

SSPC/PCSI

JOINT TECHNOLOGY UPDATE NO. 10

Procedures for Applying Thick Film Coatings and Surfacing Over Concrete Floors



This joint technology update was developed by the SSPC Unit Committee C.7.1 on Concrete Coatings and Surfacing with the assistance of members of the Polymer Coatings and Surfacing Institute

(PCSI) who joined the SSPC committee and participated in the consensus review process.

1. Scope and Description

This Technology Update discusses techniques and procedures to enhance performance of concrete floors by use of resinous systems greater than 20 mils. Flooring systems covered by this TU include: Thick film systems ($>500\mu\text{m}$), self-leveling systems, slurry systems, broadcast systems, mortar systems, fabric-reinforced systems, spray applied systems, and non-waterproofing and underlayment membranes. Thin-film coatings ($<500\mu\text{m}$) and sealers, terrazzo flooring, membrane systems designed for waterproofing, and primary and secondary containment systems are beyond the scope of this technology update. The technology update outlines techniques and procedures, with additional specific details provided in the appendices. Appendix A provides background information and requirements for the concrete substrate to which the surfacing is applied. Appendix B provides detailed information on the techniques and procedures described below.

The Technology Update is intended for use by owners, applicators, and others in the coatings and surfacings industry. It addresses the unique application properties of coating and surfacing concrete floors, and should not be used for other purposes.

2. Referenced Standards and Publications

2.1 SSPC STANDARDS AND JOINT STANDARDS¹

- SSPC-AB 1** Mineral and Slag Abrasives
- SSPC-AB 2** Cleanliness of Recycled Ferrous Metallic Abrasives
- SSPC-TU 2/NACE 6G197** Design, Installation, and Maintenance of Coating Systems for Concrete Used in Secondary Containment

SSPC-SP 12/NACE No. 5 Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating

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

2.2 INTERNATIONAL CONCRETE REPAIR INSTITUTE STANDARDS (ICRI)²

- Guideline No. 03730** Guide for Surface Preparation of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion
- Guideline No. 03731** Guide for Selecting Application Methods for the Repair of Concrete Surfaces
- Guideline No. 03732** Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays
- Guideline No. 03733** Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces

2.3 AMERICAN CONCRETE INSTITUTE STANDARDS (ACI)³

- ACI 201.1R-92** Guide for Making a Condition Survey of Concrete in Service
- ACI 201.2R-01** Guide to Durable Concrete
- ACI 364.1R-94** Guide for Evaluation of Concrete Structures Prior to Rehabilitation
- ACI 546R-96** Concrete Repair Guide

2.4 AMERICAN SOCIETY FOR TESTING AND MATERIALS STANDARDS (ASTM)⁴

- ASTM D 4260** Standard Practice for Acid Etching Concrete
- ASTM D 4262** Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces

¹ NACE standards are available from NACE International, 1440 South Creek, Houston, TX 77084-4906, or from <http://www.nace.org>.

² International Concrete Repair Institute, (ICRI), 1323 Shepard Drive, Suite D, Sterling, VA 21064. (<http://www.icri.org>)

³ American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 488333 (<http://www.aci-int.org>)



ASTM D 4541	Standard Test Method for Pull Off Strength of Coatings Using Portable Adhesion Testers
ASTM D 6237	Standard Guide for Painting Inspectors (Concrete and Masonry Substrates)
ASTM E 1907	Standard Practices for Determining Moisture-Related Acceptability of Concrete Floors to Receive Moisture-Sensitive Finishes
ASTM F 1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Sub-floor Using Anhydrous Calcium Chloride

3. Definitions⁵

Bleeding: The autogenous flow of mixing water within, or its emergence from, newly placed concrete or mortar as caused by the settlement of the solid materials within the mass. Also called water gain. (FCC)

Broadcast Flooring: Usually neat (unfilled) resins or slurries (aggregate filled) applied over a floor into which aggregate is blown by specialized equipment or thrown by hand, in a raining fashion, into the wet, uncured matrix and allowed to cure.

Broadcast to Saturation: Aggregate broadcast into a wet matrix until the surface does not show wetness of the resinous layers below.

