TECHNICAL PAPER

Water-Based Acrylic Roof Coatings for Weatherproofing

Improved Performance by Design and Process

INTRODUCTION

Over the last two decades, water-based acrylic coatings have come to dominate the paint and waterproof coatings industry. Market share gains have been driven by some thirty years of proven exterior performance coupled with various end-user trends and preferences. Environmental concerns surrounding VOC impact on air quality have fueled the substitution of solvent-containing coatings with water-based alternatives. Other health concerns related to worker and building occupant exposure and flammability risks associated with these hazardous chemicals also favor water-based systems. And we now see increased interest in the energy-saving, improved urban air quality, and longevity benefits of Cool Roof Systems that are based on acrylic coatings. This ever-growing use of acrylic coatings to weatherproof commercial and residential buildings reminds us that a growing number of contractors, specifiers and end-users need to fully understand the performance requirements of these systems and various technical, manufacturing and installation issues that either ensure or compromise required performance. This article addresses:

- Requirements for acrylic weatherproofing systems
- Key components of high performance coatings
- Risky compromises made in manufacturing coatings
- Manufacturing process impact on coating quality
- Installer link to system performance

Throughout, we focus on acrylic waterproofing for low-slope roofs, since the principles involved here translate directly to vertical wall weatherproofing with acrylic coatings.

FIELD REQUIREMENTS FOR ACRYLIC WATERPROOFING

Up-front, these systems must block bulk water movement into the substrate they protect, so the coating products themselves plus the method of application must ensure a watertight membrane. And because they are applied to a variety of substrates, including asphalt-based roofs, plastic and rubber single ply roofing, sprayed polyurethane foam, metal and concrete, the chosen coating must maintain its waterproofing and protection performance over a specific substrate type. To ensure this long-term performance, a coating system must weather well, resisting the damage wreaked by the sun's UV and hot infrared radiation. Coatings must have built-in properties to handle building movement and temperature changes that cause expansion and contraction stress. Beyond these factors, foot traffic on roofs, regional hail activity, and ice and snow buildup require added strength and flexibility.

WHAT'S IN A GOOD COATING AND WHY?

Over the years, the technology surrounding acrylic coatings has matured. Leading raw material manufacturers and top coating formulators understand the principal components of proven coatings and the role each constituent plays in meeting the above performance requirements to ensure long-lasting waterproofing. Below, we highlight many typical coating components and their contribution to durable performance based on years of exterior exposure on actual buildings.

Acrylic Polymer Resins: Our review of acrylic coatings starts with the core of a coating recipe, the acrylic emulsion polymer itself. Simply put, the acrylic polymer is the key determinant of crucial coating properties like water resistance, impact and tear strength, flexibility, adhesion to a given substrate, and overall durability. What determines the quality of an acrylic polymer vis-à-vis these performance parameters is the chemical composition of a polymer coupled with the actual synthesis process by which raw materials (monomers) are reacted to produce the final emulsion polymer. 100% acrylic compositions are preferred versus co-polymers like styrene acrylics and vinyl acrylics. Styrene acrylics often show inferior weathering and color instability due to UV attack of the aromatic chemistry in styrene; vinyl acrylics, polymers often used in cheaper interior paints, show poorer water resistance due to hydrophilic properties of the vinyl chemistry. 100% acrylic polymers, however, are totally transparent to UV rays, so they function as durable binders that can hold a coating film together for the long haul. 100% acrylics have proven superior adhesion properties, being the key components of caulks, architectural sealants, and tape and label adhesives. And properly engineered acrylic polymers provide the right balance between strength and stretch, also known as toughness. For instance, typical paints are not waterproof coatings and always develop small cracks over time due to building movement and temperature fluctuations. Paints are based on "hard" acrylic polymers. Waterproofing coatings, however, must be formulated with so-called "elastomeric" acrylic polymers that impart more low-temperature flexibility while maintaining other crucial strength, adhesion and water resistance properties. The bottom line is that incorporating the appropriate acrylic polymer is an essential determinant in the overall performance of an elastomeric acrylic coating. And the four most proven 100% acrylic polymers in terms of actual exterior low-slope waterproofing installations are: Rhoplex® EC-1791, Rhoplex EC-2540, Rhoplex 3640 and Rhoplex EC-2885; all manufactured in ISO 9002-certified plants by Rohm and Haas Company.

