paints, coatings + sealants

CHOOSING PRODUCTS AND PROCEDURES FOR BEST PERFORMANCE

COURTESY VALSPAR

Waubonsee Community College in Plano, Ill., chose a metal panel system coated with a protective white polyvinylidene fluoride (PVDF) resin-based finish. The architect for the 33,000-sf project was Holabird & Root.

BY C.C. SULLIVAN, CONTRIBUTING EDITOR

Architectural coatings are slathered all over commercial buildings, but they are far from one-size-fits-all. "Most are designated for specific uses, such as roof coatings, wall paints, or deck finishes," says Neal Rogers, a group R&D leader with CCP Composites (ccponline.com), and chair of the ASTM International Committee D01 on Paint and Related Coatings. They're similar in purpose, however, as the ASTM committee reminds us: "Each architectural coating must provide certain decorative, durable, and protective functions." Specific test protocols help ensure that the performance features meet the intended uses. Preparation, application, and maintenance techniques are also important to success.

Increasingly, Building Teams are doing a thorough life cycle analysis when matching building materials with appropriate paints, coatings, and sealants. For instance, zinc primers—whether used with polyurethanes, fluorourethanes, vinyls, or other topcoats—will dramatically extend the life and durability of building elements. Their use is increasing for buildings following their popularity in road and bridge construction, where more than 90% of owners now mandate the use of metallic zinc.

LEARNING OBJECTIVES

After reading this article, you should be able to:

- **+** LIST the environmental impact factors of architectural paints and coatings.
- **+** DISCUSS the implications of paint color choices on environmental sustainability and occupant health.
- **+** DESCRIBE test protocols and specifications that can guide the selection of paints and coatings for specific building types.
- **+** EXPLAIN effective methods of surface preparation for multiple substrate categories.

LIFE CYCLE ASSESSMENTS ENABLE SMARTER CHOICES IN COATINGS

Life cycle assessments (LCAs) help specifiers and owners make good choices by allowing apples-to-apples comparisons. LCAs also enable effective sustainability comparisons, yielding an easy, effective methodology for specifying products, materials, and systems. The typical LCA for architectural paints and coatings assesses costs per year of service. ASTM E-917, "Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Products," is one of the most-used methods for making the calculations.

Alternatives are available, as many in the industry seek to improve and perfect LCA calculations based on different variables or specific measurement goals—for instance, sustainability goals. A good example is the recent LCA devised by the National Center for Manufacturing Sciences (NCMS). Nicknamed the "Coatings Counselor," the organization's tool assesses life cycles for volatile organic compounds in paints and coatings (http://bit.ly/193vXNA). It includes environmental impacts from each stage of the product life of a paint or sealant:

- Petrochemicals and minerals in the ground
- Raw material extraction and refining
- Coating formulation and manufacturing
- Applying the coating to an item
- Use on the coated item during its service life
- Disposal of the item at the end of its service life.

Calculated outputs for this LCA include regulated emissions (VOCs as well as hazardous air pollutants, or HAPs) in addition to greenhouse gases, solid waste, and consumed energy. Each of these outputs is rated for its impact, calculated based on the relative reactivity and toxicity, as well as its availability to volatizing and atmospheric persistence.

Stakeholders who want to minimize their VOC impact by specifying the most suitable coating may not yet have access to a thorough enough LCA. The recently released Paints and Architectural Coatings Environmental Study (PACES), funded by the coatings industry and co-sponsored by the EPA and other government agencies, stated as much. “Questions as to whether there is a need for reformulation of paint in the context of durability, cost, and environmental benefits remain unanswered,” said the group. “The focus of future research should be the acquisition of data needed to complete a comprehensive life cycle assessment.”