Carbonation: Reaction between carbon dioxide and a hydroxide or oxide to form a carbonate, especially in cement paste, mortar, or concrete. The reaction with calcium compounds to produce calcium carbonate. (FCC)

Capillary space: Microscopic channels on concrete small enough to draw liquid water through to be adsorbed on the inner surface. (FCC)

Hydration (of Cement): The reaction of water with the calcium silicate, aluminate, or aluminum/ferrite components of fine Portland cement grains necessary for the setting and curing of concrete. Hydration results in the formation of calcium hydroxide and colloidal gels that occupy a larger volume than the original cement.

Keyed (Key in): The process of removing the concrete substrate in order to create a durable termination border for a fluid-applied flooring system.

Lap Length: The length of overlapping of steel reinforcing bars.

Planarity: The general evenness of a substrate in an intended dimension. Planarity should not be confused with levelness. A sloped area, for example, should be "in plane," without low or high spots, but is not level.

Pozzolan: Asiliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but will, in a finely divided form, and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. (FCC)

Recoat Time: The amount of time required for a coating, slurry or mortar to dry or cure before a subsequent coat can be applied successfully.

Slump: A measure of the consistency of freshly mixed concrete, mortar, or stucco equal to the subsidence measured for the nearest 1/4 inch (6 mm) of the molded specimen immediately after removing the slump cone. (FCC)

Slurry Floor: Generally 100% solids or zero VOC chemically cured resins, incorporating use of inert fillers or powders, producing a flowable, but not necessarily self-leveling mixture. Slurry floor materials are usually troweled to the thickness of the largest aggregate in the material.

Resin: General term applied to a wide variety of polymeric products, which may be natural or synthetic. They may vary widely in color. In a broad sense, this term is used to designate any polymer that is a basic binder material for coatings and plastics.

Self-Leveling Flooring: Resinous or polymer-cementitious based materials that tend to flow out when applied over a floor, seeking its own level. Self-leveling systems generally require built-up termination strips as opposed to key-in terminations for stopping points.

Skim Coat: A thin layer of resin- or cement-based mortar used to smooth surface irregularities. Usually edges are feather-edged without the use of keyed terminations.

Sloping Correction: 1) An adjustment applied to a distance measured on a slope to reduce it to a horizontal distance between the vertical lines through its end points. 2) The process of installing a given pitch to a surface.

Soluble Alkali Ions: Substances that form charged hydroxide bases that dissolve in water.

4 ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.(<http://www.astm.org>).

5 Definitions followed by (FCC) were taken from Fundamentals of Coating Concrete. The remaining definitions were developed by the SSPC Committee on Thick Film Coatings and Surfacing for Concrete, and are proposed as additions to the next revision of the SSPC Protective Coatings Glossary.

Tie-In: In an installation sequence, the joining of additional material to material already placed.

4. Pre-Application Procedures

4.1 Condition Surveys: Accurate and thorough condition surveys should be performed by experienced and qualified firms or personnel prior to specification preparation. Surveys should be carried out according to referenced standards, including but not limited to ACI 201.1R-92 and ICRI Guideline 03732. Appendix A provides background information about characteristics of concrete designed for resinous floor coating application.

4.2 General Concrete Substrate Requirements: Proper design and placement of the underlying concrete are essential to the proper performance of any resinous surfacing system. Appendix A addresses critical issues that should be considered in the composite system of concrete and its surfacing, but is not all-inclusive. Detailed concrete and concrete substrate requirements are discussed at length by ACI 364.1R-94, ACI 201.2R-01, ACI 546R-96; ICRI Guidelines 03730, 03731 and 03732; and The Fundamentals of Cleaning and Coating Concrete, as well as a host of other standards and publications.

5. General Surface Preparation

5.1. Treatment for Alkali Silica Reaction: Sections of surfaces with unacceptable levels of Alkali Silica Reaction (ASR) should be treated either by application of a mitigating surface treatment approved by the surfacing manufacturer or by removal and replacement according to specifications or using methods as described in ICRI 03730. See Appendices A.2.2.1 and B.2.1 for discussion of ASR and remediation procedures.

