The durability of concrete is an important concern for owners of concrete highway barriers and dividers (sometimes known as Jersey barriers). Concrete can provide good performance throughout the service life of the barrier. Good concrete can have an extremely long life span under the right conditions.

Water, although important for concrete hydration and hardening, can also play a role in decreasing the durability of concrete. Water not consumed in the hydration reaction will remain in the microstructure pore spaces and create tiny capillaries. In areas of the country that are subjected to freezing and thawing, water containing de-icing chemicals is drawn into the concrete through these capillaries. This external source of alkali reacts with the amorphous silica in the aggregates to form an alkali-silica gel. As this gel swells, causing an increase in pressure and expansion and cracking of the aggregate, the concrete cracks and shows signs of spalling. Such deterioration ultimately adds costs for maintenance and replacement of the concrete barriers. To prevent this deterioration, many DOTs in the United States specify a pigmented coating for concrete barriers on their Qualified Products List (QPL). The specified systems include both smooth and textured finishes, and range in technology from solvent-borne (including coatings based on epoxies, acrylics and vinyltoluene resins) to waterborne (including acrylics).

With increasingly stringent health, safety, and environmental regulations, waterborne coatings systems offer coatings users a safe and effective method for protecting their structure. The impact of environmental regulations on paint and coatings manufacture and application is perhaps most obvious in the lowering of volatile organic compound (VOC) limits. Waterborne coatings are one way in which coating manufacturers are trying to meet the strict limits. Waterborne acrylic coatings also offer the advantages of lower toxicity, lower odor, lower or no risk of flammability, easy and safe clean-up, and less hazardous disposal relative to solvent-borne coatings. And waterborne acrylics have also shown excellent performance in real world scenarios and are being used increasingly in light- and medium-duty industrial maintenance applications.

In this article, we describe the development of a new waterborne elastomeric acrylic resin designed specifically to survive the thermal rigors a coating for highway barriers must endure. The article begins by explaining how an elastomeric waterborne acrylic resin became the focus of the study. The article then describes testing of a coating based on the new resin against a variety of commercially available coatings for highway barriers.

**Direction of the Study**

The study described in this article was initiated with the goal of developing a waterborne acrylic coating that has good performance over concrete and that might be suitable for the particular application of concrete highway barriers. To
determine the direction of the investigation, several commercially available waterborne resins were evaluated in coatings over concrete for resistance to spalling in the thermal cycling protocol. The resins were chosen to span the various acrylic technologies currently used in architectural and industrial coatings, and were formulated into the same masonry coating formulation.

Initial resins tested included those designed for industrial maintenance, architectural, building products, and traffic/road marking coatings. The coatings based on industrial maintenance, architectural, and traffic paint binders proved to be much too hard to survive the expansion and contractions of the concrete during thermal cycling. The coatings cracked, wrinkled, lost adhesion, and in some cases almost completely delaminated. The best performing coating was based on a waterborne elastomeric acrylic resin. Although it still showed some minor blistering of the film, there was no evidence of the film cracking or splitting. Results of this early screening can be seen in Fig. 1.

It appeared from this early screening study that a flexible resin with a low glass transition temperature (Tg) would be especially suited to withstand the forces of expansion and contraction which the concrete substrate undergoes during thermal cycling; hence, we focused our development work on modifying the existing elastomeric waterborne acrylic to make it suitable for highway barrier service. Because of their low Tg and corresponding low minimum film formation temperature (MFFT), elastomeric acrylic resins can be formulated at very low VOC levels, often less than 50 g/L. They can also be applied in fairly thick films (e.g., one coat at 20 mils of dry film thickness) without mudcracking, which is very difficult to achieve with higher Tg waterborne acrylic resins. Modifications to the elastomeric acrylic binder have led to the development of a new resin. A coating based on this experimental waterborne acrylic polymer was then made and compared to commercial controls in testing on concrete substrates. The test method is described in the next section.

**Test Method**

Coatings were tested on concrete using ASTM C 672, a test method for spalling resistance of concrete surfaces exposed to deicing chemicals. Spalling, also called scaling, is the loss of surface material in patches of varying size. Damage can occur when water, trapped in the cement paste or absorbed by porous aggregate, freezes. The resulting expansion and contraction creates stress throughout the concrete. When the pressure from the ice exceeds the strength of the concrete, the concrete weakens and fails. Freezing also causes aggregate failure, especially close to the exposed surface.