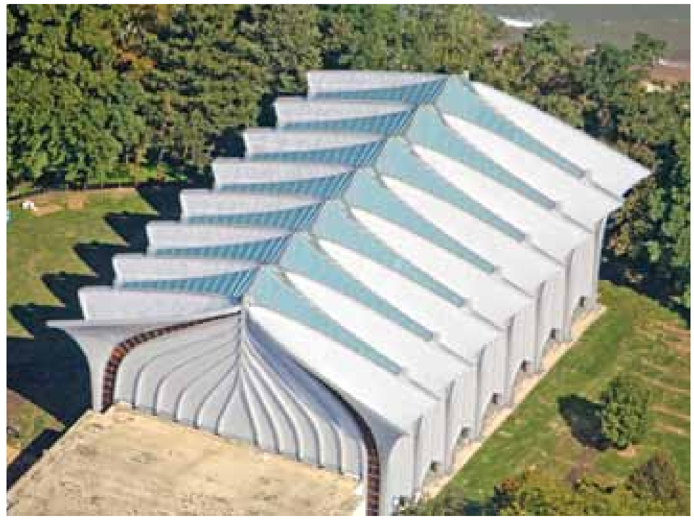
IMPACT OF COLOR ON LIFE CYCLE

Color is generally considered an aesthetic choice, dictated by taste, context, and occupant preference. However, there is increasing evidence that color choices have considerable impact on the utility and sustainability of occupied built space. The term *color factors*—used by a growing number of Building Teams—reflects the interplay of a building’s intended use, context, efficiency, image, and market with the selection of building materials and applied colors.

For exteriors, there are important consequences to color choices. For instance, Building Teams seeking lasting, vivid colors in areas with powerful ultraviolet exposure or corrosive salt air have traditionally gravitated to heavy-metal pigments like lead and chrome. When those choices were eliminated due to health concerns, durability and color fading became inextricably linked color factors. Newer fluorourethane finishes have filled the gap, providing long-term color stability using job-site spray application. (The preceding generation of fluorourethanes had to be shop-applied and baked on to achieve the same super-durable finish.) For metal façades and roofs, these spray or heat-treated formulations are now a best practice for ensuring long-term visual and physical performance.

FIVE IMPORTANT QUESTIONS TO ASK
before you specify coatings

1. Will the finish be factory-applied or site-applied?
2. What color factors are important for the application?
3. What is the expected life cycle performance, and how will you assess it?
4. What environmental and health impacts must be controlled?
5. Does the construction plan and QC approach ensure proper surface preparation and application?



COURTESY ARKEMA

The roof of the North Shore Congregation Israel synagogue in Glencoe, Ill., is treated with a polyvinylidene fluoride (PVDF) coating that reduces solar heat gain and UV emissivity to create a cool roof.

At the same time, Building Teams have paid increasing attention to roof colors, especially when the ratio of roofing area to interior space is high. “Cool roofing,” initially restricted to white and light grey materials and coatings, now dominates the market, based on the concept that higher reflectivity reduces cooling loads. Manufacturers have learned to increase reflectivity using glass or ceramic particles, and are taking advantage of reflectivity research involving darker, more traditional roof colors.

COLOR, IEQ, AND PSYCHOLOGY

Interior color choices can also have significant consequences for triple-bottom-line sustainability, particularly as related to occupant health and productivity. Since the major health concern has been off-gassing of VOCs, interior finish manufacturers have supported research into low- and no-VOC alternatives to conventional paint and other established products, introducing them at increasingly competitive price points.

The importance of these industry efforts was reinforced by an EPA study revealing that architectural coatings can account for 9% of all emissions from consumer and commercial products (http://1.usa.gov/IKU2hO). Some applications, such as those for certain healthcare buildings, require additives like fungicides and biocides, making reductions in VOCs among other elements of paint composition more critical.

How does color choice come into play here? In fact, shade and intensity are more significant factors than particular colors. Most pigments used in colorants add VOCs to the base paint. Because deeper hues require higher amounts of colorant, they will have higher levels of VOC emittance. For projects and clients demanding color intensity, the U.S. Green Building Council recommends that paint composition begin with a low-VOC or zero-VOC base (http://bit.ly/IunNUt). Low-VOC base paint is recommended for lighter shades, too, of course.

Colors also play a significant role in environmental psychology. Just as daylight and exterior views have been shown to be crucial factors in occupant health, morale, and productivity, interior finishes and materials have an enormous impact. Designers must consider how color will interact with other aspects of the space, such as lighting, architectural features, and furniture.

Research conducted on behalf of paint manufacturer Sherwin-Williams shows that muted, neutral colors reduce visual weight, and light colors can help make a room look larger. The same research also reinforces the long-held belief that placement matters: red paint on walls conveys energy and advancement; the same color on floors exudes confidence, the report concluded. A red ceiling, however, is typically perceived as "weighty and annoying." Green is recommended for interior environments, especially those in which activities require more concentration or meditation (http://bit.ly/1aDeIyM).

