# Emerging Technologies to Combat CUI

**Peter Bock**
**Performance Polymers Americas**
**North American Operations**
**Houston, TX**
**pbock@pp-bv.com**
**peterbcui@gmail.com**
**713-396-6383**

NIA National Insulation Association®

Fall Summit
EDUCATE | ENGAGE | ELEVATE 2017

# Corrosion Under Insulation

**What's really under there?**

# Corrosion Under Insulation

## Emerging Technologies to Combat CUI

1. Oldies but Goodies Updated
2. Evaluating “Current” Technology
3. Emerging Technologies

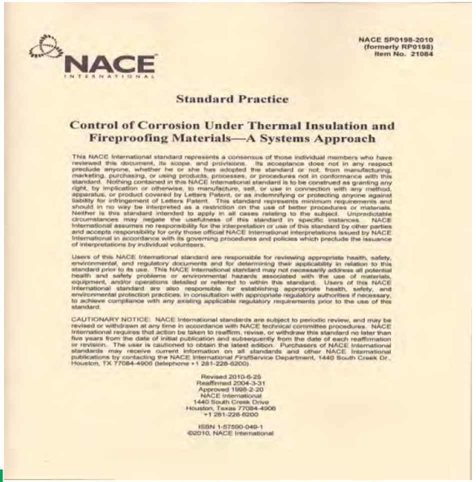
# Corrosion Under Insulation

1. Oldies but Goodies Updated
   NACE SP 0198-2017 "Revised"
2. Evaluating "Current" Technology
   NACE TG 425 Draft Report
   NACE TG 525 Draft Report
   NACE TG 615 Progress
3. Emerging Technologies
   Third Generation Polysiloxane

# Corrosion Under Insulation

## 1. Oldies but Goodies Updated

### NACE SP 0198-2017 “Revised”



NACE SP0198-2010
(formerly RP0198)
Item No. 21084

NACE INTERNATIONAL

**Standard Practice**

**Control of Corrosion Under Thermal Insulation and Fireproofing Materials—A Systems Approach**

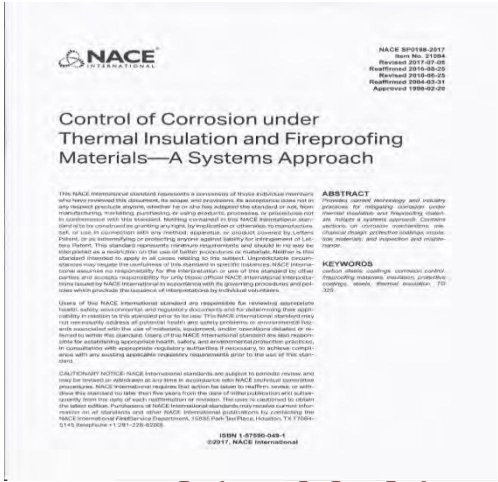
This NACE International standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone, whether he or she has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in conformance with this standard. Nothing contained in this NACE International standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by Letters Patent, or as indemnifying or protecting anyone against liability for infringement of Letters Patent. This standard represents minimum requirements and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. NACE International assumes no responsibility for the interpretation or use of this standard by other parties and accepts responsibility for only those official NACE International interpretations issued by NACE International in accordance with its governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

Users of this NACE International standard are responsible for reviewing appropriate health, safety, environmental, and regulatory documents and for determining their applicability in relation to this standard prior to its use. This NACE International standard may not necessarily address all potential health and safety problems or environmental hazards associated with the use of materials, equipment, and/or operations detailed or referred to within this standard. Users of this NACE International standard are also responsible for establishing appropriate health, safety, and environmental protection practices, in consultation with appropriate regulatory authorities if necessary, to achieve compliance with any existing applicable regulatory requirements prior to the use of this standard.

CAUTIONARY NOTICE: NACE International standards are subject to periodic review, and may be revised or withdrawn at any time in accordance with NACE technical committee procedures. NACE International requires that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication and subsequently from the date of each reaffirmation or revision. The user is cautioned to obtain the latest edition. Purchasers of NACE International standards may receive current information on all standards and other NACE International publications by contacting the NACE International *FirstService* Department, 1440 South Creek Dr., Houston, TX 77084-4906 (telephone +1 281-228-6200).

Revised 2010-6-25
Reaffirmed 2004-3-31
Approved 1998-2-20
NACE International
1440 South Creek Drive
Houston, Texas 77084-4906
+1 281-228-6200

ISBN 1-57590-049-1
©2010, NACE International



NACE INTERNATIONAL

NACE SP0198-2017
Item No. 21084
Revised 2017-07-05
Reaffirmed 2016-08-25
Revised 2010-06-25
Reaffirmed 2004-03-31
Approved 1998-02-20

Control of Corrosion under Thermal Insulation and Fireproofing Materials—A Systems Approach

This NACE International standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone, whether he or she has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in conformance with this standard. Nothing contained in this NACE International standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by Letters Patent, or as indemnifying or protecting anyone against liability for infringement of Letters Patent. This standard represents minimum requirements and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to this subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. NACE International assumes no responsibility for the interpretation or use of this standard by other parties and accepts responsibility for only those official NACE International interpretations issued by NACE International in accordance with its governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

Users of this NACE International standard are responsible for reviewing appropriate health, safety, environmental, and regulatory documents and for determining their applicability in relation to this standard prior to its use. This NACE International standard may not necessarily address all potential health and safety problems or environmental hazards associated with the use of materials, equipment, and/or operations detailed or referred to within this standard. Users of this NACE International standard are also responsible for establishing appropriate health, safety, and environmental protection practices, in consultation with appropriate regulatory authorities if necessary, to achieve compliance with any existing applicable regulatory requirements prior to the use of this standard.

CAUTIONARY NOTICE: NACE International standards are subject to periodic review, and may be revised or withdrawn at any time in accordance with NACE technical committee procedures. NACE International requires that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication and subsequently from the date of each reaffirmation or revision. The user is cautioned to obtain the latest edition. Purchasers of NACE International standards may receive current information on all standards and other NACE International publications by contacting the NACE International *FirstService* Department, 15835 Park Ten Place, Houston, TX 77084-5145 (telephone +1 281-228-6200).

