EXPLORING THE MECHANISM AND LONGEVITY OF THE XOX CORROSION INHIBITOR®

Thermal insulation is an integral part of the petrochemical and refining industry, used to conserve energy, maintain process control, and ensure operator safety. Insulation systems, comprised of thermal insulation, jacketing, mastics, and sealants, are designed to keep water out to maintain the integrity of the thermal insulation and limit corrosion under insulation (CUI). However, even the best designed and installed systems sometimes become compromised, resulting in the presence of water at the pipe surface. As such, it is essential to understand how the chemistry of thermal insulation affects CUI potential.

By analyzing the CUI surface layer (or absence of a CUI layer), engineers can understand how insulation chemistry can influence their long-term corrosion prevention strategy. The guide below will help engineers establish their first step in building a comprehensive corrosion mitigation strategy.

EXPLORING THE INFLUENCE OF THE XOX CORROSION INHIBITOR ON SURFACE CORROSION

We used EDS testing to identify the byproducts that formed on the surface of the carbon steel metal coupons as a result of the ASTM C1617 test protocol. The results identified the composition of the corrosion surface layer and the relative percentages of each byproduct based on the insulation's leachate chemistry.

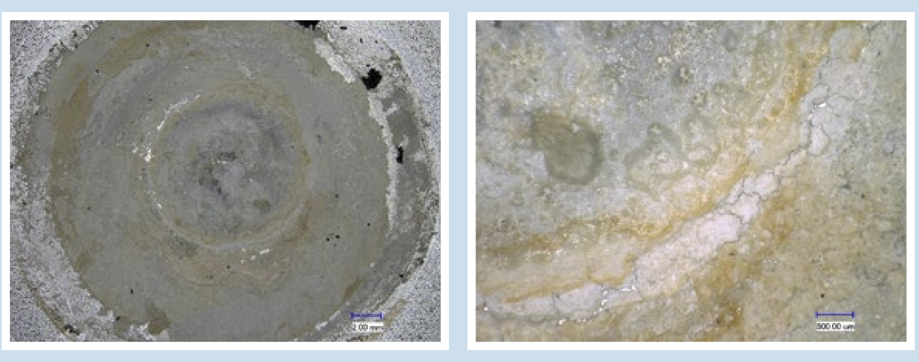
- **Insulation materials with the XOX Corrosion Inhibitor were shown to decrease the proliferation of corrosion on metal surfaces by depositing a layer of protective silicates and ions onto the metal surface.**
- **This layer was present when testing Thermo-1200® water-resistant calcium silicate and Sproule-WR 1200® hydrophobic expanded perlite – both of which have the XOX Corrosion Inhibitor.**
- **The surface layer that developed from the XOX Corrosion Inhibitor had a chemical composition that was consistent with documented standard ASTM C795 requirements for limiting stress corrosion cracking of stainless steel.**

	Composition (Atomic %)	
Sample ID	**Fe**	**Silicates & Ions**
Thermo-1200 water-resistant calcium silicate with XOX Corrosion Inhibitor	0.00	36.95
Sproule WR-1200 hydrophobic expanded perlite with XOX Corrosion Inhibitor	0.91	43.07
InsulThin HT® hydrophobic microporous blanket	1.34	9.96
MinWool-1200® water-repellent mineral wool	16.90	5.62
Hydrophobic silica aerogel blanket	26.44	2.57
5 ppm Cl Stardard	54.0	1.6

WITH XOX CORROSION INHIBITOR

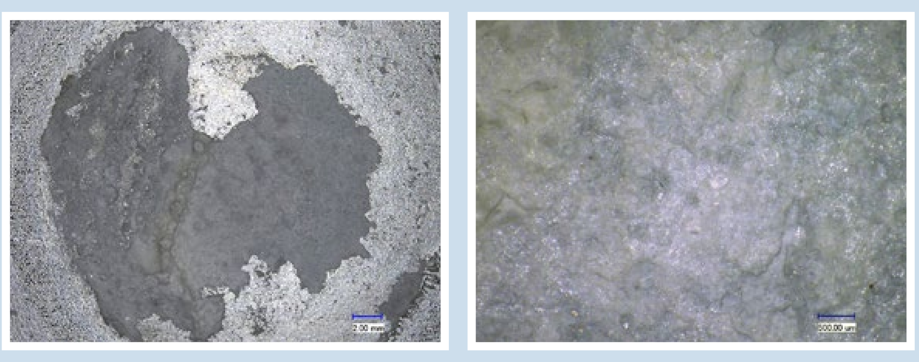
SAMPLE 1 → Thermo-1200 Water Resistant Calcium Silicate

- Shows no corrosion (0% iron oxide) on the surface of the calcium silicate coupons.



