

NACE No. 6/SSPC-SP 13, Surface Preparation of Concrete

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ABSTRACT

This NACE International/SSPC joint standard practice covers the preparation of concrete surfaces before the application of protective coating or lining systems. The standard includes two updated tables, Table 1 details classes of surface preparation, and Table 2 provides minimum acceptance criteria for concrete surfaces before coatings are applied and relevant test methods. The updated Appendix (nonmandatory) includes two additional tables, Table A1 provides typical surface properties of finished concrete, and Table A2 provides an extensive list of surface preparation methods for concrete surfaces. This standard should be used by specifiers, applicators, inspectors, and others who are responsible for defining a standard degree of cleanliness, strength, profile, and dryness of prepared concrete surfaces.

KEYWORDS

abrasive blasting, acid etching, cementitious repair, coating adhesion, coatings, concrete, lining systems, NACE No. 6, protective coating systems, surface preparation, spalling, surface profile, tensile strength, TG 417, vacuum cleaning, waterjetting

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Foreword

In NACE/SSPC standards, the terms “shall,” “must,” “should,” and “may” are used in accordance with Paragraph 2.2.1.8 of the Agreement between NACE International and SSPC: The Society for Protective Coatings. The terms “shall” and “must” are used to state mandatory requirements. The term “should” is used to state something considered good and is recommended but is not mandatory. The term “may” is used to state something considered optional.

This NACE International/SSPC Joint standard covers the preparation of concrete surfaces before the application of protective coating or lining systems. This standard should be used by specifiers, applicators, inspectors, and others who are responsible for defining a standard degree of cleanliness, strength, profile, and dryness of prepared concrete surfaces.

This standard was originally prepared in 1997 by NACE/SSPC Joint Task Group (TG) F, “Surface Preparation of Concrete.” It was reaffirmed in 2003 by NACE Specific Technology Group (STG) 04, “Coatings and Linings, Protective—Surface Preparation,” and SSPC Group Committee C.2, “Surface Preparation.” It was revised in 2018 by TG 417 (formerly Task Group F). This standard is issued by NACE under the auspices of STG 04, and by SSPC Group Committee C.7.7.

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Section 1: General

- 1.1** This NACE/SSPC standard details the requirements for surface preparation of concrete by mechanical and chemical methods before the application of bonded protective coating or lining systems.
- 1.2** The standard details specific methods of surface preparation as well as the amount of surface cleanliness and profile achievable by each method. The specifier is responsible for choosing the appropriate class of surface preparation from Table 1 for the intended protective coating and intended service conditions and these should be agreed upon by all parties involved (owner and/or specifier, manufacturer and contractor).

Table 1 Classes of Surface Preparation			
Class	Method	Profile Range (CSP) ^(A)	Section Referenced
D-VC	Vacuum Cleaning	NC ^(B)	4.2.2
W-LP	Low Pressure Water Rinse	NC ^(B)	4.2.2
W-DS	Detergent Scrubbing	NC ^(B)	4.2.3
W-SC	Steam Cleaning	NC ^(B)	4.2.3
W-AE	Acid Etching	1 – 3	4.4
W-WJ	Waterjetting (includes Hydrodemolition and Hydroblasting)	3 – 10	4.3.2
M-GRD	Grinding – Dry	1 – 2	4.3.4
M-GRW	Grinding – Wet	1 – 2	4.3.4
M-ABD	Abrasive Blasting – Dry	3 – 7 ^(A)	4.3.1
M-ABW	Abrasive Blasting – Wet	3 – 7 ^(A)	4.3.1
M-SB	Shot Blasting	3 – 9 ^(A)	4.3.1
M-SC	Scarifying	4 – 7	4.3.3

^(A) ICRI⁽¹⁾ 310.2,¹ Concrete Surface Profiles (CSP); see footnote in Appendix A, Table A2.
^(B) No Change

- 1.3** The requirements of this standard are applicable to all types of cementitious surfaces including, but not limited to, cast-in-place concrete floors and walls, precast slabs, masonry walls, shotcrete surfaces and cementitious grouts, overlayers and/or underlayers.
- 1.4** The composition and installation of new concrete and cementitious repair material may affect the selection and application of a coating system. It is the responsibility of the designer to specify the concrete composition, admixtures, finishing procedures, curing method or compound and form release agents; and cementitious repair materials that ensure the concrete is suitable for coating. The chemical, physical (abrasion), and environmental exposure conditions also must be defined for the appropriate coating system to be selected.
- 1.5** Existing concrete surfaces must be properly evaluated before the application of a coating system. It is the responsibility of the owner/specifier to assess the condition of the concrete to ensure the substrate is sound and suitable for coating.
- 1.6** An acceptable prepared concrete surface should be free of contaminants, laitance, loosely adhering concrete, and dust, and should provide a sound, uniform substrate suitable for the application of protective coating or lining systems.

⁽¹⁾International Concrete Repair Institute (ICRI), 3166 S. River Road, Suite 132, Des Plaines, IL 60018.

1.7 This standard provides minimum requirements for a concrete surface following surface preparation and specific test methods and acceptance criteria for surface tensile strength, profile, cleanliness, residual contaminants, pH, and moisture content.

1.8 The mandatory requirements of this standard are given in Sections 1 to 7 as follows:

Section 1:	General
Section 2:	Definitions
Section 3:	Inspection Procedures Before Surface Preparation
Section 4:	Surface Preparation
Section 5:	Inspection and Classification of Prepared Concrete Surfaces
Section 6:	Acceptance Criteria
Section 7:	Safety and Environmental Requirements

1.9 Appendix A (Nonmandatory) does not contain mandatory requirements.

Section 2: Definitions

Coating: See *Protective Coating or Lining System*.

Concrete: A material made from hydraulic cement and inert aggregates, such as sand and gravel that is mixed with water to a workable consistency and placed by various methods to harden and gain strength.

Curing (Concrete): Action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration so that potential properties of the mixture may develop.

Curing Compound (Membrane Curing Compound): A liquid that can be applied to form a membrane on the surface of newly placed concrete to retard the loss of water.²

Efflorescence: A generally white deposit formed when water-soluble compounds emerge in solution from concrete, masonry, or plaster substrates and precipitate by reaction such as carbonation or crystallize by evaporation.²

Fins: A narrow linear projection on a formed concrete surface, resulting from mortar flowing into spaces in the form work.²

Finish: The texture of a concrete surface after consolidating and finishing operations have been performed.²

Finishing: Leveling, smoothing, consolidating, and otherwise treating surfaces of fresh or recently placed concrete or mortar to produce desired appearance and service.²

High-Pressure Water Cleaning (HP WC): Water cleaning performed at pressures from 34 to 70 MPa (5,000 to 10,000 psig).³

High-Pressure Waterjetting (HP WJ): Waterjetting performed at pressures from 70 to 210 MPa (10,000 to 30,000 psig).³

Honeycomb: Voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse aggregate particles or other obstructions.²

Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface. The amount of laitance is influenced by the types and amounts of admixtures, the degree of working, and the amount of water in the concrete.⁴

Lining: See *Protective Coating or Lining System*.

