CUI testing comparison of ASTM G189 and TM 21549 on mineral wool with corrosion inhibitors

ROCKWOOL®

TECHNICAL INSULATION

ProRox | SeaRox

26-01-14

Why CUI matters

- Corrosion under insulation (CUI) is a silent destroyer in industrial facilities
- Leading cause of unplanned outages, safety incidents, and asset failure in the oil, gas, and petrochemical sectors
- Highest risk when process temperatures range from 10°F to 350°F (-12°C to 175°C)
- This is where water remains in a liquid phase, creating rapid oxidation of carbon steel assets

How CUI occurs

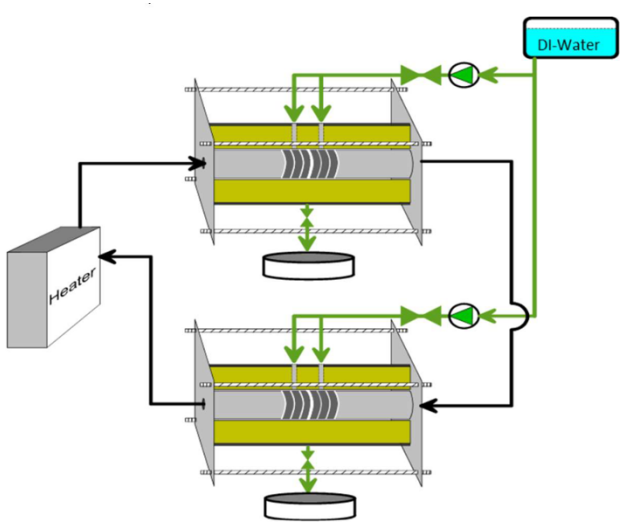
- Rain, condensation, or process leaks penetrate damaged cladding or poor seals
- Moisture becomes trapped within the insulation system, creating an electrolyte for the chemical reaction
- Thermal cycling and elevated temperatures accelerate the chemical reaction
- Catalysts like soluble chlorides coming from the environment or the insulation material can accelerate the metal loss

Test methods to study CUI

ASTM G189
Standard guide for laboratory simulation of corrosion under insulation

AMPP TM 21549
Test method for assessing the impact of an insulation material on corrosion under insulation

ASTM G189



Overview

- Introduced in the early 2000s, this is a ‘standard guide’ rather than a pass/fail test
- Primarily used for comparative testing of materials and inhibitors

Key setup features

- **Specimens:** min. 3 carbon steel, 0.187" (4.75mm) width, 2” NPS rings
- **Isolation:** rings are separated by non-conductive spacers
- **Water delivery:** water is pumped directly to the pipe surface through drilled holes

ASTM G189: experimental cycle

The specific conditions used for this report's testing were:

Step	Temp (°F/°C)	Duration (hr)	Water injection
Wetting phase	140°F (60°C)	18 hours	40 ml/10 min +2.5 ml/hr
Ramp up	140°F (60°C) to 302°F (150°C)	1 hour	None
Drying phase	302°F (150°C)	4 hours	None
Ramp down	302°F (150°C) to 140°F (60°C)	1 hour	None

Test fluid: deionised water I duration: 21 days

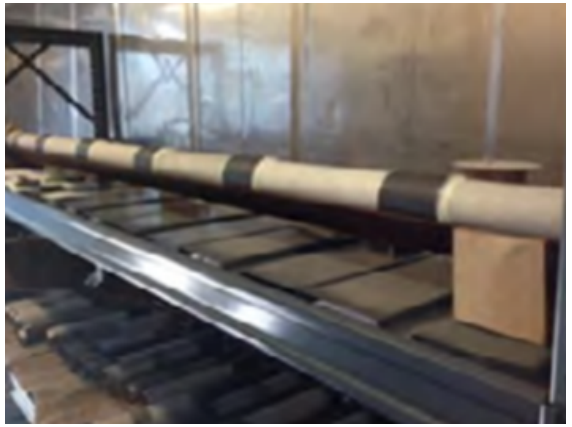
TM 21549

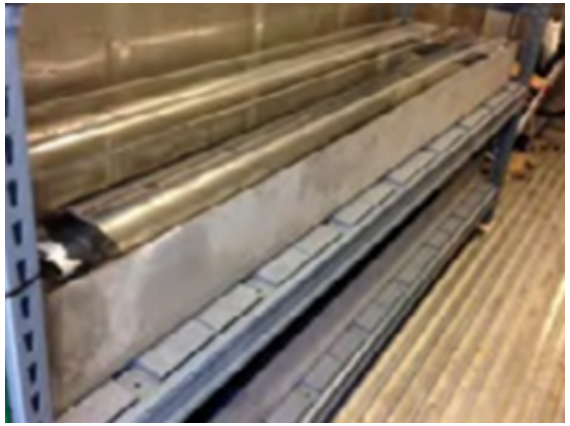
Overview

- A newer ‘test method’ developed by AMPP
- Provides a relative performance assessment under simulated and accelerated field conditions

