Fighting CUI:
Stone Wool Insulation and Key Selection Criteria to Help Contribute to Long-Term Operational Success

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Business Development Manager
ROCKWOOL Technical Insulation
Who is ROCKWOOL?

• The ROCKWOOL Group is the world’s leading supplier of innovative products and systems based on stone wool

• Insulation production started in 1937 near Copenhagen, Denmark

Release the natural power of stone to enrich modern living

11,000+
Team members

39
Countries

45
Manufacturing facilities
Who is RTI?

Industrial insulation segment

• Stone wool solutions for industrial applications

• Main business markets are:
  - Process industry
  - Marine & offshore
What is stone wool insulation?

- Discovered on the islands of Hawaii in the early 1900’s
- Fiber insulation material
- Manufactured from natural resources & recycled material

Volcanic rock  Recycling briquettes  Coke

Mineral wool  Stone wool  Slag wool  ???
Categories of stone wool insulation

- Mandrel wound pipe section
- Slab / board
- V-groove
- Wrap / blanket / mat
- Cut pipe
V-Groove

**Description:**
- Taking a slab of insulation and cutting a series of grooves in it to allow it to uniformly bend and fit around a pipe

**Strengths:**
- Ships flat – efficient shipping/storage
- Good lead times, widely available

**Weaknesses:**
- Thermal performance
- Prone to damage during handling
- Labor intensive – installation

Categories of stone wool insulation
Categories of stone wool insulation

Cut Pipe

Description:

- Taking a slab of insulation and fabricating the material into half or mitered sections

Strengths:

- Precise fit for NPS, tubes, and unique sizes
- Easy and efficient installation

Weaknesses:

- Waste from fabrication
- Fiber orientation is uni-directional (thermal and mechanical performance)
Categories of stone wool insulation

Mat/Wrap

Description:
• A rolled (and faced) material used for large diameter piping or where flexibility is required

Strengths:
• Ideal for large diameter (≥ 20”)
• Flexible for unique shapes/dimensions
• Can withstand high vibration – good acoustics

Weaknesses:
• Low resistance to compression
• Rolls can be heavy
Categories of stone wool insulation

Mandrel Wound

Description:
• High-quality material that is formed in a mold, with split/hinged sections

Strengths:
• Best thermal performance
• Consistent quality – precise dimensions
• Very easy handling and efficient installation

Weaknesses:
• Lead times
• Shipping efficiency
Why is CUI Important?

CUI = Corrosion Under Insulation
CUI is a Problem....CUI is Complex

- CUI is a significant part (40-60%) of the maintenance cost on pipes
- Over 80% of CUI occurs on piping (*Exxon study)

• CUI is a **SYSTEM** challenge!
  - Surrounding environment
  - Plant operation
  - Equipment/system design
  - Choice and installation of:
    - Coating
    - Jacketing/cladding
    - Insulation
What does the National Association of Corrosion Engineers say?

"Because CUI is a product of wet metal exposure duration, the insulation system that holds the least amount of water and dries most quickly, should result in the least amount of corrosion damage to equipment."

NACE SP0198-2016 (2.1.2)

Corrosion can be reduced by the careful selection of insulation materials.
The purpose of water repellency

For industrial insulation products:

- Provide short term protection against water exposure during installation
- Delay water ingress during service
- Reduce water absorption during service

Water increases heat loss

5% (vol.) water theoretically increases the thermal conductivity by 25%
How is water repellency achieved in mineral wool?

Difference in performance is achieved depending on:

- **Type** of additive
- **Amount** of additive
- **Application** of additive
Surface treatment vs. individual fiber treatment

Lava at approx. 2700°F (1500°C) from oven

Droplet hits rotating wheel and is launched and formed into a fiber

Fiber

Shot

Spinners rotate at high speed

Recycling production waste

Melted diabase lava

Application of the additive

High velocity air stream (Binder + WR agent)
## Advantages and disadvantages of different types of additives

