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Beyond TSA - The rise of aluminium flake silicone coatings in high-temperature CUI applications and wellhead casing protection

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Abstract

For more than four decades the oil & gas and petrochemical industries have had to contend with high maintenance costs, plant outages and sometimes catastrophic infrastructure failures caused by corrosion under insulation (CUI) of insulated pipes, tanks and vessels.

This article highlights how coating manufacturers have done superbly well in formulating silicone high temperature-resistant coatings to protect thermally insulated critical structures from the ravages of CUI. Results are presented of CUI-simulating laboratory tests of a liquid-applied aluminium flake-filled silicone coating and a metallic thermal spray aluminium (TSA) coating. The test results have value in terms of predicting the liquid coating's real-world performance for case histories provided, namely 20 years of CUI mitigation in the oil and gas industry and 10 years of corrosion protection in mostly high temperature immersion service on oilpatch wellheads.

Introduction

CUI is a particularly aggressive degradation mechanism for asset owners. Localised corrosion and pitting occur when thermal insulation traps moisture and contaminants on steel surfaces. Similar but not identical to immersion conditions, micro-environments beneath insulation include the presence of dissolved oxygen, moisture and concentration of soluble chlorides, and numerous temperature scenarios, viz, high or low temperature, repetitive thermal cycling, different rates of temperature change, and thermal shock[1].

High-performance silicone temperature resistant coatings, often described as inert multi-polymeric matrix (IMM) coatings, are single-component (1K) or two-component (2K) inorganic coatings that exhibit high heat and cryogenic resistance, respectively up to 650°C (1202°F) and down to -196°C (-321°F). They have also been shown to provide broad anticorrosion performance at ambient and high temperature for harsh environments when tested according to ISO 12944-6:2018 (CX being the highest corrosion category for extreme environments) or exposed to real world CX conditions[2].

Some mechanisms of action are discussed for an aluminium flake-filled IMM liquid-applied coating and a metallic TSA coating applied to carbon steel pipes. The ISO19277:2018 Houston Vertical Pipe Test was employed to simulate certain CUI conditions where temperatures cycled between 96°C (205°F) and 446°C (835°F)[3,4]. High-performance coatings for CUI mitigation need to have the right balance of heat resistance, anticorrosive properties and flexibility. According to NACE SP0198 the critical corrosion temperature ranges that a high heat coating must withstand are -4°C (25°F) to 175°C (347°F) for carbon steel, and 50°C (122°F) to 175°C (347°F) for stainless steel[5].

Industrial and marine process assets that operate at high or low temperatures often require corrosion protection for steel vulnerable to CUI or chloride-induced external stress corrosion cracking (ESCC). As a result, carbon steel coated with IMM coatings or TSA is often specified when CUI temperatures range from -196°C (-321°F) to 650°C (1202°F).

Against this backdrop, the following key questions are of interest:

1. For CUI mitigation, what is better as the last line of defence: a liquid applied aluminium flake-filled IMM coating or TSA for corrosion protection and long-life coating performance?

2. Do the aluminium-flake pigments in an IMM coating enhance the coating's reliability and predictability of success for decades of CUI mitigation in cyclic temperature service?

3. Could the same aluminium flake-filled IMM coating deliver 10-years corrosion-free performance for immersion service on hot wellhead carbon steel surface casings?

4. Does the CUI simulation test method for the IMM coating show good predictability with its real-world performance?

Mechanisms of action

IMM coating containing aluminium flake pigments

Aluminium flake pigments in the IMM coating are not sacrificial and there are not enough aluminium flakes in contact with each other to set up a perturbation network. They have an aluminium oxide film, are coated with resin, and IMM films are electrically inert at the coating-substrate interface.