Key setup features

- **Specimens:** 12-inch (305mm) long pipe spools, 2 in nominal pipe diameter
- **Isolation:** rings are separated by non-conductive spacers
- **Water delivery:** spools are submerged with ¼” hole drilled down to the surface at top and bottom





TM 21549 – cyclic wet dry exposure for 3 months

Weeks 1-4 – distilled water
Weeks 5-12 – 1500 ppm chloride (daily)

Exposure CUI profile used for the test

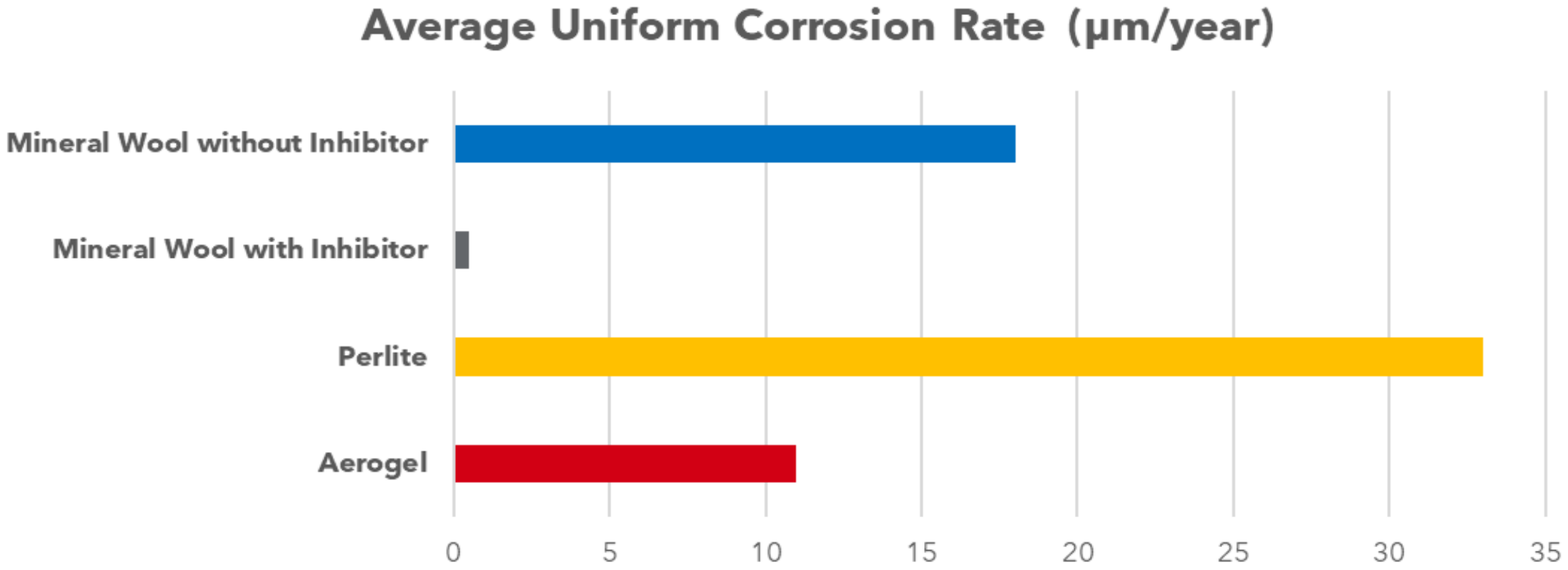
Day/time		Wet/dry condition	Heater temperature (°F)
Monday	7:00 am	Fill (wet)	70
	4:00 pm	Drain (dry)	
Tuesday	7:00 am	Fill (wet)	300
	4:00 pm	Drain (dry)	
Wednesday	7:00 am	Fill (wet)	70
	4:00 pm	Drain (dry)	
Thursday	7:00 am	Fill (wet)	300
	4:00 pm	Drain (dry)	
Friday	7:00 am	Fill (wet)	70
	4:00 pm	Drain (dry)	

