SSPC: The Society for Protective Coatings

TECHNOLOGY GUIDE 26

CONCRETE FLOOR COATING SYSTEM SELECTION GUIDE

1. Scope

This guide provides specifiers, owners, and installers with descriptions of generic floor coating systems for specific service environments, including the basic benefits and limitations of the most widely used polymer chemistries incorporated into these systems. Flooring system selection is dictated by several factors, including existing substrate conditions, performance requirements, installation restrictions, and aesthetics, as well as budget. Criteria to assist in evaluating the various systems are included. This guide does not provide tank lining or vertical coating recommendations.

2. Background and Use

There are several publications that provide guidance for system selection outlining system design and/or general considerations.[1-8] This document consolidates systems selection criteria. Flooring system selection is dictated by several factors including:

- existing substrate conditions
- performance requirements
- installation restrictions
- regulatory compliance
- aesthetics, as well as
- budget

These criteria are identified here to assist in evaluating the appropriate floor coating system selection. Every application will vary by condition of existing concrete, installation environment and schedule, use conditions, exposures, expected life and budget. System selection for a specific application should involve the recommendation of material manufacturers to ensure proper performance and compliance with expectations. In most cases, more than one system will provide satisfactory service, but aesthetics or performance qualities may vary.

3. Units of Measure

This standard guide is based upon US Customary units and provides approximate conversions to IEEE/ASTM/SI10[(1)] International Standards (SI) units, which are presented for information only.

4. Terms and Definitions

Floor Coating: Liquid-applied or cast-in-place polymer material applied to concrete substrates for improving resistance to chemicals, enhancing resistance to impact and wear, imparting enhanced performance properties, and/or for aesthetic appearance purposes. *Discussion: Resinous flooring, broadcast flooring, seamless flooring, and slurry flooring are all types of floor coatings. Section 6 contains descriptions of the various floor coating types listed below:*

Broadcast Flooring: (Section 6.4)
Self-Leveling Flooring Systems (Section 6.3)
Slurry Flooring: (Section 6.4)
Thin-mil Coatings: (Section 6.2)

Polymer Concrete: Concrete in which a polymer is added or used instead of portland cement to bond the aggregate together. *Discussion: Polymer concrete may also be a combination of Portland cement and polymer resins.*

Sealers and underlayments (Section 6.1): Sealers and underlayments are components or options for concrete treatment but generally not considered "coating" systems.

w/cm (Water to Cementitious Material): The ratio of water to cementitious material used to form concrete. Generally calculated to optimize the amount of water used to mix and place concrete.

5. Factors Affecting Systems Selection

5.1 Substrate: The concrete substrate to which the flooring system is to be applied is critical to the long-term performance of the flooring system. Seamless systems require a substrate that has little or controlled movement in order to maintain the integrity of the system. Concrete joints are installed to minimize cracking and to control the location of shrinkage cracks. Limits to the water to cementitious material (w/cm) ratio,[16] paste-to-aggregate ratio,[17] and other factors should be considered during installation.

Inspection and testing of the concrete floors should be performed to determine the surface preparation requirements

[(1)] ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, phone int+1-610-832-9500. For referenced ASTM standards, visit the ASTM website <http://www.astm.org>

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for a floor coating system. This is especially important when resurfacing or repurposing an existing concrete floor versus new construction.[9] The condition of the prepared surface must meet the requirements of the flooring system selected and specified.[10-11] The methods used to achieve these conditions vary and are discussed in detail in other publications.[12] Existing coatings or curing compounds are usually removed prior to the application of a new coating system. Flooring system manufacturers will dictate the minimum surface preparation profile and cleanliness required for the system to be installed.