Corrosion protection from aluminium flake pigments in organic coatings is reasonably well understood, but far less so in inorganic IMM high-heat silicone coatings. Notwithstanding, plausible mechanisms of action in both cases include:

Buffering pH and cathodic inhibition

In aqueous NaCl environments, cathodic reactions occurring during metal corrosion generate hydroxide (OH^-) ions, giving rise to alkalinity beneath the coating. If the coating lacks sufficient alkali resistance, a high pH moving front may cause cathodic disbondment, coating adhesion loss, and corrosion of the underlying steel. Importantly, this degradation can occur away from the scribe or defect in the coating, meaning scribe creep might appear minimal even while significant cathodic delamination and under-film corrosion is taking place[6].

When aluminium flake pigments are incorporated into the coating, in the first instance, they can react with the OH^- ions to de-passivate and form soluble aluminate. This reaction helps lower the local pH and mitigate cathodic disbondment[7–9].

$$Al_2O_3 + 2[OH^-] \longrightarrow 2[AlO_2^-] + H_2O$$

$$4Al + 4[OH^-] + 3O_2 \longrightarrow 4[AlO_2^-] + 2H_2O$$

$$[AlO_2^-] + 2H_2O \longrightarrow [Al(OH)_4^-]$$

Adventitious (or trace) protons on the pigments or within the silicone resin can then react with the basic aluminate to produce aluminium hydroxide ($Al(OH)_3$), which gradually converts into aluminium oxyhydroxide and oxide species (AlOOH, Al_2O_3) - a process analogous to the maturation of iron hydroxide into stable iron oxyhydroxide and oxide corrosion products.

$$[Al(OH)_4^-] \rightleftharpoons Al(OH)_3 + [OH^-]$$

$$[Al(OH)_4^-] \xrightarrow{[H^+]} Al(OH)_3 + H_2O$$

$$Al(OH)_3 \rightrightarrows AlOOH + Al_2O_3$$

The $Al(OH)_3$, AlOOH, Al_2O_3 and associated intermediates occupy the disbonding crevice and may deposit on the corroding metal interface, stifling any cathodic activity. The otherwise stable aluminium flake can therefore be imagined as a reservoir of cathodic inhibitors in the IMM coating that is only activated once high pH conditions are established at the cathode half-cell reaction.

Barrier protection

Envisaged to delay or prevent the diffusion of water, oxygen and ionic species through a coating, diffusion barrier protection in the form of a tortuous path of lamellar-shaped and parallel-oriented pigment particles is sometimes given greater credence than it perhaps deserves. In one study, aluminium flakes in an epoxy coating decreased the oxygen diffusion rate, but oxygen permeability was less affected, water imbibition only slightly affected, and the ionic conductivity of the epoxy increased as the pigment volume concentration increased.[8]

Factors that influence a coating's barrier properties include (a) loadings and types of high aspect ratio lamellar pigments such as glass flake, aluminium flake and micaceous iron oxide (MIO), (b) resin crosslink density and network structure, (c) type of solvent, (d) coating thickness, and (e) resin synergy with pigments. Enhanced barrier protection is expected from a coating formulated with 20 to 30% loadings by weight of high aspect ratio lamellar pigments, as in the aluminium flake-filled IMM coating than one with only 6 to 9% loadings by weight in a typical epoxy coating.

In addition to the barrier properties, the high level of aluminium flake also enhances the mechanical properties of the IMM coating by reducing the coefficient of thermal expansion. This results in lower stress in the coating when exposed to thermal cycles[10].

Thermal spray aluminium (TSA)

For atmospheric environments, the largely sacrificial anodic property of TSA makes it an outstanding choice for corrosion protection of carbon steel. Successful case histories for TSA performance of 20 to 40 years are common[11].

TSA can be good for CUI mitigation when assets rapidly change temperature from cryogenic temperatures to several hundred degrees and then go back to cryogenic conditions again. This rapid and massive amplitude temperature change is not conducive, however, to the survival of IMM high heat coatings. Theoretically, aluminium corrosion products formed on TSA could also provide a measure of barrier protection as they accumulate and block pores in the TSA metallic structure.