<table>
<thead>
<tr>
<th>Type of additive</th>
<th>Organic / inorganic</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral oil based</td>
<td>Organic</td>
<td>• Cost</td>
<td>• Temperature stability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Dust control</td>
<td>• Migration (mobility of the oil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Risk of wash-out during service</td>
</tr>
<tr>
<td>Silicone oil based</td>
<td>Inorganic</td>
<td>• Ease of application</td>
<td>• Risk of offset of coating operations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Temperature resistance</td>
<td>• Migration</td>
</tr>
<tr>
<td>Inorganic resin</td>
<td>Inorganic</td>
<td>• Temperature resistance</td>
<td>• More difficult to employ in production process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No risk of migration</td>
<td>• Higher cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No effect on coating operations</td>
<td></td>
</tr>
</tbody>
</table>

**Inorganic resins** are the superior additive for water repellency… and are silicone oil free!
### Water absorption (partial immersion) according to EN 13472

<table>
<thead>
<tr>
<th>Type of additive</th>
<th>Water absorption after 24 hr, (kg/m²)</th>
<th>Water absorption after 24 hr, heat aged material (24h at 250°C / 482°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Mineral oil based (EN)</td>
<td>0.5</td>
<td>30</td>
</tr>
<tr>
<td>B. Mineral oil based (EN)</td>
<td>1.4</td>
<td>44</td>
</tr>
<tr>
<td>C. Mineral oil based (non-EN)</td>
<td>8.2</td>
<td>51</td>
</tr>
<tr>
<td>D. Mineral oil based (non-EN)</td>
<td>0.6</td>
<td>70</td>
</tr>
<tr>
<td>E. Mineral oil based (non-EN)</td>
<td>3.5</td>
<td>61</td>
</tr>
<tr>
<td>F. Silicone oil based (EN)</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>G. Silicone oil based (EN) *</td>
<td>0.1</td>
<td>46</td>
</tr>
<tr>
<td>H. Inorganic resin</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

- To meet the EN standard….the **non-heated** must be < 1 kg/m²
Water absorption (full immersion) according to ASTM C1763

Other insulation materials

- Water Absorption (Vol %)
- Water Absorption after 2 hr recovery (Vol %)
- Water Absorption after 48 hr recovery (Vol %)

2 hours immersion, no heat treatment
Results of simple corrosion testing

Weight loss due to corrosion – wet insulation on carbon steel coupons

<table>
<thead>
<tr>
<th>Mineral oil</th>
<th>Inorganic resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

- EN
  - no heat aging
  - Weight loss = 6 mg
- Non-EN
  - no heat aging
  - Weight loss = 70 mg
- EN
  - heat aged 24 hr at 250°C
  - Weight loss = 242 mg
- EN
  - no heat aging
  - Weight loss = 7 mg
- EN
  - heat aged, 24 hr at 250°C
  - Weight loss = 2 mg

Water in the insulation system causes corrosion of unprotected metal
Changing Perception:  Open-Cell Insulation vs. Water Absorption

**OLD**

The industry perception is that open-cell insulation absorbs water……*high risk of CUI*

**NEW**

“*Class of it’s own*”

1st open-cell, water repellent insulation on the North American market

Mineral wool with an inorganic resin additive
Typical Products for Technical Insulation

Cold
-65°F (< -54°C)
-65°F to 50°F
(-54°C to 10°C)
Cellular glass
Perlite (loose fill)
Foams
Cold boxes
Gas processing

Intermediate
50°F to 175°F
(10°C to 80°C)
Stone wool
Calcium silicate
Foams
HVAC
District heating

Hot
175°F to 1200°F
(80°C to 650°C)
Stone wool
Perlite
Aerogel

Hot
> 1200°F
(> 650°C)
Ceramic fiber
Refractory
Furnaces
Ovens
Boilers

Typical Products for Technical Insulation

- Cellular glass
- Perlite (loose fill)
- Foams
- Cold boxes
- Gas processing
- Stone wool
- Calcium silicate
- Aerogel
- Cellular glass
- Perlite (loose fill)
- Foams
- Air conditioning
- Cooling systems
- HVAC
- District heating
- Petrochemical plants
- Refineries
- Power plants
- Ceramic fiber
- Refractory
- Furnaces
- Ovens
- Boilers
- Petrochemical plants
- Refineries
- Power plants
- HVAC
- District heating
- Low temperature applications
- Intermediate temperature applications
- High temperature applications

Cold boxes
Gas processing
Air conditioning
Cooling systems
HVAC
District heating
Petrochemical plants
Refineries
Power plants
Furnaces
Ovens
Boilers
Ceramic fiber
Refractory
Foams
Stones
Calcium silicate
Aerogel
Cellular glass
Perlite (loose fill)
Stone Wool vs. Calcium Silicate

Why is it important to compare and contrast these materials?