5.2 Moisture Vapor Transmission Rate: If the moisture vapor transmission rate exceeds 3 lbs per 1,000 ft² in 24 hours as tested in accordance with ASTM F 1869 or E 1907 or exceeds the minimum moisture levels recommended by the surfacings manufacturer, coatings or surfacings should not be applied until moisture levels meet required limits. If the project schedule must be expedited, moisture levels may be adequately reduced by various commercial surface treatments. (See Appendices A.2.2.2 and B.2.2 for discussion of MVT and its mitigation.)

5.3 Following rehabilitative treatments, the surface should be retested in accordance with ASTM F 1869 or ASTM E 1907.

5.4 The surface should be checked for the presence of chlorides, sulfates, and other soluble salts in a manner acceptable to the owner or surfacing manufacturer. See Appendix B.2.3 for more details. Soluble salt samples used for testing should be extracted and analyzed according to procedures established in the procurement documents or per the coating manufacturer's recommendations. If soluble salt removal

is required but no method for extraction and analysis of test results is specified or stated by the owner, agreement between contracting parties on acceptable methods of testing for soluble salt contamination should be reached prior to starting the job, in a manner acceptable to the surfacing manufacturer.

5.5 All surface imperfections should be repaired before surfacing. Repair materials and methods should comply with specifications and/or manufacturer's instructions. Generally, surface repairs are made with mortars of the same or similar resin bases as the floor surfacing to be placed. For example, epoxy mortars should be used for substrate repair over which an epoxy surfacing is to be applied; urethane mortars where urethane flooring will be applied; vinyl ester mortar where vinyl ester flooring will be applied, etc. As an alternative, polymer modified concrete can be used for repairs based upon manufacturer's recommendations. Appendices B.3 and B.5 provide information on repair procedures, as does ICRI Guideline 03733.

5.6 The concrete surfaces to which repair material will be applied should be sound and solid, free of dust, dirt, greases, and oils. Appendix B.4 provides information on removal of oil and grease.

5.7 Surface Profile: Surfacing and coatings generally form a bond through mechanical attachment during the curing process. A profiled substrate surface will gain maximum adhesion. ICRI Guideline 03732 provides comprehensive, informative guideline tools that are useful in determining required profiling methods. Plastic replicas of typical surfaces produced by these methods are useful in correlating specified profile to that which is produced or required in the field. Optimum profile is required to produce proper adhesion and performance of coatings and surfacings; too little or too much substrate profile may be detrimental to performance of a specific overlay system. See Appendices B.8 and B.9 as well as SSPC-SP 13/NACE No. 6 for additional details on surface preparation of concrete.

5.8 Masking and Protection: Surfaces adjoining or adjacent to the area being finished that are not intended to be coated or surfaced should be protected from trowel, power trowel, roller spatter, overspray and other misplacement of materials, as well as from dirt, dust or debris generated by the application operation (see Appendix B.11.1).

6. Application of Thick Film Coatings and Surfacing

6.1 Pre-Application Procedures: The work area should be checked to ensure environmental conditions for application are within specifications, that the work area layout facilitates ease of application, that traffic control procedures are in place, and that adequate lighting is provided (see Appendix B.10.4).

6.2 Mixing: Most resins (unless mixed by an application unit) and aggregate blends should be mixed in accordance with

specifications and the surfacing manufacturer's requirements. See Appendix B 11.2 for more detail.

6.3 Priming: Most manufacturers' floor coating and surfacing systems require use of primers to enhance adhesion of the system to the prepared substrate and to minimize outgassing, the release of air from concrete as concrete temperature rises (see Appendix B.11.3).

6.4 Examination for Contaminants: The surface should be inspected for other contaminants which may have formed during or following cure, such as dirt, dust and other forms of debris, as well as for oils or other substances which may have collected on the surface. Depending upon the facility or operation, the ongoing processes may generate dust, dirt, or oily mists that may collect on a cured surface. People may walk over cured or uncured surfaces, especially after applicators leave the project, tracking contaminants on the surface. Detection and removal of contaminants prior to next application is required for adhesion. Under certain conditions epoxy primers or intermediate coats may develop amine blush, which must be removed prior to application of subsequent coatings or surfacings. Inspection for and removal of all contaminants prior to any subsequent application of coatings or surfacings is necessary for their proper adhesion. See Appendix B. 11.4 for more detail.