Sacrificial protection

It is important to note that TSA has some significant limitations for CUI mitigation due to the reactivity and consumption of metallic aluminium in the 82°C (180°F) to 110°C (230°F) hot water brine temperature range[12]. TSA is usually thought to behave as a sacrificial anode in hot water brine immersion, and beneath wet or damp insulation that will not dry out. Salts, particularly chlorides, can increase in concentration as temperature cycles. The boiling point of water will rise, and the solubility of oxygen will plummet as the temperature climbs into the hot water-brine range. The oxygen, however, can easily be recharged from the atmosphere and has only a short diffusion path to the steel substrate.

Recent studies have compared the corrosion behaviour of TSA coatings in hot immersion conditions in an autoclave set-up versus corrosion behaviour in a CUI simulation set-up (per ASTM G189 method).[13] While the TSA coating was found promising in hot-immersion conditions, it was subjected to degradation in CUI simulation tests. In an insulated set-up, the direct contact between insulation and the insulated surface created oxygen concentration cells, the same as those experienced in a crevice[13-15].

A CUI environment for TSA with moisture is not just 'hot immersion' rather it is 'hot immersion within a crevice' with flashing of trapped moisture at the insulation-coating interface at boiling temperatures. This flashing creates cavitation-like effects, causing the coalescence and fracture of pores, creating a pathway for the seepage of electrolyte (i.e., trapped moisture) under the TSA.[13] Since the pH of a CUI environment is near-neutral, the sacrificial nature of TSA will be impeded (making it the cathode) at the flashing temperatures (i.e., 95°C (203°F)), causing active dissolution of the underlying carbon steel[16].

Experimental test program

The resistance to CUI by an aluminium flake-filled (20-30% by weight) IMM coating and TSA (Type 1100) on coated carbon steel pipes was evaluated based on the ISO19277:2018 Houston Vertical Pipe Test[4,17].

According to the coating manufacturer's published technical data sheets, steel pipes (A513) were abrasive blasted to NACE No.2. One set of steel pipes was sprayed with one coat of a liquid IMM coating to achieve 8 mils dry film thickness (DFT). The other set of steel pipes was thermally sprayed with TSA to achieve a coating thickness of approximately 12 mils DFT. The pipes were then encased in calcium silicate (Cal-Sil) insulation and wrapped with aluminium foil (Figure 1).

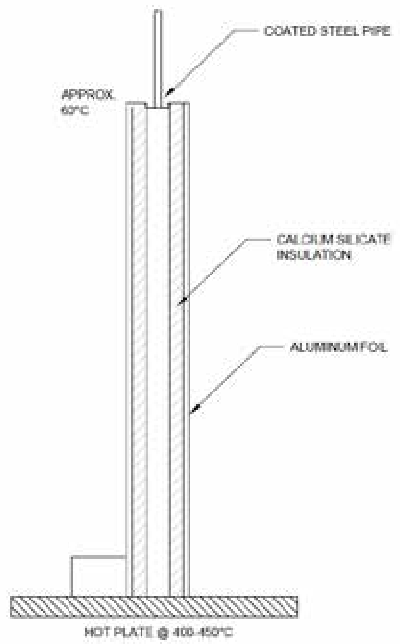


Figure 1: Coated, insulated and clad pipe sample schematic

Each day, one litre of a 1% sodium chloride (NaCl) solution was poured into the top of the Cal-Sil insulation surrounding the pipe. The pipes were placed on a hot plate that, within two to three hours, resulted in a temperature gradient along the pipe from 95°C (203°F) to 450°C (842°F) (Figure 2).

Figure 2: CUI simulated tests of IMM and TSA coated test pipes on a hot plate

After eight hours on the hot plate, the insulated pipe was removed from the heat and placed in a shallow pan. One more litre of 1% NaCl solution was poured into the insulation, and the insulated pipe was allowed to cool overnight. Both ends of the insulation were left open to facilitate entry and drainage of the NaCl solution. The liquid was mostly absorbed by the insulation, with only a small amount of drainage from the bottom. The procedure was repeated five days a week for six weeks, for a total of 30 cycles.