The ASTM C 672 method used consists of applying the coating by brush or airless spray to a 4” x 6” concrete block, and drying at ambient conditions for 1 week. Caulk is applied around the edge of the block to form a dam to hold a 1/4” layer of water on the coated surface. Water is ponded on the surface and frozen at -18 C (0 F) for 16 hrs. The block is removed from the freezer, and approximately 6 g of sodium chloride is sprinkled on top of the ice. The ice is allowed to melt for 4 hrs, and then the resulting solution is rinsed off the surface with fresh water. The block is dried for 4 hrs and rated for blistering, wrinkling, and damage to the coating or concrete. The cycle is then repeated. On weekends, the samples are left in the freezer, so one week yields five cycles.

Separate experiments were run with a modification to the ASTM method to allow for another factor of exterior weathering – exposure to UV light. The coatings were first subjected to a week of exposure in an accelerated weathering cabinet that includes UV exposure, and
with an undamaged coating was always run for comparison. The concrete test substrates included standard concrete made according to ASTM C 192 standards for a 4000 psi mix and aged over 28 days. Natural sand was used as the fine aggregate and crushed stone (3/8 in.) was used for the coarse aggregate. Concrete prepared according to ASTM C 192 and aged outdoors for one year was also used to simulate the painting of weathered concrete. In addition, high water content concrete was prepared using a 10% excess of water, and concrete with a high salt content concrete was prepared by adding 0.2% sodium chloride to the concrete mix. For the high water and salt content concrete, a 6/2/1 ratio of a sand/Portland cement/water mixture was used, and the coarse aggregate was omitted.

Commercially available coatings used in the testing on concrete included a solvent-borne two component epoxy, a solvent-borne textured coating based on a vinyltoluene acrylic resin, a solvent-borne acrylic, and a waterborne acrylic coating based on a higher Tg resin. All of the commercial systems included in this study are products which appear on Qualified Product Lists (QPL) of various United States transportation agencies for use over concrete highway barriers. Experimental waterborne acrylic binders were formulated into a white topcoat formulation (36% PVC, 58% volume solids) using titanium dioxide and calcium carbonate pigments.

The commercial coatings were applied at their recommended film thicknesses. The solvent-borne acrylic and waterborne acrylic (based on higher Tg resin) were applied in two coats in order to obtain the desired film thickness.

**RESULTS AND DISCUSSION**

Results of the cyclic freeze/thaw test (ASTM C 672) are shown pictorially in Figs. 2 through 4.

The cyclic method involves ponding water on the surface of the coating, freezing overnight, and then thawing with the
Bayer Polyaspartic and Waterborne Polyurethane Resin Technologies

Solutions for Today's Coatings Problems

Polyaspartics
- Fast cure
- High film build (25 mils)
- Non yellowing
- Color and gloss retention

2K Waterborne Polyurethane Resins
- Odorless
- 24-hour cure time
- Abrasion resistant
- 0.250 g/l VOC
- UV light stable
- High gloss
- Ultra-low VOCs
- Weatherability

www.PolyasparticCoatings.com
www.WaterbornePolyurethanes.com

Call your coatings supplier for more information on polyaspartic and waterborne polyurethane coatings.
aid of deicing chemicals, in this case sodium chloride. An uncoated concrete block, run as a control, began to show scaling of the concrete surface after only 6 cycles, and had heavy deterioration with exposed aggregate after 30 cycles. The experimental waterborne elastomeric acrylic coating performed very well in this test, and after 50 cycles showed no signs of damage. The waterborne acrylic based on a higher Tg binder also showed no damage after 50 cycles. The good performance of the waterborne systems is probably related to their good flexibility, as the failure mechanism for the solvent-
borne systems appears to be initial cracking and flaking of the film, which then exposes the bare concrete.

The better adhesion of the waterborne acrylics is another likely factor in their good performance. As shown in Fig. 2, the solvent-borne systems began to show damage to the coating and concrete at much earlier times. Although difficult to see from the photograph in Fig. 2, the textured vinyltoluene acrylic started to fail by flaking of the paint after only 10 cycles. A close-up of the failure mode at 10 cycles is shown in Fig. 3, and after 25 cycles, 100 percent of the coating surface showed this type of failure. The two-component solvent-borne epoxy displayed film cracking and adhesion loss after 42 cycles. The solvent-borne acrylic coating failed completely at even earlier times, and after only 20 cycles much of the coating had flaked off the concrete.

Similar results were obtained on coatings that had been damaged prior to the cyclic testing (Fig. 4). Even after having been scored by a knife, the experimental elastomeric waterborne coating performed very well with no blistering or adhesion loss after 50 cycles. The solvent-borne two-component epoxy and solvent-borne acrylic showed similar failure mechanisms as for the undamaged films, but only at much shorter times. The cuts in the film no doubt allowed faster water penetration, resulting in a greater expansion and contraction of the concrete. The textured vinyltoluene acrylic began to fail through the same flaking mechanism pictured in Fig. 3, but at approximately 15 cycles.