Moisture testing should be performed on concrete according to manufacturer's requirements. Concrete is a porous substrate. The movement of moisture within and through concrete can be problematic for low permeance coating systems. New construction designed to receive a low-permeance coating utilizes a vapor retarder[13] below the slab on grade.[14-15]

Existing slabs to be coated may not have a vapor retarder below the slab and should be tested for the presence and movement of moisture vapor using standardized tests when installing a moisture sensitive system.[18-21]

5.2 Performance Considerations: The first step in selecting the flooring system to be used in a specific application is to define the performance requirements. These typically include, but are not limited to, protection of the concrete substrate for chemical and/or mechanical damage, enhancing the flooring performance, protecting the flooring system from use conditions, and providing added aesthetic value.

5.2.1 Aesthetics and Ease of Cleaning: Concrete may be coated simply to improve aesthetics, light reflectance, and/or ease of cleaning. Concrete coatings will prevent the absorption of water, chemicals, and other liquids. Untreated concrete also tends to dust with use. Coatings and sealers provide a finish that minimizes dusting while providing a surface that is easier to clean.

5.2.2 Chemical Exposure: Seamless flooring systems are frequently required to protect concrete from chemical exposure. Concrete is an alkali substrate and is easily eroded in acidic conditions. Most foods and juices are acidic in nature. When evaluating chemical exposure, it is important to identify the chemicals, the duration of exposure, the concentration, and the temperature of exposure. ACI 515.2 provides a detailed list of chemicals and the resistance properties of various resin systems.[22]

Concrete can also deteriorate from contaminants other than acid. Due to the porous nature of concrete, oils, grease, and other substances can penetrate the slab causing staining, degradation, or both. Coatings are used to protect the concrete from these contaminants.

Flooring systems are designed with several base chemistries to provide protection. A more detailed discussion of the benefits and limitations of each of these chemistries can be found in Section 6 of this document.

5.2.3 Abrasion: Concrete is a strong building material when measured for compressive strength. The concrete paste, however, has a relatively low tensile strength (about 10% of compressive strength). This means that concrete can crack, chip or spall relatively easily if not treated or protected. When evaluating the area of service, consider the traffic and potential abrasive exposure.

5.2.4 Impact: Like the risk presented by abrasion, impact incidences can cause chips and cracks in concrete. Heavy impact areas will dictate the flooring systems selection. Thin coatings, especially highly crosslinked rigid chemistries, will chip and transfer the impact force to the concrete. The concrete under the coating has the potential to powder, causing delamination even if the coating does not chip. High build systems are generally recommended for high impact areas. These systems are specifically designed with aggregates that minimize the risk of system damage while protecting the concrete.

5.2.5 Thermal Buffering: Floor coating systems tend to exhibit different physical properties than the concrete substrate. In the case of rapid temperature change, differential thermal expansion and contraction properties can cause bond line stress or stress within the coating. To address this issue, systems are designed with high aggregate content and application thickness to minimize the risk of disbondment, blistering and cracking. Cementitious resinous systems are frequently used in these situations, although other resinous mortar systems can also be successfully used.

5.2.6 Slip Resistance: Slip resistance is a critical performance consideration, especially for areas expected to be wet or have contaminants on the floor between cleaning. Most resinous floor coating systems are not porous. This changes the coefficient of friction (COF) of the floor surface. Flooring systems incorporate a surface texture to reduce make the surface less slippery. SSPC published a guide for evaluation of slip resistance[23] and is developing a standard to quantify this texture during the specification, installation and maintenance stages of the flooring system.[24]

5.2.7 Specialty: Specialty system design and supplementary treatments in combination with standard flooring systems can address specific performance requirements.

5.2.7.1 Electrostatic: Flooring systems can minimize the risk of explosion, fire or electronic equipment damage caused by electrostatic discharge. These systems are formulated to ground or dissipate the static electric potential. Conductive flooring (25,000 to 1,000,000 ohms resistance) is most commonly used in munition facilities and other high explosion risk or highly flammable storage areas to dissipate electrical charges to avoid static sparks. Electronics manufacturing facilities most often specify flooring in the dissipative range 10^6 - 10^9 ohms.[25-27]

5.2.7.2 Fire and Spark Resistance: A number of building codes require flooring systems to meet Class 1 flame and smoke development ratings per ASTM E648.[7] In most cases, resinous flooring systems will be self-extinguishing when applied to concrete. During installation, however, some products contain volatile solvents and specific manufacturers' safety and installation instructions must be followed.

