White Paper

Protective Interior Coatings for Waterworks Valves

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Introduction

Since the 1990's, two types of epoxy coatings have been commonly specified and used for iron valves in the waterworks industry: fusion bonded epoxy (FBE) and liquid epoxy. Both coatings are based on thermo-set epoxy systems with similar corrosion resistance and are described in the American Water Works Association's Standard AWWA C550, "Protective Interior Coatings for Valves and Hydrants". Fusion bonded epoxy is applied to preheated components in powder form in an electrostatic or fluidized bed process followed by thermal curing. Liquid epoxy is a two-component mixed material that is applied by spray, brush or other methods and chemically cures after application. The purpose of this paper is to explain the typical requirements that apply to these coatings and compare some of their properties.

The resilient-seated gate valve manufacturers in Europe led the valve industry in the adoption of epoxy coatings starting in the 1970's. They realized that a corrosion resistant surface is critical in gate valves. The interior coating of the body serves as the mating sealing surface and must also resist abrasion and erosion for high localized fluid velocities. Conversely, it was not until 2010 that the quarter-turn ball and butterfly valve AWWA standards adopted epoxy as the standard interior coating.

Another driving force for the use of advanced epoxy coatings was environmental concerns. U.S. valve manufacturers must not only comply with air emission requirements but must also actively engage in activities that help mitigate the effects of climate change. Coating processes for valves have migrated from solvent-based coatings to epoxy coatings with high solids content to reduce volatile organic compounds (VOC's), which are a serious air pollutant. Similarly, powder-based coatings such as fusion bonded epoxy produce no VOC's.

Valve Coating Standards

AWWA set the standard for waterworks valve interior coatings to provide long-term corrosion resistance for water, wastewater, and reclaimed water service having a pH range of 4 to 9 (AWWA, 2013). The epoxy coatings are qualified for this service by subjecting test coupons to 90-day immersion tests at the full range of pH at 158°F. The coating is also tested for impact resistance by dropping a weight onto the surface in accordance with ASTM D2794. In production, coatings are visually examined for defects and randomly tested to verify coating thickness. The result has been the production of valves with highly reliable epoxy coatings for over 40 years.

Over the last decade, there has been significant debate among valve users and producers about setting standard requirements for epoxy coating thickness and holiday testing. Because of the intricate geometry of gate valves, providing uniform coating thicknesses and holiday testing on a production basis can be costly, therefore, the associated valve standards require only a minimum coating thickness of 6 mils for gate valves and 8 mils for quarter-turn valves (Figure 1). Project specifications and manufacturers' specifications typically indicate a higher coating thickness in the range of 8 to 16 mils depending on the coating and application. Holiday testing is important to guarantee the integrity of the coating but production holiday testing has been deemed an optional requirement based on the purchaser's ability to bear the cost.

FIGURE 1: Quarter-Turn AWWA C507 Ball Valve with Fusion Bonded Epoxy

Additional requirements were initiated by the U.S. Environmental Protection Agency, who in the 1990's, began regulating drinking water additives including treatment chemicals and water system components including valves and coatings. A consortium of organizations produced a standard ANSI/NSF 61, "Drinking Water System Components – Health Effects" which provides testing protocols for exposing products to test water and measuring contaminant levels extracted during a 14-day immersion test. Various state water authorities adopted the NSF 61 requirements resulting in an entire industry of testing authorities with labs dedicated to certifying products to this new standard.

From the start, the waterworks valve industry found the NSF 61 approval process to be burdensome and costly. Despite the fact that all of the materials in a valve, including the coating, could be independently tested to verify compliance with NSF 61, the standard required that actual production valves be tested by independent labs on a frequent interval. Ironically, NSF 61 does not consider the quality, impact strength, adhesion strength, and the corrosion resistance of the coating; only the coating's propensity to add contaminants to the water system.

Moreover, while treatment chemicals and pipeline coatings may have a significant impact on water quality because of their immense water contact surface area, a valve and its coating comprise an insignificant percentage of a water system's surface area. Normalization factors were developed in the standard to take this into account resulting in coating manufacturers certifying various coatings for either pipe or valve service. Finally, purchasers are warned in valve standards that specifying alternate coatings or materials will invalidate the valve's NSF 61 certification (AWWA, 2015).

Coating Process

In general, the AWWA standards defer to that epoxy coating producers to publish a set of surface preparation requirements including surfaces that must be dry, clean, and free of oil, oxidation, and foundry dust. The substrate should have a minimum 1.5 mil roughness profile with no sharp edges to anchor the coating. Valve manufacturers typically employ a near-white grit blasting operation to meet these requirements and provide a good surface profile for the coating. Care is taken to prevent oxidation of the blasted surfaces before coating by performing the coating within the same work shift as blasting.