Exposure to UV light is another of the
forces to which exterior coatings are subjected. It was decided to modify the ASTM C 672 test to also include UV exposure, to better simulate the stresses which a film may experience in actual weathering. A week of UV-A exposure was added to the test after every 5 freeze/thaw cycles.

The experimental waterborne elastomeric acrylic resin, in a simple, 36 PVC, 58% volume solids, white formulation, was compared to the same commercially available coatings used in the previous test. The solvent-borne commercial controls, including a two-component epoxy, a textured vinyltoluene acrylic, and an acrylic displayed the same modes of failure (cracking and peeling) but at a much faster rate. The commercial waterborne system based on a higher Tg acrylic resin, which performed very well in the previous test after 50 thermal cycles, did start to show some cracking in this test after 8 weeks of UV-A exposure and 40 thermal cycles. The experimental elastomeric acrylic showed no blistering, cracking, or splitting of the
films after 10 weeks of UV-A exposure and 50 thermal cycles.

To stress the experimental system even more and also mimic the real world variability of concrete, a test series was performed over various types of concrete. A control concrete was made using a 6/2/1 Sand/Cement/Water composition. A very porous concrete was made by increasing the water level 10%. To increase the alkali/aggregate reaction, 0.2% sodium chloride was added to another batch of concrete, which did produce surface crazing of the dried concrete. Finally, since it is known that concrete hardens as time passes, and the hydration reaction gets slower and slower as the calcium silicate hydrate forms, a control batch of concrete was aged outdoors for 12 months. The experimental waterborne coating was again compared to commercially available systems recommended for con-

---

Fig. 5 (facing page): Experimental elastomeric acrylic and commercial coatings after ASTM C 672 thermal cycling and UV-A exposure on high salt content concrete. Coatings on concrete made with 0.2% salt added to concrete mixture.

Fig. 6: Example of small cracks seen in the commercial waterborne acrylic based on a higher Tg resin. Close-up of the surface cracking mode of failure observed for the harder, commercial waterborne acrylic coating after 30 cycles of the cyclic freeze/thaw test (ASTM C 672) and 6 weeks of UV-A exposure. Close-up corresponds to the concrete block pictured in Fig. 5. Scale shows one millimeter per division.
Fig. 7 (above): Experimental elastomeric acrylic and commercial coatings after ASTM C 672 thermal cycling and UV-A exposure on very porous concrete. Coatings on porous concrete, made with 10% additional water in the concrete mixture.

Fig. 8 (right): Close-up of the surface cracking mode of failure. Close-ups correspond to the concrete blocks pictured in Fig. 7.
crete highway barriers.

The uncoated concrete blocks, ran as controls, began to show scaling of the concrete surface after only 5 freeze/thaw cycles and 1 week of UV-A exposure. All uncoated blocks were heavily damaged after 10 thermal cycles and 2 weeks of UV-A exposure. Figures 5 and 6 show the results for the coatings on the “high salt” concrete. The experimental elastomeric waterborne acrylic coating performed very well, and after 50 cycles showed no signs of damage. The two-component epoxy and the solvent-borne acrylic coatings displayed severe film cracking and adhesion loss after 30 cycles. The commercial waterborne acrylic did have many hairline cracks by 30 cycles, an example of which can be seen in Fig. 6. The “high water” concrete produced similar results, although not as dramatic, and can be seen in Fig. 7. The 2K epoxy system and the solvent-borne acrylic have many hairline cracks which can be seen in Fig. 8. The concrete that had been aged for 12 months showed excellent strength and durability. All coatings over the aged concrete performed quite well, suggesting that in repaint situations or when painting previously unpainted concrete which has weathered, the choice of coating is less critical than when painting new concrete.

Often, the base of a highway barrier is striped with a traffic paint containing reflective beads as a safety feature. Although commercial traffic paints perform very well on concrete and asphalt roads and pass numerous freeze/thaw cycles in the field, there have been some reports that they can lose adhesion to the smooth, vertical concrete highway barriers. However, if the entire barrier were painted with the experimental elastomeric acrylic, then adhesion of the traffic paint to the bare concrete is not critical. To test this concept, a concrete block was coated by airless spray with the new elastomeric acrylic and dried vertically before it was striped with a commercially
available traffic paint and reflective glass beads. The coatings were tested according to the ASTM C 672 procedure. The experimental acrylic has excellent compatibility and adhesion with commercially available reflective traffic paints and showed no signs of failure after 50 thermal cycles (Fig. 9).