SAMPLE 2 → Sproule WR-1200 Hydrophobic Expanded Perlite

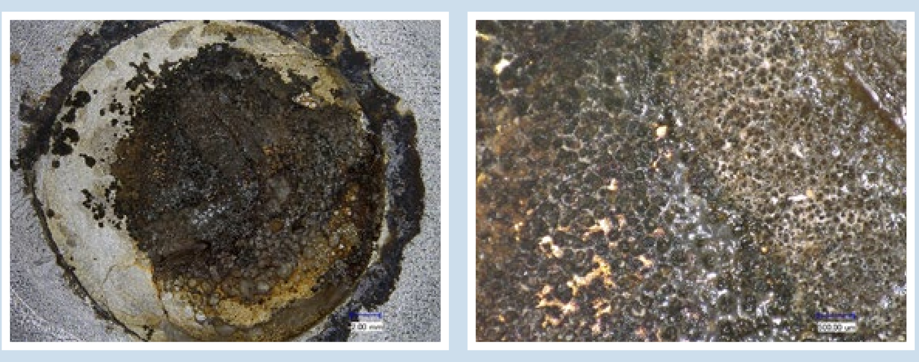
- Shows negligible amounts of corrosion (0.9% iron oxide) on the surface of the perlite coupons.
- The leachable silicates and ions on the surface of the perlite and calcium silicate coupons are acting as a protective layer to prevent corrosion damage to the surface of the metal coupons.



WITHOUT XOX CORROSION INHIBITOR

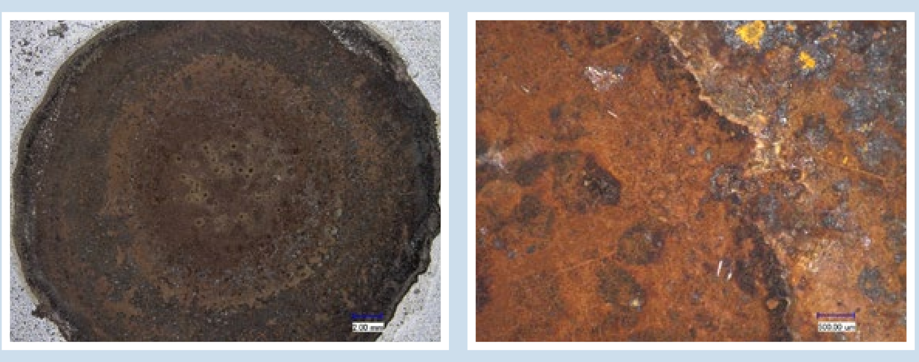
SAMPLE 3 → InsulThin HT Hydrophobic Microporous Blanket

- The InsulThin HT sample had a buildup of carbon on the surface. There is no visible corrosion on the surface or around the carbon surface layer.
- Additionally, the iron oxide in the sample was very low, at just 1.3%. It has been hypothesized that the inert carbon layer may be acting as a protective layer to prevent corrosion damage to the surface of the coupons.



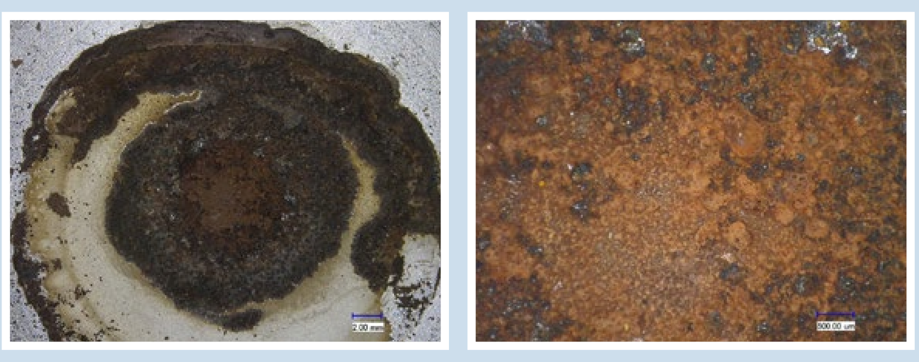
SAMPLE 4 → MinWool-1200 Water-repellent Mineral Wool

- The MinWool-1200 sample had a substantially higher amount of rust, showing an iron oxide content of 16.9% on the surface layer.
- There is no protective layer of slicates and ions or carbon present in the mineral wool sample.



SAMPLE 5 → Silica Aerogel Hydrophobic Blanket Sample

- The hydrophobic silica aerogel blanket sample showed the most significant amount of rust, at 26.4% of iron oxide.
- No protective silicate layer or carbon buildup is present.



