general progression of testing for each prequalification test procedure.

- 5.2. *Equipment:*

- 5.2.1. An electronic weigh scale having a capacity not less than 4000 g and a sensitivity of 0.1 g.
- 5.2.2. Conditioning chamber capable of maintaining 50 ± 4 percent RH at $23 \pm 1^\circ\text{C}$ (72 to 75°F), consistent with [T 160](#).
- 5.2.3. Thermostatically controlled oven, accurate within $\pm 2^\circ\text{C}$ ($\pm 3.6^\circ\text{F}$). When oven-drying is called for, cool oven to lab temperature before samples are placed in it. Then increase the oven temperature to the specified drying temperature at the rate of no more than 20°C/h (36°F/h).
- 5.2.4. Moist cure room complying with [ASTM C511](#).
- 5.2.5. Sandblasting equipment, including a steel plate shield with a 100-mm² opening and a steel plate shield with a 300-mm² opening.
- 5.2.6. Ultraviolet exposure chamber capable of producing 25 to 35 watts/m² of ultraviolet radiation over the surface of a 0.6-m² (6-ft²) area. Lamps should emit at 368 nm. GE F40BL (part number 10526) was used to achieve this irradiance level in NCHRP 244 testing.
- 5.2.7. Freezing-and-thawing apparatus and related testing equipment conforming to the requirements of [ASTM C666/C666M](#), Method A.

- 5.3. *Screening Performance Cube Tests for Water Vapor Transmission, Saltwater Absorption, Chloride Permeability, and Sealer Penetration Depth or Coating Thickness:*

- 5.3.1. *Test Overview*—This test procedure outlines the details to manufacture, store, and test cubes for testing water vapor transmission, saltwater absorption, chloride permeability, and depth of penetration or coating thickness of sealers.

- 5.3.2. *Test Sample Preparation and Treatment:*

- 5.3.2.1. *Casting and Storing Concrete Test Cube*—Select a representative and standard source of cement and aggregates. Use well-graded, normal density aggregates meeting the requirements of [M 6](#) and

M 80 (ASTM C33/C33M) and having a maximum nominal aggregate size of 13 mm to 19 mm ($1/2$ to $3/4$ in.). Use rigid molds to produce cubes of 100 ± 1.5 mm (4 ± 0.06 in.) on a side constructed of plastic-treated plywood or other nonabsorptive surface. Do not use form oils or release agents that could contaminate the concrete surfaces. The concrete mixture should have a water/cement ratio (w/c) of 0.50 and an air content of 5 to 7 percent. The plastic slump should be between 75 and 125 mm (3 and 5 in.). The concrete should be designed to have a 28-day compressive strength between 27 and 31 MPa (4000 and 4500 psi) but its value may vary depending on local materials and testing needs. Keep water/cement ratio, maximum aggregate size, and air content requirements fixed. Use a moderate cement content, preferably near 300 kg/m^3 (505 lb/yd^3). Do not use fly ash or other supplementary materials. Use a chloride-free, lignosulfonate water-reducing admixture to obtain the correct slump, if needed. Other **ASTM C494/C494M** Type A water-reducing admixtures may be used if they do not contain chloride or other material that may affect the pore structure. Do not use a superplasticizer (high-range water-reducing admixture). Use a Vinsol resin air-entraining admixture unless testing includes the effect of other air-entraining admixtures. Table 1 provides guidelines for a recommended mix design; however, other mix designs can be used if those designs are more typical of the concrete to be treated.

Table 1—Guidelines for a Recommended Mix Design

Constituents/Properties	Guideline
Water to cement ratio (w/c) ^a	0.5
Nominal maximum aggregate size ^a	13 to 19 mm ($1/2$ to $3/4$ in.)
28-day compressive strength (design)	27 to 31 MPa (4000 to 4500 psi)
Entrained air content ^a	5.0 to 7.0%
Slump	75 to 125 mm (3 to 5 in.)
Cement content	300 kg/m^3 (505 lb/yd^3)
Sand content, % total aggregate	40 to 42
Fineness modulus of sand	2.4 to 2.9
Air-entraining agent	Neutralized Vinsol resin or equivalent
Water-reducing agent	Lignosulfonates

^a Controlling guideline.

5.3.2.2. *Sample Fabrication*—Fabricate specimens in accordance with **ASTM C192/C192M**. Measure and account for aggregate moisture contents to ensure that the exact water to cement ratio (w/c) is used. Measure the concrete plastic properties including slump (**ASTM C143/C143M**), air content (**ASTM C231/C231M**), temperature (**ASTM C1064/C1064M**), and unit weight (**ASTM C138/C138M**). Consolidate cubes to minimize the amount of surface voids in the cubes and strike off flush with a wood or magnesium float. Do not use steel trowel or aluminum float. Cover with moist towels and plastic, such that the surfaces of the cubes are not marred or damaged but are kept moist. For each batch produced, cast a minimum of three 4-by-8-in. cylinders for compressive strength testing.

Identify the finished surface with a small felt-pen mark. Maintain this face in an upward facing orientation throughout the course of the testing unless otherwise noted. Re-mark the surface whenever it is removed by sandblasting or other procedures.

