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Underwater Coatings For Contamination Control

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UNDERWATER COATINGS FOR CONTAMINATION CONTROL

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ABSTRACT

The Idaho National Laboratory (INL) deactivated several aging nuclear fuel storage basins. Planners for this effort were greatly concerned that radioactive contamination present on the basin walls could become airborne as the sides of the basins became exposed during deactivation and allowed to dry after water removal. One way to control this airborne contamination was to fix the contamination in place while the pool walls were still submerged. There are many underwater coatings available on the market for marine, naval and other applications. A series of tests were run to determine whether the candidate underwater fixatives were easily applied and adhered well to the substrates (pool wall materials) found in INL fuel pools.

Lab-scale experiments were conducted by applying fourteen different commercial underwater coatings to four substrate materials representative of the storage basin construction materials, and evaluating their performance. The coupons included bare concrete, epoxy painted concrete, epoxy painted carbon steel, and stainless steel.

The evaluation criteria included ease of application, adherence to the four surfaces of interest, no change on water clarity or chemistry, non-hazardous in final applied form and be proven in underwater applications. A proprietary two-part, underwater epoxy owned by S. G. Pinney and Associates[1] was selected from the underwater coatings tested for application to all four pools. Divers scrubbed loose contamination off the basin walls and floors using a ship hull scrubber and vacuumed up the sludge. The divers then applied the coating using a special powered roller with two separate heated hoses that allowed the epoxy to mix at the roller surface was used to eliminate pot time concerns. The walls were successfully coated and water was removed from the pools with no detectable airborne contamination releases.

INTRODUCTION

The Idaho National Laboratory (INL) deactivated several aging fuel storage basins that were no longer needed. Testing was completed to ensure radioactive contamination present on the basin walls could not become airborne and spread as the sides of the basins became exposed and allowed to dry subsequent to water removal. One way to preclude airborne contamination was to fix the contamination in place while the pool walls were still underwater. A series of tests were run to determine whether the candidate underwater fixatives were easily applied and adhered well to the substrates (pool wall materials) found in INL fuel pools.

[1] PRODUCT DISCLAIMER: References herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, do not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government, any agency thereof, or any company affiliated with the Idaho National Laboratory.

Through the use of internet searches, phone calls, and email, fourteen candidate underwater coatings, shown in Table 1, were targeted for tests. Substrate materials representative of those found in the Test Area North (TAN-607) pool with epoxy painted concrete walls, the Materials Test Reactor (MTR) canal with stainless steel lined concrete walls, the Power Burst Facility (PBF-620) with stainless steel lined concrete walls on the bottom and epoxy painted carbon steel lined walls on the upper portions, and the bare concrete walls of the 603 Overflow Pit, an isolated portion of the 603 basins at the Idaho Nuclear Technology and Engineering Center (INTEC) were also chosen for testing. The typical water temperature in the pools varies from 55^{o}F to 80^{o}F, depending on the individual pool and the season, respectively. Lab tests were conducted at room temperature, which also varied between 55^{o}F to 80^{o}F.

Table I. Underwater Coatings Evaluated[2]

Product Name	Supplier
Wet/Dry 700 Epoxy	Progressive Epoxy Polymers, Inc.
Ultra Phix-UW	Ultra Polymers, Inc.
NMP 1710 Epoxy	National Maintenance Products
NMP 1720 Epoxy	National Maintenance Products
Corro-Coat FC 2100 Epoxy	Progressive Epoxy Polymers, Inc.
Alocit 28.15 Epoxy	Alocit Systems
Carboguard Mastic A-788	Somay Product
Diver-cote RA 500UW-HV	Chemco International
Diver-cote RA 500UW-LV	Chemco International
Marine-Flex 570	Edison Coatings Inc.
Euro-vinyl CV02	Euronavy
Euro-paste 326	Euronavy
Euro-diver 1 323 Epoxy	Euronavy
UT-15 Underwater Epoxy	Picco Coatings Co. (S. G. Pinney)

The following performance criteria were evaluated during the tests. The underwater coating must:

- Be easy to apply
- Adhere well to the four surfaces of interest

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- Not change or have a negative impact on water chemistry or clarity
- Not be hazardous in final applied form
- Be proven in other underwater applications.

In addition, it is desirable for the coating to have a high pigment or high cross-link density to prevent radiation from penetrating.

