Exterior Wall Coatings for Concrete and Masonry

By Michael P. Edison

Specifiers and users of exterior wall coatings face a daunting array of product choices. For formulators of these coatings, the alternatives may be even more overwhelming, as they must choose among an almost unlimited number of combinations of the thousands of available raw materials and chemical intermediates.

A clear definition of application and performance objectives is the first essential in making appropriate coating selections. Is the purpose of the coating primarily decorative, or are there specific waterproofing objectives as well? Are there particular conditions that will affect application, such as high or low temperatures, a site prone to high winds or moisture, or a congested location with a high potential for "collateral damage"? Does difficulty of access for eventual recoating mandate a selection with higher initial cost but longer service life? Is the site historic and subject to the U.S. Secretary of the Interior's Preservation guidelines in addition to the general performance requirements? Once these and other similar questions have been answered, the process of sorting through the various options can begin.

Waterborne or Solventborne?

One of the most basic decisions is whether to limit selections to products in which water is the primary vehicle. Waterborne coatings generally offer significant advantages, including low odor and toxicity, VOC compliance, ease of clean-up, and reduced fire hazard in storage. They also tend to be more tolerant of residual dampness in substrates at the time of application, a condition common to concrete and masonry wall systems. After several decades of concerted effort and development work by raw materials and coatings manufacturers, waterborne coatings have evolved to a point where they generally perform as well or better than solventborne alternatives and will be the clear choice in most applications.

In some applications with special requirements, however, solventborne coatings may still be the only viable alternative. This will be particularly true in cases requiring extremely fast drying or for applications at very low temperatures.

It should also be noted that most waterborne coatings incorporate some level of organic solvents, which aid in latex coalescence, film formation and in controlling drying rates. Product VOC content can be used as a general yardstick for comparing solvent levels in otherwise similar products.

Choosing a Binder

Coating ingredients can be categorized into several basic groups, and selections made by formulators in each of these categories will determine the specific application and performance properties of the coating:

Binders—These are the materials that hold the coating together and adhere it to the wall.

Pigments and Extenders—These provide color, hiding of the substrate, bulk, and hardness, among other properties.

Solvents—These are carriers for the active ingredients, allowing them to be spread evenly over the wall surface. They also control drying rate, which has an important influence on film formation, penetration, and adhesion.

Additives—There are a wide variety of additives used in wall coatings. These range in their functions from viscosity, leveling, and foam control to ultraviolet stabilization and antimicrobial protection.

Of these groups, the binder has the most profound impact on coating properties and performance. It is the binder's function to form a film and hold together all of the other ingredients, as well as to develop good adhesion to the substrate and to withstand the rigors of exterior exposure.

A wide variety of binders is commercially available and in use for exterior masonry wall coatings today. These can be roughly divided into two groups:

- Organic binders include the full range of synthetic resins commonly used in latex paints, including acrylics, alkyds, polyurethanes, epoxies, polyesters, polyvinyl acetates, and others. Copolymers, which combine more than one basic functional group, are also common, including acrylic copolymers with polyurethane, epoxy, vinyl acetate, and polystyrene. Copolymers combining different acrylic groups are also widely used. As each group has its own typical range of performance characteristics, copolymers can often provide properties unavailable from a single, homogeneous polymer (homopolymer).

Table 1: History of wall coating binders

Timeline	Binder types	Uses
Prehistoric: 10,000 years ago	Blood, mud, sap, weeds, berries	Interior cave wall painting
Egyptians: 4,000 years ago	Distemper: casein, egg whites, milk, gums, starches	Interior decorative wall coatings
Romans: 2,000 years ago	Lime, whitewash, Roman cement (Pozzolana)	Interior/exterior wall coatings waterproof renders
Industrial era: 1870s	Drying oils, casein	First factory-produced, interior/exterior commercial paints
Late 19th /early 20th Centuries	Portland cement, silicates	Durable exterior masonry paints
World War II	Vinyl acetate, polyurethane, epoxy, silicone	Synthetic replacements for scarce natural ingredients
Post-war era: 1950s	Polyvinyl acetate, SBR latex, acrylic latex	Interior and exterior latex paints
1970s	Gloss acrylic latex	Replacement for oil-based paints and enamels
1980s	High-performance waterborne acrylics, epoxies, silicones, polyurethanes	VOC compliant coatings
1980s/1990s	One-part potassium silicates	Durable masonry coatings

Some natural binder materials are also organic, including oils and casein.