During weekends, the specimens were left in dry, 70° F temperature conditions

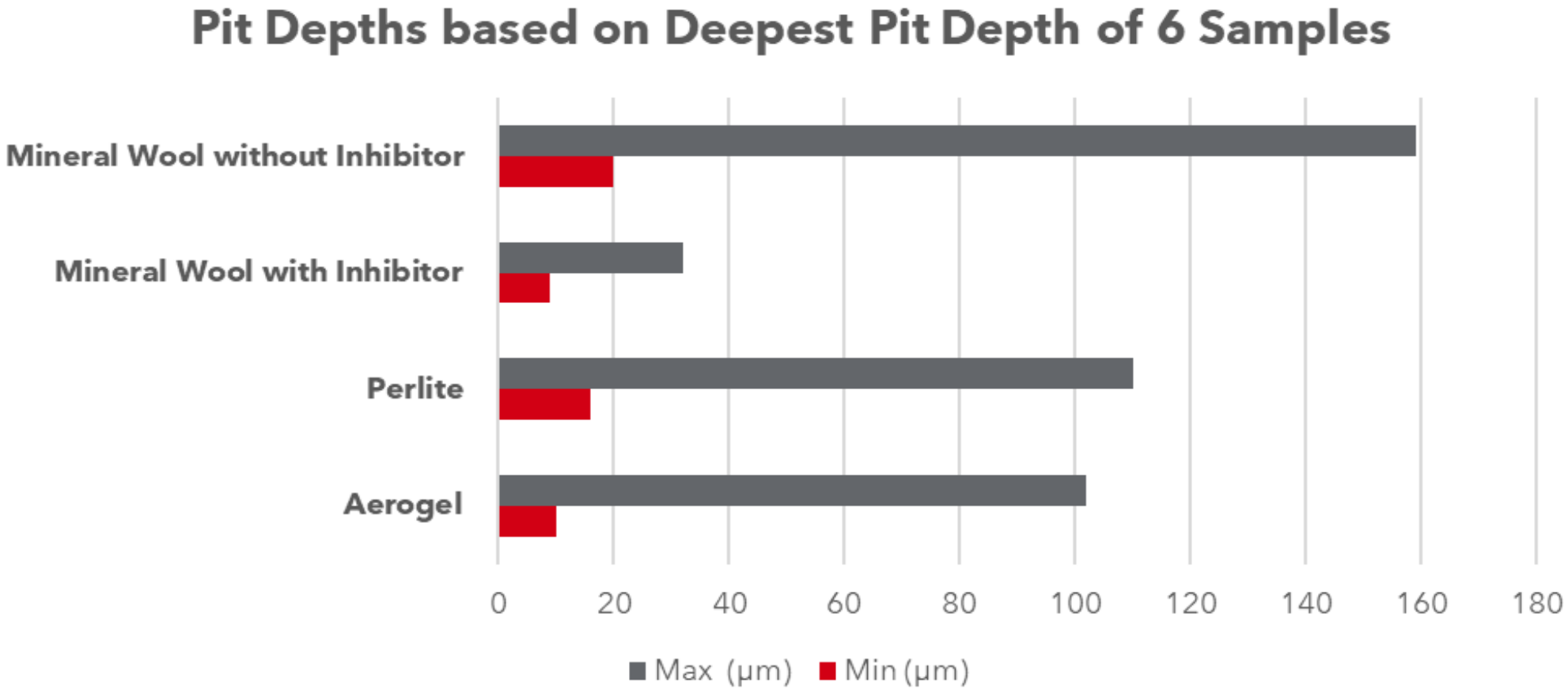
Critical differences in methodology

	ASTM G189	TM 21549
Specimen size	0.187" (4.75 mm) thin rings, 2 in nominal diameter Great for weight loss calculation	12" (305 mm) width Representative of real pipe sections, allowing for realistic corrosion patterns
Water delivery	Pumped Forces water to the metal, bypassing insulation's water-repellant properties	Submerged Allows hydrophobic insulation to potentially repel water ingress
Drying phase	Customisable	Prescriptive