ISBN 1-57590-049-1
©2017, NACE International

**ABSTRACT**

*Provides current technology and industry practices for mitigating corrosion under thermal insulation and fireproofing materials. Adopts a systems approach. Contains sections on corrosion mechanisms, mechanical design, protective coatings, insulation materials, and inspection and maintenance.*

**KEYWORDS**

*carbon steels, coatings, corrosion control, fireproofing materials, insulation, protective coatings, steels, thermal insulation, TG 325*

# NACE SP 0198-2017

NACE SP0198-2017
Item No. 21084
Revised 2017-07-05
Reaffirmed 2016-08-25
Revised 2010-06-25
Reaffirmed 2004-03-31
Approved 1998-02-20


**ABSTRACT**

*Provides current technology and industry practices for mitigating corrosion under thermal insulation and fireproofing materials. Adopts a systems approach. Contains sections on corrosion mechanisms, mechanical design, protective coatings, insulation materials, and inspection and maintenance.*



**KEYWORDS**

*carbon steels, coatings, corrosion control, fireproofing materials, insulation, protective coatings, steels, thermal insulation, TG 325.*

# Needed Revisions to NACE SP 0198-2010:

- Seal Coating of TSA
- New Elevated Temperature Coatings
- Novolac/Phenolic/“Other” Epoxy
- Spray-On Insulation Products
- Nonmetallic Jacketing Materials
- Conform to CINI
- Conform to EFC
- Conform to ISO

# Corrosion Under Insulation

## Revisions actually made in NACE SP 0198-2017:

- Mentions CINI
- Includes SSPC SP-16 (Brush Blast Prep)
- Corrects TSA Seal Coat
- One liner about spray-on Insulation

# Corrosion Under Insulation

SP0198-2010

**Table 1**
**Typical Protective Coating Systems for Austenitic and Duplex Stainless Steels Under Thermal Insulation**

| System Number | Temperature Range [(A)] [(B)] | Surface Preparation [(C)] | Surface Profile, µm (mil) [(D)] | Prime Coat, µm (mil) [(E)] | Finish Coat, µm (mil) [(E)] |
|---|---|---|---|---|---|
| SS-1 | –45 to 60 °C (–50 to 140 °F) | SSPC-SP 1[11] and abrasive blast | 50–75 (2–3) | High-build epoxy, 125–175 (5–7) | N/A |
| SS-2 | –45 to 150 °C (–50 to 300 °F) | SSPC-SP 1 and abrasive blast | 50–75 (2–3) | Epoxy phenolic, 100–150 (4–6) | Epoxy phenolic, 100–150 (4–6) |
| SS-3 | –45 to 205 °C (–50 to 400 °F) | SSPC-SP 1 and abrasive blast | 50–75 (2–3) | Epoxy novolac, 100–200 (4–8) | Epoxy novolac, 100–200 (4–8) |
| SS-4 | –45 to 540 °C (–50 to 1,000 °F) | SSPC-SP 1 and abrasive blast | 15–25 (0.5–1.0) | Air-dried silicone or modified silicone, 37–50 (1.5–2.0) | Air-dried silicone or modified silicone, 37–50 (1.5–2.0) |
| SS-5 | –45 to 650 °C (–50 to 1,200 °F) | SSPC-SP 1 and abrasive blast | 40–65 (1.5–2.5) | Inorganic copolymer or coatings with an inert multipolymeric matrix.[(F)] | Inorganic copolymer or coatings with an inert multipolymeric |

SP0198-2010

**Table 1 (Continued)**
**Typical Protective Coating Systems for Austenitic and Duplex Stainless Steels Under Thermal Insulation**

| System Number | Temperature Range [(A)] [(B)] | Surface Preparation [(C)] | Surface Profile, µm (mil) [(D)] | Prime Coat, µm (mil) [(E)] | Finish Coat, µm (mil) [(E)] |
|---|---|---|---|---|---|
| SS-6 | –45 to 595 °C (–50 to 1,100 °F) | SSPC-SP 1 and abrasive blast | 50–100 (2–4) | Thermal-sprayed aluminum (TSA) with minimum of 99% aluminum, 250–375 (10–15) | Optional: sealer with either thinned epoxy-based or silicone coating (depending on max. service temperature) at approximately 40 (1.5) |
| SS-7 | –45 to 540 °C (–50 to 1,000 °F) | SSPC-SP 1 | N/A | Aluminum foil wrap with min. thickness of 64 (2.5) | N/A |

(A) The temperature range shown for a coating system is that over which the coating system is designed to maintain its integrity and capability to perform as specified when correctly applied. However, the owner may determine whether any coating system is required, based on corrosion resistance of austenitic and duplex stainless steels at certain temperatures. Temperature ranges are typical for the coating system; however, specifications and coating manufacturer's recommendations should be followed. SS-4, SS-5, SS-6, and SS-7 may be used under frequent thermal cyclic conditions in accordance with manufacturer's recommendations.
(B) Temperature range refers to the allowable temperature capabilities of the coating system, not service temperatures. An experienced metallurgist should be consulted before exposing duplex stainless steel to temperatures greater than 300 °C (572 °F).
(C) To avoid surface contamination, austenitic and duplex stainless steels shall be blasted with nonmetallic grit such as silicon carbide, garnet, or virgin aluminum oxide. Because there are no specifications for the degree of cleanliness of abrasive blasted austenitic and duplex stainless steels, the owner should state the degree of cleanliness required after abrasive blasting, if applicable, and whether existing coatings are to be totally removed or whether tightly adhering coatings are acceptable.
(D) Typical minimum and maximum surface profile is given for each substrate. Acceptable surface profile range may vary, depending on substrate and type of coating. Coating manufacturer's recommendations should be followed.
(E) Coating thicknesses are typical dry film thickness (DFT) values, but the user should always check the manufacturer's product data sheet for recommended coating thicknesses.
(F) Consult with the coating manufacturer for actual temperature limits of these coatings.