- Inorganic binders include lime, portland cement, and solutions of silicate compounds. Their matrixes are very different from the organic binders in both chemistry and structure, resulting in very different performance properties.

Organic Coatings

While epoxies, polyurethanes, polyesters, and other binders have some specialized applications, the worldwide wall coatings market is heavily dominated by acrylic latex technology. By some estimates, as much as 85% of all the paint produced and sold worldwide is based on acrylic latex technology.

Acrylic binders may be characterized as either "pure" acrylics or as copolymers with other functional groups. Pure acrylics, often marketed as "100% acrylics," incorporate one or more acrylic functional groups.

While acrylic copolymers, with other functional groups such as polystyrene, may benefit from the positive characteristics of those groups, such as higher chemical resistance, water resistance, and/or adhesion, they also tend to be diminished by the negative characteristics of those groups. Accordingly, styrene-acrylic copolymers have a greater tendency to discolor and/or chalk when exposed to sunlight. Vinyl acetate-acrylic copolymers offer lower costs than pure acrylic systems, but also suffer from the reduced water resistance typical of the vinyl acetates.

Pure acrylics are an extremely versatile group of resins. Although somewhat higher in cost than some of the alternatives, they are valued for their good color retention and exterior durability. Different acrylic functional groups produce polymers with very different properties. Methyl methacrylate, for example, produces extremely hard polymers, such as those that may be used in bullet-proof glazing. Ethyl acrylate produces relatively soft polymers, such as may be used in acrylic caulks. By combining different acrylic groups, copolymers with the desired balance of hardness, adhesion, flexibility, and water resistance can be obtained.

Elastomeric Acrylic Coatings

Harder acrylic binders are the bases for durable, dirt resistant decorative exterior wall coatings. On the opposite end of the scale, elastomeric acrylic coatings have the capacity to elongate and recover when exposed to cyclical stress, as may be encountered when bridging small "working" cracks in concrete and masonry. Softer acrylic coatings also tend to induce less stress in previously applied coatings over which they are applied, prolonging service life for applications on previously painted surfaces.

Although many acrylic coatings are marketed as "elastomeric," not all of them display the properties of a true elastomer. Many acrylic latex coatings display high elongation at moderate temperatures.

True elastomers will not only elongate, but will also recover substantially after the stress is removed. They will also remain elastomeric at low temperatures, including the full range of normal exterior service temperatures. Many acrylic latex coatings become brittle at temperatures below 40 or 50 °F (4 to 10 °C), while true elastomers remain flexible at temperatures below 0 °F (–18 °C). True elastomers also remain permanently flexible, substantially retaining their ability to elongate and recover even after 10 to 20 years of exterior exposure. Low-cost acrylic latex coatings are rendered flexible by incorporation of plasticizers, which soften otherwise normally harder polymers. These plasticizers eventually wash out or break down, leaving behind an embrittled coating with increased tendency to crack, flake, or peel.

Disadvantages of acrylic elastomers include a higher tendency to collect dirt over time and a general tendency to reduce moisture vapor transmission rates through coated surfaces. While waterborne acrylic coatings can generally be classified as "breathable," or able to transmit moisture vapor, most will significantly cut vapor transmission rates compared with uncoated surfaces. Reductions in vapor transmission rates on the order of 50 to 90% are typical. Whereas elastomeric coatings generally require application of thicker films to develop the capacity to stretch across working cracks without tearing, they tend to reduce vapor transmission rates even more significantly than coatings applied at lower film thickness. Some manufacturers, however, have developed elastomeric acrylic coatings with relatively high vapor permeability. The most breathable acrylic elastomeric coatings exhibit vapor transmission characteristics which rival even some potassium silicate coatings, which are prized for their high permeability.