According to research conducted for furniture manufacturer Norix, interior color schemes can have a significant impact in rehabilitation typologies, such as correctional institutions and behavioral healthcare facilities. Institutional approaches to interiors, once focused on neutral colors, greys, and whites, are becoming "more expressive." Colors in otherwise severe institutional environments "are seen as pluses to help humanize subjects and in staff areas, provide visual interest and a sense of care," according to the report. "Tensions are lowered, morale boosted, and environments made safer" (http://bit.ly/IG9QlJ).

Color choice is playing an increasingly significant role in the

WARREN JAGGER / COURTESY THE ARCHITECTURAL TEAM

Color selection can be integral to healthcare delivery, as in the memory care wing of Stonebridge, an assisted-living and post-acute care facility in Burlington, Mass. The environment has been carefully designed by The Architectural Team to avoid stress triggers for memory-support patients.

achievement of client goals for built space across the full range of project types, inspired by evidence-based principles of environmental psychology. The corporate sector uses such principles to improve employee recruitment and boost staff retention. According to research conducted at Texas A&M, healthcare outcomes can also be improved by supportive interior design. Specifically, the study suggests that the ideal healing environment is "stimulating, not overly neutral, with an interesting use of color and positive distractions that focus on nature and color" (http://bit.ly/1gatWTV). The study reports that patients in vibrant surroundings often recovered 3/4 of a day faster than patients in more neutral settings, while requesting fewer pain-relieving medications and exhibiting fewer confrontational behaviors.

TECHNOLOGY, SOCIAL SCIENCE GUIDE SPECS

Clearly the selection of color is a weightier decision than merely combining hues that seem to suit the context or the owner's preferences. Driving the paint or coating selection are technical issues and as well as "softer" social science considerations.

Emissions. On the side of hard science is the issue of emissions, encompassing both occupant health and the effect of coating formulations on ozone production and air pollution. Enlightened Building Teams are driving this awareness, but as a recent white paper from the Oregon Department of Environmental Quality says, "Emission reductions are also coming from consumer education, improved work practices, or product specifications through regulation. Labeling laws, in conjunction with consumer education, like labels on paint cans specifying ingredients or VOC content, could help to reduce use of some solvents and eliminate the use of others" (http://bit.ly/18olNn3). Most important, however, is end-user education. That's where the Building Team becomes a key influence, says the Oregon DEQ.

As savvy end-users and building managers know, all packaged coating products arrive on the job site or the loading dock with labels listing HAPs and any toxic content. However, the Oregon agency notes that building owners "using them for their stated purposes may be unaware of associated toxic air pollutants and potential for personal exposure." Beyond that, many ingredients are not listed, or may be listed in a generic manner that masks the actual chemical ingredient. That's why many authorities having jurisdiction, federal agencies, and even building owners are mandating labeling laws or standards that require detailed information on all ingredients. At a minimum, increased awareness gives Building Teams the chance to choose less toxic alternatives.

Some emissions concerns related to paints and coatings stem from life cycle factors, such as surface cleaning, preparation, and renovation. One issue of building reconstruction practice is the use of methylene chloride (MeCl), which has been a common ingredient in paint strippers for years. Emissions of MeCl from this use led to EPA regulations introduced in mid-2011, requiring Building Teams to notify EPA if they are using MeCl paint stripping systems and to certify they have implemented the appropriate "best management practices to minimize emissions of the chemical." Contractors that use more than 1 ton (the equivalent of 181 gallons) of MeCl per year—

calculated by the amount of the raw chemical alone, not the total weight of the stripper compound—must also write a minimization plan and post signs outlining the plan anywhere the paint removal operations are taking place (http://1.usa.gov/IGbLH3).

Hazardous metals. Other materials face tough scrutiny, too. Incredibly, the next issue facing commercial Building Teams may be lead-based paint—a product that has been regulated for decades in the residential sector. Remediation rules apply when renovation, repair, and repainting are undertaken in public housing built before 1978 (so-called "target housing"). Rules for disclosing lead content also affect private property sales and tenant leasing. Both of these ideas seem logical for public, commercial, and industrial facilities, according to the EPA, which took public comments last summer for a new rule to that effect. Though many groups attacked the new rules as unnecessary, the activity has been spurred by a lawsuit brought by environmental activists, which will force the EPA to make a new rule on lead paint by July 2015.