**NACE SP 0198-2010/2017 Stainless Steel Coating Recommendations**

**(Carbon steel recommendations are essentially identical)**

| | |
|---|---|
| 00–150 | matrix, 100–150 (4–6) |
| prayed (TSA) ium of num, 10–15) | Optional: sealer with either thinned epoxy-based or silicone coating (depending on max. service temperature) at approximately 40 (1.5) thickness. (not recommended for TSA under insulation) |
| foil wrap | N/A |

# Corrosion Under Insulation

## NACE SP 0198-2010/2017 Stainless Steel Coating Recommendations

**(Carbon steel recommendations are essentially identical)**

SP0198-2010

Table 1
Typical Protective Coating Systems for Austenitic and Duplex Stainless Steels Under Thermal Insulation

| System Number | Temperature Range [A][B] | Surface Preparation [C] | Surface Profile, µm (mil) [D] | Prime Coat, µm (mil) [E] | Finish Coat, µm (mil) [E] |
|---|---|---|---|---|---|
| SS-1 | –45 to 60 °C (–50 to 140 °F) | SSPC-SP 1[1] and abrasive blast | 50–75 (2–3) | High-build epoxy, 125–175 (5–7) | N/A |
| SS-2 | –45 to 150 °C (–50 to 300 °F) | SSPC-SP 1 and abrasive blast | 50–75 (2–3) | Epoxy phenolic, 100–150 (4–6) | Epoxy phenolic, 100–150 (4–6) |
| SS-3 | –45 to 205 °C (–50 to 400 °F) | SSPC-SP 1 and abrasive blast | 50–75 (2–3) | Epoxy novolac, 100–200 (4–8) | Epoxy novolac, 100–200 (4–8) |
| SS-4 | –45 to 540 °C (–50 to 1,000 °F) | SSPC-SP 1 and abrasive blast | 15–25 (0.5–1.0) | Air-dried silicone or modified silicone, 37–50 (1.5–2.0) | Air-dried silicone or modified silicone, 37–50 (1.5–2.0) |
| SS-5 | –45 to 650 °C (–50 to 1,200 °F) | SSPC-SP 1 and abrasive blast | 40–65 (1.5–2.5) | Inorganic copolymer or coatings with an inert multipolymeric matrix,[F] 100–150 (4–6) | Inorganic copolymer or coatings with an inert multipolymeric matrix,[F] 100–150 (4–6) |

# Corrosion Under Insulation


Novolac-grade epoxy that
failed at well below 400°F
due to excess thickness applied
on the bolts, not excessive temperature.
Use of an IMM or Silicone Hybrid
would have prevented the failure.

# Major Epoxy Coating Manufacturers Agree:

- **“Novolac” and “Phenolic” are no longer valid designations to determine performance of air-dry elevated temperature epoxies.**
- **Current formulations are mixtures of resins and temperature tolerance is not indicated by resins used.**
- **Recommended maximum temperature should be based on product data sheets or third party lab tests, not resin name.**
- **400°F is marginal maximum for many CUI service conditions.**

# Corrosion Under Insulation

**Major Generic Types of Insulation Listed in NACE SP 0198-2010, 2017**
**(Listings are unchanged from the 2008 [2010] document)**

| NACE SP 0198 Listing | | Type | ASTM |
|---|---|---|---|
| Par. 5.2.1 | Pg. 27 | Calcium Silicate | ASTM C533 |
| Par. 5.2.2 | Pg. 27 | Expanded Perlite | ASTM C510 |
| Par. 5.2.3 | Pg. 28 | Mineral Fiber/Wool | Various ASTM |
| Par. 5.2.4 | Pg. 28 | Cellular Glass | ASTM C552 |
| Par. 5.2.5 | Pg. 28-29 | Organic Foams | Various ASTM |
| Par. 5.2.5 | Pg. 29 | Ceramic Fiber | ? |
| Not Listed | | Aerogel Blanket | |
| Not Listed | | Epoxy Syntactic Foam | |
| Not Listed | | Spray-On Acrylic | |
| Not Listed | | Spray-On Third-Generation Polysiloxane | |

# Corrosion Under Insulation

## Insulation Performance per NACE SP 0198-2017

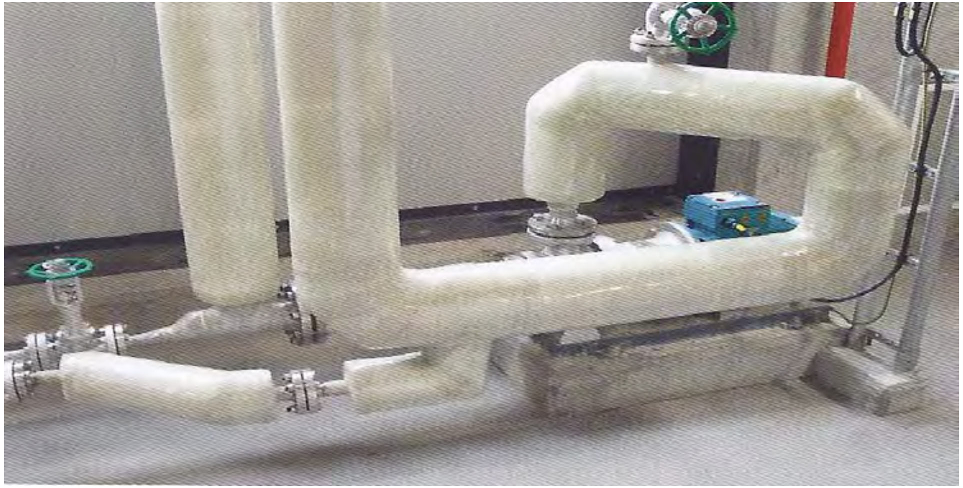
- **NACE SP 0198-2017 still assumes (incorrectly) that all versions of a generic type of insulation are identical in characteristics and performance. *"5.2 Differences between specific commercial products within a generic type are not addressed."***

- **No mention is made (or allowance given) for "improved" versions of generic insulation types. API RP 583 shares this shortcoming and needs to be updated.**

# Jacketing Performance NACE SP 0198-2017

- NACE SP 0198-2017 still spends 11+ pages showing mechanical designs where poor design may “permit water to bypass the insulation, thereby corroding the substrate metal.”
- Jacketing gets 6 paragraphs, unchanged from the 2010 document.
- Nonmetallic jacketing still gets short shrift, as does fabric for removable insulation.