Porosity: Small voids that allow fluids to penetrate an otherwise impervious material.

Protective Coating or Lining System (Coating): For the purposes of this standard, protective coating or lining systems (also called protective barrier systems) are bonded thermoset, thermoplastic, inorganic, organic/inorganic hybrids, or metallic materials applied in one or more layers by various methods such as brush, roller, trowel, spray, and thermal spray. They are used to protect concrete from degradation by chemicals, abrasion, physical damage, and the subsequent loss of structural integrity. Other potential functions include containing chemicals, preventing staining of concrete, and preventing liquids from being contaminated by concrete.

Release Agents (Form-Release Agents): Materials used to prevent bonding of concrete to a surface.²

Scaling: Local flaking, or peeling away, of the near-surface portion of hardened concrete or mortar.

Sealer (Sealing Compound): A liquid that is applied to a concrete surface to prevent or decrease the penetration of liquid or gaseous media during exposure. Some curing compounds also function as sealers.

Soundness: A qualitative measure of the suitability of the concrete to perform as a solid substrate or base for a coating or patching material. Sound concrete substrates usually exhibit strength and cohesiveness without excessive voids or cracks.

Spalling (Concrete): The spontaneous chipping, fragmentation, or separation of a surface or surface coating. (For the purposes of this document, spalling includes a fragment, usually in the shape of a flake, detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the larger mass; a small spall involves a roughly circular depression not greater than 120 mm (5 in) in depth and 150 mm (6 in) in any dimension; a large spall, may be roughly circular or oval or in some cases elongated, is more than 120 mm (5 in) in depth and 150 mm (6 in) in greatest dimension.)

Surface Porosity: Porosity or permeability at the concrete surface that may absorb vapors, moisture, chemicals, and coating liquids.

Surface Preparation: The method or combination of methods used to clean a concrete surface, remove loose and weak materials and contaminants from the surface, repair the surface, and roughen the surface to promote adhesion of a protective coating or lining system.

Surface Profile (Texture): Surface contour as viewed from the edge.

Surface Air Voids: Cavities visible on the surface of a solid.

Ultra-High-Pressure Waterjetting (UHP WJ): Waterjetting performed at pressures greater than 210 MPa (30,000 psig).³

Section 3: Inspection Procedures Before Surface Preparation

3.1 Concrete shall be inspected before surface preparation to determine the condition of the concrete and to determine the appropriate method or combination of methods to be used for surface preparation to meet the requirements of the coat-

ing system to be applied. Inherent variations in surface conditions seen in walls and ceilings versus those in floors should be considered during the selection of surface preparation methods and techniques. For example, walls and ceilings are much more likely than floors to contain surface air voids, fins, form-release agents, and honeycombs. ACI⁽²⁾ 364.1R⁴ provides useful guidance for inspection and evaluation of structures.

3.2 Visual Inspection

All concrete surfaces to be prepared and coated shall be visually inspected for signs of concrete defects, physical damage, chemical damage, contamination, and excess moisture.

3.3 The Degree of Concrete Cure

All concrete should be cured using the procedures described in ACI 308.⁵ Curing requirements include maintaining sufficient moisture and temperatures for a minimum time period. Surface preparation performed on insufficiently cured or low-strength concrete may create an excessively coarse surface profile or remove an excessive amount of concrete.

3.4 Concrete Defects

Concrete defects such as honeycombs and spalling shall be repaired. The procedures described in ICRI 310,^{1,6} or ACI 301⁷ may be used to ensure the concrete surface is sound before surface preparation. Further information on investigation of defects may be found in ICRI 210.4⁸ and NACE SP0308.⁹

3.5 Physical Damage

3.5.1 Several common surface preparation methods are likely to reduce the tensile strength of the prepared substrate. Bond strengths achieved on surfaces prepared with high-impact mechanical cleaning methods are frequently shown to be lower than those achieved when nonimpact cleaning methods are used. This reduction in bond strength can be attributed to “bruising,” cracking of the cement paste, and loosening of the aggregate without fully separating from the underlying concrete. This layer of interconnecting microcracks typically extends to a depth of 3 to 10 mm (0.12 to 0.4 in) and it is generally accepted that damage increases with the increasing weight and power of the equipment used.

3.5.2 Concrete should be tested for soundness by the qualitative methods described in Appendix A, Paragraph A4.3.

3.5.3 When qualitative results are indeterminate, or when a quantitative result is specified, concrete shall be tested for surface tensile strength using the methods described in Appendix A, Paragraph A8.

3.5.4 Concrete that has been damaged because of physical forces such as impact, abrasion, or corrosion of reinforcement shall be repaired before surface preparation if the damage would affect coating performance. Repairs should be made in accordance with ACI 301, ACI 562,¹⁰ ACI 546,¹¹ NACE SP0390,¹² or Appendix A, Paragraph A4.

3.6 Chemical Damage

⁽²⁾American Concrete Institute International (ACI), 38800 International Way, Country Club Drive, Farmington Hills, MI 48331.

3.6.1 Concrete is attacked by a variety of chemicals, as detailed in ACI 515.2R¹³ and PCA⁽³⁾ IS001.¹⁴

3.6.2 All concrete surfaces that have been exposed to chemicals shall be tested and treated for contamination as described in Paragraph 3.7.

3.6.3 Concrete that has been exposed to chemicals shall be tested for soundness by the qualitative methods described in Appendix A, Paragraph A4.3.

3.7 Contamination

3.7.1 Contamination on concrete surfaces includes all materials that may affect the adhesion and performance of the coating to be applied. Examples include, but are not limited to, dirt, oil, grease, chemicals, and existing incompatible coatings.

3.7.2 Contamination may be detected by methods described in Appendix A, Paragraph A5. These methods include, but are not limited to, visual examination, water drop (contact angle) measurement, pH testing, petrographic examination, and various instrumental analytical methods. Core sampling may be required to determine the depth to which the contaminant has penetrated the concrete.

3.7.3 Concrete surfaces that are contaminated or that have existing coatings shall be tested by the method described in Appendix A, Paragraph A8 to determine whether the contamination or existing coating affects the adhesion and performance of the coating to be applied.