01 Educate

02 Similar market, usage, and competitive landscape

03 Clarify industry perceptions

04 Robustness of the materials
No insulation is perfect….

Select the appropriate insulation material that best meets the requirements of system
Key Selection Criteria for Technical Insulation

Selecting an insulation material requires an understanding of the key properties that will satisfy design requirements and contribute to long-term operational success.
Fire Resilience

— Extremely resilient to fire
— Remains stable at very high temperatures
— Non-combustible
— Works to contain fire and prevent it from spreading
— Does not contribute to the development and spread of fire or the release of toxic gases
— 1200°F + maximum service temperature
— < 25/50 flame/smoke (ASTM E84)
Thermal Properties

Effects of High Temperature on Thermal Conductivity

— **Minimal impact** on thermal conductivity was found, (+/- 5%) — both stone wool and calcium silicate

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![Graph 1: Thermal conductivity of calcium silicate](image)

**Thermal conductivity of calcium silicate**

- **As Is**
- **Heated**

![Graph 2: Thermal conductivity of stone wool mandrel wound](image)

**Thermal conductivity of stone wool mandrel wound**

- **As Is**
- **Heated**
## Thermal Properties

### Thickness Needed

<table>
<thead>
<tr>
<th>Material</th>
<th>2&quot; pipe</th>
<th>4&quot; pipe</th>
<th>6&quot; pipe</th>
<th>12&quot; pipe</th>
<th>24&quot; pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>400°F</td>
<td>600°F</td>
<td>1000°F</td>
<td>400°F</td>
<td>600°F</td>
</tr>
<tr>
<td>Stone wool</td>
<td>1.5&quot;</td>
<td>2&quot;</td>
<td>4.5&quot;</td>
<td>1.5&quot;</td>
<td>2.5&quot;</td>
</tr>
<tr>
<td>Calcium silicate</td>
<td>1.5&quot;</td>
<td>2.5&quot;</td>
<td>4.5&quot;</td>
<td>2&quot;</td>
<td>3&quot;</td>
</tr>
</tbody>
</table>

- **Design criteria for calculations:**
  - Jacketing = new, bright aluminum (0.04 emittance)
  - Maximum outer surface temp. = 140°F (personal protection)
  - Ambient temp. = 77°F
  - Wind speed = 0 mph
  - Pipe = horizontal, steel

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Stone wool mandrel wound + 0.5"
Acoustic Capabilities

ISO 15665
— Insulation systems are classified by their insertion loss performance and the diameter of pipe which they are applied
— Uses A, B, and C performance classification. Class A denotes the lowest performance and C denotes the highest/best performance

ISO / Shell DEP
— Shell poses additional requirements, which are represented within the Shell DEP spec #31
— A version of the ISO 15665 standard to include a higher noise attenuation (i.e. class D)

<table>
<thead>
<tr>
<th>Product Property</th>
<th>Standard</th>
<th>Stone Wool Mandrel Wound</th>
<th>Calcium Silicate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion loss</td>
<td>ISO 15665 Class A, B, &amp; C ISO/Shell Class D</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Water Properties

Water Absorption

EN 13472 Test “Rain” – 24 hrs

Simulates the water absorption caused by exposure to rain during product installation

Water Absorbed (kg/m²)

<table>
<thead>
<tr>
<th>Material</th>
<th>Water Absorbed (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-heat treated Stone wool mandrel wound with inorganic resin</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Heat treated Calcium Silicate</td>
<td>75.2</td>
</tr>
<tr>
<td>Heat treated Calcium Silicate</td>
<td>72.3</td>
</tr>
</tbody>
</table>

Stone wool mandrel wound with inorganic resin

Calcium Silicate

Non-heat treated

Heat treated @ 482°F (250°C)
Water Properties

Water Absorption

**ASTM C1763 “Immersed” – 2 hrs**

Measuring the water absorption as a result of direct immersion in liquid water

Water Absorption (vol. %)