# Corrosion Under Insulation



**Jacketing doesn't need to be shiny (or metal) to be good.**

# Corrosion Under Insulation

## Now for the good things in NACE SP 0198-2017!

**It is still a solid, reliable document, it just needs a little more updating.**

# Corrosion Under Insulation

## Now for the good things in NACE SP 0198-2017:

- Excellent discussion of corrosion mechanisms
- Good discussion of ESCC and its prevention for SS
- Good guidance on problems with sealants and mastics
- Good discussion of need for inspection of CUI
- Good discussion of basic RBI systems for CUI
- Separation of block/fibrous from spray-on insulation

NEW! "1.10… insulation layer that is directly bonded to the steel substrate. In such applications, CUI conditions are eliminated."

# Corrosion Under Insulation

## 2. Evaluating "Current" Technology

**NACE TG 425 Draft Report**

**"State of the Art in CUI Systems"**

# Corrosion Under Insulation

**Purpose of TG 425 Committee:**

1. To observe and evaluate whether NACE SP 0198 is valid, in that it is used for specification, product selection, and field installation of CUI projects.

2. To make recommendations to NACE TG 325 (the SP-0198 committee) regarding future changes to NACE SP 0198.

3. To evaluate new products and processes that should be included in future revisions of NACE SP 0198.

# TG 425, PROPOSED NACE TECHNICAL COMMITTEE REPORT, "STATE OF THE ART IN CUI COATINGS"; DRAFT Figure 1

**NOT APPROVED: This draft of a proposed NACE International technical commtitee report is for committee use only and must not be duplicated in any form for publication or any use other than NACE committee work.**

| REFERS TO NACE SP 0198/2010 TABLE AND SYSTEM | TABLE 1, SYSTEM SS-5 TABLE 2, SYSTEM CS-8 | TABLE 1, SYSTEM SS-5 TABLE 2, SYSTEM CS-8 | TABLE 1, SYSTEM SS-5 TABLE 2, SYSTEM CS-8 | TABLE 1, SYSTEM SS-4 TABLE 2, SYSTEM CS-8 | TABLE 1, SYSTEM SS-6 TABLE 2, SYSTEM CS-5 | TABLE 2, SYSTEM CS-8 | TABLE 1, SYS SS-2, SS-3 TABLE 2, SYS CS-3,4,8 | Not in SP 0198 |
|---|---|---|---|---|---|---|---|---|
| **SYSTEM CHARACTERISTICS** | **INERT MULTIPOLYMER MATRIX OR HI-BUILD SILICONE** | **ALUMINUM-FILLED HI-BUILD SILICONE** | **HIGH-BUILD SILICONE** | **THIN FILM SILICONE** | **THERMAL SPRAY ALUMINUM** | **INORGANIC ZINC** | **NOVOLAC EPOXY PHENOLIC EPOXY** | **FUSION BOND EPOXY** |
| Maximum Continuous Operating Temperature °F/°C | 1,000 °F/540 °C | 750 °F/400 °C | 1,000 °F/540 °C | 1,000 °F/540 °C | 1,170 °F/635 °C | 750 °F/400 °C | 400 °F/205 °C | 230 F/110 C |
| Maximum per coat DFT mils/microns | 5 - 6 mil/125 - 150 µm (2 coats) | 8 mil/200 µm | 4 - 5 mil/100-125 µm (2 coats) | 1 - 1.5 mil/25 - 38 µm (3 coats) | 10 mil/250 µm | 3 mil/75 µm | 5 - 8 mil/125 - 200 µm (2 coats) | 14-21 mils/350-525 microns |
| Recoatable with self for CUI service | **YES** | **YES** | **YES** | **YES** | **YES** (if not sealcoated) | **NO** | **YES** | **NO** |
| Maximum total DFT for CUI service | 18 mil/450 µm | 12 mil/300 µm | 10 mil/250 µm | 4.5 mil/113 µm | 10 mil/250 µm | 3 mil/75 µm | 10 - 16 mil/250 - 400 µm | 28-42 mils/700-1050 microns. |
| Minimum Surface Prep required for CUI | NACE #3, SSPC-SP 6 or -SP 11 | NACE #3, SSPC-SP 6 or -SP 11 | NACE #2, SSPC-SP 10 or -SP 11 | NACE # 2, SSPC-SP 10 | NACE # 2, SSPC-SP 10 | NACE #3, SSPC-SP 6 | NACE # 2, SSPC-SP 10 | NACE # 1 OR 2, SSPC-SP 5 or 10 |
| Single Component, no catalyst | **YES** | **NO** | **NO** | **YES** | **YES** | **NO** | **NO** | **YES** |
| **notes** | | 2-component, short pot life | 2-component, long pot life | | Requires complex application equipment, 'hot work" permit | 2 or 3 component | 2 component, DFT and recoat interval critical | Shop application process, requires bake cure |
| Can be applied over Stainless Steel | **YES** | **YES** | **YES** | **YES** | **YES** | **NO** | **YES** | **YES** |
| **notes** | | | | Does not provide protection against Chloride Induced Stress Corrosion Cracking | Aluminum foil wrap is an approved alternate | | Maximum Service Temperature too low for SS CUI service | Relatively low Max Service Temperature |
| Tie-in and field repair with self | **YES** | **YES** | **YES** | **YES** | **YES** (if not sealcoated) | **NO** | **YES** | **YES** |
| **notes** | | | | | Requires complex application equipment, "hot work" permit | Difficult; Usually not recommended per PDS | Pot Life and DFT may be issues | Requires bake cure. May require preheat. Usually repaired with liquid epoxy. |
| Corrosion Resistant at Ambient Temperatures | **YES** | **YES** | **YES** | **NO** | **YES** | **YES** | **YES** | **YES** |
| **notes** | | | Requires heating for cure | | | | | |
| Survives intermittent hot salt water immersion | **YES** | **YES** | **YES** | **NO** | **YES** | **NO** | **YES** | **YES** |
| **notes** | | | Requires heating for cure | | If no large areas of bare steel | | | |
| Anodic (significant sacrificial metal content) | **NO** | **NO** | **NO** | **NO** | **YES** | **YES** | **NO** | **NO** |
| **notes** | | Trivial Aluminum Content | | Trivial Aluminum Content | | | | |
| Can be applied to hot surface (max. temp. °F/°C) | **YES** | **YES** | **YES** | **YES** | **YES** | **NO** | **YES** | **YES** |
| **notes** | 600 °F/316 °C | 248 °F/120 °C | 450 °F/232 °C | 200 °F/93 °C | No limit up to 1,170 °F/635 °C | | Typical ~300 °F/150 °C Max DFT, Recoat Interval is critical | Requires bake cure |
| Suitable for Cyclic Hot/Cryogenic Service | **YES** | **YES** | **YES (limited)** | **NO** | **YES** | **NO** | **YES** | **NO** |
| **notes** | Different, Limited DFT Range | | Full range after heat cure | | | | limited max operating temp. | |
| VOC Content (High/Low/Zero) | **HIGH** | **HIGH** | **HIGH** | **HIGH** | **ZERO** (if not sealcoated) | **LOW** | **LOW** | **ZERO** |
| Relative material and labor cost (High/Mod/Low) | **MODERATE** | **MODERATE** | **MODERATE** | **LOW** | **HIGH** | **MODERATE** | **LOW** | **MODERATE** |
| **notes** | | | | | 4 to 10 x cost of Epoxy | | | |
| Air Dries to Hard Film | **NO** | **NO** | **NO** | **NO** | **YES** | **YES** | **YES** | **NO** |
| Usable to overcoat new or aged Inorganic zinc | **YES** | **YES** | **Not Recommended** | **YES** | **NO** | **NO** | **YES** | **NO** |
| **notes** | | | | Does not provide meaningful corrosion resistance in any CUI situation | | | significantly lowers maximum operating temp. | significantly lowers maximum operating temp. |

