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Corrosion under insulation (CUI) and Insulation systems

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Presentation Outline

1. Critical factors influencing CUI
2. The issue
3. Evidence from CUI simulations
4. The Golden Guideline for mitigation of CUI
5. Three key rules to apply the Golden Guideline
6. Four principles for insulation selection
7. Analysis of six generic insulations
8. Questions

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1. **Critical factors that influence CUI** (from design to decommissioning)

Factors that can combine to cause, accelerate and/or prevent CUI are:

- **Operating temperatures**
  - Cyclic temperature operation (-20°C to +320°C)
  - Static temperature operation (-5^{0}C to +175^{0}C)
- **Choice and installation of coating system**
- **Design, choice & installation of insulation system.**
- **Plant operation**
- **Surrounding environment**

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2. The issue

Corrosion of steel occurs in the presence of water and oxygen under all insulation

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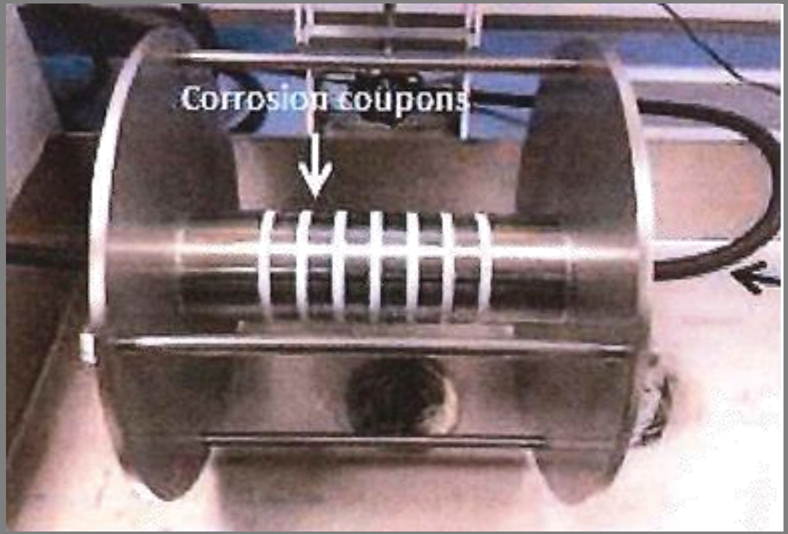
3. Evidence from CUI simulation

Methodology: Test Method – ASTM G189-07

- Test apparatus constructed to contain **six generic insulation material types** in one test.
- Tested on **carbon steel.**



Before installing insulation

After installing insulation

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3. Evidence from CUI simulation

Methodology (cont):

- The insulation is **wetted** and **dried** in set cycles of cold (60°) and hot (150°C).

Cyclic test	One cycle		No. of cycles
Duration	20 hours	4 hours	21 (21 days)
Temperature	60°C	150°C	
Wet / Dry	Wet	Dry	

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3. Evidence from CUI simulation

Methodology (cont):

- The liquid (demi water) used is **recycled** so that **leaching products** of the specific insulation **influence the corrosion.**

Insulation	**Aerogel blanket**	**Calcium silicate**	**Cellular glass**	**Fibreglass**	**Polyisoc'te (PIR)**	**Stone wool**
Top side						
Bottom side						

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3. Evidence from CUI simulation

Observations (by METALOGIC)

- **Corrosion occurred under all tested insulations.**
- **With water introduced onto the steel surface:**
  - Insulation materials open to water vapour diffusion performed better than closed cell materials.
  - Insulation materials with a vapour open system performed better than those with a vapour closed system.
- **Material with higher concentrations of leached chloride gave higher corrosion rates (independent of insulation type).**

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3. Evidence from CUI simulation

Conclusion (by METALOGIC)

The rate of CUI is driven by the DURATION OF WET METAL EXPOSURE to leached salts and other compounds reacting with water.

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3. Evidence from CUI simulation

Results & conclusions published at:

NACE INTERNATIONAL

CORROSION 2017 Conference & Expo

(New Orleans, USA – March 2017)

NACE Paper No. 8877

https://store.nace.org › Conference Papers

(Copies of this paper are available after today's presentation)

4. The Golden Guideline for mitigation of CUI

The insulation material that holds the least amount of contaminated water on the steel surface, for the shortest time, provides the lowest corrosion rates.

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5. Three key rules to apply the Golden Guideline

- Properly designed and installed jacketing/cladding system.
- Use of a suitable coating system for steel pipe and vessel surface protection.
- Choosing an insulation material and system with important ‘corrosion reduction’ characteristics.