Demold specimens at the age of 24 ± 2 h and store samples in moist-curing room at $23 \pm 2^\circ\text{C}$ (70 to 77°F) with 100 percent relative humidity. Test specimens may be kept in storage for a maximum of 182 days before starting testing unless special curing requirements are being evaluated. Do not coat any samples until after a minimum of 42 days of moist curing, unless evaluating the effect of the sealer on new concrete.

Identify each cube to its batch. Prior to use, weigh, number, and label each cube for future identification. Label in a manner that does not affect the water absorption or the accuracy of weighing.

5.3.2.3. *Number of Samples*—For each sealer to be tested, select a minimum of 12 cube samples. A minimum of 6 of these cubes will serve as untreated control cubes. Conditioning of 2 additional samples is recommended in case alternate specimens are needed. Report the curing age of each cube sample used.

If the sealer is being tested for use on traffic-bearing surfaces, abrasion testing (Section 6.2) and Time-to-Cure (Section 6.4) testing are required. Abrasion testing will not require any additional samples, but for Time-to-Cure (Section 6.4) testing, 4 additional cubes are needed (2 cubes for each temperature at which curing time is tested).

If the sealer is also being tested for cyclic freezing resistance according to Section 7.2, another 6 cubes are required.

If optional tests for the Effect of Wet (SSD) Concrete Surface Condition at Time of Sealing (Section 8.3.1) or for Performance at Temperature Extremes (Section 8.2) are being performed, additional sets of 6 cube samples are need for each test.

In addition, select a minimum of 3 cubes to be oven-dried for each concurrently conducted test program (i.e., only one set of cubes for oven drying is needed for each sealer evaluation program even if multiple sealers are tested).

It is suggested that additional cube samples be conditioned for sealing to account for cube variations or damage during the initial steps in the test program. These can then be returned to the moist-curing cabinet for reuse if they are not needed.

Note that 6 concrete test slabs 300 by 300 by 130 mm (12 by 12 by 5 in.) are required for each cyclic weathering test conducted according to Section 5.3. These slabs are cast from the same concrete used for the cubes.

Deicer scaling resistance is performed on 3 treated and 3 untreated [ASTM C672/C672M](#) test slabs manufactured with non-air-entrained concrete according to Section 7.3.

A summary of the cube samples required for the various tests are shown in the following table:

Table 2—Cube Samples Required for Screening Performance Cube Tests

Test	Treated Cubes	Untreated Control Cubes
Moisture content	—	3
Basic prequalification	6 ^a	6
Time-to-cure	2 ^b	—
Cyclic freezing	3	3
Effect of wet (SSD) surface	6	—
Performance at temperature extremes	6	—

^a Plus two additional cubes recommended as alternates.

^b Number of cubes per temperature.

When all specimens are fabricated from the same batch of concrete, assign individual specimens randomly to each set. When the specimens are fabricated from more than one batch of concrete, distribute the individual specimens among each set so that, as close as is possible, an equal number of specimens in each set are taken from each batch.

Examine cubes and do not use cubes having large surface voids or poorly consolidated areas. Check cubes for surface voids and only use cubes with less than 3 percent of the surface area covered by voids (or 18 cm² [2.8 in.²] of void area). Do not include surface voids smaller than 10-mm (0.4-in.) diameter in this measurement. Cubes with more than 3 percent voids can be used as nontreated control samples.

Note 1—An acceptable estimate of the area of surface voids can be made by measuring the number and diameter of all voids greater than 10-mm (0.4-in.) diameter to the nearest millimeter and calculating the total area assuming each void is a perfect circle.

5.3.2.4. *Total Moisture Capacity of Cubes and Baseline Chloride Content*—After 35 days or more of wet curing, remove 3 cubes from the moist-curing room for determination of the total moisture

content. The cubes should include at least 1 cube from each represented batch of concrete and no fewer than 3 cubes total. Determine the saturated surface-dry weight (W_{ssd}) by drying the surfaces of the cubes with a towel and weighing to the nearest 0.1 g. Oven dry cubes at 93 to 96°C (200 to 205°F) until they reach a constant weight (W_{od}), defined as the weight achieved with less than 1/2 percent change in 24 h per [ASTM C642](#), Oven-Dry Mass. Calculate the total moisture capacity (M_{ssd}) in percent by weight as follows:

$$M_{ssd} = ((W_{ssd} - W_{od})/W_{od}) \times 100\% \text{ by weight} \quad (1)$$

Split the oven-dried cubes using the procedure outlined in Section 5.3.6. Pulverize one half of the split cube by crushing and grinding to a powder. All sawing or crushing shall be done dry (i.e., without water). All material shall pass a 0.300-mm (No. 50) sieve. All pulverizing tools and sieves shall be washed with alcohol or distilled water and shall be dry before use with each sample. Test this half of the split cube for acid-soluble chloride content in the same manner to be employed in Section 5.3.6.2; this is the baseline chloride content for the concrete.

Note 2—This chloride testing can be performed later in conjunction with chloride penetration testing on treated cubes to be performed in Section 5.3.6. The oven-dried cubes should be stored in sealed plastic bags if testing is to be delayed.