# Corrosion Under Insulation

| SYSTEM CHARACTERISTICS |
|---|
| Maximum Continuous Operating Temperature °F/°C |
| Maximum per coat DFT mils/microns |
| Recoatable with self for CUI service |
| Maximum total DFT for CUI service |
| Minimum Surface Prep required for CUI |
| Single Component, no catalyst |
| notes |
| Can be applied over Stainless Steel |
| notes |
| Tie-in and field repair with self |
| notes |
| Corrosion Resistant at Ambient Temperatures |
| notes |
| Survives intermittent hot salt water immersion |
| notes |
| Anodic (significant sacrificial metal content) |

| |
|---|
| Anodic (significant sacrificial metal content) |
| notes |
| Can be applied to hot surface (max. temp. °F/°C) |
| notes |
| Suitable for Cyclic Hot/Cryogenic Service |
| notes |
| VOC Content (High/Low/Zero) |
| Relative material and labor cost (High/Mod/Low) |
| notes |
| Air Dries to Hard Film |
| Usable to overcoat new or aged Inorganic zinc |

**Top and bottom of left column, TG 425 chart**

**Generic Coating Types Listed**

- **Inert Multipolymeric Matrix Hybrid**
- **Titanium-Aluminum Silicone Hybrid**
- **High Build Silicone Hybrid**
- **Thin Film Silicone**
- **Thermal Spray Aluminum**
- **Inorganic Zinc**
- **Novolac/Phenolic Epoxy**
- **Fusion Bond Epoxy**

**To be added:**

**Inorganic Siloxane Zero VOC**
**Inorganic Siloxane**
**Inorganic Siloxane Ultra High Build**

# Corrosion Under Insulation

- **Draft Report suspended in mid-2015, awaiting update of SP-0198-2010.**
- **It started up again in late 2016.**
- **Currently being revised to include third generation polysiloxanes.**
- **New chart will have 3 additional columns and will be 2 pages in portrait format.**

# Corrosion Under Insulation

## 2. Evaluating "Current" Technology

### NACE TG 525 Draft Report

**"Test Methods to Evaluate Thermal Properties and Performance of Insulative Coatings"**

# Corrosion Under Insulation

NACE INTERNATIONAL
THE CORROSION SOCIETY

**Date Prepared: yyyy-mm-dd**
**TG 525**
This draft of a proposed NACE standard is for committee use only and shall not be duplicated in any form for publication or for any use other than committee work.

PROPOSED NACE STANDARD TEST METHOD

**"Test Methods to Evaluate Thermal Properties and Performance of Insulative Coatings"**

Draft No.1: Prepared and Submitted to NACE Headquarters by Task Group; Edited and Processed by NACE Headquarters—(Month) (2016)

NACE International
1440 South Creek Drive
Houston, Texas 77084-4906
+1 281-228-6200

# Corrosion Under Insulation

## NACE Committee TG 525 Draft Report:

**Originally intended to only include acrylic spray-on testing designed for syntactic foam (solid) coatings.**

**Purposes:**
1. **Provide test for thermal efficiency of spray-on insulation.**
2. **Standard to compare spray on vs. other insulation.**
3. **Evaluate heat aging of insulative coatings.**

*"1.2: covers temperature range of 80 to 350°F., dft.*(dry film thickness) *of 20-200 mils*
*1.4: lab testing, not for block or form insulation or for >200 mils dft.*
*1.9: all thermal ageing tests must be done on hotplate, not oven."*

# Corrosion Under Insulation


Premature breakdown of acrylic spray-on insulation due to heat stress and atmospheric exposure.