Titanium Dioxide (TiO_2): TiO_2 is termed a *prime pigment* in acrylic coating formulations due to its impact on coating durability and reflectivity. TiO_2 comes in different grades at different prices. Various grades can oxidize at different rates and cause different degrees of coating chalking over time. TiO_2 is also opaque to UV radiation and blocks these harmful rays from reaching the substrate beneath the protective coating. TiO_2 adds whiteness and reflectivity to an acrylic coating system, impacting the overall energy efficiency of a Cool Roof System. A chalky coating installation may signal the use of a coating based on insufficient TiO_2 levels or inferior grades of TiO_2.

Zinc Oxide (ZnO): ZnO is another so-called prime pigment that provides opaqueness to UV, whiteness and reflectivity to a well-formulated acrylic coating. More importantly, ZnO also resists mildew and algae growth and unlike other coating mildewcides, does not leach out of the dried coating film or get destroyed by continued exposure to UV rays. ZnO also provides additional chemical bonding between polymer molecules, making for tougher and more water resistant coating films. Often, however, ZnO causes instabilities in a coating mixture so that many coating formulators do not take advantage of the benefits of incorporating ZnO into their products but opt for "easier-to-produce" recipes.

Fire Retardants: The last of the prime pigments are inorganic materials that suppress smoke generation and flame spread. Fire retardant coatings are required for achieving certain widely sought fire ratings like UL 790. Aluminum Trihydrate is the most common retarder used in coatings. While some retarders eventually migrate out of a dry coating film, Aluminum Trihydrate does not.

Extender Pigments: Whereas prime pigments provide color, UV blocking, and fire resistance, so-called *extender pigments* mainly impact coating abrasion resistance, overall coating raw material cost, and possibly color retention. Typical extender pigments are Calcium Carbonate ($CaCO_3$), Talc powder, Clay and Silica. These different pigments can not be readily substituted for one another since they differ in long-term oxidation that impacts color retention, and they also have different so-called oil absorption rates that will impact the amount of polymer required to meet certain coating performance properties. Maintaining the integrity of coating quality by consistently using a well-specified grade of a specific extender pigment is essential.

Dispersants and Surfactants: These "salt and pepper" additives impact the ease and uniformity of how prime and extender pigments are blended into an acrylic coating. They also provide in-can stability so that a coating remains a uniform blend that can be applied consistently and efficiently in the field. Dispersants and surfactants also affect the water resistance of coatings, so the top coating manufacturers develop unique know-how on how to balance the advantages and drawbacks of these additives.

Defoamers: Elastomeric waterproofing coatings are more viscous than typical paints and are applied at thicknesses 10-20 times that of decorative paints. Air entrapment then becomes a critical concern for coating quality and long-term performance. Entrapped air, often exacerbated by necessary inclusion of dispersants and surfactants, creates zones of weakness in coating systems, so use of proper amounts of an appropriate defoamer ensures a better performing membrane.

Preservatives: Acrylic coatings are water-based and susceptible to bacteria and fungal growth both in packaged storage and later as a dry installed coating. To ensure storage stability and film integrity in the field, appropriate "salt and pepper" mildewcides and algaecides should be incorporated into quality coatings. Various leading biocides are available, so the top coating formulators balance these additives with ZnO to achieve the best in-can and dry coating preservation possible.

Thickeners: Three classes of thickeners, namely, cellulosic, attapulgite clay and associative thickeners, are used to achieve a stable coating with the right rheology. Coating viscosity and overall rheology affect application efficiency, sag resistance for vertical wall waterproofing, and overall water resistance. The subtleties of developing coating recipes with appropriate levels of specific thickeners should not be underestimated.

Plasticizers: Plasticizers are additives used in conjuntion with cheaper, harder paint polymers to provide the added flexibility properties that elastomeric waterproofing coatings need. The problem is that these *external* plasticizers migrate out of coatings, causing discoloration, dirt pickup and loss of reflectivity, mildew and algae growth, and overall coating embrittlement. In terms of specifying acrylic coatings for long-term performance, just say "no" to formulations with plasticizers.

Coalescent Solvents & Glycols: Historically, paint manufacturers often required these additives to compensate for harder paint polymers and freezing conditions that paints see in long-term storage and transport to end-users. Such additives, however, increase the VOC content of acrylic coatings, affect in-field dry times, and increase overall cost. The sophisticated waterproof coating manufacturers take advantage of state-of-the-art soft acrylic polymers and incorporate glycols only when absolutely necessary.