3.7.4 In extreme cases of concrete damage or degradation, or thorough penetration by contaminants, complete removal and replacement of the concrete may be required.

3.8 Moisture

Moisture levels in the concrete may be determined by the methods described in Paragraph 5.5.

Section 4: Surface Preparation

4.1 Objectives

4.1.1 The objective of surface preparation is to produce a concrete surface that is suitable for application and adhesion of the specified protective coating system.

4.1.2 Protrusions such as from sharp edges, fins, and concrete spatter shall be removed during surface preparation.

4.1.3 Voids and other defects that are at or near the surface shall be fully exposed during surface preparation.

4.1.4 All concrete that is not sound shall be removed so that only sound concrete remains.

4.1.5 Concrete damaged by exposure to chemicals shall be removed so that only sound concrete remains.

⁽³⁾ Portland Cement Association (PCA), 5420 Old Orchard Rd., Skokie, IL 60077.

4.1.6 All contamination, form-release agents, efflorescence, curing compounds, and existing coatings determined to be incompatible with the coating to be applied shall be removed.

4.1.7 The surface preparation method, or combination of methods, should be chosen based on the condition of the concrete and the requirements of the coating system to be applied.

4.1.8 All prepared concrete surfaces shall be repaired to the level required by the coating system in the intended service condition.

4.2 Surface Cleaning Methods

4.2.1 The surface cleaning methods described in Paragraphs 4.2.2 and 4.2.3 shall not be used as the sole surface preparation method of concrete to be coated as they do not remove all laitance or contaminants or alter the surface profile of concrete. These methods shall be used as required, before and/or after the mechanical and chemical methods described in Paragraphs 4.3 and 4.4 and the effectiveness of any surface preparation should be verified following any method selected.

4.2.2 Vacuum cleaning, air blast cleaning, and water cleaning as described in ASTM⁽⁴⁾ D4258¹⁵ may be used to remove dirt, loose material, and/or dust from concrete.

4.2.3 Detergent water cleaning and steam cleaning as described in ASTM D4258 may be used to remove oils and grease from concrete.

4.3 Mechanical Surface Preparation Methods

4.3.1 Dry abrasive blasting, wet abrasive blasting, vacuum-assisted abrasive blasting, and centrifugal shot blasting, as described in ASTM D4259,¹⁶ may be used to remove contaminants, laitance, and weak concrete, to expose subsurface voids, and to produce a sound concrete surface with adequate profile and surface porosity. See Table A2.

4.3.2 High- or Ultra-High pressure water cleaning or waterjetting methods as described in the four joint NACE/SSPC waterjetting standards, ASTM D4259, ICRI 310.3R,¹⁷ or the WaterJet Technology Association's⁽⁵⁾ (WJTA-IMCA) "Recommended Practices for the Use of High Pressure Waterjetting Equipment,"¹⁸ may be used to remove contaminants, laitance, existing coatings, and weak concrete, to expose subsurface voids, and to produce a sound concrete surface with adequate profile and surface porosity. See Appendix A, Table A2.

4.3.3 Impact-tool methods may be used to remove existing coatings, laitance, and weak concrete. These methods include scarifying, scabbling, and rotary peening, as described in ASTM D4259. Impact-tool methods may fracture concrete surfaces or cause microcracking and may need to be followed by one of the procedures in Paragraphs 4.3.1 or 4.3.2 to produce a sound concrete surface with adequate profile and surface porosity. The soundness of a concrete surface prepared using an impact method may be verified by one of the surface tensile strength tests described in Appendix A, Paragraph A8.

4.3.4 Power tool methods, including circular grinding, sanding, and wire brushing as described in ASTM D4259, may be used to remove existing coatings, laitance, weak concrete, and protrusions in concrete. These methods may not

⁽⁴⁾ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

⁽⁵⁾WaterJet Technology Association, 917 Locust, Suite 1100, St. Louis, MO 63101-1419.

produce the required surface profile and may require one of the procedures described in Paragraphs 4.3.1 or 4.3.2 to produce a concrete surface with adequate profile and surface porosity. See Table A2.

4.3.5 Surface preparation using the methods described in Paragraphs 4.3.1 through 4.3.4 shall be performed in a manner that provides a uniform, sound surface that is suitable for the specified protective coating system.

4.4 Chemical Surface Preparation

Acid etching, as described in ASTM D4260 may be used to remove laitance and weak concrete and to provide a surface profile on concrete surfaces.¹⁹ This method requires complete removal of all reaction products and pH testing to ensure neutralization of the acid. Acid etching should not be used in areas where curing compounds, sealers or contaminants prevent the acid from reacting with the concrete. Acid etching shall only be used where procedures for handling, containment, and disposal of the hazardous materials are in place. Acid etching with hydrochloric acid (e.g., muriatic acid) shall not be used where corrosion of metal in the concrete (rebar or metal fibers) is likely to occur.

4.5 Surface Cleanliness

After the concrete surface has been prepared to the required soundness and surface profile, surfaces may still need to be cleaned by one of the methods described in Paragraph 4.2 to remove the residue created by the surface preparation method or to remove spent media.

4.6 Patching and Repairs

4.6.1 Before proceeding with patching and repairs, the prepared concrete surface shall be inspected in accordance with Section 5. After the patching and repairs of the concrete surface are completed, the repaired areas shall be re-inspected in accordance with Section 5.

4.6.2 All gouges, surface air voids, and other surface anomalies shall be repaired to a level required by the coating system as specified in the procurement documents.

4.6.3 All repair materials, both cementitious and polymeric, should be approved or recommended by the coating manufacturer as being compatible with the coating to be applied.

4.6.4 The repair material shall be cured in accordance with the manufacturer's published instructions.

4.6.5 The repaired section may require additional surface preparation before coating application.

Section 5: Inspection and Classification of Prepared Concrete Surfaces

5.1 Concrete Surface Tensile Strength and Coating Adhesion

5.1.1 ASTM D7234²⁰ is used to measure coating adhesion; the preferred method is to apply a test patch of the intended coating system (or just the primer) over the prepared concrete surface and then perform ASTM D7234 on the coated (or primed) concrete surface. (See Appendix A, Paragraph A8.)

5.1.2 If it is not possible to apply a test patch of the intended primer or coating system, or where there is a need to verify or determine the tensile strength of the bare concrete surface or concrete repair material, ASTM C1583²¹ should be performed after the specified surface preparation has been completed. (See Appendix A, Paragraph A8.)

5.2 Surface Profile

5.2.1 If a specific surface profile is required for the performance of the coating system to be applied, the profile shall be specified in the procurement documents.