The relative concentration of iron or iron oxide in the samples corresponds to the relative performance of the insulations in the ASTM C1617 corrosion test method.

The iron oxide present in the analysis is the formation of rust or generalized surface corrosion, and the research results indicate that the XOX Corrosion Inhibitor present in Thermo-1200 calcium silicate and Sproule WR-1200 expanded perlite strongly influences the amount of corrosion that forms on the surface of the coupons.

HOW LONG DOES THE XOX CORROSION INHIBITOR LAST?

As engineers and facility operators consider using insulations with the XOX Corrosion Inhibitor in their CUI defense strategies, an important question has come to rise: how long does the XOX Corrosion Inhibitor last? To test this, 12 samples of Thermo-1200 water-resistant calcium silicate were subjected to 40 wet/dry cycles. For each cycle, the insulation was immersed in tap water (6 samples) or salt water (6 samples) for 8 hours and then dried in an oven for 16 hours.

The insulation then underwent the ASTM C1617 test protocol to determine whether the protective silicate and ion layer remained consistent even after repeated wet-dry cycling.

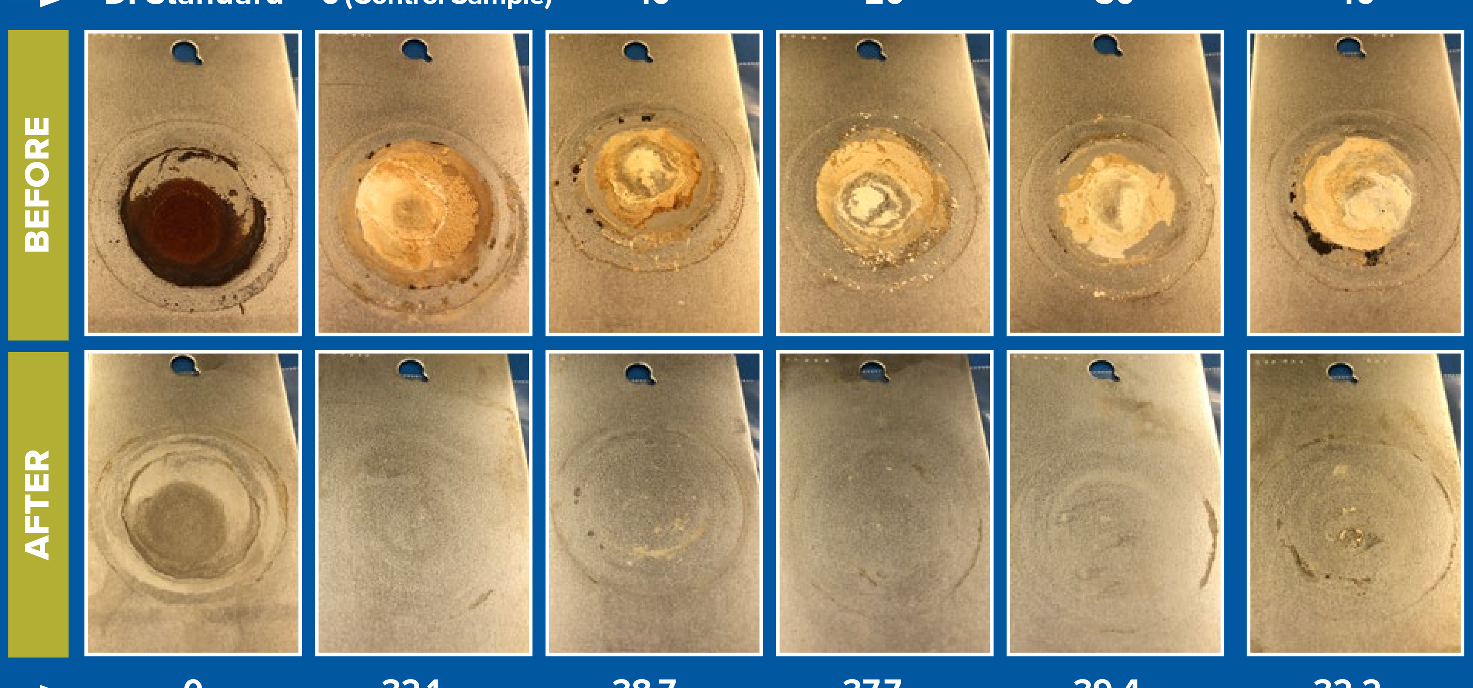
- This study shows that the protective attributes of the XOX Corrosion Inhibitor do not decrease over time with either tap or saltwater.
- This is evident by the sustained presence of the protective silicate and ion surface layer after 40 wet/dry cycles of the insulation.