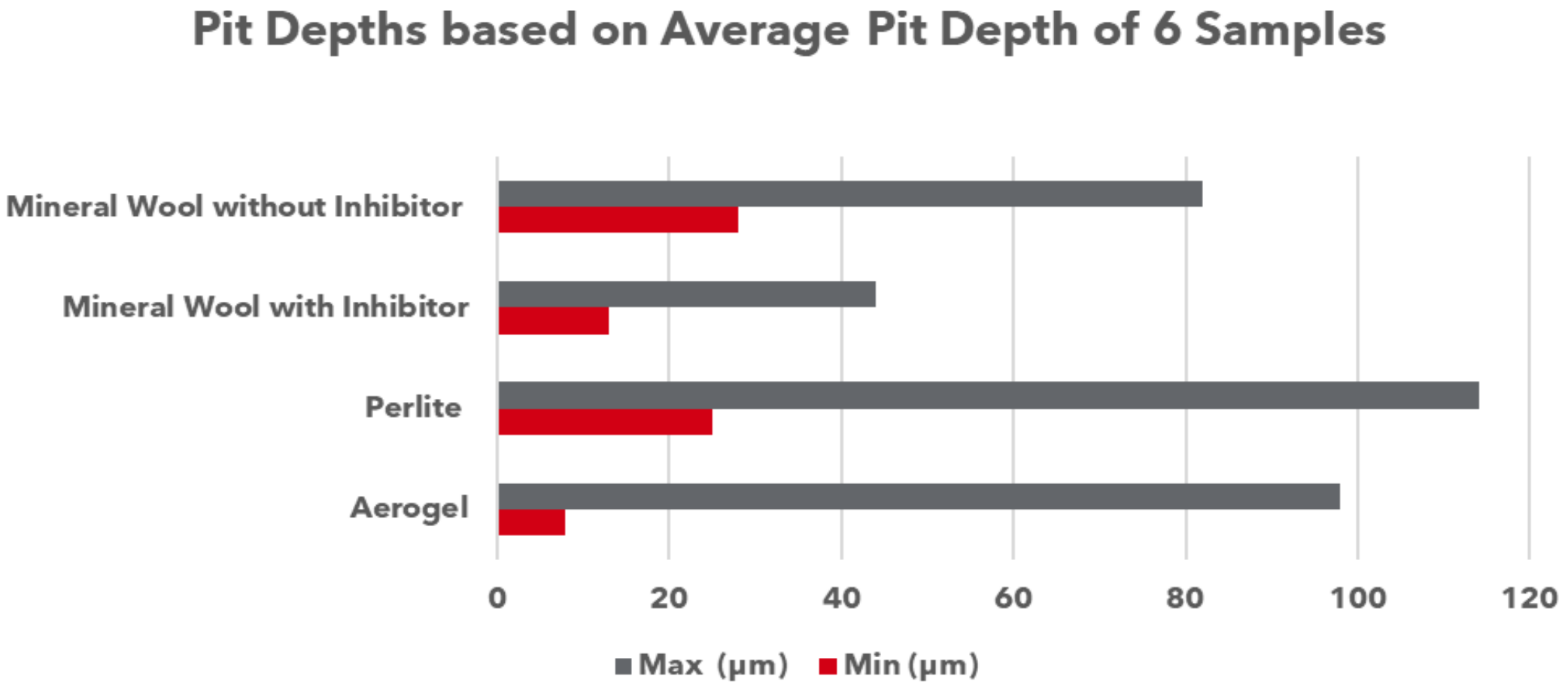
Results: ASTM G189 uniform corrosion



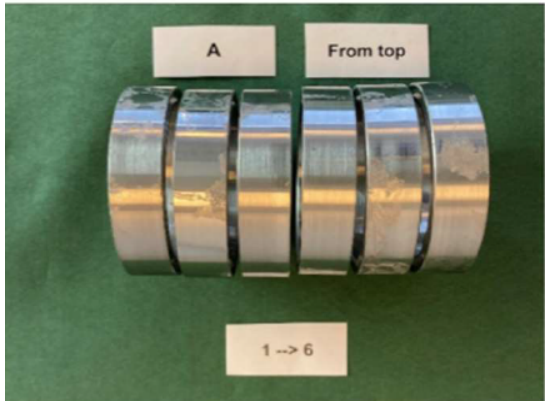
ASTM G189 results: pit depth – *deepest* pit depth



