Revisiting Corporate Standards for Capital Projects: A Case History

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Corrosion Problems under Insulation

In the mid-seventies, corrosion engineers along the U.S. Gulf Coast noticed serious corrosion problems with carbon steel and austenitic stainless steels under insulation and with carbon steel under cementsitious fireproofing. The corrosion was most prevalent in chloride- or sulfate-containing environments and was further aggravated in locations with high humidity, high rainfall, and salt-laden air. The most serious problems occurred under thermal insulation at temperatures ranging from 140 F to 400 F (60 C to 200 C) for austenitic stainless steel and from 140 F to 250 F (60 C to 120 C) for carbon steel.

The nature of the corrosion under insulation was different for carbon steel compared to austenitic stainless steel. Carbon steel showed accelerated general corrosion and pitting while stainless steel showed stress corrosion cracking from chlorides. Some equipment had to be replaced entirely.

The preponderance of the problems generated a great deal of interest in the corrosion community and led to an international conference on this subject in 1983. In 1986, NACE initiated an effort to disseminate consensus information concerning accepted practices for designing insulated surfaces and for selecting protective coatings for carbon steel and austenitic stainless steels under thermal insulation and cementsitious fireproofing. This work was performed under NACE task groups T-6H-31 and T-5A-30, subcommittees of Unit Committee T-6H on Coating Materials for Atmospheric Service and Unit Committee T-5A on Corrosion in Chemical Processes, respectively.

The work of these 2 committees resulted in the 1989 NACE Publication, 6H189, "A State-of-the-Art Report of Protective Coatings for Carbon Steel and Austenitic Stainless Steel Surfaces Under Thermal Insulation and Cementsitious Fireproofing." The most significant conclusions drawn by the authors of the document were that:

- severe-service, immersion-grade coatings were needed for successful long-term protection of insulated carbon steel equipment operating in the hot water range of 140 F to 250 F (60 C to 120 C); and
- stainless steel needed to be painted when exposed to chloride-containing environments.

Initial Revision of an Obsolete Corporate Standard

In 1987, with the NACE publication still under development, a petrochemical company began capital projects for 2 new facilities on the Gulf Coast. The coating standard for the projects was an updated version of a company paint standard originally written in the 1960s.

In the original standard, uninsulated carbon steel vessels and piping operating up to approximately 200 F (93 C) were typically painted with a three-coat system consisting of an inorganic zinc for galvanic protection; an epoxy intermediate coat for build, corrosion resistance, and permeability resistance; and a urethane topcoat for corrosion resistance and gloss retention. Typically, insulated carbon steel equipment operated up to 200 F (93 C) either was not painted or was painted with various one-coat systems including inorganic zinc, red lead, or other alkyl-based paints. Insulated equipment and piping were handled in this manner because no particular corrosion problems were anticipated by most engineers. The prevailing thought had been that insulated equipment did not need the same protection from the environment as uninsulated systems because the insulation itself offered protection. Interestingly, insulated carbon steel vessels operating from 0 F to 50 F (-17 C to 10 C), a less severe service than the hot service, were coated, typically with an inorganic zinc and 1 to 2 coats of a chemically curing epoxy for protection against corrosion from condensation.

The primary change made to the standard in 1987 was to specify a premium grade coal tar epoxy for insulated carbon steel equipment and piping operating up to 250 F (120 C). A coal tar epoxy was chosen for its known resistance to se-
were water-based services, its ability to be applied in relatively heavy thicknesses (10-mil dft [250-micron dft]) in 1 coat, and its ability to withstand temperatures up to 300 F (149 C). A decision was made not to paint stainless steel vessels or piping because of economics and because no problems had been experienced at this particular location.

Included at the end of the standard was a series of paint tables that specified the paint systems to be used for each type of construction material. The tables were based on operating temperatures, type of equipment, service, and whether the material was insulated or uninsulated.

Problems Encountered on the Project
The initial painting philosophy adopted by the owner was to topcoat as much of the processing equipment and piping in the shop as possible, including small-bore piping. Because various problems developed, such as the volume of piping and adverse weather, a significant amount of piping ended up being painted in the field.