6.5 General Application Techniques: Application idiosyncrasies of specific coating and surfacing types are detailed in Appendix B.12. Appendix B.10.5 describes some of the specialized application equipment used for application of surfacing materials.

6.5 Recoat Time: The recommended recoat time for application of the next coating or surfacing layer should be strictly observed. Some systems require immediate application of the next material to be installed directly into wet primer. Others vary by time and temperature, and still others require the primer to be cured. Specifications and manufacturer's data sheets and application instructions should be consulted for specific direction.

6.6 Application of Aggregate (if required): Slip resistance is generally attained by adding specifically sized or graded aggregates such as aluminum oxide, garnet, steel, silica or polypropylene beads to the final finish. Thicker flooring systems may utilize other methods that will be described in the following sections. The degree of slip-resistant texture is best chosen by the user. The specifier and applicator are cautioned against making final texture selection for the user. Both specifier and applicator, however, can work together to provide submitted samples of texture to the owner or user for final approval and selection (see Appendix B.12.2).

7. Post Application Procedures

7.1 Cleanup: After application, the project area should be cleaned to a "broom-clean" condition, or to the condition required by the contract specification. All trash and construction debris should be properly disposed off-site or in designated disposal areas. All masking and protection should be removed (see Appendix B.14.1).

7.2 Touch up: Any coating or surfacing irregularities discovered after masking and protection have been removed should be touched up according to repair procedures approved by the owner's representative (see Appendix B.14.2).

7.3 Tools, equipment, and materials: All equipment, tools and unused materials should be removed from the site (see Appendix B.14.3).

7.4 Protection: If required by specification or agreement, the floor should be protected as specified or with appropriate protection material such as plywood or composite board with taped joints, laid over polyethylene sheets (see Appendix B.14.5).

8. Inspection

8.1 Qualified, full time inspection by the owner's inspector or a third-party inspector should be performed from job-start to job-completion, especially during preparation and application operations, to provide a systematic, efficient quality control procedure by which to assist the owner and contractor in meeting specified and manufacturer's requirements. Inspections and stop points are best established prior to beginning the installation. Positive results gained by qualified, full time inspection cannot be overemphasized, and is deserving of greater detail beyond the scope of this document. For the purposes of this document, inspection should be continuous, ensuring prerequisite requirements of operations are carried out completely, tested and results recorded according to specifications, manufacturer's requirements and as suggested by this technology update.

8.2 Before final cleanup, inspect the project for deviations in specifications. Deficient work should be corrected in accordance with repair procedures as approved by the owner's representative. The following is a list of qualities or properties that are defined and agreed upon prior to installation and should be inspected in the course of application and after completion :

- Uniform color
- Gloss
- Texture and degree of slip resistance
- Straightness and neatness of termination lines
- Planarity of floor

- Depressions or humps in sloping runs which could affect liquid flow
- Smooth transitions at floor and trench drains
- Smooth finishes at cove radii, internal and external corners
- Smooth transitions at in-floor terminations
- Smooth transitions at intersections of adjacent floor surfaces
- Full application and finished edges of sealants
- Spatter of cured and uncured resinous materials on surfaces not being coated

8.3 Final Inspection. After final clean up, and any preliminary deficiency remediation, reinspect according to procedures described in this section.

9. Disclaimer

9.1 This technology update is for information purposes only. It is neither a standard nor a recommended practice. While every precaution is taken to ensure that all information furnished in SSPC technology updates is as accurate, complete, and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, coatings, or methods specified herein, or of the technology update itself.

9.2 This technology update does not attempt to address problems concerning safety associated with its use. The user of this specification, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for ensuring compliance with all governmental regulations.

10. References

- Farney, James A. and Kosmatka, Steven H. Diagnosis and Control of Alkali-Aggregate Reaction in Concrete. Skokie, IL, Portland Cement Association 1997: ISBN 0-89132-146-0.
- The Fundamentals of Cleaning and Coating Concrete. Pittsburgh, PA, 2001: SSPC - The Society for Protective Coatings. SSPC 01-10, ISBN 1-889060-61-5.
- The Inspection of Coatings and Linings. Pittsburgh, PA, 2003: SSPC - The Society for Protective Coatings. SSPC 03-14, ISBN 1-889060-75-5.