The insulation was removed from the pipes and the IMM and TSA coatings assessed as a function of temperature: visually (ISO 4628) and by optical microscopy, scanning electron microscopy (SEM), electrochemical impedance spectroscopy (EIS) and coating porosity (CSAZ245.20).

Results and discussion

Aluminium flake-filled IMM coating and TSA on steel pipes

Figure 3 shows the visual performances of the aluminium flake-filled IMM coating and TSA on the carbon steel pipes when heated from 95°C (203°F) to 450°C (842°F) under cyclic CUI simulation conditions. Visually, both coatings performed well with only slight evidence of degradation around 450°C (842°F).

Close inspection of SEM photomicrographs of the IMM coating in Figures 4a and 4b shows greater distortion and interlacing of the 18-micron-sized aluminium flakes

Figure 3: IMM coating (top) and TSA (bottom) on the carbon steel pipes when heated from 95°C (203°F) (left hand side) to 450°C (842°F) (right hand side)

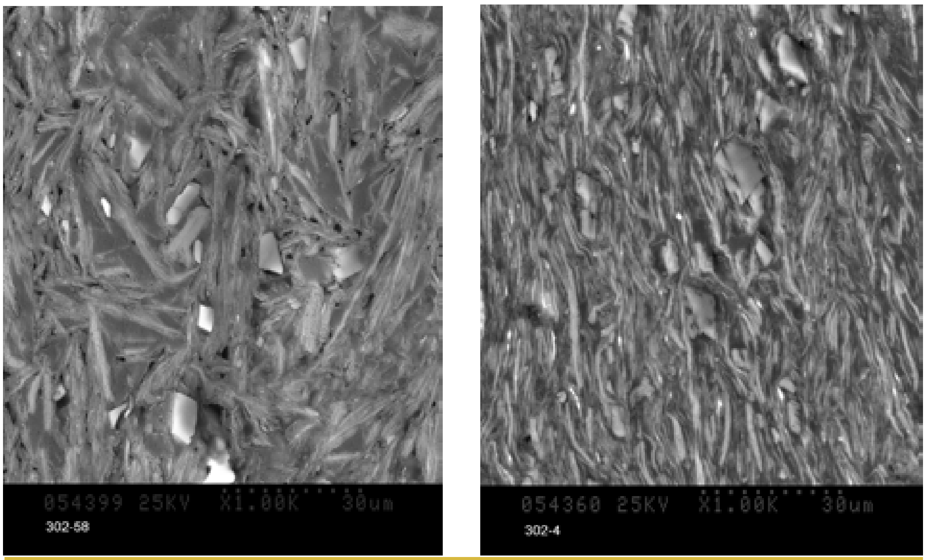


Figure 4a: SEM photomicrograph of IMM at 100°C; 4b: SEM photomicrograph of IMM at 400°C

at 400°C (752°F) than at 95°C (203°F). Independent of temperature, the IMM coating porosity was approximately 1% and little to no evidence of rust formation was seen (Figure 5).

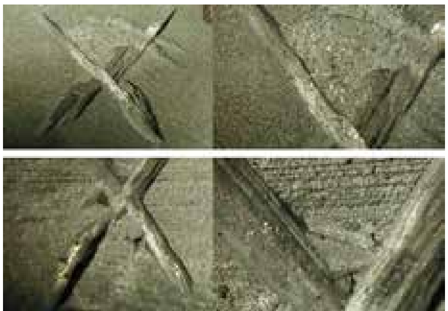


Figure 5: IMM X scribe adhesion. Top row 400°C. Bottom row 200°C. No adhesive disbondment or rust bleed-through

Figures 6a and 6b show the SEM photomicrographs of TSA after testing at 400°C (752°F) and 95°C (203°F), respectively.

As expected, considerable porosity was observed, ranging from 5 to 15%. Some rust formation was seen close to an X-scribe in TSA at 400°C (752°F), which was not seen in the aluminium flake-filled IMM coating (Figure 7).

These comparative results between aluminium-flake IMM coating and TSA accord well with the authors' field experience, in that in non-ideal field conditions TSA can be challenging to apply, and higher levels of porosity and the potential for rust through can occur.