The following are examples of the types of problems encountered in the shop and field.

Weaknesses in the Standard
- The standard did not address how to handle ancillary components of insulated equipment. Several shop fabricators interpreted the paint tables to mean that piping in the shop was possible, including small-bore piping. Because various problems developed, such as the volume of piping and adverse weather, a significant amount of piping ended up being painted in the field.

Extensive masking and additional curing time were then needed before the masked-off areas could be painted. This procedure resulted in significant additional painting labor and shop usage costs because some shop fabricators were charging for floor space used during curing.
- No instructions were given in the standard on how to paint carbon steel loose or “Van Stone” flanges used on stainless steel piping. Many flanges were typically painted with the expensive three-coat inorganic zinc/epoxy/urethane system for uninsulated carbon steel at a significant cost. Additional problems arose with painting Van Stone flanges associated with stainless steel piping operating at elevated temperatures. According to the paint tables, these flanges were to be painted with inorganic zinc and a high-temperature silicone-based topcoat. However, other standards on the project prohibited the use of inorganic zinc in contact with stainless steel because of the potential for liquid-metal embrittlement in the case of a fire. Many flanges had to be repainted.
- The paint tables were inconsistent in the dft range specified for different paint manufacturers and the same application. One manufacturer’s paint might be specified with a dft range of 4 to 6 mils (100-150 microns) while a second vendor’s paint might specify a single six-mil (150-micron) dft. The fabrication shops rightly indicated that hitting a dft of 6 mils (150 microns) on the nose would be impossible. As silly as this situation might seem, addressing this requirement called for extensive communications through the proper contractual channels with subsequent delays in painting.

Lack of Experience in Paint Inspection
- Problems occurred when the shop inspectors wrote non-conformance inspection reports based on a vessel not meeting specified minimum final dfts in some areas by a mil or so. The painter would re-spray these areas with the overspray resulting in excessive millage in areas that originally were within the specification. In one instance, a vessel painted with coal tar epoxy exhibited 20 mils (500 microns) dft in some locations. The excess thickness had to be addressed in the same manner as the under-tolerance thickness.

Problems Related to Bad Weather
- Much of the painting of equipment and piping was performed in the winter, which was unusually cold, wet, and contracted. The project involved so much piping and equipment that the shops could not paint all items indoors. Some painting operations were halted until the weather improved. Even when the weather was not wet, the low humidities associated with the low temperatures extended the curing times of the inorganic zinc primers, preventing topcoating and shipping.

Lack of Flexibility To Address Problems In-House
- One manufacturer attempted to paint a vessel with a coal tar epoxy coating outdoors when the temperature was less than 50 F (10 C), the minimum allowed. Unfortunately, because the material was stored below 50 F (10 C), it increased in viscosity. To compensate for the increased viscosity, the paint was added excessive amounts of thinner. Excessive thinning resulted in runs and sags as the applied paint warmed up during the day. Because the standard specified no runs or sags, the inspector rejected the paint application. The manufacturer, in turn, contested the inspection, and the owner had to arbitrate the dispute, all through time-consuming channels.
- There was always an urgency to move shop-fabricated equipment to the field quickly. The required was often in conflict with the extended curing times of some of the chemically curing paints, even in the best of weather conditions. As a result, equipment often arrived with the uncured coating damaged from shipping and handling. A separate paint contract was implemented just to handle the equipment arriving in the field with damaged paint.

Lack of Knowledge about Rationale for Selected Systems
- Another issue concerned painting piping insulated at specific locations for personnel protection. The engineering contractor had specified the insulated paint system for all of the pipe in that system, based on the insulation requirements. Hundreds of linear feet of uninsulated piping were painted with the insulated system, even though only a small portion of the piping was actually insulated. The issue was primarily one
of aesthetics. The insulated paint system is black while uninsulated carbon steel operating at the temperatures involved was specified by the plant to be another color.
- The standard included specified colors for the topcoat of uninsulated equipment, based on plant preference, where choices were available. Regardless of whether the paint standard was included with the purchase order or not, items such as valves and pumps always ended up being painted with the shop-preferred paint, usually an alkyd-based paint. On at least one occasion, a decision was made to repaint numerous pumps with the proper color. Successfully painting over alkyd paints with a chemically curing epoxy required taking special precautions to assure compatibility.