TEST PROCEDURES

The coatings were applied underwater in a non-radioactive test at the North Boulevard Annex (NBA). Each coating was applied to four different substrates: epoxy-painted concrete; bare concrete; epoxy-painted carbon steel; and stainless steel. The test equipment included clear plastic containers (1.5 feet deep, 2.5 feet long, 1.5 feet wide), brushes, rollers, trowels, stirring sticks, and small containers for mixing up the coatings. Before use, the test containers were washed with soap to remove surface contaminants.

. The stainless steel and carbon steel test coupons were cut (8" squares) from stock material. The carbon steel plates were then painted with epoxy paint and allowed to cure according to manufacturer's recommendations. Standard concrete bricks (6000 psi concrete – 4" wide X 8" long X 2" deep) were also used and half of these bricks were coated with epoxy paint. Before placing the steel coupons in the water, they were washed to remove loosely adhered surface contaminants. The metal test coupons were glued with a silicone adhesive in a vertical orientation, to the sides of the clear plastic containers. A separate container was used for each coating to avoid cross-contamination among different fixatives. Concrete test coupons were placed in water to soak for at least 48 hours before the start of testing then transferred to the test container with the metal samples and the test container was filled with water. To avoid excessive rusting of the carbon steel coupons, the test containers were filled with water on the test day. Before and during testing, the water temperature was monitored with a thermocouple since water temperature can have a significant impact on product performance and on epoxy coating pot life (the length of time between mixing and hardening).

Each coating was mixed according to the supplier's instructions. Careful attention was paid to the expected pot life to ensure that the coating was applied to all four test coupons before hardening. The coating was applied underwater to the vertical surface of each of four test coupons; one of each type of substrate material. The applicator (brush, roller, trowel) was selected based on the supplier's recommendation and discretion of the person completing the application. During application of the fixatives, observations were recorded, including the following:

- Ease of application
- Viscosity (subjective assessment)
- Effectiveness of application method
- Workability
- Applied thickness

- Product control
    - Mixing
    - Pot time
    - Runny, bubbles, lumpy
- Underwater transport of mixed product
    - Impact on water clarity
    - Chunks or drops that float or settle to bottom
    - Film on water
- Coverage
- Adhesion

After curing, the samples were analyzed by visual inspection for adhesion, surface roughness, cracking, and any other notable blemishes. In addition, an attempt to remove the fixative from the test coupon by hand scratching with a scraper (screwdriver) at an angle of about 45 degrees, and striking with a hammer was made. The results were compared to determine which coatings displayed the best adhesion to the test coupons. This information, combined with the observations made during application, was analyzed and the three fixatives exhibiting the most desirable performance, according to the above criteria, were selected. Still and video photos were taken of the test apparatus, fixative application, cured fixative, and adhesion testing.

Upon completion of the analysis, the water was disposed of in the floor drain (after straining to remove any chunks of cured coating that could have plugged the drain). The test equipment was disassembled and the test coupons were stored for future reference. The unused fixatives were disposed of or stored in approved locations.

TEST RESULTS

The three coatings that were the easiest to apply and adhered well were the NMP 1710, Corro-Coat FC 2100 Epoxy, and the UT-15 Underwater Epoxy. However, there is some concern on the Corro-Coat FC 2100 since after several weeks it broke off the stainless steel surface. Many of these coatings require a roughened surface to adhere well according to manufacturer's instructions and this may be why this coating came off. The surfaces were not roughened prior to application to more closely simulate field application conditions. In several cases, applied coatings bonded well to the epoxy painted surfaces but caused the bond of the epoxy paint to the surface of the coupon to weaken.

Water samples were analyzed for the UT-15 coating and the Corro-coat FC 2100 coating to determine the presence of undesirable organic compounds. The samples were analyzed using a carboxen SPME (solid phase micro extraction) technique. The SPME is sensitive to organics down to the part per billion range. The SPME probes were placed in the samples for approximately 15 minutes, whereafter they were inserted into the injector of a Shimadzu GCMS for analyses. No hazardous organic components were detected.

Based on these results, use of the UT-15 (Figure 1) and the NMP 1710 coatings were recommended for use in the actual fuel basins.

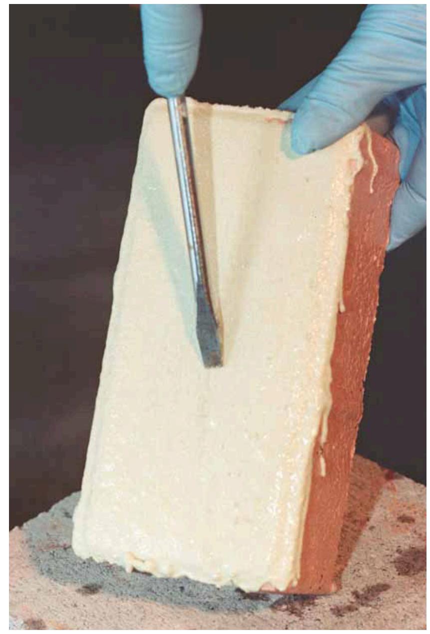

Figure 1. UT-15 adhered well to all surfaces when applying and after drying.