RISKY COMPROMISES TO AVOID

In this age of increasing business competition, especially in mature industries like acrylic coatings, and with market trends favoring environmentally-friendly and reflective coatings, contractors, specifiers and end-users will inevitably face a multitude of coating offerings from both small and large and new and established manufacturers. Like so many industries, all sorts of performance claims and price deals arise. Relative to the performance needs discussed earlier, namely, durable waterproofing over a specific substrate, acrylic coatings are not all created equal. Here are some all-too-common formulation approaches that risk long-term performance:

- Coating formulators switch from the most proven and durable 100% acrylic polymer raw materials to less expensive styrene acrylic and vinyl acrylic chemistries.
- Coating formulators switch to new, lower-cost "me-too" 100% acrylic polymer offerings that have not been thoroughly tested in years of actual exterior waterproofing applications.
- Coating formulators start blending together various lower-cost polymers creating "new and improved" products that lack track history in actual field applications.
- Coating formulators modify product recipes to reduce cost but trade-off on quality and performance by:
  - Using inferior grades of TiO_2
  - Reducing the level of Polymer compared to all pigments (see PVC below)
  - Reducing the levels of Polymer and Prime Pigments (TiO_2) in favor of cheap Extender Pigments ($CaCO_3$)
  - Decreasing the levels or eliminating altogether preservatives such as ZnO and Biocides
  - Reducing the Volume Solids of the final coating product (i.e. more water per gallon)

Contractors, specifiers and end-users should understand a key coatings concept called PVC (pigment volume content). PVC refers to the ratio between all pigments and the combined amount of pigments plus polymer. Higher PVC means there is less polymer relative to prime and extender pigments. Lower PVC means the coating formulation is rich in the most important raw material, acrylic polymer. A minimum standard for a softer elastomeric polymer coating would be 43% PVC, however, other systems require PVC's in the 30%-40% range for optimum toughness and adhesion properties.

The bottom line is that by increasing PVC (realizing that quality polymers are 20-40 times the cost of extender pigments), by switching to lower-cost and new polymers, and by juggling between higher cost prime pigments and cheaper extender pigments, a coatings manufacturer can shave $1.50-$3.50 per gallon off manufacturing cost. This corresponds to $0.05-$0.35 per square foot of installed acrylic coating. The majority of acrylic-based Sprayed Polyurethane Foam Roofing Systems and Coating Restoration Systems would "benefit" around $0.05-$0.12/ft^2 while fully reinforced Acrylic Waterproofing Membranes would "benefit" around $0.09-$0.35/ft^2. But recall that these systems typically install for around $1.00-$4.00/ft^2 and are designed to be renewable every 15-20 years and sustainable to avoid more frequent re-roofing that typically costs $1.00-$3.00/ft^2 every 5-12 years.

The Risk is that for a very small % reduction in total installed cost; actual life-cycle costs can substantially increase because a less proven and inferior acrylic coating system might:

- Lack important strength, elongation and adhesion properties
- Succumb to UV attack and premature weathering
- Be less reflective and energy efficient
- Lack water and microbial resistance
- Pick-up dirt more readily, affecting aesthetics and reflectivity
- Cure less uniformly and mud crack

Inferior acrylic coating systems suffering from these deficiencies will mean less weatherproofing performance, shorter coating and roof system performance life, and overall higher operating, capital and life-cycle costs.

ASTM D6083 VERSUS ASTM D412: BETTER GAUGING ACRYLIC COATINGS

Early in 1998, ASTM International published the D6083-97 specification titled "Standard Specification for Liquid Applied Acrylic Coating Used in Roofing." The goal of the ASTM Technical Committee D-08 on Roofing and Waterproofing, was to establish a *minimum* benchmark standard for 100% acrylic elastomeric latex coatings used in roofing systems. ASTM D6083 addresses two important shortcomings in the industry that greatly impacted how facilities professionals could assess whether a specific acrylic roof coating met minimum property and performance criteria:

- The absence of one unifying set of performance requirements left manufacturers presenting product data that varied in scope and emphasis.
- The frequent reference to test protocols that did not fully define testing conditions so that data generated under such protocols could not be directly compared.

Manufacturers routinely list Tensile Strength and Elongation values for their coating products. High performance acrylic coatings have substantial strength and flexibility—or so-called "toughness". Prior to ASTM D6083, manufacturers frequently referenced ASTM D412 "Standard Test Methods for Rubber Properties in Tension," but ASTM D412 unfortunately does not clearly specify key testing and equipment conditions such as the gage length and cross head speed of the Instron machine, or the exact temperature and humidity conditions for the test. Conducting the ASTM D412 tensile strength and elongation tests at different conditions can significantly affect reported results. Because of this, facilities professionals would sometimes end up comparing "apples to oranges" when trying to decide on an acrylic roof coating that best suited their needs.