5.2.2 The surface profile of prepared concrete surfaces should be evaluated after cleaning and drying but before repairs or application of the coating.

5.2.3 The surface profile may be evaluated by comparing the profile of the prepared concrete surface with the ICRI Guideline No. 310.²¹ concrete surface profile (CSP) comparator chips.

5.2.4 If accepted by all parties, the methods described in Appendix A, Paragraph A7 also can be used to determine the surface profile of the concrete surface.

5.3 Surface Cleanliness

5.3.1 All prepared concrete surfaces shall be inspected for surface cleanliness after cleaning and drying but before making repairs or applying the coating. Refer to Appendix A, Paragraph A5. If the concrete surfaces are repaired, they shall be reinspected for surface cleanliness before applying the coating.

5.3.2 Prepared concrete surfaces may be inspected for surface cleanliness by lightly rubbing the surface with a dark cloth or pressing a translucent adhesive tape on the surface. The test method and acceptable level of residual dust shall be agreed on by all parties.

5.3.3 The method used to verify compatibility of the coating to be applied over a contaminated surface or over contaminated surfaces that have been cleaned and prepared should be approved by the coating manufacturer and specified in the procurement documents.

5.4 pH

5.4.1 If a specific pH range is required for proper performance of the coating system to be applied, the pH of the concrete and acceptable methods of measurement shall be specified in the procurement documents.

5.4.2 ASTM D4262²² or other agreed upon methods can be used to determine pH.

5.4.3 If the concrete surfaces are prepared by acid etching, pH measurements of concrete surfaces should be conducted after rinsing, but before the prepared surface has dried.

5.5 Moisture Content

5.5.1 If specific moisture content is required for proper performance of the coating system to be applied, the moisture content of the concrete and acceptable methods of measurement shall be specified in the procurement documents.

5.5.2 Prepared concrete surfaces should be tested for residual moisture after cleaning and drying but before the application of the coating.

5.5.3 ASTM D4263,²³ ASTM F1869,²⁴ or ASTM F2170²⁵ should be used to determine the residual moisture content in concrete. ACI 302.2²⁶ should be used as a guide for further information.

5.5.4 If required or accepted by all parties, any of the methods described in Paragraph 5.5.3 may be used to determine the moisture content of the concrete surface.

Section 6: Acceptance Criteria

6.1 The minimum acceptance criteria for prepared concrete surfaces shall be in accordance with Table 2, or as specified in the procurement documents.

6.2 If the requirements by the manufacturer for specific coatings are more stringent than listed in Table 2, the more stringent requirements shall apply.

Table 2			
Minimum Acceptance Criteria for Concrete Surfaces Before Coatings are Applied			
Property	Test Method	Light Service^(A)	Severe Service^(B)
Surface tensile strength	ASTM D7234	1.4 MPa (200 psi) min.	2.1 MPa (300 psi) min.
and/or			
Surface tensile strength	ASTM C1583	1.4 MPa (200 psi) min.	1.7 MPa (250 psi) min.
Surface profile	ICRI No. 310.2	CSP 2 min.	CSP 3 min.
Surface cleanliness	ASTM D4258 (Visible dust)	No significant dust	No significant dust
Residual contaminants ^(C)	ASTM F21 ^{27,28}	Water droplets wet surface immediately forming a continuous uniform film	Water droplets wet surface immediately forming a continuous uniform film
pH (acid etching)	ASTM D4262	-1pH to +2pH change in rinse water	Not Recommended
Moisture content ^(D)	ASTM D4263	No visible moisture	No visible moisture
and/or			
Moisture content ^(D)	ASTM F1869	15 g/24 hr/m ² (3 lb/24 hr/1,000 ft ²) max.	15 g/24 hr/m ² (3 lb/24 hr/1,000 ft ²) max.
and/or			
Moisture content ^(D)	ASTM F2170	80% max.	80% max.
<p>^(A) Light service refers to exposure conditions such as light traffic (i.e., foot traffic and light rubber wheeled carts), moisture, nonaggressive chemicals or freeze/thaw cycles.</p> <p>^(B) Severe service refers to exposure conditions such as heavy machinery traffic (i.e., forklifts, heavy trucks, or steel wheeled carts), deleterious chemicals, immersion or thermal shock (e.g., hot water washing or steam cleaning).</p> <p>^(C) Though the figures in ASTM F21 depict the assessment results on nickel specimens, the standard and water films depicted are applicable to concrete surfaces.</p> <p>^(D) NOTE: There are two scenarios where the criteria for Moisture Content in Table 2 may not apply. The first is at or below grade or outdoor slabs or walls where it may be impossible or impractical to achieve the low level of moisture indicated. The second scenario is where moisture suppressing or moisture tolerant coatings are specified. See Paragraph A9 in Appendix A for more information.</p>			

Section 7: Safety and Environmental Requirements

- 7.1 Disposal of contaminants, old coatings, acid from etching, and contaminated water and blasting media shall comply with all regulations of the applicable facility and regulatory agencies.
- 7.2 Handling of hazardous materials, machinery operations, worker protection, and control of airborne dust and fumes shall comply with all health and safety regulations of the applicable facility and regulatory agencies.

References

1. ICRI 310.2 (latest revision), "Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays" (Des Plaines, IL: ICRI).
2. ACI 116R (latest revision), "Cement and Concrete Terminology, SP-19(90)" (Farmington Hills, MI: ACI).
3. SSPC Protective Coatings Glossary, 2011 (Pittsburgh, PA: SSPC).
4. ACI 364.1R (latest revision), "Guide for Evaluation of Concrete Structures Before Rehabilitation" (Farmington Hills, MI: ACI).
5. ACI 308 (latest revision), "Standard Practice for Curing Concrete" (Farmington Hills, MI: ACI).
6. ICRI 310.1 (formerly No. 03730) (latest revision), "Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion" (Des Plaines, IL: ICRI).
7. ACI 301 (latest revision), "Specifications for Structural Concrete for Buildings" (Farmington Hills, MI: ACI).
8. ICRI 210.4 (latest revision), "Guide for Nondestructive Evaluation Methods for Condition Assessment, Repair, and Performance Monitoring of Concrete Structures" (Des Plaines, IL: ICRI).
9. NACE SP0308 (latest revision), "Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures" (Houston, TX: NACE).
10. ACI 562 (latest revision), "Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings and Commentary" (Farmington Hills, MI: ACI).
11. ACI 546 (latest revision), "Guide for the Selection of Materials for the Repair of Concrete" (Farmington Hills, MI: ACI).
12. NACE SP0390 (latest revision), "Maintenance and Rehabilitation Considerations for Corrosion Control of Existing Steel-Reinforced Concrete Structures" (Houston, TX: NACE).
13. ACI 515.2R (latest revision), "Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete" (Farmington Hills, MI: ACI).
14. PCA IS001 (latest revision), "Effects of Substances on Concrete and Guide to Protective Treatments" (Skokie, IL: PCA).
15. ASTM D4258 (latest revision), "Standard Practice for Surface Cleaning Concrete for Coating" (West Conshohocken, PA: ASTM).

