

Third Generation Polysiloxane CUI Coatings and Sprayable Insulation For Hot, Cold And Cyclic Service; Lab Testing And More Than Five Years Of Field Experience

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ABSTRACT

Third Generation Polysiloxane (TGPS) ambient curing CUI mitigation coatings have been used in the petrochemical industry for over five years. These coating technologies have demonstrated positive results in lab testing as well as both shop and field application for asset management in elevated temperature, cryogenic and cyclic applications across a wide range of service temperatures. TGPS coatings have also demonstrated effective use of a two-step (primer-insulation) CUI mitigation system when compared to traditional (CUI coating-fibrous or granular insulation-cladding) systems.

Key words: Polysiloxane, CUI, insulation, third generation

INTRODUCTION

Corrosion Under Insulation (CUI) is a well-known industrial problem that has been plaguing asset owners for decades. CUI presents one of the costliest corrosion factors for Oil and Gas, petrochemical and general processing industries and can result in unplanned shutdowns, maintenance, repairs or even explosions while in service. Due to the risk factors present, many methods to prevent CUI have been adopted, trying to find best practices to minimize the risk of potentially catastrophic events caused by CUI.

The CUI concept is composed of a three-component system:

1. Steel – substrate for processing chemicals (constant or in cyclic temperature operation)
2. Insulation – provides thermal efficiency
3. Cladding – protection for insulation and steel from atmospheric elements

In practice the cladding system is rarely sealed completely, so water from rain, dew, fire deluge water, steam condensation or cooling tower spray is often able to penetrate the system through an ingress point in the cladding, generally where complex structures pose difficulty maintaining a watertight system. Additionally, where potentially permeable, moisture sensitive insulation is used, condensation build up is a frequent CUI contributor. Once water has penetrated the system at an ingress point such as a break, seam, gap, or incompletely sealed valve, water may be absorbed into the insulation, eventually causing saturation or a high concentration, and it may cause CUI if the steel is not fully protected. Potential contaminants like acid or high salt content from rain or chemicals (chlorides /sulphides) leaching from insulation systems can form highly corrosive compounds, accelerating the corrosion rate.

Commonly used materials for industrial processing equipment and storage vessels are carbon and stainless (austenitic or duplex) steels (CS) and (SS). Both steel types are susceptible to CUI via multiple corrosion mechanisms. Per NACE SP 0198 -- 2017, temperatures where high CUI (either in cyclic or constant operation) is likely in CS are between -4 to 175°C (-25 to 350°F). In SS, the temperatures where CUI is likely to occur are between 50 to 175°C (120 to 350°F). The rate of corrosion is directly related to the suitability of CUI coating and its service performance, the insulation type used, and cladding installation quality.

PRODUCTS AND SYSTEMS

Specifiers and asset owners have a wide selection of CUI-related materials to choose from a variety of suppliers when designing and building plants and for maintenance. To aid this process, the main universal guidance document available is NACE SP 0198 – 2017 *The Control of Corrosion Under Thermal Insulation and Fireproofing Materials – A Systems Approach* which lists suitable material selections in cladding, insulation and coatings. Listing coating selection as per operating temperature and chemistry allows classifications and easier for coating selection.

Generally, usage and specification of CUI coatings is dependent on operating temperatures of processing equipment. NACE SP 0198 --2017 “The Control of Corrosion Under Thermal Insulation and Fireproofing Materials – A Systems Approach” is an industry standard for CUI coating classifications.

From the early of 1970’s, when red lead coatings were no longer acceptable, inorganic zinc (IOZ) coatings were used as a CUI coating. However, due to the sacrificial properties of IOZ coatings the zinc may be rapidly consumed under insulation (cyclic wet/dry) environments providing inadequate corrosion protection. As the “zinc dust” used in IOZ coatings became more and more lead-free, the sacrificial properties of IOZ coatings made them less and less suitable as a single coat under insulation. Instead, if used, IOZ must be overcoated with a suitable CUI resistant finish coat, and in most cases use of IOZ becomes redundant. Epoxy coatings are predominantly used as cost effective coating systems for lower temperatures in CUI.

Since 2010, NACE has included inorganic copolymer (IC) and inert multi polymeric matrix (IMPM) coatings for the recommended full temperature range of industrial CUI mitigation, from -45 to 650°C (-50 to 1200°F). Various versions of IMPM are available on the market and are now at second generation status by many suppliers. From a chemical perspective, IC and IMPM type coatings can be classed as polysiloxane coatings.

