
Standard Practice for Quality Assurance, Job Site Quality Control, and Reapplication of Protective Sealers for Portland Cement Concrete

AASHTO Designation: R 94-19 (2023)¹

Adopted: 2019

Reviewed but Not Updated: 2023

Technical Subcommittee: 4c, Markings and Coatings



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1. SCOPE

- 1.1. This practice covers procedures and test methods for quality assurance testing and job site quality control for protective sealers for protecting new concrete or prolonging the life of sound, in-service concrete used in highway structures. It is assumed that the sealer has been tested and prequalified through T 384. This practice provides testing methods for routine and job site product quality assurance and for assessing the field performance of sealers, and includes methods to assess when reapplication should be performed.
- 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:*
 - < T 278, Surface Frictional Properties Using the British Pendulum Tester
 - < T 384, Protective Sealers for Portland Cement Concrete
- 2.2. *ASTM Standards:*
 - < C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
 - < 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
 - < D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method



- < 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
- < 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
- < F2170, Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In Situ Probes

2.3. *Other Reports:*

- < Alberta Infrastructure, Technical Standards Branch, Alberta. BT005, Test Procedure for Measuring the Waterproofing Performance of Core Samples Taken from Sealed Concrete Surfaces
- < Cady, P. D. and E. J. Gannon. *Condition Evaluation of Concrete Bridges Relative to Reinforcement Corrosion*, Vol. 8: *Procedure Manual*, Report No. SHRP-S/FR-92-110. Strategic Highway Research Program, National Research Council, Washington, DC, 1992.

2.4. *RILEM Recommendation:*

- < RILEM Commission 25-PEM. Recommended Tests to Measure the Deterioration of Stone and to Assess the Effectiveness of Treatment Methods. *Materials and Structures*, Vol. 13, No. 3, 1980, pp. 175–253.

3. ROUTINE AND JOB SITE QUALITY ASSURANCE TESTING

- 3.1. This testing is recommended to establish that the sealer material supplied to a job site or ordered for use by maintenance forces is the same material and has the same performance as the material that was tested in the prequalification testing conducted according to T 384. This testing includes sealer material characterization tests and selected performance tests.
- 3.2. *Sealer Sampling*—Sample a minimum of 1 qt of material for each manufacturing lot supplied. It is preferred to sample complete units of material; however, small samples of large units are allowed. Ensure that the sample container is clean, has an airtight seal, and is nonreactive with the sealer. Thoroughly mix each component prior to sampling.
- 3.3. *Material Characterization Tests for Job Site QA*—Material characterization tests are used to collect data on the basic characteristics of the material, including composition, solids content, and specific gravity. These tests are primarily used for comparison of materials sampled during routine and job site quality assurance with prequalified materials. These tests should be performed on samples of the batch or batches of sealer material that are supplied for project use. The test results should be compared to the data on file from the prequalification testing.
- 3.3.1. *Spectral Analysis (FTIR-ATR)*—Fourier transform infrared-Attenuated Total Reflection (FTIR-ATR) analysis provides a chemical fingerprint of a material system that can be used to compare one material to another and to compare batches of a particular material. Analysis can be carried out by transmission or by internal reflection. Analyses of the same material may not be comparable when data is collected in different modes (i.e., transmission vs. reflectance) or when different sample preparation techniques are used. When comparing spectra, it is important to ensure that data was collected under the same conditions, including sample preparation and

instrument conditions. Because comparative analyses need to be carried out with the same sample preparation techniques, review and repeat the processes used for FTIR during the prequalification testing.

Use ASTM E1252 for testing in transmission. Use ASTM E573 for testing by reflectance (attenuated total reflection or other method). Compare the results to the testing performed during the prequalification and confirm a favorable match as deemed by the specifier.

- 3.3.2. *Gas Chromatography (GC)*—Gas chromatography (GC) can be used in addition to or in combination with FTIR as a method for chemical analysis of sealer materials. The procedure used to analyze the sealer by GC will depend on the instrument, column type, and sealer being analyzed. The results will be affected by the instrument and run parameters, such as choice of stationary phase, carrier gas, and carrier gas flow rate. Once a procedure is developed (carrier gas, carrier gas flow rate, stationary phase, etc.) the procedure should be followed for each additional analysis, to provide data suitable for comparison. Refer to ASTM E355 for utilizing gas chromatography.

Review and repeat the processes used for GC during the prequalification testing. For each material type, define a suitable set of operating parameters. These parameters include: stationary phase, injector, detector, carrier gas, carrier gas flow rate, column temperature, run time, injection volume, and other applicable parameters. Obtain and file the dated chromatogram and any other information (component identification or quantification) provided. Document the collection conditions and details of sample preparation. Compare the results to the testing performed during the prequalification and confirm a favorable match as deemed by the specifier.

- 3.3.3. *Solids Content*—Measuring solids content of sealer materials is useful to monitor the uniformity of the material from lot to lot and to ensure that the materials are the same as those that were tested in the prequalification approval testing. Unlike spectroanalysis, which gives a qualitative spectrum, solids content measurements provide a quantitative measurement of nonvolatile content. Fillers or pigments will be measured in solids content measurements, and changes in the type (density) or concentration of fillers or pigment can lead to different solids content measurements. Changes in solvent may not be apparent in solids content measurements. This measurement is used for quality control purposes and also to calculate the weight of sealer applied to the test samples.