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Appendix A

Comments (Nonmandatory)

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the provisions herein.

A1 General²⁹⁻³²

A1.1 This standard does not recommend surface preparation methods or differentiate levels of surface preparation that are specifically required for various protective system designs, types, thicknesses, and end-use requirements. These specifications should be decided and agreed upon by all parties (e.g., the specifier, facility owner, coating manufacturer, and contractor).

A1.2 Concrete and its surfaces are not homogeneous or consistent and, unlike steel, cannot be discretely defined. Therefore, visual examination of a concrete surface is somewhat subjective. The acceptance or rejection of a prepared concrete surface should be based on the results of specific tests, including, but not limited to, tests for surface tensile strength, contamination, and moisture. Test applications of the proposed primers or coating systems also should be conducted and tested.

A1.3 Joints, cracks, and curing shrinkage of concrete, chemical exposure and mechanical abrasion should be considered in the design of the protective coating system; however, these topics are beyond the scope of this standard. See NACE SP0892,³³ ACI 515.2R,¹³ and NACE Publication 6G197/SSPC-TU 2³⁴ for more information.

A1.4 When a significant amount of weak, deteriorated, or contaminated concrete is removed during the course of surface preparation to achieve a sound surface, the profile of remaining concrete is often too rough for the intended coating system. In these cases, and where form voids and surface air voids must be filled, patching or grouting materials are specified to repair or level the concrete surface. See NACE SP0892, NACE SP0390, NACE Publication 6G197/SSPC-TU 2, and Paragraph A4.4 of this Appendix for more information about patching materials.

A2 Concrete Finishing and Surface Characteristics

A2.1 The method used to finish concrete surfaces affects the concrete's surface profile, composition, porosity, and density. These surface properties affect the adhesion and performance of concrete coatings. Typical surface properties obtained using the most common finishing methods are given in Table A1. These properties are evaluated before surface preparation.

Table A1 Typical Surface Properties of Finished Concrete

Method	Profile ^(A)	Porosity ^(A)	Strength ^(A)	Problems
Formed concrete	Smooth to medium	Low to medium	Medium	Voids, protrusions, release agents
Wood float	Medium	Medium	Medium	
Metal trowel	Smooth	Low	High	
Power trowel	Smooth	Very low	High	Very dense
Broom finish	Coarse to very coarse	Medium	Medium	
Sacking	Smooth	Low to medium	Low to high ^(B)	Weak layer if not properly cured
Stoning	Smooth to medium	Low to medium	Low to high ^(B)	Weak layer if not properly cured
Concrete block	Coarse to very coarse	Very high	Medium	Relatively high degree of porosity/potential for pinholes in applied coatings
Shotcrete ^(C)	Very coarse	Medium	Medium	Too rough for thin coatings

^(A) These surface properties are based on similar concrete mix, placement, and vibration and before surface preparation.

^(B) Strength depends on application and cure.

^(C) Shotcrete may be refinished after placement, which would change the surface properties given in this table.

A2.2 No preferred method of finishing concrete to accept coatings has been established by the concrete coating industry. The surface cure, surface preparation method, and type of coating system to be applied are all factors in determining the suitability of any specific concrete finishing method. For example, broom finishing is sometimes used because it gives a profile for the coating; however, most of the profile may be removed during surface preparation if the surface is not properly cured, negating this inherent advantage of the broom finish. When sacking is used to fill voids in formed concrete surfaces, subsurface voids are created, and the added cement is usually removed during surface preparation as a result of improper cure of the added cement paste.

A2.3 Use of a metal trowel is gaining acceptance as the preferred finishing method for horizontal surfaces to be coated provided the surface is not excessively trowelled, the concrete is cured properly, and the laitance is removed before coating.

A2.4 Photographic examples of concrete finishes are shown in ASTM PCN:03-401079-14.³⁵

A3 Concrete Cure³⁶

A3.1 Maintaining sufficient moisture and proper temperature in concrete in the early stages of cure is important to ensure development of the designed strength. Keeping the surface moist until sufficient strength has developed at the surface is important to ensure formation of sufficient surface strength, to reduce curling, and to reduce surface cracking.

A3.2 ACI 3085 recommends seven days of moist curing for Type I portland cement concrete and three days for Type III portland cement concrete, if the temperature is above 10 °C (50 °F). ACI 308 also recommends numerous methods to properly cure concrete, including the use of sealing materials and other methods to keep concrete moist.

A3.3 ACI 308 also gives recommendations on the use of curing compounds, which are commonly used immediately after placement and finishing of concrete surfaces to reduce moisture loss and improve surface cure. The curing compound should either be compatible with the coating or be removed during surface preparation.

A3.4 The Traditional 28-day Waiting Period^{37, 38}

A3.4.1 The traditional 28-day waiting period after concrete placement and before coating installation is a controversial topic that involves all parties. Although the waiting period is not usually required for surface preparation, it affects the timing of surface preparation because many coatings are applied within 24 hours after surface preparation.

A3.4.2 The 28-day waiting period originated from the structural benchmark to test concrete strength at 28 days after placement to verify that the tested strength met the design strength. The 28-day waiting period was adopted by the coating industry because it usually allows sufficient time for concrete surface strength to develop and for excess moisture to evaporate.

A3.4.3 Many factors can reduce or increase the time required for strength and moisture levels to be acceptable. In addition, many construction schedules do not allow for a 28-day waiting period. For these reasons, quantifying surface requirements are preferred over the traditional 28-day waiting period. See Paragraph A8.

A3.4.4 NACE SP0892 does not recommend a specific cure period, but does address surface dryness, surface strength requirements and other surface quality issues.

A4 Identification and Repair of Surface Defects and Damage³⁹

A4.1 Physical and Chemical Damage

A4.1.1 Existing concrete structures that have been subjected to mechanical damage (caused by impact or abrasion), chemical attack, or rebar corrosion are restored to provide a uniform, sound substrate before coating application.

A4.1.2 To best receive and hold the patching material all deteriorated concrete should be removed and the surrounding sound concrete cut using the procedures described in ICRI 310.1⁶ Some contaminants have a detrimental effect on the rebar or the applied coating if they are not completely removed.