**CONCLUSIONS**

The results from the evaluations over concrete demonstrate that a new waterborne elastomeric acrylic resin can produce coatings with the same excellent adhesion to concrete and masonry surfaces as their predecessors have shown as architectural wall coatings over masonry surfaces.³ Their flexibility leads to efficient bridging of minor surface cracks, and allows some movement of the crack from temperature changes without damage to the film. The results shown here suggest that this flexibility also allows good resis-
G-Shield 74™

Graffiti and dirt protection in one coat

Clariant has developed an easy-to-use, easy-to-clean, clear solution against aggressive and damaging graffiti and unsightly dirt.

G-Shield 74™ is an innovative, durable coating which provides protection from graffiti and grime. Markers, paints, inks, tar, sap, grease, dirt and other stains cannot permanently adhere to the G-Shield 74™ protected surfaces.

Additionally, G-Shield 74™ will not alter the normal appearance of the substrate and is resistant to commercial cleaning solutions, and aggressive brake fluids. The protected material can be cleaned numerous times without reaplication or damage to G-Shield 74™.

G-Shield 74™ can be easily applied and because it is a thin coating, G-Shield 74™ is very economical — especially for large surfaces.

In addition to protection from graffiti and grime, G-Shield 74™ provides effective protection from UV radiation and weathering. Compared with unprotected surfaces, the G-Shield 74™ protected surface displayed no tarnishing, gloss reduction, scratching, or paint damage.

Did we raise your interest?
Please contact Stephanie Melton

150 N. Specialty Polymers
A Clariant Corporation Business
1967 A. Pioneer Road
Huntingdon Valley, PA 19006

Tel: 215.937.6100
Fax: 215.937.6224
stephanie.melton@clariant.com
www.kovocorp.com

Click our Reader-e-Cart at paintsquare.com/hv
tance to the stresses imposed by freeze/thaw cycling and deicing chemicals. The more rigid solvent-borne coatings evaluated in this study fail under these thermal stresses due to cracking of the film, and the resultant intrusion of water and salts.

New developments in waterborne acrylic polymer technology provide coatings for industrial applications that also possess a number of other desirable attributes. Benefits over solvent-borne coatings include lower VOC levels, low toxicity, user-friendliness (e.g., one component coatings), and easy cleanup that are already key properties of waterborne coatings. This study has also shown that the performance of the waterborne elastomeric acrylic coating can equal or exceed that of commercial solvent-borne products. Good adhesion properties and protection of the concrete from freeze/thaw cycling, water, and deicing chemicals suggest that waterborne elastomeric acrylics could find utility in the maintenance of our transportation infrastructure, as well as for other industrial maintenance of concrete.

The ability of the coating to perform well over a variety of "good" and "bad" concrete is a key benefit, and would allow the use of this technology for both acceptable and marginal substrates. Compatibility with commercial traffic striping paints also suggests that a good coating system for concrete highway barriers would consist of an elastomeric acrylic basecoat with a stripe of reflective traffic paint. This system combines the safety benefits of the reflective stripe with that of the white basecoat because a white barrier will reflect light better than a dark barrier and improve pedestrian and driver safety at night.4

REFERENCES
Dr. Leo J. Procopio received his Ph.D. in inorganic chemistry from the University of Pennsylvania. He joined Rohm and Haas Company at its Spring House, PA, research laboratories in 1991 as a senior scientist in the Industrial Coatings group. He was initially involved in new product development of waterborne acrylic latex coatings for concrete substrates. He has spent the past 12 years carrying out exploratory research, new product development, and technical service work in the area of waterborne coatings for the industrial finishes market. He is a group leader in the Architectural and Functional Coatings Technical Service department at Rohm and Haas. He is a member of the ACS, FSCT, and SSPC, and he chairs the SSPC committee C.1.4.c on Waterborne Acrylic Coatings.

Anne M. Bacho has been a chemist with Rohm and Haas Co. for 20 years. For the past five years, she has conducted research for industrial and maintenance coatings for protecting metal. Before that, she worked on polymer design for wood, roof, and wall coatings; inks and graphic arts; and floor polishes, earning five patents for her work in those areas. A member of SSPC, she serves on Committee C.1.4.A, Waterborne Acrylic Coatings and Committee C.7.2, Concrete Coatings. She is also a member of the American Concrete Institute and the Philadelphia Society for Coatings Technology. She is a graduate of LaSalle University with a Bachelor’s degree in chemistry.


Setting the Standard for
Surface Cleaning Equipment all over the World

Abrasive transport and recovery equipment.
Vacuum and/or mechanical.

Ventilation systems.
Portable and stationary.

Dehumidifiers.
Adsorption or refrigerated.

Blast room design & installation.
Equipment for complete blast-and paint room installations.

Call us and benefit from more than 3 decades of experience...