ASTM G189 results: pit depth – *average* pit depth

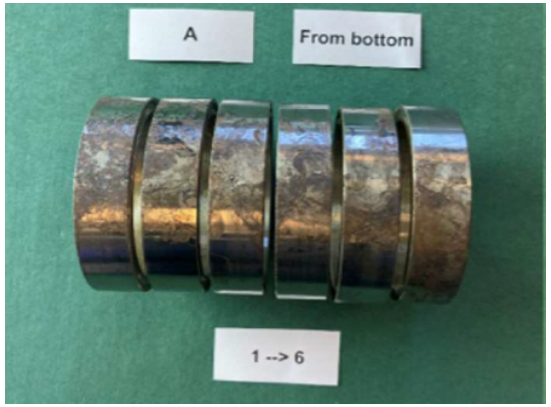


ASTM G189 results: mineral wool without inhibitor



Sample A

- After test
- Before cleaning
- Top view

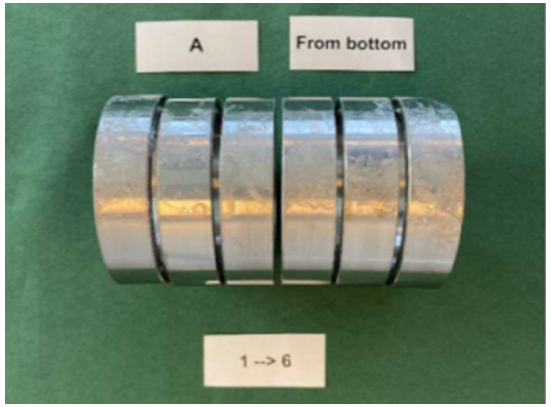


Sample A

- After cleaning
- Top view

Sample A

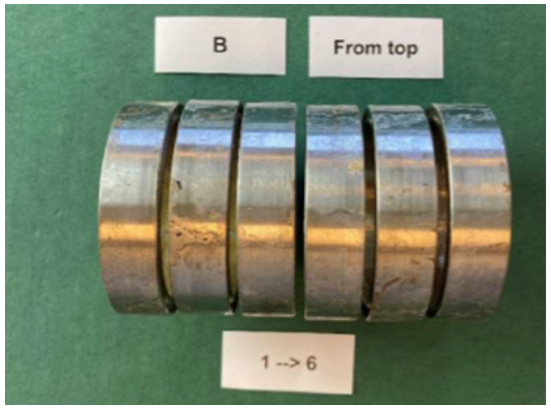
- After test
- Before cleaning
- Bottom view



Sample A

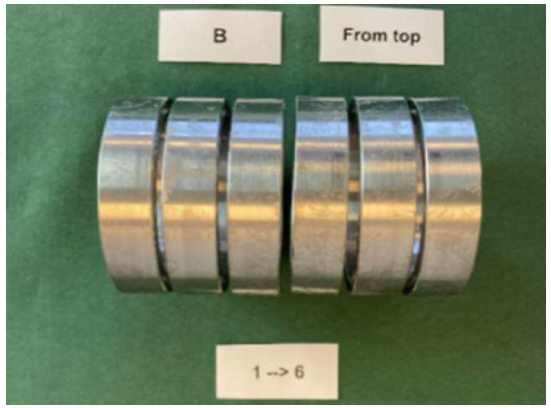
- After cleaning
- Bottom view

ASTM G189 results: mineral wool with inhibitor



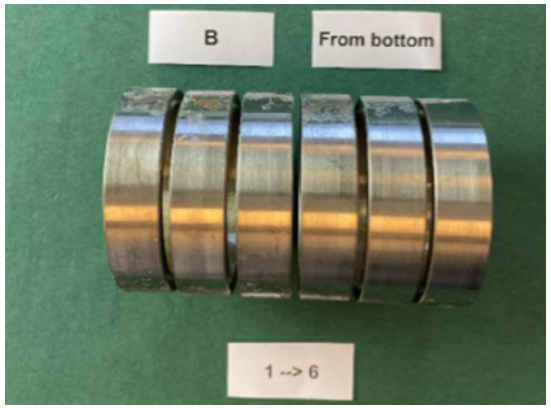
Sample B

- After test
- Before cleaning
- Top view



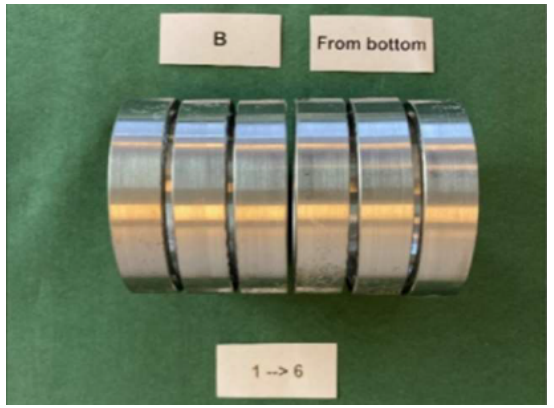
Sample B

- After cleaning
- Top view



Sample B

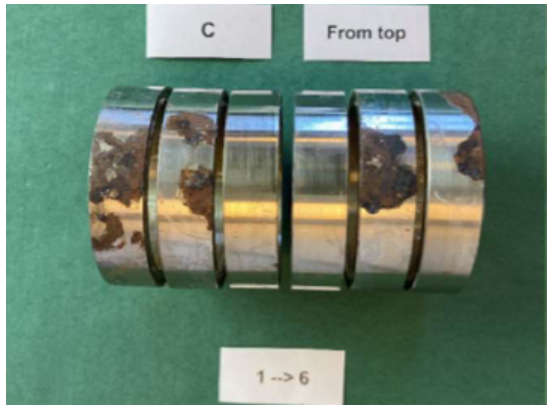
- After test
- Before cleaning
- Bottom view