Appendix A: Background Information

A.1 General Concrete Substrate Requirements

Detailed concrete and concrete substrate requirements are discussed at length in ACI 364.1R-94, ACI 201.2R-92, ACI 546R-96; ICRI Guidelines 03730, 03731 and 03732; and The Fundamentals of Cleaning and Coating Concrete, as well as a host of other standards and publications. Although the

enormity of the subject matter could easily command several sets of specific documents, the intent of this document and this section is to provide the owner, specifier, manufacturer, contractor, inspector and other interested parties with concise, pertinent information and data as they generally relate to coatings and surfacings applied over concrete floors. It is important for the reader to understand that this document only addresses critical, yet not all-inclusive, issues that should be considered in the composite system of concrete and its surfacing.

Concrete is mainly a mixture of Portland cement, water, and mineral aggregate, usually sand and gravel. Sometimes additives are used such as fly ash and pozzolans. The mixture cures and hardens by hydration. Water in the mix combines chemically with the cement to bind the aggregate into the rigid mass known as concrete. Although properly formulated and cured concrete is strong and rigid, it can be attacked both physically and chemically. Physical attack usually results in cracking and spalling. Concrete is very strong in compression but relatively weak in tension. It can and often does crack. Concrete is also fairly porous and subject to osmotic and capillary forces that absorb and release water. Absorbed water can freeze within the concrete and cause spalling and cracking.

Strength-gain, wear-resistance, and shrinkage properties of every concrete mix design are affected by the water-to-cementitious (w/c) ratio, normally expressed as the weight (pounds) of mixing water per weight (pounds) of cement. Concrete with a lower water-cement ratio gains more strength than concrete with a greater one, but such low ratios may be difficult to place and consolidate properly because of the stiffness of the mix. Chemical admixtures (water reducers) are often used to increase workability of the concrete while keeping the water-cement ratio low. High water-cement ratios increase shrinkage cracking and reduce surface wear resistance and compressive strength.

Approximately 0.19 lb of water for each 1 lb of cement is required for complete cement hydration. Roughly twice that ratio, or 0.38 lb of water per each 1 lb of cement, is required for mixing, because additional water is absorbed on gel pore surfaces and the cement particles must all be wetted. More water may be added to enhance workability when placing concrete, but any amount in excess of 0.38 lb per lb of cement is not required for the hydration process and may eventually leave the concrete via evaporation or as bleed water. Such excess water increases shrinkage and contributes to the formation of cracks and continuous capillaries in the hardened concrete paste. These capillaries become channels for moisture movement and for intrusive and harmful chemical solutions after the cured concrete is placed in service. Wet curing will minimize incidence of these capillary channels.

A.1.1 Designing floors for resinous floor systems: While concrete slabs should be placed in accordance with standard ACI practices, it is equally important that the concrete be designed to accommodate the intended end use. A water-cured, light steel troweled finish is most suitable for subsequent application of resinous systems. Any placement method, however, that

maximizes surface strength is acceptable. Minimal finishing normally produces the strongest surface.

Wet-cured concrete (ACI 308-92, Chapter 2), by use of burlap and waterproof cover, is preferred over use of curing compounds. Although excellent curing compounds are available, proper wet curing facilitates hydration without potential for chemical interference of the curing compound with subsequent resinous system application.

New concrete (Type 1 Portland cement) is designed to develop about 80% of its design strength in 7 days and nearly all of its overall strength in 28 days. Excess residual or free water not used in the hydration process of cement will continue to migrate out of the concrete until it reaches equilibrium with its environment. There is a potential problem in the placement of resinous systems over new concrete even after 28 days if excess water is still present, if the excess water is continuing to move from the concrete to the environment above the slab. It is the movement of moisture vapor within the slab—not the total quantity of moisture within the slab—that creates subsequent problems with non-permeable floor surfacings.

An effective concrete substrate must be low in permeability and high in density. The general mix design shown in Table A.1 is an example of a mixture that will yield a suitable substrate.