# Corrosion Under Insulation

**Table 1**
**Information on Test Methods and Test Panel Preparation**

| Test No. | Name of test | Long-Term Thermal Ageing? | Standard and/or Section this standard | Minimum No. of Panels | Panel Size (mm/inch) | Type Substrate | Coating Thickness (mm/Mil) |
|---|---|---|---|---|---|---|---|
| **Thermal Tests** | | | | | | | |
| 1 | Thermal Efficiency | N | Section 7 | 1-uninsulated 1-insulated | 305 x 305x 95 12 x 12 x 0.375 | Al | 0, 3.0 0, 120 |
| 2 | Thermal Conductivity | N | ASTM C177 or C518 | 1 or 2 | Per standard & test lab | PTFE for free film | 7.6 300 |
| 3 | Thermal Conductivity with thermal ageing | Y | Section 9 | 1 | 305 x 30 5x 95 12 x 12 x 0.375 | AL | 3.0 120 |
| 4 | Validation for Personnel Protection | N | NACE TM XXX[4] | 5 | 102 x 203 x 6.4 4 x 8 x 0.25 | AL | 5 thick. in svc range |
| 5 | Hemispherical and Normal emissivity | Y | ASTM E408[5] method A or C | 4 | Per standard & test lab | AL | 2.5 – 3.0 100 - 120 |
| 6 | Solar Reflection/absorption | N | ASTM E903[6] | 1 | Per standard & test lab | Al | 0.6 – 1.0 25 - 40 |
| **Coating Integrity, Durability and Performance** | | | | | | | |
| 7 | Adhesion pull tests AGED | Y | ASTM D4541[7] & Section 11 | 12 | 76 x 152 x 3.2 3 x 6 x 1/8 | ~~Al or~~ CS | 2.5 – 3.0 100 - 120 |
| 8 | Cyclic hot/wet with ageing | Y | Section 12 | 1 | 305 x 305x 95 12 x 12 x 0.375 | ~~Al~~ CS | 3.8 – 4.1 150 - 160 |
| 9 | Thermal shock RESISTANCE | Y | Section 13 | 3 | SMALLER 76 x 152 x 3.2 3 x 6 x 1/8 | ~~Al~~ CS | 3.8 – 4.1 150 - 160 |
| 10 | Blister resistance test (No thermal conditioning) | N | Section 14 | 14 | 76 x 152 x 3.2 3 x 6 x 1/8 | ~~Al~~ CS | 3.8 – 4.1 150 - 160 |
| 11 | % Mass loss | Y | Section 15 | 2 | 3 x 6 x 30 mils | AL | 3.8 – 4.1 150 - 160 |
| 12 | Mandrel Bend Test (Flexibility) | Y | Section 16 | 1 | 6 x 6 free-film | PTFE for Free-film | 2.5 – 3.0 100 - 120 |
| 13 | Flame spread | N | ASTM E84[8] | Per standard & test lab | | | |
| 14 | Smoke developed | N | ASTM E84 | Per standard & test lab | | | |
| 15 | Prohesion salt Fog test | Y | ASTM D5894[9] & section 17 | 6 | 76 x 152 x 3.2 3 x 6 x 1/8 | CS | 2.5 – 3.0 100 - 120 |

**Testing duration is 4000 hours (almost 6 months).**

# Corrosion Under Insulation

## Revisions to TG 525 Draft Test Procedures Needed to Cover Third-Generation Siloxane Ultra High Build

Hot Plate Test at ~550°F 20 Minutes Duration

Top Panel: Third Generation Siloxane Spray-On Insulation

Lower Panel: Typical Acrylic Spray-on Insulation

# Corrosion Under Insulation

**Heavy-Duty Hot Plates for TG 525 Testing**

# Corrosion Under Insulation

## 2. Evaluating "Current" Technology

## NACE TG 516 Draft Report

**"Standard Practice for Evaluating Protective Coatings for Use Under Insulation"**

# Corrosion Under Insulation

**There is some disagreement and uncertainty in the committee about test methods:**

- **The "standard test" proposed by**
- **end users costs $25,000 per test;**
- **requires separate tests ($25,000)**
- **at different temperatures; must be**
- **done by an outside, third-party lab;**
- **and may have to be repeated for each requesting end user.**


- **More cost-effective test methods are being discussed.**

# Corrosion Under Insulation

## 3. Emerging Technologies

### Third Generation Polysiloxane

**Non-Hybrid Zero VOC CUI Coating to 572° F**
**Non-Hybrid CUI Coating to 1200° F**
**Non-Hybrid Waterborne Spray-on Insulation to 750°F**

# Corrosion Under Insulation

Paper No.
9331

NACE INTERNATIONAL CORROSION 2017 Conference & Expo

**Performance of Next Generation CUI Mitigation Systems**

Neil Wilds Technical Marketing Manager
Sherwin Williams Protective & Marine Coatings
Bolton BL2 2AL, United Kingdom
Neil.Wilds@sherwin.com

Corrosion under Insulation (CUI) is one of the costliest problems facing the Oil & Gas and Process industries today. According to corrosion engineers, problems such as major equipment outages and unexpected maintenance costs stemming from CUI account for more unplanned downtime than all other causes. Thermal insulation of piping, valves, tanks or vessels is achieved by an INTEGRAL SYSTEM comprising of corrosion mitigation

**Paper presented at NACE Corrosion 2017 by Neil Wilds, Global Technical Marketing Manager, Sherwin Williams Protective and Marine Coatings**

# According to Mr. Wilds' paper:

- Products currently listed in SP 0198 are "second generation."
- They were "state of the art" 10 to 12 years ago.
- They have inherent defects:
  - IMM/IC (2nd Gen) polysiloxanes are solvent based with high VOCs, stay soft after air dry, have poor atmospheric resistance, stay solvent sensitive, require heat cure for full strength, have poor UV resistance
  - CUI epoxies require exacting application and dry film thickness, have relatively low operating temperatures.