Sample B

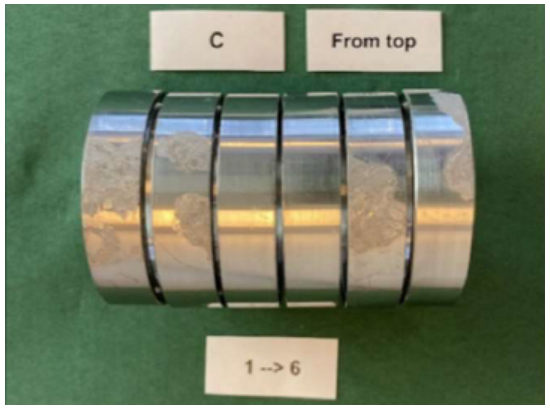
- After cleaning
- Bottom view

ASTM G189 results: Perlite



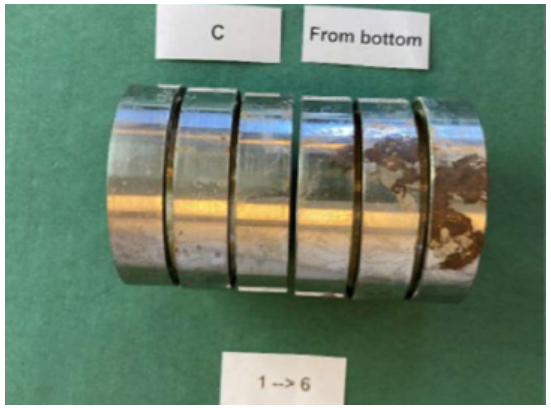
Sample C

- After test
- Before cleaning
- Top view



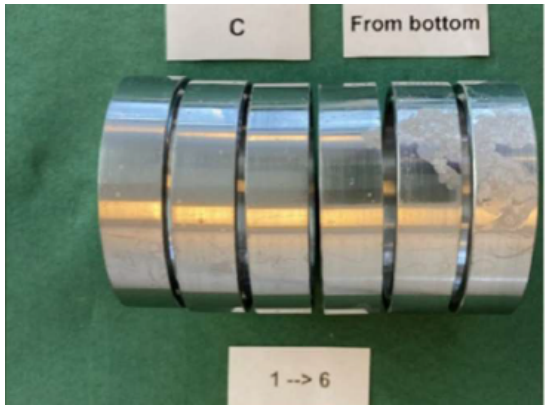
Sample C

- After cleaning
- Top view



Sample C

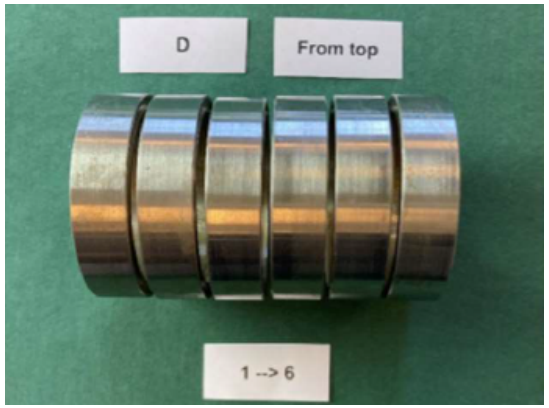
- After test
- Before cleaning
- Bottom view