In cases involving relatively weather-tight building envelopes with internal moisture barriers, acrylic wall coatings will generally provide adequate permeability for applications on concrete and masonry wall systems. Eventual recoating of surfaces painted with organic wall coatings, however, will result in further reductions in vapor transmission rates and in the course of one or more reapplications, over time, vapor transmission may become insufficient. At that point, removal becomes necessary to avoid damage to the substrate. The removal process itself can be damaging and is relatively costly.

While many commercial and industrial buildings tend to have relatively short design service lives in terms of economic write-off, most buildings will remain in service for as long as they are practically maintainable. Buildings with historic value have an additional mandate to be preserved. Often, these concerns can be addressed by selecting high-quality acrylic coatings with high-moisture vapor permeability and maximum long-term resistance to sunlight, microbiological attack, and moisture.

Frank Lloyd Wright's Guggenheim Museum, built in 1959 in New York, was coated with a highly breathable acrylic elastomer in 2004

Many mass-market latex paints, however, are designed first and foremost to be highly competitive in cost and formulation compromises of performance are commonly made to lower the cost of these products. Some manufacturers may also view paint systems that offer long-term durability as having a potential negative impact on resale business, as the more frequently buildings require repainting, the more paint they can hope to sell over time.

As a result of the limitations common to many commercial paints, greater attention has recently been focused on the long-term costs and impact of various wall coating alternatives. As these full life-cycle implications are given greater weight, the use of high-permeability, durable inorganic coating systems has increased dramatically.

Inorganic Coatings

Limewash was the first durable inorganic masonry coating, and its use extends back to ancient cities more than two thousand years ago. It is still in use to some extent today. Lime (calcium hydroxide) applied to exterior masonry walls reacts with atmospheric carbon dioxide to form a crust of calcium carbonate.

The disadvantages of limewash include a relatively short service life and high labor costs for application. While high in permeability, water resistance is limited and it is not uncommon for damage to become evident in as little as one year in severe weather climates, or for reapplication to be required on a 2- or 3-year cycle. Tendencies toward streaking and other aesthetic anomalies do not meet the high expectations of many owners and specifiers.

In the past century, portland cement has been used to form a more durable inorganic coating. Properly formulated, applied and cured portland cement-based coatings can provide higher durability and water resistance than limewash, although more rigid and somewhat lower in permeability. Application costs are generally higher than for acrylic latex paints, and results are less consistent in terms of film thickness, texture, and color uniformity. Long-term adhesive performance has generally been poorer than for acrylic coatings, and acrylic latex admixtures have sometimes been substituted for all or part of the mixing water to improve cement paint adhesive performance and to reduce or eliminate wet-curing requirements.

While latex-modified portland cement paint compositions can be useful in situations where the development of texture and film build are desired, these characteristics are often undesirable. The addition of build and texture can be positive in situations where there has been significant erosion of original surfaces, or where previous repairs are a poor match to original substrates in terms of texture. But in cases where the objective is decoration and protection without obscuring surface detail or otherwise altering surface profile, portland cement-based coatings are less suitable than other alternatives.

Masonry coatings based on potassium silicate have been in use in Europe for more than a century. Potassium silicate has the capacity to react with a variety of mineral and metallic building substrates to form stable, permeable structures. Permeability close to 100% is reported for some of these coatings.

The inorganic structure provides several additional benefits. These include fire resistance, resistance to mold, and other biological growth, and in some cases, superior resistance to long-term moisture exposure.