FUEL POOL APPLICATION

The initial baseline plan for the deactivation of the fuel basins had workers standing at the edges of the basins and on rafts or bridge cranes using long-handled tools to manually scrub the walls and basin surfaces. There was significant risk of skin contamination, of workers falling into the basin or sustaining injuries from the awkward working positions. Analysis of the safety and radiation exposure risks presented by this approach drove the team to look for a safer way to get the work done. The commercial nuclear power industry routinely uses divers to perform many types of plant maintenance and operations, including removing sludge and debris, repairing basin coatings, and welding reactor components. It was decided that divers trained for nuclear work would be used to complete the INL fuel basins cleanup and fixative application (Figure 2). The use of divers to apply the fixative underwater drastically reduced the risk of contamination from the walls and floors of the basins becoming airborne as the water was removed. Other advantages included avoiding the repetitive-stress injuries that would have resulted from the awkward working positions, elimination of an elaborate scaffolding system and reducing the risk of workers falling into the water.

Figure 2. Diver enters basin at Test Area North.

S. G. Pinney commercial divers were chosen to complete this work. Before beginning dive activities, all areas to be worked on were surveyed by the divers themselves. The potential for finding unexpected debris items during cleanup of the basins was anticipated. The dive master was in constant voice and video contact with the divers during dive operations. Divers were instructed not to pick up anything before scanning it. There were no instances in which a diver entered an unsurveyed area or picked up objects that had not been surveyed. They first scrubbed the loose contamination off the basin walls and floors using a ship hull scrubber and vacuumed up the sludge. They then applied the UT-15 coating using a two-hose power roller system, which mixed the epoxy at the roller head, and eliminated the pot life concerns.

At times, the divers had to kneel on the floor or otherwise came into contact with the basin surfaces with body parts other than their feet, which were extra heavily protected. Divers exiting the pool were surveyed immediately and occasionally found to have loose contamination affixed to their suits where contact was made with the basin surfaces. The contamination was removed and subsequent dives were made in suits with duct tape covering likely contact areas. These practices ensured all ALARA goals were met.

The epoxy coating is much more difficult to apply under water than house paint in air. It took considerable effort to get a complete coating that passed the dive master's inspection. The divers also had to deal with the bubbled and loose paint layer on the TAN basin walls and the rough, bare concrete surface on the 603 Overflow Pit walls. The condition of the existing surfaces directly affected the time needed to apply the fixative.

The project sought and received from S. G. Pinney a three-year warranty on the fixative coating for each basin. The coating is designed to last 10 years, and the warranty includes periodic inspections, with crews returning to reapply fixative as necessary. This helps ensure the pools are in safe 'storage' condition during the indeterminate time prior to closure, and also minimizes maintenance costs over the same period of time.

After the epoxy fixative coating passed inspection, water was removed from all four basins. The fixative minimized the risk of airborne contamination by trapping residual contamination on the basin walls. This allowed the pool deactivation goals to be safely met and marked another milestone in closing facilities at the INL which are no longer needed to help ensure US civilian and energy safety.

Figure 3. Applying fixative to the wall of the MTR canal.

CONCLUSIONS

Fourteen underwater coatings were evaluated in laboratory tests for use in fixing radioactive contamination prior to draining various basins and canals at the INL. Of those coatings tested, two were recommended for application to actual basins to assist in their deactivation. The primary performance criterion was how well the coating adhered to the basin surfaces, but ease of application was also considered. The coating application process was subcontracted to a scuba diving team with special training, skills, equipment, and experience in nuclear work. The UT-15 coating was applied to four different basins and canals at the INL before draining the basins. This particular coating was chosen over the NMP 1710 coating because the divers had applied it before and the diving company would provide a three-year warranty on the UT-15 coating. The use of divers to apply the fixative underwater drastically reduced the risk of contamination from the walls and floors of the basins becoming airborne as the water was removed. Other advantages included a avoiding the repetitive-stress injuries that would have resulted from the awkward working positions, elimination of an elaborate scaffolding system and reducing the risk of workers falling into the water.