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## **The Use of Optically Activated Pigmented Epoxy Systems in Water Storage Tanks**

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### **Abstract:**

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Optically Activated Pigmented (OAP) coating systems have become a U.S. Navy requirement in marine ballast tank coating applications because the OAP systems can help assure correct applications of epoxy linings. In steel and concrete water storage tanks, OAP technology can aid in eliminating holidays; identifying pin holes; and reducing premature failures caused by poor film thickness on edges, angles, or areas that are often difficult to inspect. Epoxies that meet the ANSI/NSF Standard 61 for coating of potable water service are available with OAP technology. This presentation will show how OAP technology works, the benefits of OAP technology against the difficulties of traditional holiday detector method and the field result of OAP technology.

**Key-word:** Holiday Detector, OAP Technology, Water Storage Tanks

### **Introduction:**

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Consultants and owners are constantly looking at new technology in coating formulations to increase the life cycle of their water tank linings. These technologies have included the incorporation of organic zinc-rich primers inside steel tanks and have driven coating specifiers to products with higher volume solids and film thicknesses. Led by actions of the U.S. Navy to maximize the life of coatings in immersion, a pigment can now be incorporated into coatings that enables coatings to fluoresce. Added to coatings complying with the NSF Standard 61, OAP can increase the life cycle of a coating system by insuring proper coverage and installation of high volume solids coatings.

### **The Issue:**

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#### **Corrosion in Water Storage Tanks**

A common cause of premature coating failures in water storage tanks is uncoated, exposed substrate or exposed zinc-rich primer that goes undetected during the inspection process. These conditions occur not only in the inside wet areas of a water storage tank, but also,

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commonly, in the areas above the intended water level of the vessel itself. The potential coating failure mechanisms can be broken into several distinct categories, which could all be prevented by OAP technology. Pinholes and holidays, insufficient film thickness, and improper coverage of stripe-coated areas are three of the mechanisms, and will be discussed below.

### **Pinholes and Holidays**

Basic corrosion theory tells us that any pinhole, holiday, or discontinuity exposing ferrous metal substrates will result in pinpoint rusting, undercutting of the coating around the pinhole, and, ultimately, rapid coating failure and corrosion of the steel. Pinholes or discontinuities can occur for many reasons and at any level in the painting process. Holiday detection is designed to identify pinholes, thus allowing the applicator to address the uncoated areas. Specifications typically require holiday detection, often following the NACE RP0188 recommended practice guidelines, but the guidelines can be difficult to follow in an elevated water tank, where one undetected holiday or discontinuity can result in considerable coating failure when immersed in potable water.

Failures resulting from pinholes and holidays are amplified if the pinhole is present over one of the zinc-rich primers commonly used in the fabrication of today's water storage tanks. Zinc is a highly reactive metal, and, when the pinhole is exposed to water, zinc hydroxide and hydrogen gas are produced. Blisters and coating failures caused by the reaction process are frequently located in areas that are difficult to reach for coating application and that can be difficult to inspect and perform using traditional (NACE RP0188) holiday detection testing.

### **Insufficient Film Thickness**

Maximum dry film thickness (DFT) of coatings in contact with potable water surfaces is directed by extraction testing results to comply with the NSF Standard 61. Although the standard typically is concerned with excessive film thickness, many failures in water tanks can be attributed to insufficient DFT. Since permeability of a coating is directly affected by film thickness, relatively thin coats of epoxy coatings can exhibit less than desirable permeability characteristics. When thin coats are put into water immersion service, some molecular water will eventually get through the material and can reach the substrate or the zinc-rich primer, which can lead in each case to significant failures of the tank lining.

Areas of low or insufficient film thickness typically will not be detected with holiday detection testing. Currently, there is no acceptable nondestructive test or quality assurance mechanism that can point out insufficient film thickness of successive coats of paint. The only assurance we can have is by random checks of the DFT using magnetic gauges. Random checks cannot be assurance of a consistent coating film, free of thin intermediate coats or topcoats.

### **Stripe Coating**

Among the most common areas of coating failure and early corrosion are edges, sharp angles, or radiuses of steel water storage tank interiors, both above and below the intended water level. If not addressed by stripe coating, such areas will invariably result in low coating film thickness.

Even the use of 100% solids epoxy coatings that meet “edge retentive” qualifications will often result in lower film thickness on edges due to the methods of application common in water storage tanks. Without actually observing the stripe coating, or inspecting the tank prior to overcoating these stripe coated areas, inspectors or others on water tank projects have, at this time, no method to assure that this crucial step is successfully completed according to specifications.

### **OAP Technology**

Virtually any coating can be made to fluoresce. Optically Active Additives (OAA) can be added to an existing coating in very small amounts, similar to adding a color pigment to a coating. Normally, the OAA, like a color pigment, will not have a detrimental effect on the coating or its desired performance.

### **Holiday Detection of OAP Coatings**

The visible range of the electromagnetic radiation spectrum is typically between 400 nm and 760 nm. UV-A range, which is used for OAP inspection, falls between 320 nm and 400 nm. Holiday detectors in development can contain either the lamp or LED light required to illuminate the film, and a camera sensor to scan the coated surface. The lamp/sensor head is typically connected to a small analyzer pack, which holds the controls and electronics to operate the holiday detector.