Tensile bond strength of a concrete substrate is important in concrete design. Tensile strength of concrete is approximately 10% of its compressive strength. Most resinous surfacings manufacturers prefer minimum tensile bond strength to be 350 psi as measured per ASTM D 4541.

A.2 Surface Preparation Considerations for Concrete Substrates

A.2.1 Chemical Attack: Chemical attack can occur because concrete is alkaline and chemically reactive. It can be attacked by mineral acids; some alkalis; numerous salt solutions; and organic acids such as fermenting liquids, sugars, and animal oils. Corrosive solutions penetrating to the steel reinforcing may be particularly destructive because the large displacement of corrosion products of steel can cause cracking and spalling of concrete.

A.2.2 Alkali Silica Reaction (ASR) and Moisture Vapor Transmission (MVT): ASR and MVT are major causes for failure of coatings and surfacings applied to on-grade or below-grade concrete. Both ASR and MVT are discussed together in this subsection, as continuing research seems to bear out a homogeneous relationship between the two phenomena. Evolving data suggests moisture vapor to be the transmission force that drives greater deleterious effects of ASR toward the concrete surface and the bond line of resinous surfacings, resulting in high potential for adhesion loss.

A.2.2.1 Alkali-Silica reaction (ASR) occurs in concrete when soluble alkali ions such as sodium and potassium react with chemically active forms of silica (usually present in the sand or gravel aggregate). The reaction produces an expansive

gel, which absorbs a significant quantity of water. Expansion of the amorphous silica gel creates internal pressures within the concrete leading to paste fractures and deterioration of the concrete.

ASR is manifested by cracking followed by spalling, strength loss, and disintegration of the concrete matrix, which sometimes causes pop outs, fragments of concrete that break away leaving a shallow, conical depression.

When the amount of alkali is greater than the amount of reactive siliceous aggregates the alkali silica gel may absorb water and swell, causing expansion soon after curing. This is frequently manifested after one or more years.

A.2.2.2 Moisture Vapor Transmission (MVT): Water or liquid moves through concrete through small pores, or capillaries, in the form of vapor, always from an environment of high vapor pressure to low vapor pressure. Vapor pressure combines the effects of temperature and humidity. In general, moisture migrates from warm, humid conditions to cool dry conditions.

If the environment below a concrete slab is continuously wet, capillary action will pull liquid from below the slab into the slab, but moisture most frequently moves in concrete as a vapor driven by the differential in vapor pressure.

Providing drainage under the concrete slab helps to reduce the source of water below it. Use of vapor barriers is required to eliminate moisture sources from below the slab. The vapor barrier should meet the requirements of ASTM E 1745, with a permeability rating of 0.30 or less. Placement of this moisture barrier must be continuous and in compliance with ACI 504. ACI 302 recommends a two-inch layer of granular self-draining compactable fill above the vapor barrier. If this recommended practice is followed, extraordinary measures must be taken to keep this fill dry. If water is allowed to be captured within this layer, it will serve as a water reservoir under the slab. In most cases, it is more advantageous to pour the concrete directly onto the moisture vapor barrier, and use moisture curing techniques to prevent drying shrinkage cracking. As vapor is driven through the concrete, soluble alkali ions are transmitted with it and collect at the surface. When moisture cycles back into the slab, concentrating the ionic solution, crystals can form which can create enough force to disbond a resinous surfacing. If undetected, the combined phenomena of MVT and ASR will generally result in bond failure when concrete is used as a substrate over which resinous surfacings are applied.

Determination of the extent of ASR deterioration and subsequent concrete substrate treatment, whether removal and replacement or in-situ rehabilitation by specific rehabilitative treatments, is best determined by qualified firms or personnel during the specification preparation process.

A.2.3 Carbonation: Although naturally occurring in all atmospherically exposed concrete, the fine surface crazing and softening of concrete upper surfaces particularly manifests itself when the surface is exposed to increased levels of airborne carbon dioxide during the hardening stage. Exhaust from direct-fired heaters commonly used during cold weather

increases the carbon dioxide levels, and is a leading, though not the only, cause of carbonation.

