Applying the Right Coating

– A Specifier's Guide

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As the industry pushes further and further to lower environmental impacts, increase equipment lifespan, and reduce in-plant maintenance, it is important to consider requiring certain features when specifying valving that will help contribute to this goal. Cast and ductile iron are the most common materials used for body castings for American Water Works Association (AWWA) valves installed predominantly in the water/wastewater marketplace. While both cast and ductile iron have mechanical properties well suited for this use, these valve components require additional corrosion protection to ensure a long life cycle. AWWA standards for various valve types (Butterfly, Gate, Check etc.) have evolved over the years to include general requirements with respect to corrosion protection. For example, since 2010 AWWA Butterfly Valves for buried applications are required to have their interior and exterior surfaces shop coated with an epoxy coating (AWWA C504-4.4, 2015) conforming to AWWA C550, which is the standard that provides minimum requirements for protective interior coatings for valves and hydrants. These standards go as far as stating where the coatings are required, minimum coating thicknesses, and what methods can be used to test and confirm proper coating application. What these standards do not cover is the selection of the type of the epoxy coating; this is left up to the purchaser who is responsible for providing a coating specification for the valve they are intending to use. The difficult part for the purchaser is finding and compiling information to evaluate the available coatings, and making an informed decision on which type they require for their application.

The two most common protective epoxy coatings found in the marketplace today are two-part epoxy and fusion-bonded epoxy. Most people are familiar with two-part epoxy as you can find many of these products in your local hardware store. Two-part epoxies are packaged in two components, which must be mixed together before use. Each component is thoroughly stirred and then combined and mixed until uniform. Once mixed, their pot-life begins. Pot-life is defined as the amount of time it takes for an initial mixed viscosity to double (epotek.com – Tech Tip 26) and typically once this time expires the product needs to be thinned for further application. The following chart outlines the pot-life for a common two-part epoxy used to coat valve castings:

Table 1 – Pot-Life

TEMPERATURE (°F/°C)	POT-LIFE (Hrs.)
20/-7	-
32/0	-
40/4	7
50/10	6
60/16	5
70/21	4
80/27	3
90/32	2

Source: AMERCOAT 370 Data Sheet

This coating is most commonly applied at room temperature in the factory, so one can see from the highlighted row in **Table 1** that careful consideration must be given to ensuring appropriate amounts are batched as to not exceed the pot-life when applying. Curing dry-time for handling is typically 7 to 10 hours, but immersion of the coated casting may require 5-10 days of cure time, depending on the thickness of coating applied (*Protective Interior Coatings for Waterworks Valves*, Val-Matic). Two-Part epoxies can be applied using a brush, roller, or an airless or conventional spray, with care taken to vent vapors to promote the removal of solvents.

Fusion-bonded epoxy (FBE) is a thermoset polymer coating. The application of fusion-bonded epoxy requires a pre-heating process where the casting is placed in an oven set at 204 °C (400 °F) for a set time and monitored with a thermometer until the part reaches the required pre-heat temperature, which is typically 177 °C (350 °F). The castings are then moved to the spray location, where they are wired to a slight electrostatic charge. The epoxy, which comes in powder form, has an opposite charge, and is sprayed onto the casting. The pre-heated casting melts the powder, transforming into a liquid form. The liquid FBE film flows onto the surface that it is applied to and becomes a solid coating by chemical cross-linking. The castings are then returned to the oven for post curing for approximately 20 minutes. Once the curing takes place, the chemical cross-linking reaction is irreversible. Application of further heating will not 'melt' or disrupt the coating.

In addition to the method of application, the quality of any epoxy coating is a function of the substrate preparation, as well as the coating thickness applied to the material. After either coating process, all parts are visually examined to ensure adequate coverage and the film thickness is measured at random locations. AWWA C550 requires the coating thickness to be a minimum average of 6 mil (AWWA C550-5.1.2.2, 2017). Both two-part and fusion-bonded coatings are typically applied with a thickness that exceeds this minimum standard. AWWA C550 also references holiday spark testing, which is a non-destructive test method applied on protective coatings to detect unacceptable discontinuities, such as pinholes and voids. To ensure proper coverage, end-users and consultants can

Table 2 – Summary Performance Properties

EPOXY	SALT SPRAY – CORROSION RESISTANCE	ADHESION STRENGTH[1] (ASTM D4541)	ABRASION RESISTANCE
Two-part (PPG Amercoat 70)	> 3000 hours with no visible corrosion	6.9 MPa (1000 psi)	250 mg weight loss (ASTMD4060) 1kg load/1000 cycles
Fusion-bonded epoxy (Akzo Nobel Coatings Inc. Resicoate R4-ES)	> 3000 hours with no visible corrosion	20 MPa (2900 psi)	<40 mg weight loss (ASTMD4060) 1 kg load/1000 cycles

[1]Values taken from Product Data Sheets. In practice testing has yielded higher strengths for both two-part and FBE, but in all testing, FBE has a demonstrated and reported adhesion strength that is almost three times greater.

specify holiday testing to determine that the coating is without holidays/voids.