Tables 1 and 2, and Figure 8, present EIS data (0.1Hz) for the IMM coating and TSA. For this particular IMM coating, the ambient temperature log Z impedance pre-test value was 7.0, a low value suggesting incomplete crosslinking in the silicone resin.

Exposure to CUI conditions at 100°C (212°F), 200°C (392°F) and 300°C (572°F), however, produced a significant increase in log Z impedance values of 9.3 to 9.7. This suggests greater crosslink density and a reduction in coating permeability at higher temperatures, and good barrier properties.

Between 300°C (572°F) and 400°C (752°F), where methyl and phenyl groups are volatilising from the silicone backbone in this particular IMM coating, the log Z drop in impedance to a value of 3.3 is possibly indicative of greater metallic characteristics in the IMM film and reduced electrical resistance.

TSA had a low pre-test log Z impedance of 2.6, consistent with the metallic nature of the coating. Exposure to CUI conditions up to 400°C (752°F) resulted in a small increase in impedance with log Z values as high as 3.70. This can be explained by the formation and accumulation of oxides and/or insoluble salts that add electrical resistance as they fill pores in the metallic TSA structure.

As highlighted in the previous sections, aluminium flake-filled IMM coatings occupy a unique position in protective coatings technology suited to provide sustained corrosion protection for CUI environments.

Figure 7: TSA X scribe adhesion. Top row 400°C. Bottom row 100°C. No adhesive disbondment but rust bleed-through visible at 400°C

Case history 1

20-year CUI mitigation for high-temperature gas reactor

Two decades ago, a severe CUI issue was unexpectedly discovered during routine insulation removal on a gas processing reactor sited at a coastal location. The onset of CUI was traced to process-related factors, whereby during the cool-down cycle, the reactor would draw in small amounts of atmospheric moisture. The initially applied coating failed after two years, with severe corrosion detected at multiple points on the vertical section of the reactor.

The reactor operated under daily cyclic thermal conditions between ca 250°C (482°F) and 100°C (212°F). It was decided to rehabilitate and protect the reactor with an aluminium flake-filled IMM coating solution[18]. The surface was abrasive blast-cleaned to NACE No.2, and a single coat of the high heat coating was applied to a target of 7-10 mils DFT.

Periodic coating inspections of the IMM coating were carried out after 5, 13 and 20 years (Figure 9). Significantly, after 20 years of in-service performance, the IMM-coated steel remained corrosion-free and the coating suffered no heat degradation, flaking, loss of adhesion or decrease in film-thickness.

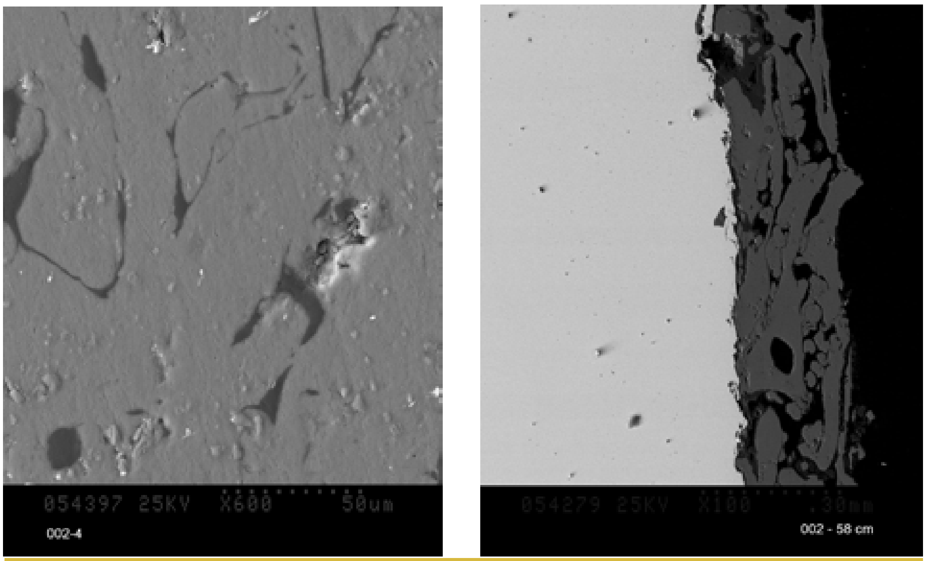


Figure 6a: SEM photomicrograph of TSA at 400°C; 6b: SEM photomicrograph of TSA at 100°C