# Corrosion Under Insulation

**Mr. Wilds gave a presentation on his paper at the TG 425 committee meeting during NACE Corrosion Technology Week in September.**

**He repeated the main points of his paper, but contrary to all expectations, his employers have not introduced a third-generation CUI coating.**

**Such coatings do exist, are being used in Europe, and were recently introduced in the United States.**

***The following information is NOT from Mr. Wilds' paper.***

# Brief Elevated Temperature Coatings History

| | |
|---|---|
| • Repurposed Organic Coatings: | Oil-Based Red Lead Primers |
| | Oleoresinous Aluminum |
| | Epoxies |
| • Repurposed Inorganic Anodic Primer: | Inorganic Zinc |
| • Elevated Temperature Inorganic : | Thin Film Silicone Enamel |
| • Repurposed Inorganic-Hybrid: | First-Generation Polysiloxane |
| • Elevated Temperature Inorganic-Hybrid: (IMM or IC) | Second-Generation Polysiloxane |
| • Elevated Temperature Pure Inorganic: (TGPS and TGPS-UHB) | Third-Generation Polysiloxane (non-hybrid) |

# Corrosion Under Insulation

20-Year-Old Red Lead
in CUI Service

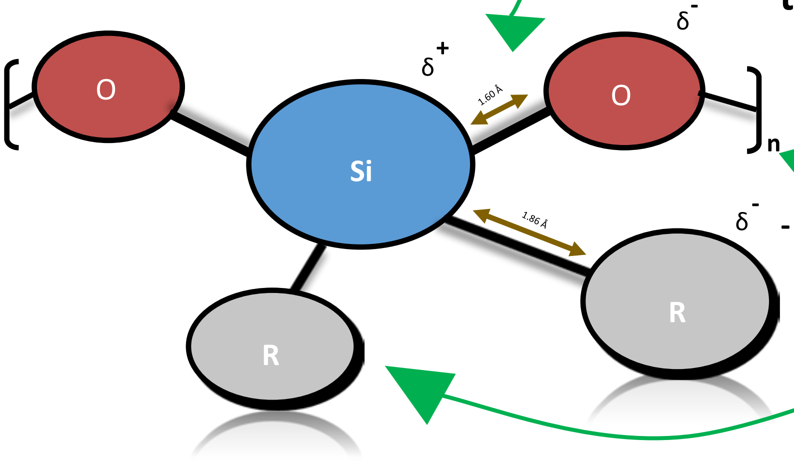
Thin Film Silicone
Applied too Thickly

18-Year-Old Inorganic Zinc in CUI Service


Transport Damage
on New Second-Generation IMM

# Third Generation Polysiloxane Coatings

## Third Generation Polysiloxane Technology (TGPS)




- Si—O bonding has excellent strength, provides high temperature and UV resistance
- Polymer chain length can be varied to optimize performance
- Reactive groups attached allow for ambient curing properties

(Overcomes traditional problems of silicones and siloxanes requiring heat curing for hardness and full strength)

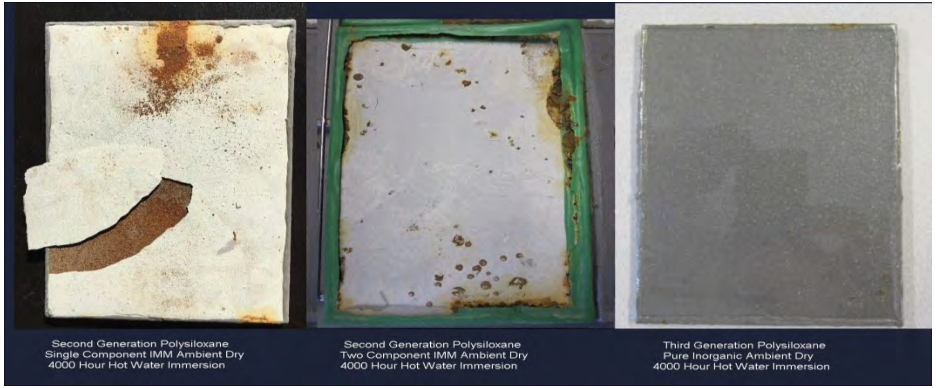
**Note: no organic (Carbon) atoms in the molecule = not a hybrid**

# Corrosion Under Insulation

**Novel pure inorganic TGPS technologies include:**

- Single pack, ambient cure, third-generation CUI (TGPS) coating, solvent based, service to 1200°F.
- Inorganic, ambient cure, liquid-applied spray—on thermal insulation up to 752ºF, waterborne, near-zero VOC, Ultra High Build, UV resistant.
- Single pack, ambient cure, third-generation solvent-free, zero VOC (CUI) coating, service to 600°F.

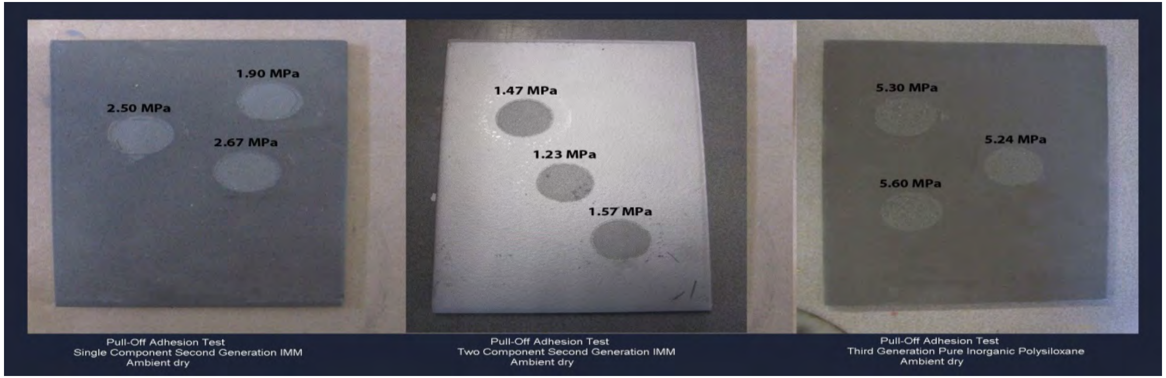
# Third-Generation Polysiloxane Coatings




