

Technical Brief

UV Protection of Coated Line Pipe

Background

Fusion bonded epoxy (FBE) is a one part powdered epoxy coating that is sprayed onto the hot metal substrate where it melts, flows and cures to give a corrosion resistant coating. The first line pipe coated with FBE was placed into service in 1960¹. Since that time, FBE coatings have become the most commonly used coating for new pipeline construction in North America. FBE coatings are formulated to meet both the requirements of the applicator who will apply the coating and the performance requirements of the end user (pipeline owner).

The primary raw materials used to formulate FBE coatings include epoxy resins, curing agents (hardeners), catalysts, pigments and fillers. Other additives may be used to control the flow characteristics, improve adhesion performance and provide other useful benefits. While there are several types of epoxy resins commercially available, those based on diglycidyl ether of bisphenol A (DGEBA) or novolac chemistry are the two epoxy resin types most frequently used in FBE coatings. While these epoxy resins can be used to make polymers with a wide range of properties and are very versatile in many ways, they are aromatic and thus have poor ultraviolet (UV) light resistance limiting their use in exterior applications.

UV Exposure – Chalking

Due to the presence of the aromatic group, epoxy resins generally absorb at about 300 nm and will degrade in the presence of UV light and humidity via photoinitiated free-radical degradation. This polymer degradation is known as chalking and results in the formation of a loose powdery residue on the pigmented coating surface. The residue on the polymer surface protects against further degradation unless it is removed. Removal of this protective barrier (either by natural or mechanical means) exposes a fresh surface which is then subject to further UV exposure and degradation.

Numerous studies have been conducted to investigate the UV degradation of epoxy resins²⁻⁵. One study investigated several possible weak links in amine cured epoxy systems and reported that the presence of the aromatic bisphenol moiety is primarily responsible for the absorption of UV light⁶. Modification of the polymer backbone by changing the chemistry (use of alternate diglycidyl ethers such as diglycidyl ether of bisphenol F and/or varying the curing agent) can have some impact on the degree chalking but does not eliminate the phenomena. In other words, all FBE pipeline coatings based on aromatic epoxy resins will chalk but there may be some difference in the degree of chalking due to slight differences in the chemistry of the various formulations.

Efforts have been made to improve the UV stability of epoxy products; however, to date commercial success of epoxy resins with improved weatherability has been limited⁷⁻⁹. These resins are much higher in price and end users have other ways to limit UV exposure as will be discussed later in this paper.



In addition to the susceptibility of specific FBE formulations to UV attack, the degree of chalking also depends on direct exposure to UV, the intensity and duration of the UV radiation, and the availability of water on the coating surface¹. A pipe stored above ground experiences the most chalking on the top (12 o'clock position), less on the sides (3 and 9 o'clock positions) and little or none on the bottom (6 o'clock position). Since the degree of chalking is dependant on the intensity and duration of the UV radiation and the presence of moisture, it is not surprising that variations in the degree of chalking observed in the field appear to be geographic-location specific.

Effects of Chalking on Coating Performance

The chalking process is polymer degradation and thus thickness loss is an obvious concern. Thickness loss is caused by alternate chalking and removal of this loose surface material by wind, rain, tidal splash or blowing particulate. The rate of thickness loss depends on the rate of removal of the protective layer as well as the factors that determine the degree of chalking reviewed in the previous section. Field experience suggests that there is considerable variance in the rate of thickness loss which tends to relate to location/geography. The chalking process takes some time to get started. One study reported a thickness reduction in the 12 o'clock position of about 20 μm (3/4 mil) after approximately a year of storage in northern US and southern Canada¹⁰. Historical observation suggests that measurable thickness loss typically begins within 9 to 18 months¹. Once started, the typical rate of loss is in the range of 10 to 40 μm (0.375 to 1.5 mil) per year.

As long as thickness has not been substantially reduced, weathering appears to have only minimal effects on the performance of FBE coatings. One published study of pipe coated in the US and installed in the Middle East showed no significant reduction in either flexibility or short-term cathodic disbondment tests (65°C, 3% NaCl, and 48 hour duration) after 3 years in a stockpile¹¹. The Cetiner study, which evaluated pipe that had been stored for approximately one year, showed no measurable reduction in performance in either the 48-hour cathodic disbondment test or hot water adhesion tests. There was however a measurable reduction in flexibility as measured by the CSA FBE flexibility test method at -30°C¹². Based on this work, Cetiner and coworkers recommended that pipe stored for longer than one year should be protected from UV radiation.

Again, it is important to keep in mind that the rate of chalking/thickness loss can vary considerably and is dependant on the susceptibility of the specific FBE formulation to UV attack, the intensity and duration of the UV exposure, the availability of moisture, as well as the rate at which the protective chalk layer is removed.

Common Industry Solutions

Many different methods have been used throughout the industry to protect coated pipe from UV radiation. As a preventative measure, many applicators apply additional coating thickness at the time the FBE coating is applied in order to compensate for any thickness loss that may occur during the time between when the pipe is coated and when the pipe is actually installed. The typical procedure in most cases is to provide a barrier between the sun and the coated pipe. The barrier could include any of the following:

1. Covering pipe stock piles with tarps.
2. Applying white wash to the UV exposed upper layer of the stock pile.
3. Applying an overcoat of an aliphatic polyurethane to the entire coated surface
4. Applying an overcoat of polyester powder coating. (Separate spray booths are required due to the incompatibility of epoxy and polyester systems)

Selection of the barrier is dependant on the length of time the UV exposure is expected. In the short term, a water permeable paint such as latex is sufficient. For longer term storage or permanent above ground usage, selection of the barrier coating and surface preparation are crucial. Prior to use, any UV-barrier coating should be evaluated for their ability to adhere to the FBE coating. Any residual chalking must be removed before application of a UV-barrier coating. The long-term adhesion performance of the UV-barrier coating can be improved by roughening the FBE coating surface with sandpaper or a light abrasive blast. For storage over two years; a weldable primer should be applied to the cutback area. This helps prevent corrosion in the cutback area and undercreep of the FBE coating.

References

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