Applying Epoxy Coatings Underwater and On Wet Surfaces

By Paul Oman* 2/01

Underwater painting sounds like some sort of parlor trick, but there are actually a number of epoxy coatings ad repair products that can be applied to damp, wet, saturated, or submerged surfaces as well as used in environments of very high humidity. Typical work sites can include pits, sumps, underwater supports, boats, piers and pilings and all sorts of below grade structures. The ability to patch, seal, encapsulate, reinforce, and protect objects, in place and in wet environments, is a much more attractive option than the alternative which is usually demolish and rebuild from scratch.

Despite the obvious advantages of moisture tolerant coating/repair products, such epoxies are not widely known or understood. The concept of underwater painting remains out of the belief of most industrial and marine maintenance professionals. However, with a slowing economy and fewer replacement dollars available, in situ rehabilitation of existing structures, no matter their location, is becoming more of a more likely option.

Epoxy Basics

First formulated in the late 1930s in the U.S. and Switzerland, epoxies can be considered a two-part, thermoset plastic. Mix two liquid components together, a heat producing reaction (known as 'Exotherm') occurs, and a hard product results. Some basic and general characteristics of epoxies are: 1) easy cure temperatures, generally from 5-150 degrees C; 2) low shrinkage; 3) high adhesive strengths; 4) high mechanical properties; 5) high electrical insulation; and 6) good chemical resistance.

With so much going for it, epoxies were produced as commercial adhesives in 1946 and as commercial coatings by 1947. The versatility of epoxies was further advanced with the early formulations of epoxies that could be applied in an uncured state to wet surfaces. These special epoxies have evolved from rather crude, unfriendly products into high performance, applicator friendly coatings.

Epoxy Curing Agents

The curing agent selection plays the major role in determining many of the properties of the final cured epoxy. These properties include pot life, dry time, penetration and wetting ability. Curing agents come in many different chemical flavors, generally based upon amines or amides. Amine based curing agents are considered to more durable and chemical resistant than amide based curing agents but most have a tendency to 'blush' in moist conditions. Blushing produces a waxy surface film on actively curing epoxy, the result a reaction with the curing agent and moisture in the air. Other potentially toxic chemicals within the curing agent can also be released in the same manner, thus amines are often viewed in light of these potential shortcomings. Amides, on the other hand, are more surface tolerant and less troubled by moisture. Fortunately for epoxy end-users involved with underwater applications, there is a small subgroup of non-benzene ring structured amines that maintain all the benefits of amines while removing the toxic leachability and moisture attracting properties of typical amines. These special polyamines form the basis for today's cutting edge underwater epoxies.

How Epoxies Work

The well known adhesion of epoxies is due to the strong polar bonds it forms with the surfaces it comes in contact with. On dry surfaces the bond between the surface and the epoxy displaces the air, which is a fluid. The same is true underwater. As on dry surfaces, the polar bond attraction is strong enough to displace the fluid, in this case the water, and produce an strong bond even underwater. Thus, painting underwater is, in theory, no different that painting above the water. The cross linking reaction of epoxies should be independent of the surrounding environment. Still most curing agents will react with water molecules rather than the epoxy base, resulting in a waxy film, mentioned above, known as amine blush. This makes them unsuitable for underwater application.

At least one modern hydrophobic, underwater epoxy goes one step farther to ensure a strong underwater polar bond with the introduction of a proprietary 'bond enhancer'. This is important because many marine structures are subjected to active cathodic protection systems. Such systems place an electrical charge on the structure's surface that will literally and actively repel the epoxy's existing polar bonding surfaces. The enhancer provides additional polar bond surfaces that are also firmly anchored into the crosslinking epoxy structure.

Epoxy Evolution

Three generations of apply underwater epoxies have emerged over the years. Each has pushed the technology window forward. The success of first generation epoxies was in their ability to be applied and cured underwater. The next generation moved these epoxies into true coating status, albeit with issues of user friendliness and chemical safety issues still to be addressed. The new third generation epoxies have addressed those issues successfully.

<u>First Generation Underwater Epoxy Coatings</u>
*Sticky, like Bubble Gum
*Knead the two parts together in hand-sized amounts and push on to the surface
*Potentially difficult to ship - may require haz-mat shipping (Corrosive Liquid -N.O.S.)
*May have short shelf life.