The new rule will address "work practice standards applicable to renovation activities in pre-1978 public and commercial buildings that create a lead-based paint hazard," according to the EPA. Two separate rules will likely emerge: One for interior renovations and the lead-laced dust they often kick up, and another for dealing with lead particles that move into soils when outdoor renovations and repainting are undertaken.

Durability. In a related issue, paint and coating durability are important for environmentally sensitive specifications. For example, lead paint was seen as a wonder material when it was first introduced because it made colors more vibrant, allowed a larger area to be coated with the same volume of product, and resisted water well, making it more cleanable. Yet the detrimental health effects—ranging from anemia to reduced cognitive function to fatal poisoning—came to easily outweigh the benefits, once they were known.

Fortunately, new coating formulations offer the desired durability without such serious attendant hazards. Among the recent innovations are resilient "antifouling paints" containing polysiloxane epoxy. These products can be used for underground steel or properties that may be flooded, or for any exposed steel that requires long, maintenance-free outdoor exposures. While generally considered for industrial and marine uses, they work well for rigorous architectural settings.

For metal, one of the big success stories in improved coating durability has been the use of zinc-based primers for steel structures, says Tom Calzone, director of bridge and fabrication sales at Carboline Company (carboline.com). "Fast-dry alkyd shop primers and older lead-based formulations provide only a fraction of the longevity of the top-performing, zinc-rich systems," he says. Life cycle cost advantages include reduced maintenance and longer periods between recoating, as well as better corrosion protection under such finish coats as polyurethane.

According to Calzone, metallic zinc protects galvanically. Zinc is inherently more reactive than iron, so it will oxidize readily and, unlike red rust, the oxidation products do not expand or propagate. Instead, they passivate the surface, reducing demand for additional oxidation. This slows corrosion beneath the coating and effectively eliminates sub-film or undercutting corrosion. In this way, says Calzone, "the zinc primer becomes a permanent asset on the structure. Maintenance painting becomes maintenance of the coating."


COURTESY LOTUS CONTRACTORS

Before coating or recoating, preparation of a concrete surface may include hand applications or pneumatic and machine-applied finishes. For this surface, an ultra-high-pressure water blasting jet is used by Lotus Contractors of San Francisco.

Resilience. In addition to durability, paint and coating specs should consider the appropriate level of flexibility and elastic recovery. Flexibility is determined not only by the distensibility of the coating but also its thickness and adhesion to the substrate, as reviewed in Mark P. Morse's article "Flexibility & Toughness" in ASTM's book *Paint and Coating Testing Manual.* "Coating films tend to lose flexibility during use due to volatilization of free plasticizing components [as well as] chemical changes such as degradation, cross-linking, and the like," according to Morse. One way to measure flexibility of a coating, he says, is to consider its softening point, the temperature at which the coating changes from hard and glassy to a more rubbery or leathery appearance.

Another measure of toughness is impact resistance, which increases in direct proportion to the molecular weight of the polymers in the paint film. These have higher tensile strength but lower viscosity, which dissipates energy and helps dampen impacts.

Curing and drying. The proper curing of applied coatings, and proper drying cycles between coats, are important to achieving maximum durability. At the molecular level, curing is really the cross-linking of polymers into long chains, giving coatings their ability to form a film or sheet. Applicators must consider the manufacturer's guidance for such variables as coverage—how much substrate a coating should cover at a given thickness—and wet thickness, which indicates at what range of thicknesses a coating can be applied. A cure/dry temperature is also given, stating a minimum for effective curing or drying.

Curing and drying needs vary by coating type. Lacquers tend to have shorter drying cycles than enamels, for example, but they don't cure—which explains why they chip and crack readily. Newer aqueous acrylic lacquers, on the other hand, merge the properties of enamels and lacquers but are more environmentally friendly than traditional lacquers. Regardless of the product used, thin coats tend to result in improved durability and lifespan: The thinner the coat, goes the common wisdom, the faster—and harder—the paint or sealant will dry.

SPECIFICATION STANDARDS ABOUND

In addition to these general specification guidelines, specific product test standards for paints and coatings are valuable for helping Building Teams compare product formulations and chemistries. The test must be suitable to the application and coating type, as ASTM's Rogers notes. Depending on the "decorative, durable, and protective functions," different test protocols are used to evaluate a coating for its intended end-use. (See Table 1 for a full list.)