Proposed Revisions to the Standard
The standard revision process had several goals:
- to reduce the cost of painting without compromising equipment protection,
- to make the standard more flexible, and
- to make topcoating in the shop easier.

A coating life of approximately 10–12 years without extensive blasting was the criterion used to balance paint selection and cost. The following specific revisions were proposed.
- Eliminating the use of inorganic zinc as a primer coat has been proposed for uninsulated carbon steel at locations of mild severity. The use of inorganic zinc as a primer under high performance paints is being rethought in the industry.3,4,5 Inorganic zinc have their own problems if not applied properly, including crazing or mudcracking if applied too thickly. This author observed many more cases of too much inorganic zinc being applied rather than not enough.
- Specifying a two-coat system has also been proposed for uninsulated carbon steel equipment in mild to moderate industrial environments. Consideration is being given to specifying a two-coat high-build maintenance epoxy primer with a urethane topcoat for uninsulated carbon steel equipment operating at temperatures up to 250 °F (120 °C). Savings and simplicity would result from eliminating the inorganic zinc primer and reducing the surface preparation requirements from an SSPC-SP 10, Near White Blast, to an SSPC-SP 6, Commercial Blast. This recommendation is somewhat controversial because it is a departure from the traditional threecoat approach; however, data suggest that total coating life might not be compromised with the new maintenance epoxies on the market.5
- Notes have been added to the appropriate tables permitting the use of low-temperature coating alternatives or alternative accelerators for chemically curing resin systems to allow painting at lower ambient temperatures.
- Where 2 paints provide comparable protection, the faster curing system has been specified to expedite shop painting.
- DFT ranges have been standardized. Where 1 vendor’s product data sheet specified a dft range of 4–6 mils (100–150 microns) and another specified 5–7 mils (125–175 microns), a compromise was made, and the systems were made equal to provide uniformity and to make the 2 offerings equal on a per-mil (micron) cost basis.
- Insulated and uninsulated stainless steel equipment and piping will be painted, state the proposed revisions. Insulated stainless steel is painted at operating temperatures between 140 °F and 300 °F (60 °C and 149 °C). Uninsulated stainless steel is painted at operating temperatures from 140 °F to 710 °F (60 °C to 100 °C). This practice is based on discovering external chloride stress corrosion cracking of austenitic stainless steel piping under insulation in an adjacent operating unit during construction of the subject project. The stainless steel piping is to be painted a different color from carbon steel piping to permit visual identification of the 2 materials.
- In the proposed revisions, all small, uninsulated insulation clips and flanges for insulated vessels will be painted with the insulated system. This will eliminate the extra curing time and associated labor costs for masking off.
- Alternative systems for more severe environmental conditions, i.e., at railroad or heavy industrial locations, have been included in the standard.
- Coal tar epoxies will be applied in 1 coat instead of 2 as before. The added benefit of eliminating intercoat adhesion problems and curing times outweighs the additional costs of not obtaining complete coverage.
- New sections have been added to the front the standard. One section specifies the quality assurance responsibilities of field and shop painting contractors and the primary engineering contractor. Another specifies repair methods for equipment and/or piping that has been incorrectly painted.

Continued Follow-Up
Because technology and regulations often change annually in the paint industry, the paint standard now undergoes a revision process once a year to maintain VOC compliance and to update obsolete systems. The standard is sent to representatives of the approved paint manufacturers, and their recommendations are requested. Based on the extensive technical revisions proposed, the latest review process included details of the proposed changes to guide their selections.

The usefulness of the proposed revisions will probably not be verified until the next project. Additional issues to be addressed include standards and specifications for applying protective coatings and linings to concrete, secondary containment structures for hazardous waste tanks, underground piping, and tank internals. Like all protective coatings standards, the corporate standard on painting under insulation should be considered a living document because of the pace of advances in technology and regulatory changes.

References