A4.1.3 A number of polymeric grouts and patching materials can be used, especially when the coating is to be applied immediately. These materials should be compatible with the coating to be applied.

A4.2 Other Defects and Imperfections

A4.2.1 Defects such as honeycombs, scaling, and spalling do not provide a sound, uniform substrate for the coating. These defects are repaired by removing all unsound concrete and then patching the concrete before surface preparation. NACE SP0390 and ICRI 310.1 describe removal and repair procedures for concrete that is spalled because of rebar corrosion.

A4.2.2 Surface air voids, pinholes, or excessive porosity may affect the application or performance of the coating. The maximum substrate void size or surface porosity that can be tolerated depends on the coating system under consideration. If voids are not filled before the coating is applied, the trapped air vapor expands and contracts and may affect the performance of the coating. For liquid-rich coatings, excess porosity at the surface may result in pinholes in the coating. Voids are usually filled after surface preparation and before coating application.

A4.2.3 Protrusions such as form lines, fins, sharp edges, and spatter may cause holidays or thin sections in the coating if they are not removed. Protrusions and rough edges are usually removed during surface preparation.

A4.3 Testing for Surface Soundness

A4.3.1 The following are common methods used to determine surface soundness:

- (a) A screwdriver, file, or pocket knife is lightly scratched across the concrete surface. If the metal object rides over the surface without loosening any particles and leaves no more than a shiny mark, the surface is sound. If this process gouges the surface, the surface is not sound.
- (b) The concrete surface is lightly struck with the edge of a hammer head. If the hammer rebounds sharply with no more than a small fracture at the impact area, the surface is sound. If it lands with a dull thud and leaves powdered dusts in the indentation, the surface is not sound.
- (c) A chain is dragged across horizontal concrete surfaces. Differences in sound indicate unsound concrete and holes or pockets within the concrete.

A4.4 Patching of Concrete Surface Imperfections

A4.4.1 Repair Materials are used to repair, patch, smooth, or seal the concrete surface to provide a substrate that is suitable for the coating system to be applied. These materials are applied after surface preparation and require the following characteristics:

- (a) good adhesion to the existing substrate;
- (b) adequate strength to meet the service conditions of the coating system;
- (c) low volumetric and linear shrinkage during cure under the environmental service conditions; and
- (d) compatibility with the coating to be applied.

In addition, the patching material is often required to cure sufficiently, be traffic bearing, and be ready to recoat in a short time frame (usually within 24 hours).

A4.4.2 Shrinkage of the patching material may reduce the adhesion of that material to the concrete substrate. Differences in thermal expansion between the concrete, patching material, and coating system, cause stresses during thermally induced movement that may reduce adhesion between these layers.

A4.4.3 The most common types of patching materials are cementitious, polymer-modified cementitious (usually acrylic), and polymeric (usually epoxy or urethane). Cementitious materials are lower in cost than polymeric materials, but polymeric materials generally cure faster and have higher strengths, better adhesion, and increased chemical resistance.

A4.4.4 Patching materials are available in a range of consistencies for application to vertical or horizontal surfaces by a variety of methods. The amount of filler also varies. For example, grouts for deep patching are typically highly

filled, while porosity sealers may be minimally filled or unfilled. Numerous proprietary materials are low-shrinking, non-shrinking, or expanding.

A4.4.5 Additional surface preparation may need to be performed on cured patching materials to ensure the patched surface meets the requirements of the coating system.

A5 Identification and Removal of Contaminants⁴⁰⁻⁴²

A5.1 Hydrophobic Materials

A5.1.1 Hydrophobic contaminants may exist on new or existing concrete surfaces as form-release agents, curing compounds, sealers, existing coatings, oil, wax, grease, resins or silicone. They may be qualitatively detected by a simple water drop test where they cause the water to bead upon the surface. A specific procedure for conducting this type of test in-situ and quantifying the results is found in ASTM F21.²⁷ If the water-drop or atomizer test is inconclusive, a few drops of muriatic acid may be dropped on the surface; if there is no visible foaming reaction, then a contaminant exists on the surface. Analytical techniques such as infrared analysis or gas chromatography may also be used to detect and identify these contaminants in core samples.

A5.1.2 Oils and greases can be removed by steam cleaning, baking soda blasting or washing with alkaline detergents and degreasers. When deposits are very heavy, scraping or the use of absorbents may be necessary in conjunction with these methods. The surface must be thoroughly rinsed of all cleaning solutions and tested again before further surface preparation is conducted. Hydrocarbon solvents are not recommended for oil and grease removal as they tend to spread the contamination and facilitate further penetration into the concrete.

A5.1.3 Curing compounds, sealers, form-release agents, and coatings should be removed by the least destructive, most practical, economic, and safe method available. Removal methods such as grinding, abrasive blasting, wet abrasive blasting, waterjetting or scarifying are often used. Chemical strippers are generally not recommended. In some cases, the manufacturer of the coating system to be applied may consider the existing sealer or curing compound to be compatible negating the need for removal.

A5.2 Laitance

A5.2.1 Laitance is a weak layer of fine particles of cement and aggregate formed on the surface when the concrete is over worked or over wet (see definition in Section 2). Laitance must be removed before the application of a coating system. Most coatings form a tenacious bond to the laitance, but the laitance is a friable layer that is only loosely adhered to the concrete underneath. If not removed during surface preparation, the coating and laitance detach at the interface between the laitance and concrete substrate. Laitance may be detected by running a sharp instrument, such as a screwdriver, over the surface with moderate-to-heavy pressure and noting the mark left on the surface. Laitance typically fractures or crumbles, leaving powdery or gritty residue behind. Laitance may be removed using the methods described in Table A2.

A5.3 Salts and Reactive Materials

A5.3.1 Salts, sulfates, efflorescence, chemical reaction products such as, acids, alkalis, and by products of chemical attack of concrete, can sometimes be detected by pH testing, soundness testing using the screwdriver test, or visual examination. When these methods are not successful, chemical analysis techniques are required.

A5.3.2 Efflorescence consists of salts that are carried to the surface by the migration of water through the concrete. The water evaporates leaving the salt deposit behind. For this reason, it is important to ascertain the source of the moisture when the concrete is to be coated to avoid other complications such as detachment by hydrostatic pressure. Some of these salts may remain water soluble so that high-pressure water washing alone may cause them to penetrate back into the concrete. Others may react with the atmosphere and become water insoluble. The salts may be removed by brushing with a stiff brush followed by water washing or by abrasive blasting. In some cases, they may be removed by first uniformly wetting the surface with water, then applying a diluted solution of muriatic or acetic acid followed immediately by an alkali wash and rinsing. In addition, the salts may be removed by using the methods described in Table A2.