For example, the substrate must be adequate for conducting the test and must also provide relevant durability information. ASTM International is currently developing a new standard on selecting wood substrates for evaluating weathering performance (http://bit.ly/19k2qM5). The proposed standard, WK32654 – Practice for Selecting Wood Substrates for Weathering Evaluations of Architectural Coatings, reflects the increasing complexity of wood-based materials used in building applications and the varied techniques of architectural product finishing, says ASTM committee member Marek Gnatowski, Ph.D., who is also Technical Director and President of Polymer Engineering Company Ltd. (www.polymerengineering.ca).

"Properly designed and tested coatings increase the longevity of architectural elements and reduce maintenance costs to building owners," says Gnatowski. "On the other hand, forest resources that supply high-quality old-growth solid wood to the construction industry for architectural applications are becoming scarce." New wood composite products such as gluelams, wafer boards, finger-joint siding, and composite trims have complicated testing, and many of the new products use younger trees, which perform differently as a coating substrate.

Other typical tested performance criteria include outdoor exposure, resistance to humidity and water immersion, staining resistance, and adhesion, as well as temperature changes and compatibility with detergents that may be used for cleaning. Aesthetic factors that may be essential to the architectural concept are checked with tests for gloss uniformity or the appearance of efflorescence on certain surfaces. Federal tests provide ways to study abrasion resistance (STD 141A), which is given in cycles/mil: a critical test for a concrete floor coating, for example.

For coatings used in structural assemblies, a key consideration is load capacity, tested with ASTM 2625 B for solid-film lubricants, for example, and given in pounds per square inch (psi). Another more direct measure is endurance or wear life of solid-film coated elements subject to steel-on-steel contact, tested using ASTM 2625 A or similar, which is given by time as a number of minutes based on performance in the test.

For all coatings used on building exteriors in wet, coastal areas or in locations where ambient corrosion is a concern, salt spray testing is seen as a cost-effective, simple way to compare the durability of

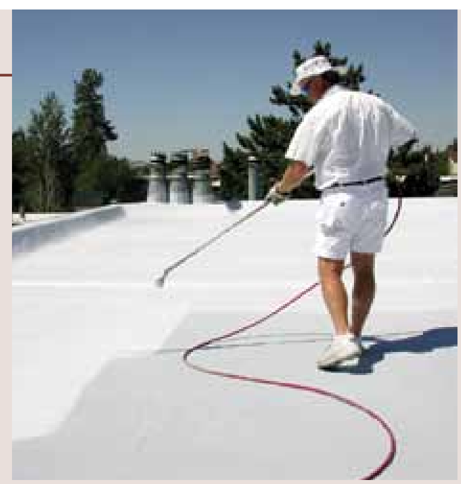
COLOR CHOICES for sustainable roofs

According to research by Lawrence Berkeley National Laboratory, carefully specified cool roofing can significantly reduce cooling loads (http://1.usa.gov/IRR8bZ). An increase in reflectivity of 35% percent – from 20% reflective dark grey to 55% reflective weathered white – has been shown to reduce cooling loads by up to a fifth of the annual total in temperate climates. This phenomenon has important implications for all types of roofing materials, from shingles to membranes to coated metals.

Aesthetic preferences often create a barrier to improved reflectivity. For instance, like the single-family residential market, the low- to mid-rise multifamily market has resisted white or near-white tones, except for buildings with flat roofs. Hoping to improve acceptance of cool roofs, LBNL's Heat Island Group conducted research with industry partners to produce recommendations for cool colors that will satisfy owners' preferences. The research focused on pigments that reflect greater levels of near-infrared (IR) wavelengths, which produce the most heat.

This important research enabled the creation of a database of cool colors for use with tiles, wood shingles, metal roofing, and other products. Comparisons between standard colors and their cooler counterparts demonstrated significantly improved reflectance in the near-IR spectrum, while being nearly indistinguishable to the naked eye. For instance, the tonal difference between a standard brown and a "cool brown" may be all but impossible to discern. Yet the cooler brown is nearly 20% more reflective than the conventional—27% reflectivity, compared with 8% (http://1.usa.gov/1aDbZ8B). Elastomeric coatings on the market improve reflectivity, as do other products like single-ply membranes.