**Two Second-Generation Hybrids (IMM) left and center versus Third-Generation Inorganic (TGPS) (right)**

**Hot-Water Immersion**
Salt water 194ºF (4000 hrs)

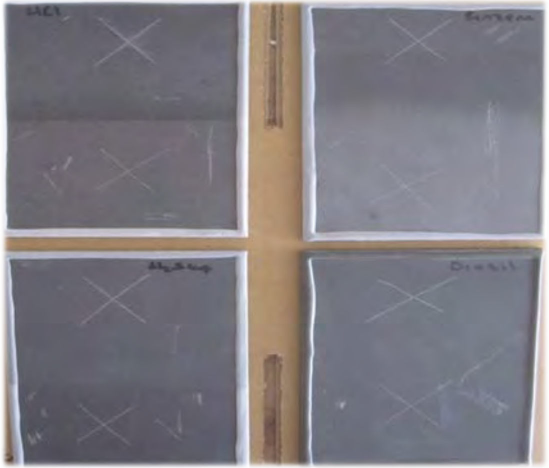
**Dolly Pull-Off**
Adhesion to steel



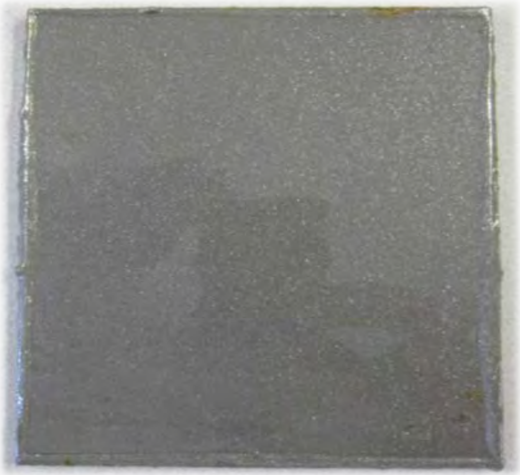

NIA National Insulation Association®

# Third-Generation Polysiloxane Coatings

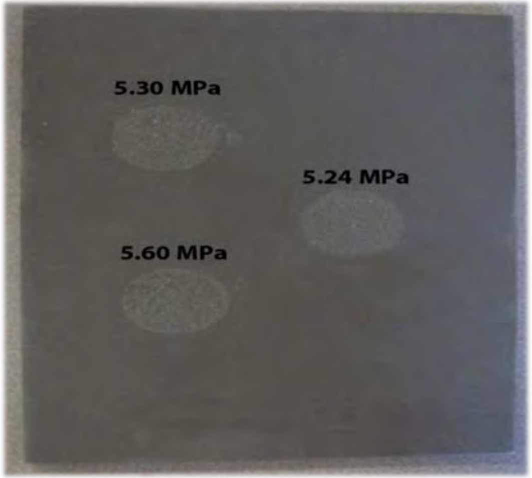
**Acid and Solvent Immersion**
720 Hour Exposure



**Hot Water Immersion**
Salt Water 194°F(4000 hrs)



**Dolly Pull-Off**
Adhesion to Steel



# Third-Gen Polysiloxane Product Systems

1

| CUI Under Traditional Insulation (-320 to 1200ºF) | | |
|---|---|---|
| 1st coat | TGPS Coating | 6 mils + Dry Film Thickness |
| 2nd coat | TGPS Coating | 6 mils + Dry Film Thickness |

| This System also Requires: | |
|---|---|
| 3rd step | Block, batt, or mat insulation |
| 4th step | Sheet metal or plastic jacketing |

2

| CUI Insulation with Primer (-76 to 752ºF) | | |
|---|---|---|
| 1st coat | TGPS Coating | 6 mils DFT |
| 2nd coat | TGPS -- UHB | 400 mils + Dry Film Thickness |

3

| Spray-On Insulation DTM (-76 to 752ºF) | | |
|---|---|---|
| 1 coat | TGPS – UHB applied DTM | 400 mils + Dry Film Thickness |
| | One Coat and You are Done | |

# Third-Generation Polysiloxane Spray-On Insulation

- (TGPS UHB) = third-gen PSX Ultra Hi Build
- Single component, waterborne
- VOC 1 (yes One) g/l
- Spray applied, 400 mils, one coat
- Apply directly to metal or over CUI primer
- Does not require jacketing
- UV and Chemical resistant
- Service to 750°F

# Corrosion Under Insulation

| THICKNESS (mils dft.) | INITIAL TEMPERATURE (°F) | REDUCED TO DEGREES (F) | REDUCTION DEGREES (F) |
|---|---|---|---|
| 800 | 752 | 131 | 621 |
| 800 | 572 | 111 | 461 |
| 800 | 392 | 97 | 295 |
| 800 | 212 | 86 | 126 |
| | | | |
| **400** | 752 | 151 | 601 |
| **400** | 572 | 127 | 445 |
| **400** | 392 | 113 | 279 |
| **400** | 212 | 90 | 122 |
| **400** | 122 | 70 | 52 |
| | | | |
| 200 | 392 | 125 | 267 |
| 200 | 212 | 93 | 119 |
| 200 | 122 | 77 | 45 |

.07 w/mk = .485 btu-in / hr -- ft -- ° $F^2$

# Corrosion Under Insulation

- Sag resistance of TGPS-UHB
- Newly applied, app. 500 mils wet
- 65°F air and surface temperature, 55% r.h.

# Corrosion Under Insulation

## Emerging Technologies to Combat CUI

1. Oldies but Goodies Updated
2. Evaluating “Current” Technology
3. Emerging Technologies

# Corrosion Under Insulation

## Questions?


**Peter Bock**
**Performance Polymers Americas**
**North American Operations**
**Houston, TX**
**pbock@pp-bv.com**
**peterbcui@gmail.com**
**713-396-6383**