A5.3.3 Residual acids and alkalis are first neutralized and then removed by high-pressure water cleaning.

A5.4 Microbial Induced Concrete Corrosion

A5.4.1 Microorganisms such as fungus, moss, mildew, algae, decomposing organic matter, and other organic growths can sometimes be detected by visual examination and in some cases by testing the pH. The effects of microbial infestation may be purely aesthetic, such as in the case of mildew staining, but microbially induced concrete corrosion as seen in areas such as sewers and digesters eventually affects the structural integrity of the concrete. In the case of the latter, a hammer test may be used to check for integrity of the concrete surface (ASTM C805⁴³), or even an ultrasound test for deeper corrosion (ASTM C597⁴⁴).

A5.4.2 Microorganisms creating an aesthetic issue such as fungus, moss, algae and/or decomposing organic matter are removed by scraping, abrasive blasting, or waterjetting followed by treating the surface with sodium hypochlorite (household bleach) and rinsing with water.

A5.4.3 Concrete that is susceptible to, or has sustained damage such as from acid producing bacteria, should first be prepared by one of the methods listed in Table A2 to provide a sound concrete surface. A surface applied corrosion inhibitor may be applied before the intended coating system.

A6 Surface Preparation Methods⁴⁵⁻⁴⁷

The surface preparation methods described in this standard are listed in Table A2 with their intended use, profile created, typical problems encountered when using each method, and solutions to those problems. Additional information may be found in ICRI 310.2.

Table A2 Surface Preparation Methods					
Class	Preparation Method	When Used	Profile Created ^(A)	Problems	Solutions
D-VC	Vacuum Cleaning	Removes loose debris only	No Change	N/A	N/A
W-LP	Low Pressure Water Cleaning ^(B)	Cleans Surfacing	No Change	Wets Concrete	Let concrete dry
W-DS	Detergent Scrubbing	Emulsifies oil and grease	No Change	Detergent and emulsified contaminants	Low pressure water rinse Let concrete dry
W-SC	Steam Cleaning	Cleans Surface, removes some oil and grease	No Change	Wets Concrete	Let concrete dry
W-AE	Acid Etching	Removes laitance, imparts a profile and cleans surface	CSP1 to CSP3	Hazardous, neutralization, inhibited by membranes, curing compounds, grease and oil contamination, wets concrete	Use other acids pH testing Let concrete dry Use other methods
W-WJ	High and Ultra High Pressure Waterjetting	Removes laitance and some concrete, imparts a profile and cleans surface	CSP3 to CSP10	Wets concrete Coarse profile	Let concrete dry None ^(C)
M-GRD	Dry Grinding	Removes laitance, imparts a profile and cleans surface	CSP1 to CSP2	Dust and debris	Vacuum clean
M-GRW	Wet Grinding	Removes laitance, imparts a profile and cleans surface	CSP1 to CSP2	Wet sludge, debris Wets concrete	Low pressure water rinse Let concrete dry
M-ABD	Dry abrasive blasting	Removes laitance and some concrete, imparts a profile and cleans surface	CSP2 to CSP7	Dust and debris Airborne dust Noise	Vacuum cleaning Vacuum None
M-ABW	Wet abrasive blasting	Removes laitance and some concrete, imparts a profile and cleans surface	CSP2 to CSP7	Wets concrete Creates sludge	Let concrete dry Cleaning

M-SB	Shot Blasting	Removes laitance and some concrete, imparts a profile and cleans surface	CSP3 to CSP7 ^(A)	Stray Shot	Clean surface magnetically
M-SC	Scarifying	Removes laitance and some concrete, imparts a profile and cleans surface	CSP4 to CSP7	Dust and debris Bruising, striated pattern on surface	Vacuum cleaning None(C)
	Needle Scaling ^(D)	Removes laitance and some concrete, imparts a profile and cleans surface	CSP2 to CSP4	Dust and debris, striated pattern on surface	Vacuum cleaning None(C)
	Scabbling ^(D)	Removes laitance and some concrete, imparts a profile and cleans surface	CSP7 to CSP10 ^(A)	Dust and debris Bruising, irregular surface pattern	Vacuum cleaning None(C)
	Rotomilling ^(D)	Removes laitance and some concrete, imparts a profile and cleans surface	CSP9 to CSP10 ^(A)	Debris Bruising, grooving of surface and tool marks	Sweeping, Vacuum cleaning None(C)

^(A) The CSP profile produced by the various preparation methods listed here are defined in ICRI 310.2.

NOTE: There may be some differences between this standard and ICRI on the actual profile range achieved by each surface preparation standard. Each method produces a range of CSP profiles depending on the quality and strength of the concrete and the degree to which the method is applied. A nonaggressive use of a preparation method on good quality concrete results in a CSP profile at the low end of the range of listed profiles (a less coarse surface). When selecting a preparation method, a test area should be performed to determine the CSP profile.

^(B) Less than 34 MPa (5,000 psi) water pressure.

^(C) For coating systems that do not perform over a coarse profile, refinishing the concrete or an underlayment may be required.

^(D) Method is rarely used and included herein for informational purposes only.

A7 Surface Profile

A7.1 In addition to removing laitance, weak concrete, and contamination at the concrete surface, surface preparation usually opens the pores and/or creates a profile on the concrete surface. Profile increases the surface area available for bonding between the concrete and the coating, enhances adhesion at the concrete/coating interface, and helps the coating resist peeling and shear forces.

A7.2 The depth of surface profile required depends on the coating system to be used and the manufacturer's recommendation. Factors that may influence the profile selected include:

- (a) tensile and shear strength of the concrete and the coating system;
- (b) adhesion of the coating system to the concrete;
- (c) internal stresses in the coating system created during application and cure (e.g., from shrinkage);
- (d) difference in the coefficient of thermal expansion between the coating and the concrete;
- (e) modulus or stress-relaxation properties of the coating system;
- (f) thermal and chemical exposure environment; and
- (g) coating thickness.

A7.3 ASTM D7682⁴⁸ describes a method of using a replica putty to quantify the surface profile of concrete. The profile also can be subjectively compared with ICRI 310.2R (molded concrete surface profile replicas).