5.7.2.3 Waterproofing: Elevated slabs over occupied space that are either constantly wet or have the potential for excess moisture, such as showers, mechanical equipment rooms, and parking garages require a waterproofing membrane to protect the reinforced concrete and the space below. Fluid-applied, flexible membranes are applied under the flooring system to provide crack bridging capability and serve as a waterproofing membrane.[28]

5.2.7.4 Antimicrobial Certification: Resinous flooring systems can be formulated with antimicrobial agents incorporated within the resin matrix to offer complete surface protection against harmful bacteria, mold and yeasts. The flooring system must be tested and certified to claim anti-microbial activity.[29] An effective cleaning and maintenance routine must be in place to preserve the aesthetic and performance characteristics of the resin finish.

5.2.7.5 Levelness: High build resinous systems are used to provide slope (ramps or drainage) and to resurface uneven concrete. Coatings and self-leveling/broadcast systems will follow the contour of the existing surface. Hand-troweled slabs-on-ground and suspended slab surfaces are specified for flatness and levelness based upon ASTM E 1155 "Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers" and the ACI 302.1R "Guide for Concrete Floor and Slab Construction" recommendations.[14, 30]

5.2.7.6 Permeability: Concrete breathes based upon the environmental conditions that drive moisture vapor movement within the slab. Seamless flooring systems frequently have very low permeance and may not tolerate high vapor emissions. Depending upon the flooring system design, some systems, such as epoxy and urethane cement systems, have a high degree of permeability that will accommodate vapor transmissions through the concrete.

5.2.7.7 Moisture Mitigation:[31] Many resinous flooring systems have very low permeability relative to the concrete substrate. Moisture mitigation systems have been developed to address high concrete moisture vapor emissions. These treatments include polymer modified cementitious underlayments, fibrous or permeable underlayments, and moisture suppression coatings.[32-33]

5.2.8 Summary of Performance Considerations: The physical properties of the floor coating are influenced by the resin chemistry, the fillers and additives within the formulation and any aggregates that are added to complete the system during installation. The values presented in Table 1 provide an industry accepted approximation for the individual resins and systems. Manufacturers will select the most appropriate test methods for the respective resins and flooring systems to help evaluate the anticipated performance of the system for the intended application.

Comparing different flooring systems physical properties should not be the sole selection criteria. Variation in these values may not necessarily reflect better system performance. Specifiers should identify those properties relevant to the specific application. Individual test values may not necessarily reflect the system performance for a desired application. Some tests are specific to the resin only (mostly ASTM "D") while others will apply to systems containing aggregates.

5.3 Regulatory Considerations: Flooring system selection requires compliance with all local and federal mandates and guidelines. Volatile organic content (VOC) of the flooring materials is regulated by the Environmental Protection Agency (EPA) and several more restrictive geographic locations throughout the country, most notably the Southern California Air Quality Management District (SCAQMD). The Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) provide guidance for flooring installed in inspected facilities. Simply stated, the floors must be easily cleanable and provide a safe walking surface.[34]

The EPA and Registration, Evaluation, Authorization and Restriction of Chemicals (REACH – European Union) maintain a list of "Chemicals of Concern" for potential toxic, carcinogenic and/or mutagenic correlation.[7] The Safety Data Sheets (SDS) for these materials will list any potentially hazardous chemicals in the formulation. Polymer formulations are composed of active chemicals which may present health hazards in the uncured state. Once polymerized these marcomolecules are non-reactive and not classified as hazardous.