Tap Water	Composition (Atomic %)
Sample ID	**Protective Silicates & Ions**
DI Water	0.0
0 cycles	32.1
10 cycles	38.7
20 cycles	37.7
30 cycles	39.4
40 cycles	32.2

Salt Water	Composition (Atomic %)
Sample ID	**Protective Silicates & Ions**
DI Water	3.2
Salt Water 0 cycles	39.3
Salt Water 10 cycles	39.9
Salt Water 20 cycles	38.7
Salt Water 30 cycles	39.1
Salt Water 40 cycles	34.0

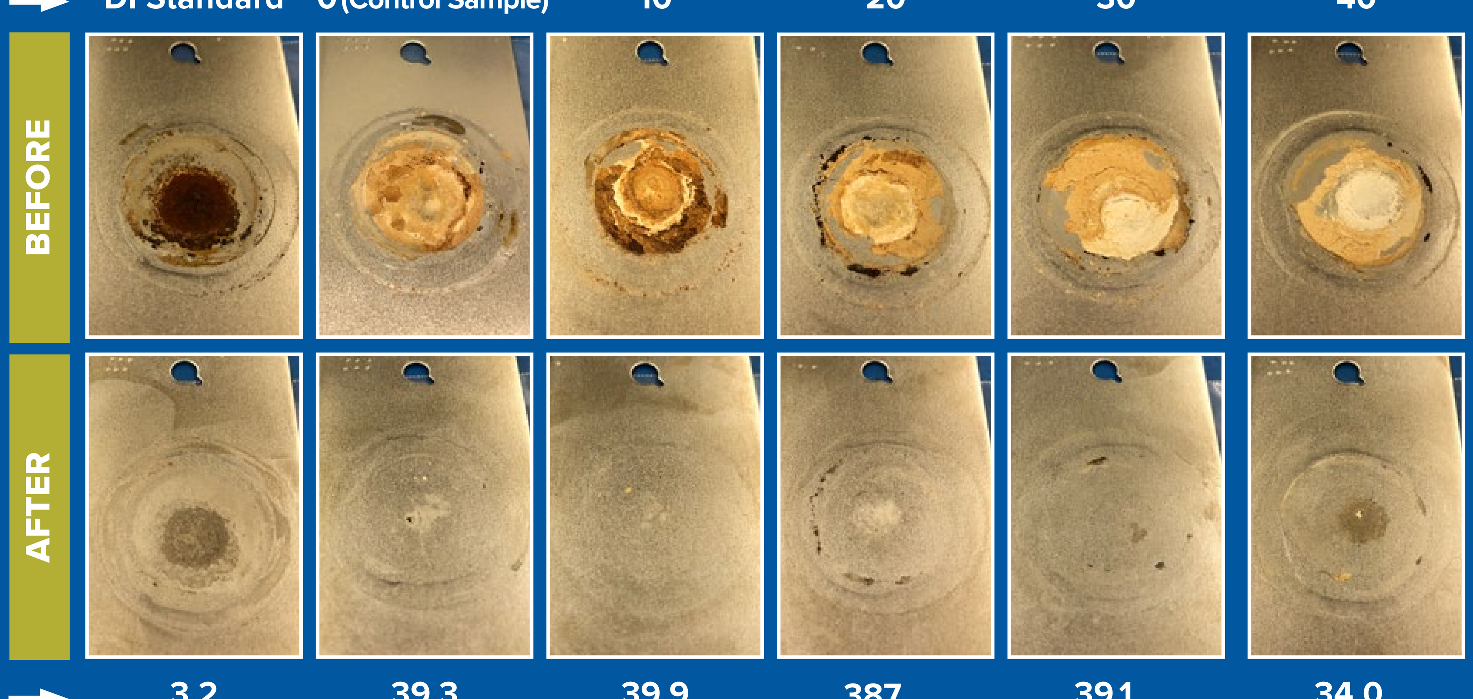
TAP WATER ANALYSIS

# of Cycles →	DI Standard	0 (Control Sample)	10	20	30	40
Composition Protective Silicates & Ions (Atomic%) →	0	32.1	38.7	37.7	39.4	32.2



SALT WATER ANALYSIS

# of Cycles →	DI Standard	0 (Control Sample)	10	20	30	40
Composition Protective Silicates & Ions (Atomic%) →	3.2	39.3	39.9	387	39.1	34.0



Although the relative amounts of the protective layer deposited by the XOX Corrosion Inhibitor varied somewhat over the course of the testing, they did not diminish over time for either environmental condition. The minor variations we saw in the surface layer composition are caused by variations in the base chemistry of the insulation, and not by the material gaining or losing its corrosion inhibiting properties as a result of wet-dry cycling.

Johns Manville
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