5.3.2.5.

Adjust Moisture Content of Cubes—After 42 and before 182 days of curing, remove the required number of test cubes (at least 12 per sealer) from the moist-curing room, pat surfaces dry with clean, soft towel and weigh to determine the saturated surface-dry weight of these cubes (W_{ssd1}). Dry cubes in the conditioning chamber that conforms to [ASTM C157/C157M](#) at 50 percent RH and 23°C [73°F] with air circulation aided by fans to achieve a moisture condition in each cube representing 70 ± 2 percent of the mean total moisture capacity (M_{ssd-m}) estimated for these cubes in Section 5.3.2.4. Complete drying within 21 days. Adjust fans to change the rate of drying as needed to be consistent with this time constraint.

Calculate the estimated oven-dry weight of each test cube (W_{od1}) using the formula:

$$W_{od1} = W_{ssd1}/(1 + (M_{ssd-m}/100)), \text{ in grams} \quad (2)$$

where:

M_{ssd-m} = the mean moisture capacity of the cubes from Section 5.3.2.4, in percent.

The target weight after drying for each test cube W_{t1} is 70 ± 2 percent of the mean total moisture capacity (M_{ssd-m}) calculated as follows:

$$W_{t1} = (0.70 \times (W_{ssd1} - W_{od1})) + W_{od1}, \text{ in grams} \quad (3)$$

The allowable difference from this target is:

$$\pm W_{t1\text{-tolerance}} = 0.02 \times (W_{ssd1} - W_{od1}), \text{ in grams} \quad (4)$$

Weigh test cubes daily until the required target weight is obtained. Select 6 cubes for sealer treatment and 6 cubes to serve as control cubes. These will be divided between chloride penetration and alkali resistance/abrasion test paths. The cubes should be selected so that the difference between the actual and target weights are minimized and to equally distribute different batches of concrete, if present. Extra cubes can be returned to the moist-curing room for future use after submerging for 48 h in water. (There will be 2 extra cubes if 14 cubes were selected for conditioning.)

Note 3—This drying process results in the surface being drier than the interior of the cubes. This simulates normal field conditions. Do not store test cubes in the adjusted relative moisture condition for later use.

5.3.2.6. *Specimen Preparation*—After conditioning and immediately prior to coating, lightly sandblast all surfaces of each cube to uniformly remove a total of 24.0 ± 2 g. Blast one face at a time to remove $4.0 \text{ g} \pm 0.5 \text{ g}$ per face. Use a steel plate shield with a 100-mm^2 opening to protect the sample edges.

Use sandblasting sand with the following gradation to produce surfaces that are uniform. Lightly brush or air-blow the samples with clean, dry air to remove sand or dust prior to weighing.

Table 3—Gradation Requirements for Sandblasting Sand

Nominal Opening		% Retained
Microns	U.S. Standard Sieve	
1180	No. 16	4–12
850	No. 20	8–15
600	No. 30	15–25
425	No. 40	35–45
300	No. 50	15–25
Pan	Pan	0–3

5.3.2.7. *Apply Sealer*—Apply sealer to cube surfaces according to the following procedures by immersion or by applying a known amount of sealer. Weigh cubes before and after treatment or measure the weight of sealer applied and record weights.

Use a maximum of two immersions or coats, unless otherwise directed. Alternate methods to treat samples are also acceptable as long as the cubes are treated uniformly and the application rate is accurately measured.

If the sealer is being tested for use on traffic-bearing surfaces, measure and record drying time and time to traffic per Section 6.4. Subsequent to treatment, maintain cubes in 50 percent RH and 23°C environment.

Calculate the weight of the sealer applied in g/m^2 and the surface coverage rate in ft^2/gal based on the sealer specific gravity and cube surface area. Record the number of immersions or brushings, the drying time between coats, and the coverage rate.

Note 4—Manufacturers usually have a range of recommended application rates, since different surface conditions and concretes will absorb or require different amounts of sealer or coating. If the minimum recommended application rate is tested successfully, the sealer should perform well at higher application rates. However, the opposite may not be true. For prequalification testing, it is important to ensure that adequate material is applied so that the sealer has the best chance of success and is fairly evaluated. In all cases, it is important that the test results be reported in terms of the application rate used in the prequalification tests. Agencies can then specify that the tested rate will be the minimum applied rate in the field.

Note 5—Some sealers and coatings contain volatile components and should be applied in a fume hood. Keep air velocity to a minimum over the cube surfaces during curing.

5.3.2.7.1. *Penetrating Sealers Applied by Immersion*—Use the following treatment process for penetrating sealers unless otherwise directed.

Obtain a container to be used for the sealer, a grating that fits over the container, and tongs that can be used to handle the cubes. Fill the container with sufficient sealer and determine the combined weight of the sealer, container, grating, and tongs. Immerse the preweighed cube to be treated with the finished surface upward for 2 min so that the cube is covered with 10 to 15 mm of sealer. Remove the cube and place it on the grating so any excess sealer is allowed to drip back into the container. When no more sealer is dripping from the cubes and after a minimum of 5 min,