Table 1: EIS data for IMM and TSA coating at room temperature

EIS of NEW CUI Pipes - 48-hour Soak (5% NaCl) at 23°C			
Coating	Panel ID	DFT (mils)	Impedance (log Z at 0.1 Hz (Ohms*cm^2)
TSA	09-808-002	12	2.6
IMM	09-808-301	8	7.0

Table 2: EIS data for IMM coating and TSA at elevated temperatures post CUI simulation test

EIS of CUI Tested Pipes - 48-hour Soak (5% NaCl) at 23°C						
Coating	Panel ID	DFT (mils)	Impedance (log Z at 0.1 Hz (Ohms*cm^2)			
			Temperature During Testing °C			
			400	300	200	100
TSA	09-808-001	13	3.1	3.3	2.9	3.7
IMM	09-808-301	9	3.3	9.7	9.3	9.5

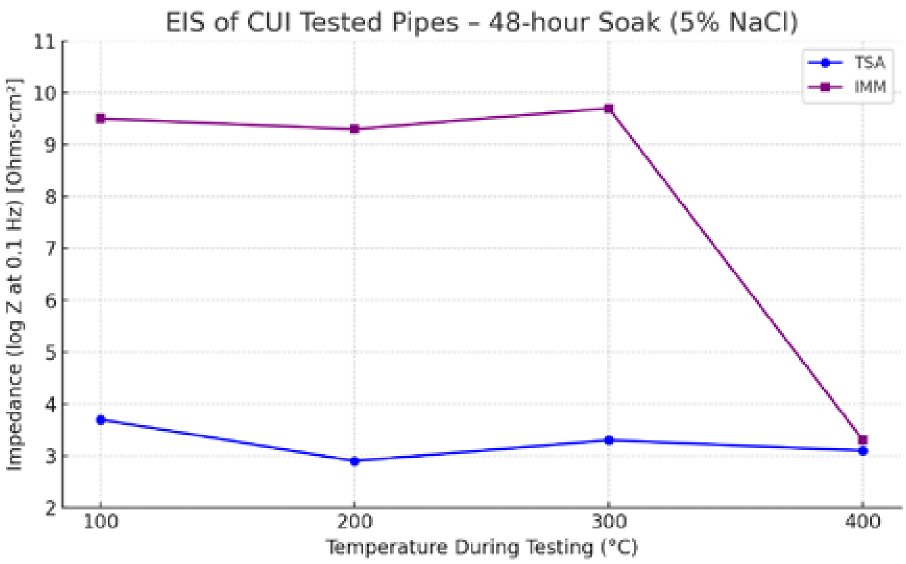


Figure 8: EIS data for IMM coating and TSA

Case history 2

10-year corrosion protection for thermal wellhead casings

In thermal operations like steam assisted gravity drainage (SAGD) and cyclic steam simulation (CSS), wellhead surface casings face extreme thermal cycling (from -40°C shut-ins to 300°C steam cycles) and aggressive chemical exposures. Water, chlorides, oil, rain and groundwater, held in place by wet bentonite, create a corrosive environment. Alternating wet/dry conditions and deteriorated concrete encasement further lower resistivity and accelerate corrosion.

Corrosion rates on carbon steel of up to 2.0 mm/year have been observed just below ground level. Traditional mitigation methods like cathodic protection or sleeves proved unreliable or too costly.