For silanes, siloxanes, or silane/siloxane blends, test using ASTM D5095. For other types of sealers, test using ASTM D2369.

- 3.3.4. *Specific Gravity*—Changes in solvent or solids concentration will affect specific gravity. Specific gravity provides a quantitative method of evaluating changes in a material from batch to batch. The method listed is suitable for both solvent-based and water-based systems.

Test the sealer per ASTM D891, Method A or Method B.

- 3.3.5. *Reporting*—Reporting shall include:

- 3.3.5.1. Trade name and lot number of the material analyzed;
- 3.3.5.2. Sealer information, lot number, date manufactured, and MSDS (Material Safety Data Sheet);
- 3.3.5.3. Dated FTIR spectrum (or spectra) with peak positions labeled, and sample preparation and analysis conditions;
- 3.3.5.4. Dated gas chromatogram and any other information (component identification or quantification) provided, along with collection condition and details of sample preparation;
- 3.3.5.5. Solids content (percent nonvolatile content) as required in the relevant ASTM method;

- 3.3.5.6. Specific gravity as required in the relevant ASTM method; and
- 3.3.5.7. Comparison data of the FTIR, GC, solids content, and specific gravity for the sealer tested during the prequalification testing.
- 3.4. *Material Performance Testing for Job Site QA Testing*—Screening Performance Tests for Water Vapor Transmission, Saltwater Absorption, and Depth of Sealer Penetration.
- 3.4.1. *Purpose of Performance Testing*—Several performance tests are recommended to ensure that formulation or raw material changes do not adversely affect the performance of sealers. These tests are recommended for job site quality control and can be used whenever sealers are ordered. The test frequency can be limited to at least one test per year for each material, if test costs become prohibitive or time is unavailable. Tests for water vapor transmission, saltwater absorption, and depth of penetration or coating thickness are recommended.
- 3.4.2. *Testing and Sample Preparation*—Test sealer material in accordance with the following prequalification test sections of T 384:
- < Moisture Vapor Transmission;
 - < Waterproofing Performance by Saltwater Immersion; and
 - < Depth of Sealer Penetration or Coating Thickness.
- Prepare test samples according to T 384, Test Sample Preparation and Treatment. Use standard cured test cubes of the same concrete mixture used during prequalification testing. Adjust the moisture content of the test cubes to 70 percent of the total moisture content M_{ssd} . Lightly sandblast the cubes and treat test samples with the sealer.
- 3.4.3. *Moisture Vapor Transmission Test*—Perform the Moisture Vapor Transmission Test as specified in T 384.
- Determine the moisture vapor transmission gravimetrically by measuring the cube weight at 0, 7, and 14 days after treatment to the nearest 0.1 g.
- Calculate the mean Drying Rate Coefficient (DRC) for the weight loss between 7 and 14 days.
- 3.4.4. *Waterproofing Performance by Saltwater Immersion Test*—Perform the Waterproofing Performance by Saltwater Immersion Test as specified in T 384.
- Use the same samples as used in the vapor transmission testing. Bring both sets of cubes, sealed and control, to the same moisture content before testing. Correct sample weights for the hardened sealer adhering to the test cubes at the end of the 14-day drying period. After conditioning, weigh specimens at room temperature and immerse cubes in 15 percent sodium chloride solution at $23 \pm 2^\circ\text{C}$ for 7 days.
- Calculate the Saltwater Absorption Ratio (SAR) of the treated cubes as a percent of the average absorption of control cubes.
- 3.4.5. *Depth of Sealer Penetration or Coating Thickness*—Determine the Depth of Sealer Penetration or Coating Thickness as specified in T 384.
- Split each treated cube and oven dry the cube half. Cool in laboratory air to room temperature, and determine depth of penetration or coating thickness using the more applicable of the two methods listed in T 384.
- Record the average, minimum, and maximum depths of penetration or coating thickness.
- 3.4.6. *Reporting*—Reporting shall include:
- 3.4.6.1. Sealer information, lot number, date manufactured, location where sampled, and MSDS;

- 3.4.6.2. Aggregate source, gradation and a complete description of the mix design and concrete properties, including casting date of cubes;
- 3.4.6.3. Concrete plastic properties including slump, air content, temperature, and unit weight;
- 3.4.6.4. Concrete compressive strength at 28 days;
- 3.4.6.5. Moisture capacity of concrete (M_{ssd});
- 3.4.6.6. Method of sealer application, number of coats, and the application rate for each sample. Note the time required for the surface of the cubes to dry after each coat;
- 3.4.6.7. The Drying Rate Coefficient (DRC) measured during vapor transmission test;
- 3.4.6.8. The weight gain during immersion (ΔW_{i7}) over 7 days of each cube;
- 3.4.6.9. Saltwater Absorption Ratio (SAR) at 7 days for the given application rate measured during saltwater immersion test;
- 3.4.6.10. Dye used for depth of penetration test, if applicable;
- 3.4.6.11. Average, minimum, and maximum depth of sealer penetration or coating thickness for given application rate OR follow the reporting requirement for the relevant coating thickness standard method for the given application rate; and
- 3.4.6.12. The comparable performance data for the sealer lot used in the prequalification testing.

