

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

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 both shop and field application for asset management in elevated temperature, cryogenic and cyclic applications across **-196 to 650° C/-321 to 750° F** operational temperatures. TGPS coatings have demonstrated effective use of a two-step (primer-insulation) CUI mitigation coating approach operating up to **400° C/750° F**, when compared to the traditional (CUI coating-fibrous insulation-cladding) systems.

Keywords: Polysiloxane, CUI, insulation, third generation

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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 on live plants

The traditional CUI prevention 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 does not truly seal from the atmospheric elements. Rain, deluge water, steam or cooling towers overspray is often able to penetrate the system through an ingress point in the cladding material, generally where complex structures pose huge difficulty in building a watertight system. Additionally, when permeable insulation (open cell) is used, condensation may also be a CUI contributor.

Once water has penetrated an insulated system via ingress points such as breaks, seams, gaps, or unsealed valve sections, it can attach the CUI coating to cause corrosion to the steel. Potential contaminants like acid, high salt content rain or leaching chemicals from the plant environment or leachate from insulation systems that can form reactive compounds accelerating the corrosion rate.

Products and Systems

Generally, usage and specification of CUI coatings is dependent on operating temperatures of processing equipment. NACE SP0198 -2017 "The Control of Corrosion Under Thermal Insulation and Fireproofing Materials – A Systems Approach" is an industry standard for CUI coating classifications. Highlighting and tabulating substrate (carbon or austenitic/duplex stainless steels) material, temperature ranges, recommended surface preparation, surface profile (R_z) and coating dry film thicknesses of CUI protective coating systems.

Inorganic zinc (IOZ) coatings were used as a CUI coating for their high maximum service temperature of near 370°C (700°F). Although there is not enough zinc in an inorganic zinc coating to melt above the melting point of zinc, the zinc dust oxidizes and loses sacrificial protection above this point. Even within acceptable operating temperatures, modern, pure- zinc inorganic zinc coatings are rapidly consumed under insulation (cyclic wet/dry) environments. In older inorganic zinc formulations, the zinc dust contained a fairly high portion of lead, providing a slower rate of sacrifice.

Epoxy coatings are predominately used for lower temperatures in CUI, epoxy novolacs range from -45 to 150°C (-50 to 300°F) and epoxy phenolics range from -45 to 205°C (-50 to 400°F). Other coatings include metallization processes, fusion-bonded epoxies and thin film petroleum wax primers.

NACE has introduced within the last 15 years inorganic copolymer (IC) and inert multi polymeric matrix (IMM) coatings for the recommended full temperature range regarding industrial CUI mitigation ranging from -45 to 650°C (-50 to 1200°F), various versions of IMM are available on the market and are now at second generation status by some suppliers. From a chemical perspective, IC and IMM type coatings are classed as polysiloxane coatings.

Table 1: Under Insulation Coatings (NACE SP0198-2017 classification) for Carbon Steel

System	Chemistry	Temperature range °C and (°F)
CS1	Epoxy	-45 to 60°C (-50 to 140°F)
CS2	Fusion bonded epoxy	-45 to 60°C (-50 to 140°F)
CS3	Epoxy Novolacs	-45 to 150°C (-50 to 300°F)
CS4	Epoxy Phenolics	-45 to 205°C (-50 to 400°F)
CS5	TSA	-45 to 595°C (-50 to 1100°F)
CS6	Inorganic copolymer (IC) / Inert multipolymeric matrix (IMM)	-45 to 650°C (-50 to 1200°F)

Coating requirements for under insulation service include temperature stability and thermal cycling, corrosion resistance, hot saline water immersion (HWI) properties, chemical resistance, mechanical properties. The coating properties must be present from application conditions and not require stoving or curing at elevated temperatures. Issues have been identified in the field with products requiring heating before providing full corrosion and mechanical properties and therefore, resistance to CUI environments. What must also be highlighted is if the need for heat curing is present, specification and use below the curing temperature should be highly avoided as CUI protection will be limited.

Although an official coating classification is certainly a huge benefit for specifiers and asset owners in coating selection for under insulation corrosion prevention, the NACE SP0198 -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, most of the methods documented are used universally for CUI coating testing. Even so, the testing standards/methods are still a relatively vague area with formulators, specifiers and asset owners often confused or undecided on 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. ISO 19277:2018 has given some needed clarity to protective coating manufacturers and asset owners across the industry for coating performance guidance.

Table 2: CUI Coating Testing Program (simplified) Table

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