This set-up is not unlike present-day holiday detection equipment, which uses either a high-voltage wire brush or low-voltage sponge wand connected to a power device/audible alarm. When the OAP analyzer detects a holiday in the coating film, it beeps to alert the inspector. UV blocking glasses are worn when using UV-A lamps.

Some LED light manufacturers include a classification statement designating many of their products as Class 1 LED. In accordance with the International Electrotechnical Commission’s (IEC) document IEC 60825-1, Class 1 LED devices are defined as requiring no eye protection. Using the OAP instruments, the tester can cover approximately 150 square feet per minute, a rate almost as fast as the tester can move his hand in a sweeping motion. Furthermore, since the instrument does not have to be grounded or in direct contact with the coated surface, sweeps of large areas or areas that typically would be difficult or impossible to inspect with a conventional holiday detector can be done efficiently and quickly.

### **Visual Inspection of Fluorescing Coatings**

A much greater benefit to the use of OAP coating technology comes from what can be done beyond simple holiday detection. Coatings manufactured with OAA can be made to fluoresce simply by illuminating the appropriate lamp or LED. Visual inspection under the appropriate lamps will show the fluorescing coating’s presence in a coating system. When a fluorescing coating is used as the epoxy prime coat of a two coat interior coating system (such as the AWWA D102-03 Interior Coating System No. 1), simple illumination of the primer before top coating will reveal holidays, pinholes, and areas of insufficient film thickness.

Although the use of holiday detection instruments would alert the inspector to pinholes not visible to the naked eye, when the OAP coating is illuminated, black or dark spots would visually indicate the location of holidays and pinholes.

If used as the intermediate or second coat in a three-coat interior coating system, such as the AWWA D102-03 Interior Coating Systems No. 2, No. 3, or No. 5, the OAP coat could be illuminated before application of the finish coat. Illumination of the OAP coat would point out areas with insufficient film thickness or areas where the substrate or the epoxy or zinc-rich primer is visible through the fluorescing film. Areas of low film thickness could not be determined or located with traditional holiday detection. Since insufficient film thickness often occurs in difficult-to-coat and difficult-to-inspect areas, monitoring by checking DFT would also be ineffective.

In all of the AWWA D102-03 Interior Coating Systems, if the OAP coating was the prime or the intermediate or second coat, a final inspection could be done after topcoating—by illuminating the tank interior to see if the OAP product is visible. If visible, it would indicate either a holiday in the finish coat, or insufficient film thickness of the finish coat. Again, neither condition can be easily or effectively monitored by traditional means. Stripe-coating with OAP coatings would allow the inspector to verify that all areas requiring stripe coating are done, that the stripe coat is of sufficient film thickness to cover the edges, and that the coat is, in turn, covered by successive coatings.

Lastly, in-service and scheduled inspection of linings during “wash outs” or annual anniversaries could show early topcoat wear, inter-coat blistering and peeling, or breaks in the topcoat film that exposes the OAP material beneath. Again, easy determination and detection of premature coating wear or breaks in the film are not possible with traditional means of inspection. Early identification of coating failure could allow consultants and owners to quickly remedy the situation before further loss of substrate and corrosion occur.

Since the testing equipment does not need to be in direct contact with the OAP film to fluoresce and since the OAA is reactive in the wet film as well as in the dry film, a contractor could monitor progress and coverage during application of the coatings, provided that he had the appropriate lamp and the lamp was explosion proof and intrinsically safe. The contractor could then correct any deficiencies in his work while the material is still wet.

### **Traditional Holiday Detection Issues**

Using traditional electric low-voltage wet sponge testers and high-voltage spark testing holiday detectors in water storage tanks can create some concerns. As guided by the typically referenced NACE RP0188, “Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates” standard recommended practice, the tester is given guidelines for the use and rate of movement of each device. Since most water tank linings are applied at DFTs below 20 mils, the low-voltage instrument is to be used for holiday detection. For low voltage wet sponge testing, per RP0188, “the sponge shall be moved over the surface of the coating at a moderate rate of approximately 0.3 m/s (1 ft/s), using a double pass over each area.” Depending on the size of the sponge being used, the rate would allow for approximately 30 sq ft of coverage per minute, not counting the time needed to mobilize and move through the tank in order to keep the sponge in direct contact with the coated surface. The instrument needs to be grounded to the conductive substrate during use, which, on the interior of a coated tank, could make locating a bare surface difficult, creating further mobilization issues.

More important than simply getting a job done faster is the additional access for inspection that OAP coatings allow. With the configuration of tank interiors, it is not possible to put the wet sponge tester in direct contact with many interior surface areas. (Coincidentally, it is mostly

in these areas where we find early coating failures and the most significant corrosion when we inspect tanks and when we are involved in forensic investigations of coating failures.)

The holiday detection instruments used in inspecting OAP coatings do not require contact with the coating or the substrate. With UV-A lamps, pinhole defects can be visible at a distance of over eight feet, depending on ambient conditions. Tanks do not have to be blacked out to perform this inspection, and the visual effects can be clearly captured on camera.

### **Conclusion**

- OAP inspection practice is much faster and assure better inspection of all surfaces (150 sq. ft. per minute by comparison);
- Capability for immediate inspection of wet coatings;
- Productivity of inspection increase 50 – 70%;
- Found 25% more defects;
- Could quickly (and visually) identify 0,25 mm – 0,50 mm diameter pinhole;
- Could visually identify low film thickness on edges;
- The paint do not loose his fluorescence capability with age.

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