A8 Concrete Surface Tensile Strength and Coating Adhesion Testing⁴⁹

A.8.1 It is important to be able to characterize the strength of the concrete surface, prepared in accordance with one or more of the procedures in this standard, to ensure it is strong enough for adequate adhesion of the coating to be applied. ASTM C1583 is suitable for determining pull-off tensile strength near the surface of the concrete (Meaning that the tensile strength of the concrete at the depth of the scoring is measured, assuming that failure occurs at that location). If failure occurs at the dolly adhesive and concrete surface interface, it is defined as bond failure. For both methods (ASTM D7234 and ASTM C1583), if failure occurs between the dolly and the dolly adhesive the result is not recorded as valid and must be discarded or repeated.

A.8.2 Though designed specifically to measure adhesion of coatings to concrete surfaces, ASTM D7234 is the most used and accepted method for ensuring adequate tensile strength of concrete surfaces for the specified coating. ASTM D7234 includes all details relevant to testing pull-off strength of coatings on concrete including equipment details and limitations, loading rates, and

interpretation of failure modes.

A.8.3 ASTM D7234 specifically details scoring through the coating down to the surface of the concrete, and therefore differs from ASTM C1583, which specifically details scoring into the concrete, well below the surface. The reason for this difference can be attributed to the purpose and scope of each of these methods, the first intending to isolate the test conditions and address the coating/substrate adhesion and the second intending to ensure that the tensile strength of the concrete is the limiting factor in the result.

A.8.4 There are many reasons to test for surface strength (either with or without the coating applied). These include ensuring the surface preparation technique(s) used was successful, and the prepared concrete surface is free from contaminants, laitance is removed, the surface is not “bruised” or micro-fractured, and although not determined or controlled by the surface preparation, that the concrete profile or surface porosity is sufficient for the coating.

A.8.5 Because of the variability in concrete, the surface preparation methods used and the choice and operation of the instruments, there is a large margin of error in the pull-off strength results obtained from these methods. Therefore, it is incumbent on all persons performing the testing and/or specifying the numeric results that equal attention is paid to the mode of failure and it is observed, interpreted, and the consequences understood.

A9 Moisture

This topic (moisture in concrete floors and related coating issues) is covered in extensive detail by Kanare in 2005.⁵⁰ Some highlights on this topic and updates are in this section.

A9.1 Sources of Moisture in Concrete

A9.1.1 Moisture or excess moisture in concrete can come from multiple sources. In the 2004 update, ACI 302.¹⁵¹ recommended using a vapor barrier in accordance with ASTM E1745⁵² for concrete slabs placed on-grade to be finished with moisture sensitive products. For new concrete, excess water can come from water of convenience during placement or rain after the initial curing process for concrete exposed to the environment. For existing concrete structures, where the water from initial placement and construction is no longer a factor, and a positive side vapor barrier is either absent or not performing adequately (e.g., perforated) the water table and capillary rise can feed the concrete and the surface with a continued source of moisture.

A9.1.2 Moisture testing of concrete floors is performed by various methods, all of which measure different phenomena. Historically, moisture was tested by indication of moisture in concrete by plastic sheet method (ASTM D4263²³), or the measurement of moisture vapor emissions rate of concrete subfloor using anhydrous calcium chloride method (ASTM F1869), both of which indicate moisture emissions during the specific time that the test is conducted, qualifying or quantifying moisture at or near the surface at the time of testing respectively. Other methods using portable handheld instruments, including electrical resistance or electrical impedance (ASTM F2659⁵³), are commonly used to perform a preliminary evaluation and compare the moisture condition content; however, the results of this test are not intended to provide quantitative data as a basis for acceptance of a floor for installation of a moisture sensitive flooring system. More recently in the United States (longer in the European Union) relative humidity testing in the concrete (ASTM F2170) has been used to assess the in situ concrete moisture levels. Most manufacturers of moisture sensitive coating systems set maximum moisture emission rates ranging from 3 to 5 lb./1000 ft²/24 hr when tested in accordance with ASTM F1869, and/or in situ relative humidity content from 75% to 80% when tested in accordance with ASTM F2170; however, the material manufacturer’s guidance should be followed regarding the moisture tolerance of their material. Note that moisture levels at the time of testing and installation are not an indicator of moisture levels in the future, which are dictated by the presence or lack of an intact moisture barrier under the concrete, subterranean groundwater levels, change in environmental conditions, and concrete properties, all of which are beyond the control of the any surface preparation method or the intended coating system.

A9.2 Issues from Excess Moisture

Issues from excess moisture for floor coating systems (which is the most researched) range from blistering (most common), to liquid exuding through pinholes in the coating, to complete disbondment. While there are many theories and some research into the reasons for coating blistering or disbonding, there is little research into the factors or predictors of these various coating issues from the concrete or concrete surface (other than alkali-silica reaction [ASR] which is a special case). While some of the coating failures can be attributed to lack of surface preparation or sufficient surface profile; and potential formulation or installa-

tion issues including multicomponent materials being mixed off-ratio, insufficient mixing, unacceptable environmental conditions (temperature, humidity, and dew point) during application and cure; trapped air, or missing required intercoat application windows, there are still many instances where disbondment or blistering occurs when all these factors are precluded.

A9.3 Theories of Moisture Issues:

Published theories of the various mechanisms for blistering in flooring can be divided into two groups:

A9.3.1 Osmosis—Osmotic blistering usually does not appear until months after coating application, and often presents as pressurized liquid filled blisters. This theory assumes concrete is the semi permeable membrane, soluble salts are extracted from the concrete and/or the coating, and the bonded, impermeable coating acts as the containment.⁵⁴⁻⁵⁸ In addition, while admitting to the osmotic phenomena, some companies tout formulas that are resistant to the process.⁵⁹⁻⁶¹

Conditions Necessary for Osmotic Blistering⁶²

- (a) Water Source
- (b) Ability of water to move in the concrete
- (c) Pressure tight coating
- (d) Semi-permeable membrane
- (e) Soluble salts/dissolved ions between semi-permeable membrane and coating
- (f) Defect sites or voids at the concrete/coating interface

A9.3.2 Nonosmosis—There are researchers who claim that blistering is not an osmotic process, and have various theories and causes ranging from vapor pressure, capillary pressure, diffusion transport, cure inhibition, excess alkali, and ASR, to name a few.⁶³⁻⁶⁵

A9.4 Moisture Mitigation Practices

While beyond the scope of this standard, in addition to the details for surface preparation given in this standard and careful control of the coating application, guidelines for negative side control or relief of moisture issues in concrete fall into two categories, treatments applied to the concrete surface and alternate coating formulations. In the first category, these treatments include polymer modified cementitious underlayments, fibrous or permeable underlayments, and moisture suppression coatings.⁶⁶⁻⁶⁷ In the second category, alternative coating systems include specific formulation restrictions, or permeable coating or flooring systems.

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