Cool roofing not only involves reflectivity but also the material's or coating's emittance, or its ability to release absorbed heat. Expressed as a number between 0 and 1 or as a corresponding percentage, coatings and materials tend to have emittance values above 0.85, or 85%, according to the EPA (http://1.usa.gov/1kfuVQi). Emittance or emissivity can significantly affect cooling loads in warm and sunny climates; coatings and materials that effectively release heat will reduce the need for cooling. In climates where heating costs predominate, this effect is less desirable. Cool roofing technology continues to develop and improve, making color choices less restrictive and less integral to performance.



COURTESY ARKEMA

For cool roofing applications, water-based polyvinylidene fluoride (PVDF) reflective coatings can be applied in the field.

coated surfaces of building components. However, seasoned specifiers note that accelerated salt-spray tests like ASTM B117 offer only a slight indication of real-world performance. One reason is that corrosion is caused by many factors in addition to salty air or moisture. Drying cycles are critical to durability of a coating, and provide a much better indicator of life expectancy in most cases.

The ASTM standard D5894-10, Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, can be a better real-world simulation. With this test method, the coating is exposed to alternating ambient fog and drying cycles at the same time that it is treated with ultraviolet (UV) light and cyclical condensation.

ADVANCES IN CORROSION RESISTANCE

Corrosion-resistant coatings have been developed specifically to "protect metal components against degradation due to moisture, salt spray, oxidation, or exposure to a variety of environmental or industrial chemicals," according to Metal Coatings Corp. (MCC), an applicator and specialty contractor that works with thermosetting fluoropolymer, baked-on, and air-dried industrial coatings (www.metcoat.com). These products, often called anti-corrosion coatings, allow for high levels of surface protection and also "inhibit contact between chemical compounds or corrosive materials," the latter called *galvanic corrosion*. Other important properties for these high-performance coatings include abrasion resistance, nonstick performance, and chemical protection.

According to applicators like MCC and Cook Composites, numerous coating types can be highly effective for corrosion resistance as part of a durable, resilient facility design using metal components. Many can be enhanced by pretreatments such as galvanizing, inorganic zinc, pickling, and phosphating, which can improve corrosion resistance.

Fluoropolymers. These are resin/lubricant blends that offer excellent corrosion protection, and they are used as a standard in the architectural market.

Xylan. This fluoropolymer is used by original equipment manufacturers to extend component life. A specified system may use Xylan as a thin film to coat bolts, for example, which effectively prevents corrosion. Xylan coatings also usually contain PTFE or other lubricants.

Molybdenum disulfide (MoS2). "Moly coatings" provide friction protection for high-pressure loads of 250,000 psi and greater, which can be helpful in certain structural and architectural applications. When load-carrying capacity, operating temperature, and coefficient of friction are concerns, moly coatings have the ability to transfer lubricant between two mating surfaces, which reduces wear over time.

Epoxy. Using air-dry epoxy or thermal-cure formulations, buildings and outdoor structures can benefit from the same cost-effective corrosion resistance afforded to marine and industrial infrastructure. The thermally treated coatings have very good resistance to abuse and impacts.

Polyurethanes. For metal surfaces, polyurethane is appreciated for its thin-film, high-gloss finish and reliable weathering. The smooth finishes resist corrosion, abrasion, and chemical exposure.

Phenolics. Where metal must be exposed to (or immersed in) salt water, acids, and solvents, phenolic coatings offer good protection, making them a favorite in the extreme conditions of many industrial facilities.

ARCHITECTURAL COATING + PAINT STANDARDS

DESIGNATION	TEST METHOD FOR
D1849 - 95	Package Stability of Paint
D2064 - 91	Print Resistance of Architectural Paints
D2243 - 95	Freeze-Thaw Resistance of Water-Borne Coatings
D2486 - 06	Scrub Resistance of Wall Paints
D3258 - 04	Porosity of White / Near White Paint Films by Staining
D3450 - 00	Washability Properties: Interior Architectural Coatings
D3730 - 10	High-Performance Interior Architectural Wall Coatings
D3928 - 00a	Evaluation of Gloss or Sheen Uniformity
D4400 - 99	Sag Resistance of Paints
D4828 - 94	Practical Washability of Organic Coatings
D4946 - 89	Blocking Resistance of Architectural Paints
D5007 – 99	Wet-to-Dry Hiding Change
D5146 - 10	Solvent-Borne Architectural Coatings
D5401 - 03	Clear Water-Repellent Coatings on Wood
D6763 - 08	Exterior Wood Stains and Clear Water Repellents
D6900 - 10	Adhesion of Latex to Gloss Alkyd Enamel Substrate
D7489 - 09	Touch-Up Properties of Architectural Coatings
D7786 - 12	Determining Enamel Holdout