5.4 Aesthetic Designs: Only after satisfying all performance and functional parameters of a flooring system can the selection of design and appearance be addressed. Most flooring resins are available in multiple colors and aggregates can be used to enhance the appearance. Ultraviolet light stability will vary among different resins. In general, the higher degree of aromaticity within the polymer chemistry the lower the UV stability.

5.5 Installation Restrictions: The time schedule and the environmental conditions during installation may also play a role in determining system selection. Polyurea, polyaspartic and methylmethacrylate systems offer rapid cure and cure at low temperatures. These chemistries can be selected to

TABLE 1
TYPICAL TEST METHODS FOR MATERIALS UTILIZED FOR CONCRETE FLOOR COATING

Physical Properties	Test Method	Explanation	Applicability	Typical Values
Abrasion Resistance	ASTM D4060 CS17 Wheel (1000 GM Load 1000 Cycles)	Determines the resistance of coatings to abrasion.	Lower values imply the coating will wear longer. Results from this test method may not accurately reflect the wear of flexible coatings.	20-100 mg loss
Adhesion	ACI 503R (Withdrawn)	Measures the pull strength of an epoxy coating to concrete.	Successful adhesion test results in failure within the concrete (100% concrete failure). Adhesion of the coating to concrete reflect material properties, concrete strength and surface preparation.	Concrete Failure
Adhesion (Pull-Off)	ASTM D7234	Measures the pull strength of a coating to concrete.	Successful adhesion test results in failure within the concrete (100% concrete failure)for coating types other than gypsum underlayments. Adhesion of the coating to concrete reflect material properties, concrete strength and surface preparation.	Concrete Failure
Adhesion (Pull-Off)	ASTM C1583	Measures the near-surface tensile strength of the concrete substrate after surface preparation or the bond strength of a repair or overlay material.	Results indicate the controlling failure mode and corresponding strength of the surface of the substrate or the bond of the overlay material.	Concrete Failure
Chemical Resistance	ASTM D1308	Determines the effect of household chemicals on clear and pigmented organic finishes, resulting in any objectionable alteration in the surface, such as discoloration, change in gloss, blistering, softening, swelling, loss of adhesion, or special phenomena.	Three test methods, each of which is particularly applicable to individual reagents under study, Spot Test, Covered, Spot Test, Open, and Immersion Test.	Observations of visual or weight changes.
Chemical Resistance	ASTM C267	Provides for the determination of changes in the following properties of the test specimens and test medium after exposure of the specimens to the medium: Weight of specimen, Appearance of specimen, Appearance of test medium, and Compressive Strength of specimen.	Test Method A outlines the testing procedure generally used for systems containing aggregate less than 0.0625 in. (1.6 mm) in size. Test Method B covers the testing procedure generally used for systems containing aggregate from 0.0625 to 0.4 in. (1.6 to 10 mm) in size. Test Method C is used for systems containing aggregate larger than 0.4 in.	Observations of visual, weight or compressive strength changes.
Chemical Resistance	ASTM D543	Evaluation of plastic materials for resistance to chemical reagents.	Provisions are made for various exposure times, stress conditions, and exposure to reagents at elevated temperatures. The type of conditioning (immersion or wet patch) depends upon the end-use of the material.	Observations of weight and dimension changes.
Coefficient of Friction	ASTM F1679 (Withdrawn 2006)	Measures the slipperiness of a surface using a variable incidence tribometer (VIT).	Higher values reflect increases traction. In practice surface cleanliness most frequently dictates slipperiness.	≥0.5 Wet and Dry
Coefficient of Friction	ASTM D2047	Laboratory test method covers the use of the James Machine for the measurement of the static coefficient of friction of polish-coated flooring surfaces	Originally designed for tile. Cannot be used for wet surfaces. Higher values reflect increases traction. In practice surface cleanliness most frequently dictates slipperiness.	≥0.5 Dry