Liquid epoxy is furnished as a two-part kit that is thoroughly mixed and applied to the valve surfaces by spray, brush, or roller taking care to vent the vapors to promote the removal of the solvents from the coating. Because of the solvents involved, there is typically a limitation to the thickness of a single coat, such as 16 mils. If a greater thickness is required, additional coats are applied within a prescribed coating window. The mixture also has a finite pot life of 3-5 hours depending on temperature and humidity conditions. Dry time for handling is typically 7 to 10 hours, but water immersion may require 5-10 days of additional cure time to assure full dispersion of the solvents.

The powder epoxy coating process involves a pre-heat process wherein the part is held in a large computer-controlled oven to 450°F for a prescribed period of time and monitored with an infrared thermometer (Figure 2) until the part reaches the desired pre-heat temperature; typically 400°F. The parts are either moved or conveyed to a spray booth where they are attached to an electrical source to achieve an electrostatic charge. The powder coating is then sprayed over the parts which are then returned to the oven for post for 10-20 minutes. In some factories the heating and spraying process are controlled with a conveyor system (Figure 3). Once removed from the oven, the parts are

FIGURE 2. Infrared Thermometer with Laser Sight

allowed to cool before installation and water immersion. Fusion bonded epoxy coatings do not require an additional 5-10 days of cure time as with liquid epoxy since no solvents are used.

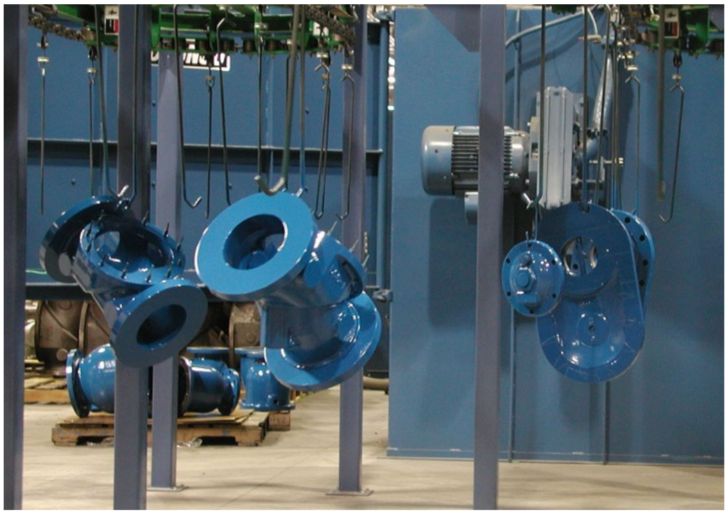

FIGURE 3. Conveyor System for Fusion Bonded Epoxy Process

Figure 4. Typical High-Voltage Holiday Test Equipment

After either coating process, all parts are visually examined to ensure adequate coverage and the dry film thickness is measured in random locations. When required by the purchaser, a holiday test is conducted to identify any voids in the coating in accordance with ASTM G62. In a holiday test, a voltage is applied over the coated surfaces and any continuity between the test wand and substrate surface will be indicated on the detector unit. Epoxy coatings less than 20 mils in thickness can be checked using a low voltage (i.e. 22.5 to 80 volts) test unit while thicker coatings require the use of high voltage test unit in the range of 500 to 10,000 volts, depending on the thickness of the coating. When voids are identified, the coating is repaired and retested.

Epoxy Coating Durability

Both liquid and fusion bonded coatings cure to a hard, smooth, and glossy finish, ideal for valve interiors. Their resistance to damage due to handling can be compared by reviewing their direct impact resistance in accordance with ASTM D2794 and adhesion strength in accordance with ASTM D4541. AWWA C550 requires a minimum impact strength of 20 in-lbs, which can be met by liquid epoxies, but is not typically reported quantitatively. Fusion bonded epoxy coatings typically have twice the impact strength and can be as high as 160 in-lbs. The adhesion strength is also rarely published for liquid epoxies but has been measured to be in the 1000 to 3000 psi range when good surface preparation practices are followed. In general, fusion bonded epoxy coatings exhibit twice the adhesion strength in the range of 3000 to 6000 psi (Val-Matic, 2013). Figure 5 illustrates the equipment used to perform the adhesion test.

FIGURE 5. ASTM D5451 Adhesion Testing Equipment

Conclusion

Epoxy interior coatings have proven to be a reliable product for waterworks valves over the last forty years due to developments in materials and standards. These coatings prevent corrosion, tuberculation, and wear in valves and promote efficient flow of fluids though piping systems.

References

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