4. JOB SITE QUALITY CONTROL TESTING

- 4.1. *Overview*—This testing and evaluation applies to sealers that have been applied to concrete bridge members or deck surfaces. Usually some minor destructive testing is necessary to evaluate the depth of penetration and waterproofing performance of the sealer. The suggested procedures include tests that minimize destructive testing. If no drilling or coring is allowed, application of the sealer to mockups of the structure may also be useful in evaluating sealer application effectiveness and application rates.
- 4.2. *Sealer and Application Job Site Quality Control Testing:*
 - 4.2.1. *Concrete Surface Conditions:*
 - 4.2.1.1. *Temperature*—Both ambient and concrete surface temperatures need to be measured prior to sealer application to ensure that the conditions are within the limits set by the sealer manufacturer or set during prequalification testing. Ambient temperature can be measured with a thermometer or thermocouple. Concrete surface temperature can be measured with an infrared surface thermometer or a contact-type surface thermometer.
 - 4.2.1.2. *Moisture*—Moisture content in the concrete should be evaluated prior to applying a sealer. Sealers may not penetrate or coat as well on saturated concrete as they would on drier concrete. Multiple methods are available for evaluating the moisture content of the concrete.

Allowing application as long as no rain has fallen on the structure in at least 3 days reduces the likelihood that the concrete is saturated with water. This is the least labor-intensive method, but the concrete may still contain undesirable levels of moisture, especially if atmospheric humidity is high.

The moisture content in the concrete can be evaluated with two standard methods: ASTM D4263 and ASTM F2170. ASTM D4263 does not require specialized equipment beyond a plastic sheet and tape, and provides results in 16 h, so the test must be initiated the day before application. The test provides a positive or negative result regarding the presence of moisture, but does not provide relative humidity or moisture content information. ASTM F2170 requires specialized relative humidity measuring equipment, and may take hours or days before readings can be taken, so the measurements must be initiated the day before sealing or earlier.

4.2.2. *Sealer Storage, Shelf Life, and Condition:*

4.2.2.1. *Storage*—The conditions under which the sealer has been stored should be documented. Containers of sealer should be stored according to manufacturer's recommendations, which generally indicate storage in a cool, dry place. Care should be taken that the sealers are not stored under conditions that are too hot, such as in a vehicle or shed that traps heat during hot days. Sealers should be kept from freezing during cold weather.

4.2.2.2. *Shelf Life and Condition (Visual)*—Some sealers may degrade or alter with time, and using the sealer on a surface after the designated shelf life can lead to reduced performance. The date of manufacture or any use-by date on the packaging should be noted prior to application and compared to the manufacturer's recommended shelf life. Sealers that have exceeded the shelf life should not be used. It is good practice to mark the date of receipt on the packaging, especially if no date of manufacture or use-by date is printed on the label.

The condition of the sealer should be evaluated visually prior to application. The sealer should be thoroughly mixed prior to evaluation. The sealer appearance should be homogeneous and essentially the same in color, apparent viscosity, and texture as during the prequalification testing. If the sealer appears different from the material that was used for prequalification, different from other packages of the same sealer, or different from a written description of the material, the provenance of the sealer material should be confirmed before it is used. Differences in appearance can indicate a potential formulation change or degradation of the material.

4.2.3. *Application Equipment, Coverage Rate, Cure, and Appearance:*

4.2.3.1. *Equipment*—Prior to applying a sealer, the application equipment should be visually evaluated. The equipment should be clean, and capable of applying the sealer in a manner suitable to deliver the necessary application rate. The equipment should be in accordance with manufacturer specs.

4.2.3.2. *Application Rate (Volume per Area) Spray Time/Area*—The application rate should be evaluated during the application process to ensure adequate coverage of the surface being sealed. There are several ways to test application rate, and the most suitable method depends on the application method and equipment. If possible, the volume or mass of sealer in the application equipment can be measured prior to application and again after application to a known surface area. From this information, the coverage rate can be calculated. If this method of coverage rate measurement is impractical, the sealer can be sprayed or otherwise applied into an empty bucket for a known amount of time. The volume or mass of the sealer in the bucket can be measured, and the application rate as a function of time determined. The amount of time required to apply the sealer to a known area then must be measured to determine application rate over a given surface area. The measured application rate should be compared to the desired application rate (determined from manufacturer's recommendations or from the prequalification tests), and adjusted accordingly.

Environmental conditions may also affect application rate. In the case of high winds, some of the sealer may blow away during spray application, resulting in a lower than desired application rate, even if the application rate, measured as described above, appears adequate. Overatomization of sealers during the spray process can also lead to excessive evaporation before the sealer reaches the concrete, and a reduced actual coverage rate. Care should be taken to avoid these conditions by careful observation of the application process.