Generally, carbonated concrete surfaces are soft or powdery, with insufficient tensile strength to maintain substrate bonding properties required for surfacing adhesion. Standard adhesion testing methods according to ASTM D 4541 can be used to determine concrete surface strength required by surfacing manufacturers and/or specifications (see Appendix B.1). A concise discussion of carbonation can be found in the chapter entitled "Condition Assessment" in Fundamentals of Cleaning and Coating Concrete).

A.3 Amine Blush

Following the cure of primers and other applied layers over which additional coatings or surfacings will be installed, the surfaces should be inspected for the presence of amine blush and other contaminants that could prevent or inhibit adhesion and contribute to intercoat delamination.

Amine blush manifests itself as an oily, greasy, waxlike residue over the surface of a cured coating or surfacing, caused by rapid solvent evaporation or the reaction of an amine component, generally in the presence of moisture or high humidity and/or in low temperatures. Specifically, an amine co-reactant in a coating or surfacing reacts with carbon dioxide and water to form an amine carbonate, which can, and usually does, adversely affect adhesion of subsequent coating or surfacing applications. Recognition and removal of amine blush is critical for successful installations.

Manufacturers do not uniformly indicate on system data sheets or application instructions product susceptibility to amine blush or precautions to be taken if their specific products are susceptible to amine blush. Product users—owners, specifiers, contractors and inspectors—should contact the manufacturer's Technical Service Department directly for clarification if precautions about amine blush are not published.

Conditions of high humidity or moisture or low or declining temperatures during cure, and especially the combination of high humidity or moisture and low or declining temperatures during cure, present high potential for blush formation.

In colder climates, isolated areas away from heat, espe-

cially near exterior walls may develop amine blush, while other areas may not. Close inspection of the entire area is recommended, paying particular heed to susceptible isolated areas. Air-conditioned areas may also present environments suitable for formation of amine blush.

Advanced stages of amine blush formation are easier to detect than less advanced formations. At this writing, no recognized standard or test method exists for detection of amine blush, limiting inspection to subjective powers of visual observation and touch. In its most advanced stage of formation, amine blush is evidenced by a milky-white opalescence on a surface, feeling very oily or greasy to a point where the surface is slippery. Initial appearance might indicate to the observer that the coating or surfacing did not cure. Less advanced formation stages may not exhibit a milky-white opalescence, but may present only a slight oily or greasy residue, difficult to feel. This stage of formation is the one that creates the most difficult problem, as subjective discovery or recognition of the phenomenon may be overlooked or missed.

Amine blush can be removed by detergent washing. Solvent washing is not recommended as residues may leave chloride salts and other bond-inhibiting contaminants on the surface. Blush is best removed by use of a floor scrubber utilizing detergent and warm water, followed by thoroughly rinsing the scrubbed surface. Allow treated surface to dry completely, and then reinspect the surface. Rewash, rinse and allow drying if blush is detected. Then reinspect. Usually amine blushing is easily removed with a single wash and rinse.

During winter months in colder climates, or at any time or location where conditions may be likely to produce amine blush, it may be appropriate to treat the surface according to Appendix B.11.4, as if amine blushing is present, but undetected.

Appendix B: Detailed Preparation and Application Procedures

B.1 Condition Assessment of Existing Substrate

The substrate receiving the surfacing should be examined carefully prior to specification preparation. Accurate and thorough condition surveys conducted by experienced and quali-

TABLE A.1
EXAMPLE OF GENERAL MIX DESIGN

Cementitious Content (minimum)	517 lbs/cubic yard
Water-Cement Ratio (by weight)	0.40-0.45
Maximum Coarse Aggregate Size	1-1/2 inches
Air content	4-6%
Slump (without high range water reducers)	< 3 inches
Slump (with high range water reducers)	6-9 inches
Compressive Strength (28 days)	5,000 psig
Permeability	low
Cement options	
Water	

fied professional firms or personnel are recommended prior to specification preparation. Surveys should be carried out as described in referenced standards, including but not limited to ACI 201.1R-92 and ICRI Guideline 03732.