While the initial set up to apply a fusion-bonded epoxy coating may be more complex than simply mixing two components together and spraying them onto a substrate, once the equipment is in place in a manufacturing facility the coating application process can be streamlined and consistently controlled. This application control and repeatability allows manufacturers to produce valves with more consistently applied coatings.

After evaluating the application differences for the two coatings, the next logical comparison would be the typical physical and performance properties of the coatings. As mentioned earlier, the main reason for using these coatings is to increase corrosion resistance. Both two-part and fusion-bonded epoxy demonstrate the same corrosion resistance as demonstrated by their performance during a salt-spray test, which is a standardized, industry accepted, test method to check corrosion resistance of surface coatings. Refer to **Table 2** for the reported salt spray testing results.

Where the two products start to differ in their performance arises when comparing their relative adhesion strength and abrasion resistance. Since these coatings are used as a physical barrier to prevent corrosion of the casting, it is essential that the coating maintain a high degree of surface adhesion (Willaim D. Callister, 2003). The adhesion strength of a typical two-part epoxy is reported to be around 1000 psi, while the adhesion strength of fusion-bonded epoxy has been demonstrated to be around 2900 psi. These results, illustrated in **Table 2**, demonstrate that fusion-bonded epoxy has an adhesion strength almost three times greater than two-part epoxy.

Figure 1 – Fusion bonded epoxy coating on valve castings.

Abrasion resistance is another important property to consider, as these coatings are used on the interior of the valves. Common water and wastewater applications subject valve interiors to flows of high velocities and pressures, sometimes with fluids that contain grit and solids. As these applications will cause wear on the interior of the valve over time, it is critical to provide the valve with a coating that best resists these conditions. Both two-part and fusion-bonded epoxies have been tested using the Taber Abraser Standard Test for Abrasion Resistance of Organic Coatings, outlined in ASTM D4060. The results, shown in **Table 2**, demonstrate that, under the same load and cycle conditions, fusion bonded epoxy is over six times more resistant to abrasion that two-part epoxy.

A final property that can sometimes be overlooked is the coating's ability to resist internal buildup of sludge or debris commonly found in water/wastewater applications. To compare the performance of the various coatings, a case study was performed at the Salt Creek Sanitary District Water and Wastewater Treatment Plant in Villa Park, IL. Three 2" AWWA C512 combination air-valves, each with different coatings, were installed on similar-sized sewage lines, which see the same flows and pressures over the same time. The valves were respectively coated as follows: one with two-part epoxy and one with fusion-bonded epoxy. The third was left with an uncoated interior, as a control. The valves were installed for a period of three years and periodically inspected to ensure proper performance. After three years in service, the valves were inspected. All valve exteriors still displayed the factory two-part, fusion-bonded epoxy and standard primer from the factory and did not exhibit excessive corrosion. Each valve was then disassembled and inspected internally. The buildup of sludge was measured on all internal components. As illustrated by the results shown in **Table 3**, the valve coated with fusion-bonded epoxy had more than fives times less volume of sludge build-up when compared with the two-part epoxy Val-Matic Valve & Manufacturing Corp., 2013.

Table 3 – Sludge Build-up on Salt Creek Air Valve Interiors

Type of COATING	FIGURES	BODY Avg. volume (cu in)	COVER Avg. volume (cu in)	FLOAT Avg. volume (cu in)	VALVE Avg. volume (cu in)
None (Control)	Figure 2	61.37	6.84	1.01	69.2
Two-part epoxy	Figure 3	48.45	1.14	18.18	67.8
Fusion-bonded epoxy	Figure 4	9.69	0.76	3.03	13.5

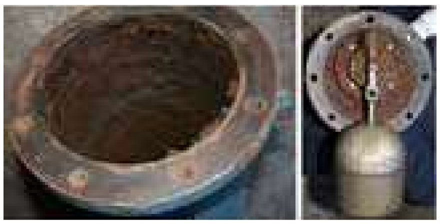

Figure 2 – Sludge build-up on uncoated internal valve casting.

Figure 3 – Sludge build-up on two-part epoxy coated internal valve casting.

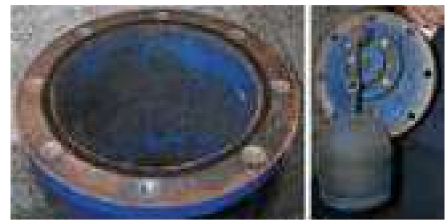

Figure 4 – Sludge build-up on fusion bonded epoxy coated internal valve casting.

These results make sense when you qualitatively observe the two coatings applied to a valve body. Fusion-bonded epoxy coating forms a smooth, low friction surface while two-part is observed to have a rougher finish.

While end-users and engineers rely on applicable AWWA standards to form the basis for many valve specifications, it's important to understand that these are set forth as a minimum guideline. Based on the properties discussed in the article, it is easy to see why FBE is commonly specified as an interior and exterior coating in water/wastewater applications in Ontario.

References

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