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6. Four principles for insulation selection relating to CUI

Water ingress cannot be avoided and will occur under all types of insulation. To mitigate the harmful effects of CUI, choose an insulation with:

- **The least water absorption.**
- **The fastest moisture dissipation.**
- **The most durable performance over the entire CUI temperature range.**
- **The lowest amount of leachable chlorides or residual compounds that react with water.**

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6. Four principles for insulation selection relating to CUI

Principle 1: Least water absorption

Achieved by:

- **Foam insulation – with a closed cell structure that is <u>not</u> effected by water** (in liquid or vapour form).

or

- **Fibrous insulation – with a <u>high level</u> of water repellency.**

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6. Four principles for insulation selection relating to CUI

Principle 1: Least water absorption (cont)

Verified by – Partial immersion testing to:

- **BS EN 1609** (Slab, mattress and blanket)
- **BS EN 13472** (Piping)

Verified by – Full immersion testing to:

- **ASTM C1763-16**

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6. Four principles for insulation selection relating to CUI

Principle 1: Least water absorption (cont)

Research paper and slide presentation:

- **Mineral wool & water repellency**

  NACE Paper No. 10929
  by Claudia Zwaag & Soren Nyborg Rasmussen
  (Copies of this paper available after today's presentation)

- **16 slide presentation**
  Based on NACE Paper No. 10929
  (Available from AIS on request)

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6. Four principles for insulation selection relating to CUI

Principle 2: Fastest moisture dissipation

Achieved by:

- **Vapour open fibrous structure** – allows water to evaporate from the surface and diffuse out through the insulation.
- **Lowest water absorption** – the drier the fibrous material the faster the dry-out time.

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6. Four principles for insulation selection relating to CUI

Principle 2: Fastest moisture dissipation (cont)

Achieved by:

- **Highest vapour flow** – material with a water vapour resistance factor closest to air (μ=1.0).
- **Non-contact** – a system where the insulation has no contact with steel surface.

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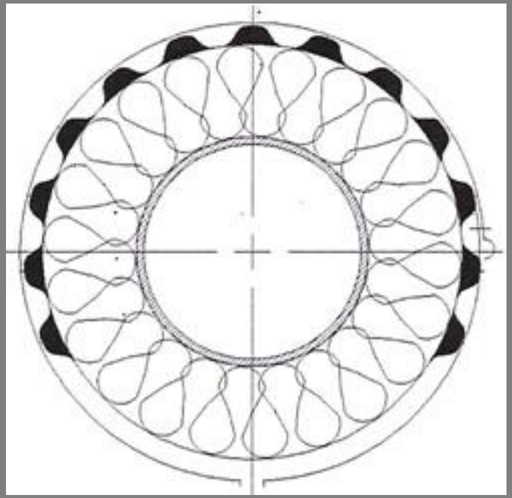
6. Four principles for insulation selection relating to CUI

Principle 2: Fastest moisture dissipation (cont)

Example: **Non-contact systems** with spacer between insulation and piping



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Corrosion Under Insulation (CUI)

6. Four principles for insulation selection relating to CUI

Principle 2: Fastest moisture dissipation (cont)

Example: **Non-contact system** with spacer between insulation and piping

(Non-contact insulation system presentation available on request)

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6. Four principles for insulation selection relating to CUI

Principle 2: Fastest moisture dissipation (cont)

Determination of Water Vapour Transmission Properties by testing to:

- **EN 12086** for water vapour diffusion resistance factor (μ)

Product examples:

Kingspan™ Tarec™pir	**μ ~ 40**
ROCKWOOL™ stone wool	**μ = 1.3**

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6. Four principles for insulation selection relating to CUI

Principle 3: Most durable CUI temperature range

Achieved by:

- **Insulation material that suitable for the maximum service temperature.**
- **If additives are used for insulation water repellency, they must maintain their properties up to 250°C.**

(Separate presentation on binders and additives available from AIS on request)

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6. Four principles for insulation selection relating to CUI

Principle 4: Lowest leachable chlorides & others that accelerate CUI

Mitigated by:

- **Using low leachable substance (≤10 mg/kg).**
- **Insulations with pH in neutral to slightly alkaline range.**
- **Conformity to the stainless steel corrosion specification ASTM C795.**

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6. Four principles for insulation selection relating to CUI

Principle 4: Lowest leachable chlorides & others that accelerate CUI (cont)

Compliance with:

- **ASTM C795** (**Acceptable Analysis Graph** for selection of insulation in contact with austenitic stainless steel)

Testing based on:

- **ASTM C692** (external stress corrosion cracking tendency of austenitic stainless steel)
- **ASTM C871** (chemical analysis of thermal insulation materials)

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7. Analysis of six generic insulations

Generic material	Brand & product example	Material structure	Product toughness	Dissipation of water (μ)	Low water absorption	Low chloride
Stone wool	ROCKWOOL™ ProRox®	Fibrous	Partial	Fast	Yes	Yes
Aerogel	Armacell® Armagel HT	Semi-closed	No	Fast	Yes	Yes
Glass wool	CSR Bradford™ Multitel	Fibrous	No	Fast	No	No
Cellular glass	PCC Foamglas®	Cellular	Yes/No	Slow	Yes	Yes
Calcium silicate	Calsilite®	Semi-closed	Partial	Slow	Yes	No
Polyisocyanurate	Kingspan ™ Tarec™pir	Cellular	Partial	Slow	Partial	No

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8. Conclusion

Questions?

Thank you

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