As discussed earlier, aluminium flake-filled IMM coatings offer a unique solution. In 2015, a novel approach was taken, one that combined silicone coating chemistry for CUI mitigation with a practical field application[19]. IMM coatings were chosen for:

- Thermal shock and crack resistance up to 400°C (752°F)
- Mechanical toughness — important for handling damage without delamination
- Tortuous path barrier effect due to aligned aluminium flakes
- Compatibility with blast-cleaned steel and hot application to around 95°C (203°F)

Field application was challenging due to the tight annular space between conductor and surface casings (about 1 ft wide, 6.5 ft deep), but with surface preparation to NACE No.1, and rigorous inspection, the coating application was done effectively using fine brushes and rollers.

A decade later, inspections showed that IMM-coated surfaces remained intact and corrosion-free, albeit dirty (Figure 10).

Cost savings were substantial: IMM coating installation ($3K–$6K) compared to casing replacement/sleeving ($150K–$1M+). As one oil major owner commented: "The IMM near surface casing program has been a great success from its inception 10 years ago. Estimates are that its use has reduced the corrosion rate by 10x, and to date, we are not aware of a case where the coating hasn't performed well."

Figure 9: IMM coating in CUI mitigation service: original corroded condition (left), 5 and 13 years (middle), and 20 years (right)

Figure 10: IMM coating immersed on surface casings: day 1 (left}, 2.5 years (middle), 10 years (right)

Conclusions

Optical microscopy, SEM, EIS and porosity determinations support a diffusion barrier protection mechanism of action occurs with an aluminium flake-filled IMM coating for CUI mitigation.

Aluminium flake pigments in the IMM coating are arguably chemically active and provide pH buffering and cathodic inhibition for CUI mitigation.

Case histories and accelerated laboratory testing of an aluminium flake-filled IMM coating in the simulated CUI conditions tried show that the liquid-applied coating is overall superior to TSA for corrosion protection.

The presence of aluminium flake pigments in an IMM coating is key to validating the coating's predictability of successful performance of 20 years in real world CUI mitigation.

The IMM coating provided 10 years of corrosion-free performance on carbon steel for mostly immersion service on hot wellhead surface casings.

The ISO19277:2018 Houston Vertical Pipe Test CUI simulation test method for the IMM coating gave results under the conditions tried that accord well in terms of the coating's real-world performance observed after 20 years.

References

1. R.D. Kane, M. Chauviere, K. Chustz, "Evaluation of Steel and TSA Coating in a Corrosion Under Insulation (CUI) Environment", NACE Corrosion Conference and Expo, Corrosion 2008, New Orleans, Louisiana, (16-20 March 2008), Paper No. 08036, 20pp: doi.org/10.5006/C2008-08036

2. M. O'Donoghue, V.J. Datta, G. Sykes, G. Ross, A. Sanseau-Blanchard, "Snoozing Not Losing: Novel IMM Coatings with Increased Productivity for CUI Service", Journal of Protective Coatings and Linings (December 2018), 35(12), 24-26, 28-37.

3. M. Halliday, "Preventing Corrosion Under Insulation – New Generation Solutions for an Age Old Problem", 46th Annual Conference of the Australasian Corrosion Association 2006, Corrosion and Prevention 2006, Hobart, Australia, (19-22 November 2006), paper 014, 510-516.

4. M. O'Donoghue, V.J. Datta, A. Andrews, S. Adlem, M. Giardina, N. de Varennes, L.G.S. Grey, D. Lachat, B. Johnson, "When Undercover Agents Can't Stand the Heat: Coatings in Action and the Netherworld of Corrosion Under Insulation", Journal of Protective Coatings and Linings (February 2012), 29(2), 24-43.

5. NACE Standard RP0198-2004. "Control of Corrosion Under Thermal Insulation and Fireproofing Materials – A Systems Approach", (Houston, Texas; NACE 2004).

6. C. Reed, "Underfilm Corrosion Creep and Cathodic Delamination: Under the Microscope", NACE International's Annual Conference and Exposition, Corrosion 2014, San Antonio, Texas, (9-13 March 2014), Paper C2014-4271.