ASTM D6083 clarifies test conditions, especially regarding tensile strength and elongation that comprise toughness. The sample shape is precisely defined (and different than ASTM D412), temperature and humidity are fixed, and cross head speed and gage length are standardized. This means that all test results from ASTM D6083 are directly comparable, unlike those from ASTM D412, and facilities professionals now have a means to compare "apples to apples."

Now, products from the same manufacturer or different products from different manufacturers can be directly compared, provided ASTM D6083 results are used. The informed facilities professional can appreciate that ASTM D6083 sets a minimum standard for certain physical and performance properties. In specific applications, performance beyond these minimums is required and specific ASTM D6083 test results become an important indicator of this additional performance requirement.

Of course, the ASTM D6083 standard also sets criteria for other important acrylic coating properties like wet adhesion, tear resistance, accelerated weathering, low temperature flexibility, water vapor permeability, water swelling, fungi resistance, volume solids and viscosity. Given these latest objective standards, contractors, specifiers and end-users should reasonably expect acrylic coating manufacturers to:

- Provide Product Data Sheets (PDS) that refer to ASTM D6083 property and performance results.
- Make available third party ASTM D6083 test reports that support PDS information.
- Note where specific coating products might not meet ASTM D6083 criteria and explain whether such deviations affect roof system performance from the standpoint of a specific building situation and the balance of performance properties most appropriate to the weatherproofing need.

THE EQUALLY-IMPORTANT MANUFACTURING PROCESS

Too often, we concentrate on a coating recipe or formulation and underestimate the important aspects of how raw materials are processed to ensure consistent quality finished product. Long-lasting acrylic coating performance results from a properly designed formulation coupled with state-of-the-art manufacturing and quality assurance. Total quality entails:

- A coating product that always meets the performance standards summarized on ASTM D6083 product data sheets.
- A coating product based on a well-defined formulation recipe proven to have long-term exterior durability.
- A coating product that exhibits good storage stability and is easily applied using industry standard equipment without any problems and hassles that could affect the uniformity, overall quality and resulting waterproofing performance.

High quality coating manufacturers will supply acrylic waterproofing coatings ready-to-use, unlike typical paint manufacturers whose products need special mixing prior to application. To ensure consistent application, coatings must be uniform in appearance, rheology and texture with no agglomeration of pigments. Odd-sized pigment particles and typical polymer "skins" must be removed from final coating products to ensure efficient, consistent and uninterrupted application—typically by airless spray equipment. And any advanced coating manufacturer must have process controls in place to minimize air entrapment during dispersing and blending operations to avoid voids in cured coatings that will actually compromise coating strength properties and durability.

INSTALLING SYSTEMS FOR SUPERIOR RESULTS

As with all waterproofing systems, improper installation can compromise the expected performance of a high quality coating recipe manufactured under a comprehensive quality system. Waterproofing is a system involving quality materials, appropriate installation specifications, and a qualified installer. Quality-oriented contractors, specifiers and end-users intent on installing coating systems that provide long-lasting, cost-effective weatherproofing should investigate a manufacturer's approval process for new and existing applicators. Are contractors approved based on current job opportunities, or are there systematic procedures for evaluating a contractor's capability to consistently install high performance waterproofing systems? Does an "approved applicator" letter or plaque have a comprehensive assessment behind it, or does a coating manufacturer "rubber stamp" a prospective contractor customer? Given the costs and risks involved safeguarding property and personnel on commercial and industrial projects, coatings customers should carefully assess how a manufacturer qualifies contractors based on various business and workmanship standards that include:

- Track history of the contractor company.
- Appropriate project and client references.
- Organizational capabilities in terms of personnel and equipment.
- Bonding and insurance limits.
- Overall financial strength.
- Training and industry certifications earned.
- Participation and leadership in professional organizations.
- Approved applicator status with other leading roofing companies.
- Safety and quality assurance programs.
- Findings from actual field inspections.
- Participates in independent inspection by third party consultants.

CLOSING COMMENTS

Weatherproofing commercial and industrial buildings with high performance acrylic coating systems is proven and cost-effective. But contractors, specifiers and end-users must now discriminate among a multitude of products offered by several manufacturers. For the many reasons discussed in this article, not all products are created equal and not all manufacturers are created equal. Keeping this reality in mind, customers of acrylic coatings should ask some probing questions prior to specifying, buying and installing the "latest, greatest acrylic" offered at the "best price."

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