<u>Second Generation Underwater Epoxy Coatings</u>
*Good underwater adhesion
*True bonding instead of sticking
*Poor storage stability (heating required) - products tended to crystalize over time
*Toxic - MDA and possible solvents
*Haz-mat shipping required

*Problem bonding to cathodically protected surfaces

Third Generation Underwater Epoxy Coatings
*Stable storage - will not crystalize over time
*Basically Non-toxic, 100% solids (0% VOC), no MDA
*Non haz-mat - unregulated shipping
*Improved application on cathodically protected surfaces
*Easy application results in productivity increase

Two Examples Of Third Generation Underwater Epoxy Repair

UNDERWATER EPOXY REPAIR – A large oil fueled power station located on the Gulf of California in Mexico receives fuel oil from tankers which unload at a deep water terminal. The discharge terminal is built at the end of a 1.2 Km long concrete pier built on 30 and 36 inch diameter steel pilings. The pier was suffering from advanced corrosion in the 'wind and water' area at its waterline. The pilings were fouled with marine growth, corrosion products and the residues of the failed coating applied at construction. Repair of the coating system had to be accomplished in the water using divers.

Epoxy was applied over the steel piling surface which had been freshly blasted using 4,000 psi water entrained river sand abrasive. The surface obtained was a mixture of white metal with islands of roughened, tightly adhering existing coating which is highly satisfactory for this application. The divers and other workers employed in this project had little previous experience of this type of work but were immediately able to properly mix and apply the modern, third generation, underwater epoxy and obtain an excellent result.

Under the conditions of application in approximately 65 - 85°F (18 - 29°C) water the epoxy cured to a firm 30-50 mil film thickness after 6-3 hours, respectively, and hard overnight. Wave action had no effect whatsoever even immediately after application before any curing had taken place. The modern epoxy showed tenacious adhesion compared to the traditional splash zone putty type products. Diver productivity was also markedly better when using modern underwater epoxies that are applied with a spreading action rather than using 'pattycake' type action of pushing and sticking handful by handful amounts of early generation putty type underwater epoxies. Later inspections showed that the epoxy coatings were still in perfect condition after two years salt water service in cold and stormy winters and hot and humid summers.

UNDERWATER EPOXY REPAIR – The largest aquarium in Australia is located in Canberra. The centerpiece attraction in this facility is a large shark encounter type tank in which visitors walk through a plexiglass tunnel set inside the tank so that the fish are on the outside and the visitors are on the inside. After some years of service there were several slow leaks inside the visitor tunnel which appeared to come from fiber optic lighting fixtures exiting the rocks at the base of the tunnel. Short of draining the entire tank it was not possible to seal these fixtures using conventional materials or techniques.

Two aquarium divers entered the aquarium equipped with a third generation underwater epoxy and abrasive pads for cleaning the fiber optic terminals. After scouring the immediate area the epoxy was applied over and around five terminals using spatulas. Adhesion to the rock and glass surfaces was strong and immediate. The one repair which could be seen by visitors was hidden by sprinkling sand and debris on the uncured epoxy repair before leaving the tank. The repairs were accomplished with no distress to the fish living in the tank.

Potential Application For Underwater Epoxies

IN-SERVICE BALLAST TANK REPAIR/COATING -- ship ballast tanks are large structures with limited access. A wing tank, for example, may be over 70 feet high from tank top to overhead. Examination of tank surfaces for corrosion generally requires extensive scaffolding in order to work safely and effectively. Scaffolding is time consuming, expensive and damages existing sound coatings because of impacts during erection and tear-down. Vessels built using reduced scantlings have little safety margin available to accommodate steel lost by corrosion. An underwater repair treatment would offer the opportunity for early repair, isolating steel corrosion which could prevent more costly repairs or even steel replacement if repair was deferred until a future scheduled drydocking.

Professional diving services and technically advanced underwater epoxies would enable permanent repairs to be made to ballast tank linings without disrupting normal operating schedules. Drydock expenses related to ballast tank repairs would be reduced by eliminating costs of scaffolding and possibly by reducing time in dock. Future costs would be reduced by eliminating scaffolding damage during current work. During the course of normal vessel operations it is possible to press up ballast tanks to the overhead using clean ocean water. With a tank filled with clear water it is possible to gain close access to all immersed surfaces using a diver supported with surface supplied air and electricity for lights, closed circuit TV and communications.

Closing

The underwater applied coating market remains a small niche within the much larger industrial and marine maintenance marketplace. Both first and second generation underwater coatings are still widely in use, primarily because of the conservative nature of the industry and the acceptance of less than user friendly underwater products. Too few users and potential users/applicators of underwater coatings are aware of the advances made in recent years. This is changing as the shift toward environmentally friendlier, and easier to use coatings are slowly causing the re-evaluation of old familiar products and the introduction of new companies with new products that better meet today's expectations. The ability of a single product to be effectively used on dry surfaces, underwater, or on saturated or dripping metal/concrete surfaces, while being both environmentally and user friendly, represents a technology that will continue to gain acceptance. The savings associated with in-situ underwater repairs and coating projects is often easy to document, as are the potential benefits from even more ambitious applications of this maturing coating technology.

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