7. B. Ramezanzadeh, M. Khazaei, A. Rajabi, G. Heidari, and D. Khazaei, "Corrosion Resistance and Cathodic Delamination of an Epoxy/Polyamide Coating on Milled Steel", Corrosion (January 2014), 70(1), 56-65: doi.org/10.5006/1039

8. O.Ø. Knudsen, U. Steinsmo, "Effect of Barrier Pigments on Cathodic Disbonding Part 2: Mechanism of the Effect of Aluminum Pigments", Journal of Corrosion Science and Engineering (1999), 2, paper 13.

9. B. Chen, M. Guizar-Sicairos, G. Xiong, L. Shemilt, A. Diaz, J. Nutter, N. Burdet, S. Huo, J. Mancuso, A. Monteith, F. Vergeer, A. Burgess, I. Robinson, "Three-Dimensional Structure Analysis and Percolation Properties of a Barrier Marine Coating", Scientific Reports (2013), 3, 1177: doi.org/10.1038/srep01177.

10. J. Zhao, W. Luo, L. Qi, L. Yuan, G. Huang, Y. Huang, X. Weng, "The High-Temperature Resistance Properties of Polysiloxane/Al Coatings with Low Infrared Emissivity", Coatings (2018), 8, 125: doi.org/10.3390/coatings8040125

11. P. Bock, "Preventing CUI with Thermal-Spray Metal Coating: New Use for a Traditional Process", Journal of Protective Coatings and Linings (February 2015), 32(2), 62-69.

12. M. Schilling – Personal Communication with M. O'Donoghue in 2011

13. A.R.K. Rana, I. Rohela, S. Karim, G. Brigham, "A Comparison of Thermally Sprayed Aluminum (TSA) Degradation Behavior Under Immersion and CUI Simulation Conditions", AMPP Annual Conference + Expo 2025, Nashville, Tennessee, (6-10 April 2025), Paper No: C2025-00024, 15pp: doi.org/10.5006/C2025-00024

14. A.R.K. Rana, J. Chapman, S.U.N. Bukhari, T. Sohail, G. Brigham, "Deviations in CUI Rate Predictions for TSA Coated Carbon Steel – A Comparison of Experimental VS RBI Approach", AMPP Annual Conference + Expo 2025, Nashville, Tennessee, (6-10 April 2025), Paper No. C2025-00179, 10 pp: doi.org/10.5006/C2025-00179

15. A.R.K. Rana, S. Karim, S. AlAchkaar, J. Umer, G. Brigham, G. Jarjoura, "An Investigation of Corrosion Behaviors of Thermally Sprayed Aluminum at Elevated Temperatures Under Thermal Insulations and Autoclave Immersion Conditions", Corrosion Journal (August 2024), 80(8), 836–850: doi.org/10.5006/4508

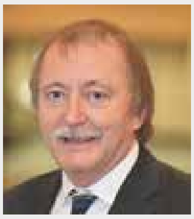
16. S. Paul, "Behavior of damaged thermally sprayed aluminum (TSA) in aerated seawater", NACE International's Annual Conference and Exposition, CORROSION 2019, Nashville, Tennessee, (24-28 March 2019), Paper No. 12766, 15pp: doi.org/10.5006/C2019-12766

17. ISO 19277:2018 Houston Vertical Pipe Test.

18. B. Biddle, "Mitigating Corrosion Under Insulation in a Gas Processing Facility 10 Years On", Offshore Technology Conference Asia, Kuala Lumpur, Malaysia, (22-25 March 2016), Paper No. OTC-26717-MS: doi.org/10.4043/26717-MS

19. N. de Varennes, N. Spence, M. O'Donoghue, V.J. Datta, "Down the Hole Without a Paddle: Corrosion Mitigation of Wellhead Surface Casings Using IMM Coatings", SSPC Conference, Coatings+ 2020, Los Angeles, California, (3-6 February 2020), Paper No: S2020-00015, 21pp: doi.org/10.5006/S2020-00015

Authors



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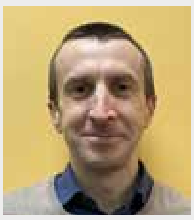

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