Sample C

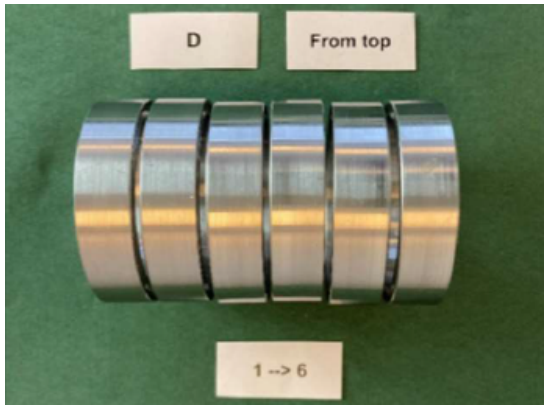
- After cleaning
- Bottom view

ASTM G189 results: Aerogel



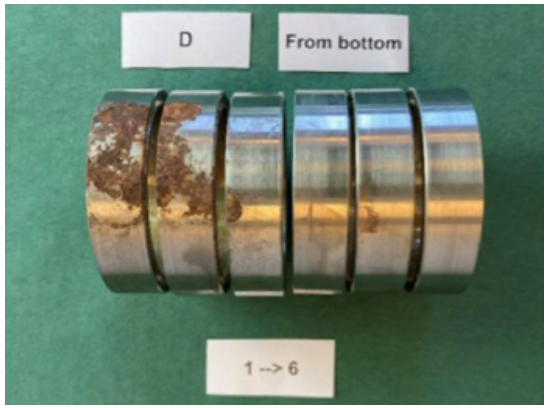
Sample D

- After test
- Before cleaning
- Top view



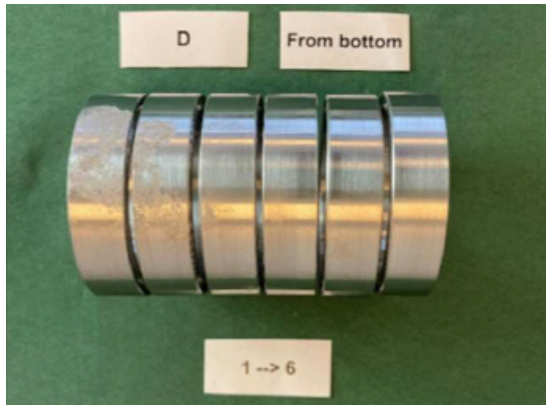
Sample D

- After cleaning
- Top view



Sample D

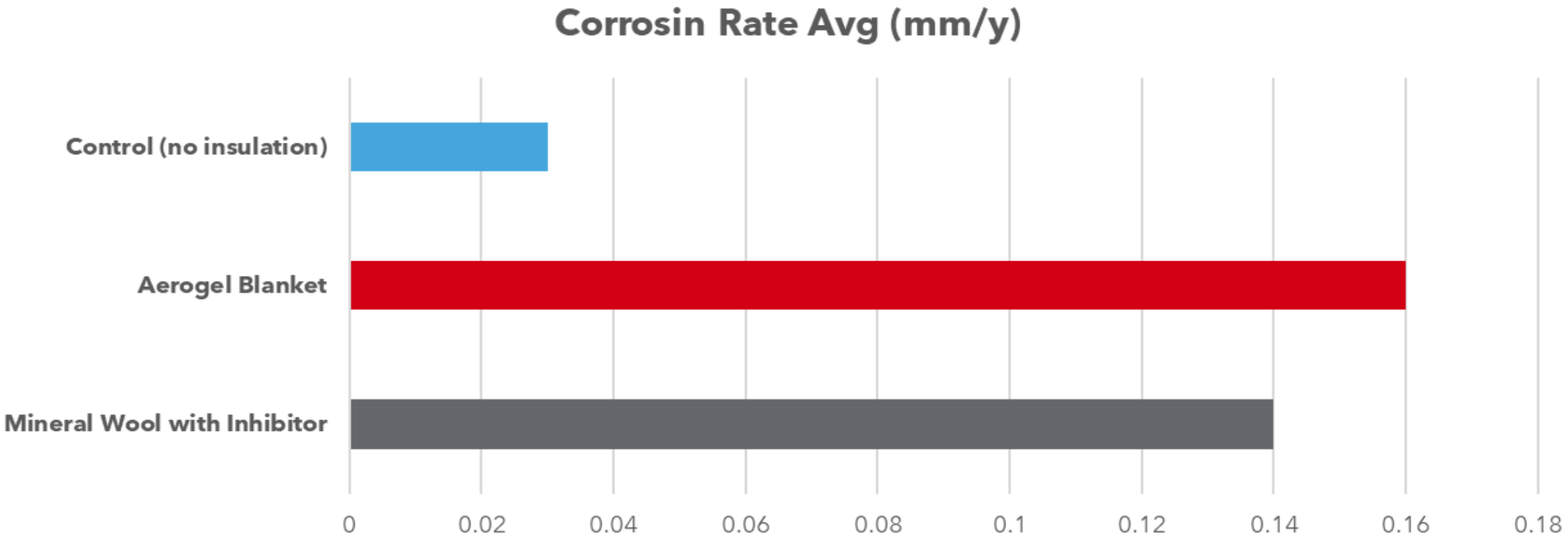
- After test
- Before cleaning
- Bottom view