SOURCE: ASTM INTERNATIONAL

Table 1. ASTM International offers a battery of tests involving architectural coatings and paints, as well as application guidelines. As they consider appropriate ways to create, evaluate, specify, and apply coatings, manufacturers, specifiers, contractors, and owners can benefit from familiarity with these tests.

Other metal finishes can provide superior protections against chemicals, such as the non-stick polytetrafluoroethylene (PTFE) and polyphenylene sulfide (PPS), but these are mainly used in industrial processing, wastewater management, and other extreme environments. Polyvinylidene fluoride (PVDF) coatings, including Kynar, have proved effective for resilient architectural coating needs.

Coating systems with anti-corrosive properties ensure that metal components have the longest possible lifespan, especially in areas such as mechanical rooms, parking garages, and other facilities with frequent chemical spillage, corrosive fumes, abrasion, or big temperature swings. But their value can be compromised if the owner or property manager fails to schedule maintenance and undertake routine touch-ups and repairs. Simple visual inspection, proper cleaning, and patching of damaged areas will extend the coating life span. For the most corrosive areas, inspect every six months, Sherwin-Williams advises; for painted exterior metals, an annual look suffices. The owner can use a proven method for inspections, according to the SSPC: The Society for Protective Coatings, such as the group's SSPC-VIS 2, Standard Method for Evaluating Degree of Rusting on Painted Steel Surfaces.

MANAGING SURFACE PREPARATION

Long before the inspections begin, decisions made in the design and construction documentation phases will determine how well chosen coatings hold up. In addition to topcoat selection and its compatibility with primers, a well-detailed application spec should be documented, including steps for surface preparation.

Improperly prepared surfaces are the bane of the Building Team's aspirations for success with paint and coating systems, leading to adhesion issues that cause about 80% of all failures, according to manufacturers. Mill scale, rust, dirt, and grease will impede the bonding between the coating and a metal substrate, causing the coating to deteriorate. Call-backs related to these kinds of "coating failures" sometimes identify the actual culprit: a finish contractor who skipped a step or two. Coating integrity and service life extend dramatically if the surface is treated correctly—so the mantra for the Building Team is to make sure surfaces are well prepped.

Among the most useful relevant standards are practices for qualifying tradespeople. ASTM's D4227 and D4228 describe a way to assess coating applicators for concrete and steel surfaces, respectively. Other standards cover the practices themselves, including surface cleaning, acid-etching, and abrading concrete and concrete masonry units, as well as ways to test the moisture content and pH of concrete surfaces, or to evaluate how a coating will interact with a corrosion inhibitor.

For owners, specifiers, and construction project managers, a careful focus on surface preparation helps to ensure a long-lasting building, especially if the project involves corroding materials such as concrete, ferrous metals, galvanized metals, and aluminum. The key to success is balancing economic concerns with environmental considerations and issues of surface contamination.

Although surface contamination is an issue during new construction projects, it is most significant in repainting and maintenance painting. Existing coatings cannot be completely removed in many cases, and loose or glossy paint along with various foreign materials, will reduce the adhesion and compatibility of the new paint. According to the Sherwin-Williams publication *Surface Preparation Guide,* the contractor should attempt to remove all oil, grease, mold, mildew, loose mortar, scale, and efflorescence (for example, by cleaning with an abrasive solution that will effectively dull the shiny surfaces at the same time). Then a spot primer is used to coat bare areas, and test applications of the coating are conducted on large areas of at least a yard square. After a week, adhesion is tested using pressure-sensitive tape following the protocol in ASTM D3359.

In general, there are eight types of surface cleaning methods used to prep building materials for application. Solvent cleaning removes dirt, oil, grease, and drawing and cutting compounds, but it does not help eliminate metal corrosion. Next, many contractors prefer to include hand-tool cleaning in the specifications to ensure mill scale and loose rust do not obstruct proper coating adhesion.