Polymers typically used in organic wall coatings contribute to flame spread and smoke generation in cases of fire. They also typically contain ingredients which are biodegradable, providing a nutrient source for algae, mold, and mildew. While most coatings contain biocides as additives to protect the coatings from degradation in the container, and some contain additives designed to hinder biological attack in situ, they cannot provide the certainty and longevity of resistance to biological attack offered by inorganic coatings formulated without biodegradable ingredients altogether.

Potassium silicate coatings frequently incorporate water repellent ingredients which offer protection from water infiltration without hindering moisture vapor transmission, an effective combination for a wide range of masonry and concrete applications. Formulations are available in several consistencies from penetrating stains to heavy paints to textured coatings.

Resistance to long-term moisture exposure can be problematic to typical acrylic latex coatings. Although many are characterized as irreversible in terms of their film formation after application, acrylic latex polymers commonly soften and swell when exposed to continuous moisture. They are therefore generally not recommended for use under immersion or high constant moisture conditions. While use of some silicates carries a risk of their becoming redissolved under high moisture and immersion conditions, properly reacted and cured treatments can effectively become insoluble. This property is of the greatest value when treating concrete and masonry structures which will be exposed to extended or repeated periods of wetness. Such applications may include planters, fountains, retaining walls, coastal exposures, and open structures such as towers, monuments, and non-traffic surfaces in parking structures.

Some silicate coatings are fortified with acrylic latex. The latex facilitates application and improves the development of adhesion. At very low levels the acrylic additives can be beneficial, but if too much acrylic latex is added to the formula, the benefits and performance of the reactive silicate

The historic Cliff House in San Francisco was coated with a mineral silicate coating in 2004

binder will suffer. These compromises typically manifest themselves in terms of reduced resistance to moisture, reduced solvent resistance, and lower bond strength. While reactive silicates will withstand continuous water immersion, silicates overextended with acrylic latex will soften and peel in relatively short order after immersion. Reactive silicates can also bond tenaciously to smooth, hard, nonporous substrates such as glass, polished stone, and glazed brick or terra cotta, whereas acrylic-modified silicates may develop poorer bond to these substrates. Reactive silicates will be sufficiently insensitive to organic solvents as to allow removal of graffiti without dissolving the coating, but acrylic-modified silicates may be dissolved by exposure to solvents.

There are some important limitations to the use of silicate coatings, however. While silicates can dry and form a film, the development of their most important performance properties can only occur if they react with the substrate. This reaction cannot occur if previous organic coatings or residues of organic coatings remain in place. Some residual water repellents may also hinder contact and reaction of the silicate with the substrate. For this reason, silicates should not be used on buildings previously painted with organic coatings unless complete removal of those coatings is assured, and pretesting of adhesion and compatibility through mock-ups is indispensable prior to large scale treatment.

Silicates are relatively hard, rigid coatings. While they maintain good compatibility with mineral substrates due to similar coefficient of thermal expansion, they cannot bridge working cracks and cannot be applied over sealants or other synthetic materials. They are also difficult to remove from porous substrates and should be considered irreversible.

Finally, silicates are currently more expensive than premium quality acrylic coatings. While this higher initial cost may be a disadvantage, the long service life provided by these coatings can result in a cost advantage when considered over the service life of the coating and the treated building or structure.

Appropriate Material Selection

Concrete and masonry restoration, decoration, and protection projects have individual objectives, conditions, service exposures, and economic constraints. Although the challenge of selecting among the myriad of available concrete and masonry coating products can be daunting, clear definition of project objectives, performance requirements, and application conditions is the first step in the process of appropriate material selection.

To meet the requirements of the full spectrum of project situations, a diverse range of materials and properties is required. While acrylic coatings will undoubtedly continue to dominate world paint markets due to convenience, moderate cost, and good performance, the use of specialized coatings such as reactive inorganic potassium silicates will also have a place in the market due to longevity, compatibility, and life-cycle cost implications.

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The author with an acrylic elastomeric coated gargoyle atop the Cathedral Basilica in Covington, Kentucky