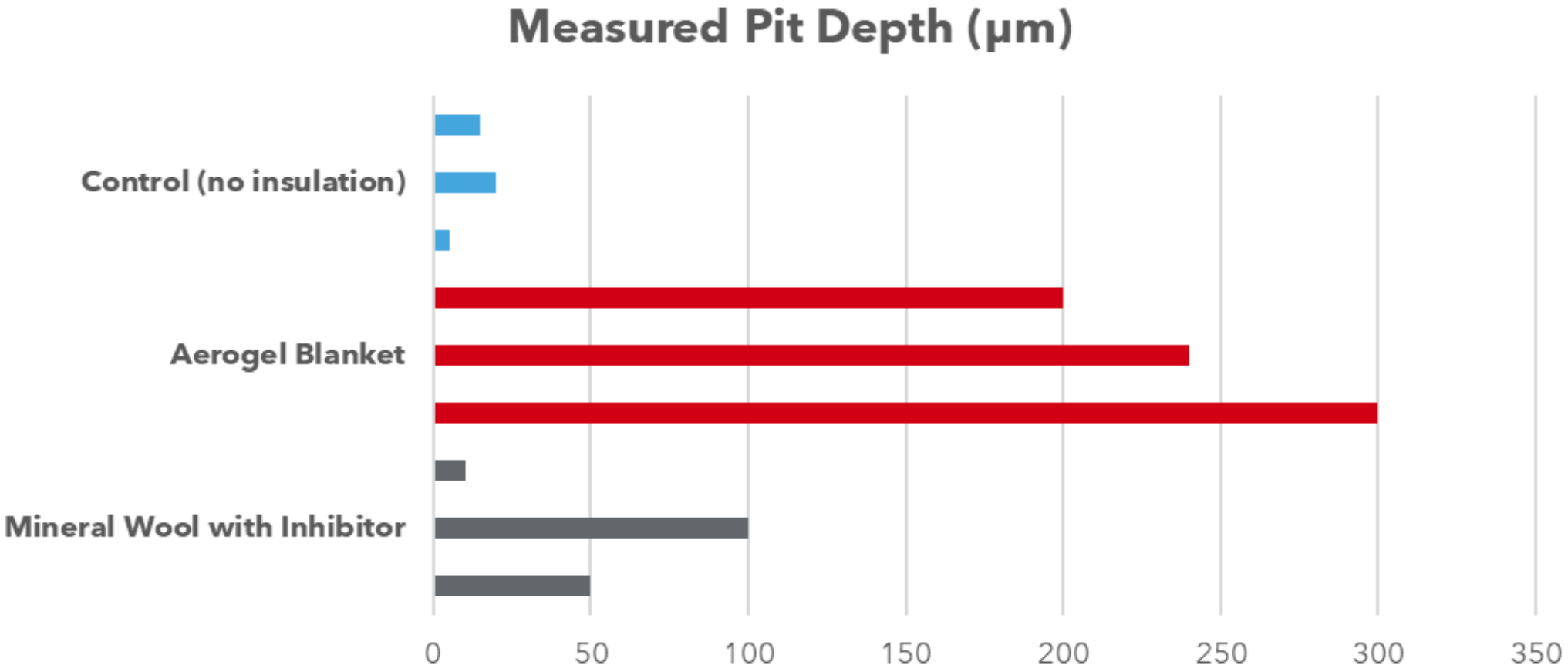
Sample D

- After cleaning
- Bottom view

Results: TM 21549 uniform corrosion



Results: TM 21549 pit depth



TM 21549 results: control – no insulation

Top

SPECIMEN 7

SPECIMEN 8

SPECIMEN 9

Bottom

SPECIMEN 7

SPECIMEN 8

SPECIMEN 9

TM 21549 results: Aerogel

Top

SPECIMEN 4B

SPECIMEN 5B

SPECIMEN 6B

Bottom

SPECIMEN 4B

SPECIMEN 5B

SPECIMEN 6B

TM 21549 results: mineral wool with inhibitor

Top

SPECIMEN 1A

SPECIMEN 2A

SPECIMEN 3A

Bottom

SPECIMEN 1A

SPECIMEN 2A

SPECIMEN 3A

Conclusions

- Both **ASTM G189** and **TM21549** reliably replicate CUI processes
- Main differences are:
  - Prescriptive (TM21549) vs flexible/ customisable (G189)
  - Specimen size – 12" (TM21549) vs thin rings (G189)
  - Water delivery – submerged (TM21549) vs pumped (G189)
  - Duration – 12 weeks minimum (TM21549) vs 21 days (G189)

- Inhibitors work: mineral wool with corrosion inhibitors significantly outperformed non-inhibited materials
- Pitting resistance: in both tests, mineral wool with inhibitors demonstrated superior resistance to localised pitting compared to Aerogel, likely due to its vapour-open nature allowing moisture release
- Both test methods are great for providing real corrosion rates, decision for selection of test method will depend on purpose of study, budget, number of tests, etc.

Thank you

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