Four types of blast cleaning are also employed: white metal blast cleaning, commercial blast cleaning, brush-off blasting, and near-white blast cleaning. Standard blast cleaning ensures removal of dirt, paint, oils, grease, rust, and mill scale, as well as any corrosion or oxidation products. Commercial-level blasting removes all foreign matter except for staining, and near-white blasting also allows for some staining to remain. Brush-off blasting takes off all foreign matter except "tightly adherent mill scale, rust, and paint," according to the standard SSPC-SP7/NACE 4. Other techniques for surface treatment include power-tool cleaning to bare metal, and high-pressure water jetting, which may be helpful for steel and other hard materials. In some cases, solid particles are added to the water streams.

Accommodating the unique characteristics of each coated surface is essential. In fact, the quality of surface preparation is a chief determinant of a coating's life span for virtually every material. Specific tips for several types of substrates follow:

Metal surfaces. Varied protocols exist for preparing metal for painting, and many are standardized by the SSPC. Aluminum and weathered galvanized metal are cleaned per SSPC-SP1, a specification for solvent cleaning, removing "all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from steel surfaces" (http://bit.ly/IGsc64). Solvent preparation should be used in conjunction with other surface treatments, such as paint stripping and removal of rust and mill scale. For steel exposed to high temperatures, the best surface preparation is abrasive blast cleaning, according to AIA's *Graphic Standards Guide to Architectural Finishes.*

Ductile iron. Iron pipe and fittings require Building Teams to follow a different protocol, the National Association of Pipe Fabricators' NAPF 500-03 (http://bit.ly/1f0pOml). Unlike rolled mill steel, ductile iron does not need blast removal of mill scale and rust, or blasting to create an anchor pattern that helps hold the coatings. Carbon steel also has a smoother texture and a different color.

Concrete. Concrete walls and foundations demand careful

Lehman College in the Bronx, N.Y., emphasizes environmental science and sustainable technologies. A new building designed by Perkins+Will includes exterior coatings selected for cool roofing characteristics and durability. Low VOC emittance was a priority for interior coatings.

preparation because their porous, breathable surfaces readily transfer moisture and expand and contract with temperature swings. Power washing can precede the use of crack fillers and patching compounds, followed by a cleaner and etcher, such as phosphoric acid solution, to further improve adhesion. Then a concrete bonding primer is used, which may include epoxies and acrylic polymers. The International Concrete Repair Institute's standard ICRI 03732, Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings and Polymer Overlays, succinctly lays out the limitations of methods for preparing concrete surfaces that receive protective sealers, coatings, and polymer overlays. Ten profiles are described and shown in images—they are also available as a handy set of cast chips—to ensure the correct concrete surface is achieved for the specified coating technique. The SSPC-SP13/NACE 6 standard defines acceptable conditions for such materials as cast-in-place concrete floors and walls, precast slabs, masonry walls, and shotcrete surfaces.

Beyond the specific methods used, Building Teams can also provide general guidance for how well prepared surfaces should be. The trade group Painting & Decorating Contractors of America (PDCA) provides a shorthand entitled "Levels of Surface Preparation," ranging from Level 1, Basic, to Level 4, Supreme (http://bit.ly/1jraBxL). This kind of description may be adequate when working with accomplished contractors and tradespeople.

For a reconstruction project, the Building Team should define a level of surface preparation that warrants adhesion. For example, it's hard to know how well previously applied paint coats are adhered to each other or to the substrate, according to PDCA. It may not be known whether mildew or other contaminants are likely to reduce coating effectiveness and stability.

Adhesion is a concern, and tape tests or other techniques can be used to ensure readiness of the substrate. But so is the quality of appearance of the finished surfaces—often the ultimate goal of paint and coating use. As PDCA notes, the level of preparation may need to include a specified alteration of the existing surface profile. Techniques include the "standard" steps in PDCA Level 2, such as patching/filling, caulking, light sanding, and hand abrading, as well as feather-edge sanding. "When poor results are obtained … then more aggressive surface preparation methods may be recommended," says PDCA. The Level 3 and Level 4 specs are designed specifically for best appearances, eliminating abrupt surface profile differences or providing a very smooth finish through resurfacing and restoration.

With attention to life cycle needs, proper product selection, and environmental concerns, the Building Team can choose coatings and paints that are ideal for the end use. A proper understanding of substrate characteristics and surface preparation will maximize the value of any investment in architectural coatings. +

> EDITOR'S NOTE

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