Floors should be examined for grease and oil deposits. Inspection by core testing is recommended in areas where oils or greases have extensively contaminated concrete for long periods. Cores that exhibit contamination present to a depth of 1 in (25 mm) or greater usually require removal of the contaminated concrete surface, rather than remediation techniques, to achieve a surface condition suitable for adhesion of coatings or surfacings. Determination of the best strategy for oil and grease removals should be developed during specification development, as described in Section B.4. Removal or remediation techniques may be time consuming. Developing a plan for proper treatment in the specification helps to ensure correct conditioning and timely execution. Investigate the facility operation to determine potential presence of unusual contaminants. Existing sealers, coatings or surfacings must be removed or treated in accordance with specifications and surfacing manufacturer's requirements.

A non-laboratory field inspection of the substrate should include:

- Verification of the dimensions of the substrate.
- Verification that the planarity and slope meet requirements and/or specifications.
- Verification that the concrete surface strength meets the surfacing manufacturer's requirements. Generally, minimum surface strength of 200 psi as measured as described in ASTM D 4541, is required for floor surfacing adhesion. A strategy should be developed for rehabilitation or removal (Section B.3) of areas of inadequate surface strength in accordance with manufacturer requirements.
- Determination of the presence of chlorides, sulfates and other soluble salts in accordance with the procurement documents or the surfacing manufacturer's guidelines. Contaminating salts are frequently present in plants and other facilities where chemicals and solvents are used. Contaminants should be removed in accordance with manufacturer's recommendations or as described in Sections B.2.
- Determination of the presence of existing sealers, coatings or surfacings. The treatment strategy should be in accordance with specifications and manufacturer's requirements.
- Determination of the moisture vapor transmission rate in accordance with ASTM F 1869 or E 1907.
- Determination of the presence of Alkali Aggregate Reaction (see Section B.2.1).

Both static and moving cracks should be identified and treated in accordance with the surfacing system manufacturer's requirements or as described in Section B.5. Spalls, pop-outs, aggregated surfaces and other imperfections should be noted and treatment strategies developed as described in the surfacing

manufacturer's requirements or as described in Section B.3. For at least two weeks prior to application, environmental conditions should be representative of normal operating conditions at the facility in order to allow the concrete substrate to reach equilibrium.

Any irregularities which do not meet the specifications should be brought immediately to the attention of the project governing authority

B.2 Surface Treatments

B.2.1 ASR Mitigation: Alkali Aggregate Reaction (AAR), including ASR (Alkali Silica Reaction) is a major cause of the failure of coatings and surfacing over concrete, but it is not easily detected in the field. It is best determined by recognized testing agencies equipped to perform petrographic analysis. If levels of ASR have been discovered and the condition of the substrate has been determined to be treatable by removal and replacement of specified sections of concrete substrate, those sections should be removed and replaced according to contract specifications or using the methods described below. If ASR mitigation has been determined to be treatable by mitigating surface treatment techniques approved by the surfacing manufacturer, those procedures should be carried out according to the contract specification or the surfacing manufacturer's instructions.

B.2.2 MVT Mitigation: Moisture vapor transmission, as defined in Appendix A, must be controlled in order to prevent subsequent bond problems with an installed impermeable coating or flooring system. The moisture vapor transmission rate should be determined in accordance with ASTM F 1869 or E 1907. If the project schedule must be expedited, moisture levels may be adequately reduced by various commercial surface treatments, which should be used in accordance with specifications or as approved by the owner and the surfacings manufacturer. The surface should be retested in accordance with ASTM F 1869 or ASTM E 1907 following rehabilitative treatments.

If the moisture vapor transmission rate exceeds 3 lbs/1,000 ft²/24 hours (15Kg/100m²/24 hours) as tested in accordance with ASTM F 1869 or ASTM E 1907, or exceeds the minimum moisture levels recommended by the surfacings manufacturer, do not apply coatings or surfacings until moisture levels meet required limits.

B.2.3 Soluble Salt Mitigation

B.2.3.1 Removal: If soluble salts, such as chlorides, sulfates and nitrates, are found or suspected to be present, they should be removed or the concrete treated prior to installation of coatings or surfacings. Such removal is generally accomplished by high pressure water cleaning as described in SSPC-SP 12/NACE No. 5. Normally, High-Pressure Water Cleaning (HP-WC) performed at pressures from 34 to 70 MPa