Coating requirements for service under insulation include temperature stability and thermal cycling, corrosion resistance, hot saline water immersion (HWI) properties, chemical resistance, and mechanical properties. The coating properties must be present from time of application and must not require stoving or curing at elevated temperatures. Issues have been identified in the field with products requiring heating before providing full corrosion resistance and mechanical properties and therefore, resistance to CUI environments in new construction. Resistance to open environmental conditions is also required, potentially for many months before installation is complete. Insulation and cladding are added, and a unit is put into heated service. Another consideration is that if heat curing is required, specification and use below the curing temperature should be avoided because CUI protection will be limited.

Although an official coating classification is certainly a huge benefit for specifiers and asset owners in coating selection for CUI corrosion prevention, the NACE SP 0198 -2017 does not provide insight, guidance or test methods for establishing coating performance. To date multiple laboratory protocols have been developed by manufacturers and asset owners, by a NACE committee, and by ISO. Most of the methods documented are used universally for CUI coating testing. Even so, the testing standards/methods are still a relatively confusing area with formulators, specifiers and asset owners often undecided or disagreeing which test(s) should be adopted to demonstrate product suitability and to distinguish performance levels between similar products.

TESTING PROTOCOL FOR CUI COATINGS

In 2018 a new CUI standard was introduced, ISO 19277:2018 Petroleum, petrochemical and natural gas industries - qualification testing and acceptance criteria for protective coating systems under insulation. The ISO 19277:2018 has given some needed clarity to protective coating manufacturers and asset owners across the industry for coating performance guidance. This standard is currently being revised; one of this paper's authors is on the revision committee.

Table 1
CUI Coating Testing Program (simplified) Table (current as of 2020)

Laboratory test	Method	Test length
CUI classification test	Vertical pipe or CUI multiple phase tests	>2000 hours
ISO 2812	Water immersion	3000 hours
ISO 9227-2	Natural salt spray	720 hours
ISO 6270-1	Water condensation	480 hours
ISO 2409	Adhesion (cross-cut)	Pre/post test
ISO 4624	Adhesion (dolly pull-off)	Pre/post test
High temperature resistance	Thermal cycle test	>14 days
Cryogenic test	Thermal cycle test	>14 days

The ISO 19277:2018 test program and criteria show demonstration of combined and individual properties of coating systems. One universal CUI protocol cannot adequately cover all the possible service conditions during a coating's service life for CUI use. Therefore, the test program should be viewed as a performance, and as a comparison of tested coatings, giving useful insights to the performance level of various CUI coating systems.

THIRD GENERATION POLYSILOXANE SYSTEMS

NACE paper 9331-2017, "Performance of Next Generation CUI Mitigation Systems" by Mr. Neil Wilds, discussed the need for a new generation of CUI coatings. The paper was comprehensive and accurate, but it discussed needs, not products, and it had opened up a dialogue on what should be the "third generation" of CUI-specific coating systems.

At the same time in 2017 and again in early 2018, NACE reaffirmed their CUI standard, SP 0198-2017, with only minor changes, leaving unanswered questions regarding the next generation of CUI coatings.

A small Dutch Firm had been selling products that qualify as "third generation" polysiloxane CUI systems since slightly before Neil Wilds' paper was published. Their products are based on pure siloxane resins, eliminating the "multipolymeric" tag from IMPM, and their products dry hard without requiring the additional bake cure needed by second generation IMPM coatings. Applied, dried but unheated, these products have full atmospheric and chemical corrosion resistance, unlike many "second generation" polysiloxane elevated-temperature coatings.

This group of "third generation" non-hybrid polysiloxane coatings includes a 1200 °F/650 °C single-component coating, a 572 °F/300 °C single-component coating with near-zero VOC, and a near-zero VOC, one-coat spray-on insulation, which has a maximum service temperature of 750 °F/400 °C, almost twice the maximum service temperature of currently available organic-resin-based spray-on insulation products. CUI systems using these products have been in field service in refineries and chemical plants in Europe for nearly five years, both in test areas and on full-scale projects. The in-service performance results are extremely encouraging.

As indicated by table 2, from application to service there are many potentially catastrophic elements which can attack and jeopardise the integrity of the coating system, resulting in compromised service life. It is vitally important to consider the main necessary coating parameters and to demonstrate the required performance levels of the protective coating.

Performance of the CUI coating after application but before being insulated and clad can be critical in new construction projects where transportation and storage before erection may involve months. Similarly, performance after insulation and cladding but before being heated is significant.