- **Stone wool mandrel wound with inorganic resin**
  - 1.66
  - 0
  - 6.8
  - 0.04

- **Calcium Silicate**
  - 58.22
  - 30.26
  - 71.7
  - 52.57

2 hr immersion

2 hr immersion (after a 2 hr 'burn out')
## Robustness

### Walkability Testing – a function of durability

<table>
<thead>
<tr>
<th>Sample</th>
<th>Jacketing</th>
<th>Thickness Recovery</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone wool mandrel wound pipe section</td>
<td>None</td>
<td>97%</td>
<td>No cracks/damage</td>
</tr>
<tr>
<td>Calcium silicate</td>
<td></td>
<td>99%</td>
<td>Cracks evident</td>
</tr>
<tr>
<td>Stone wool mandrel wound pipe section</td>
<td>0.016” aluminum</td>
<td>98%</td>
<td>Jacketing sprang back 100%</td>
</tr>
<tr>
<td>Calcium silicate</td>
<td></td>
<td>99%</td>
<td>No cracks or deformation</td>
</tr>
</tbody>
</table>
— Similar to stone wool, calcium silicate contains organic materials (cellulosic fiber) to maintain its shape

— Loss on Ignition testing results:

  • Stone wool – 3%
  • Calcium silicate – 9.7%
  • Samples were dried before testing
Recyclable, Reusable, and Abundant

— Stone wool is reusable....continuously creating new value from old materials

— Stone wool can be removed and re-installed (for many cycles) without breakage

— Stone wool is made from resources with reserves that will last millions of years
Make sure that you understand what you are buying

- ASTM standards are used to establish a minimum required level of product quality and help decision makers have confidence in the products they buy/use/specify.
- However, ASTM standards do not always provide good/clear direction for selection of materials.
- Having a high-quality and clear specification goes beyond just ASTM C547.

<table>
<thead>
<tr>
<th>Property</th>
<th>Type I (Grades A and B)</th>
<th>Type II (Grades A and B)</th>
<th>Type III (Grades A and B)</th>
<th>Type IV (Grades A and B)</th>
<th>Type V (Grades A and B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use temperature, max. °C</td>
<td>700 (700)</td>
<td>600 (600)</td>
<td>500 (500)</td>
<td>400 (400)</td>
<td>300 (300)</td>
</tr>
<tr>
<td>Reg. resistance, max. %</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
</tr>
<tr>
<td>Linear shrinkage, % change after change in use temperature</td>
<td>2 (2)</td>
<td>2 (2)</td>
<td>2 (2)</td>
<td>2 (2)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Water vapor sorption, % by weight</td>
<td>5 (5)</td>
<td>5 (5)</td>
<td>5 (5)</td>
<td>5 (5)</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Flame spread index</td>
<td>50 (50)</td>
<td>50 (50)</td>
<td>50 (50)</td>
<td>50 (50)</td>
<td>50 (50)</td>
</tr>
<tr>
<td>Smoke developed index</td>
<td>50 (50)</td>
<td>50 (50)</td>
<td>50 (50)</td>
<td>50 (50)</td>
<td>50 (50)</td>
</tr>
<tr>
<td>Apparent thermal conductivity, Btu in/h/ft²/°F</td>
<td>0.66 (0.66)</td>
<td>0.66 (0.66)</td>
<td>0.66 (0.66)</td>
<td>0.66 (0.66)</td>
<td>0.66 (0.66)</td>
</tr>
</tbody>
</table>

*The user is advised that retrofit applications (where new insulation is being applied over existing) could require knowing the thermal conductivity of the existing layer at mean temperatures above those shown. Consult a manufacturer for data at mean temperatures exceeding those listed.*

**Surface burning**
- Mandrel wound
- Cut pipe

**Water absorption**
- V-groove

**Thermal conductivity**
- Acoustics
- Installation
- Durability
- Circularity
Conclusions / Key Takeaways

CUI is a complex system challenge and is found under all types of insulation.

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

Stone wool offers many performance advantages over calcium silicate.

Water repellency, thermal performance, acoustics, durability, installation.

Mineral wools have different water repellency performance.

Mandrel wound pipe sections with an inorganic treatment help mitigate the risk of CUI.

Having a high-quality and clear spec goes beyond just ASTM requirements.
Combat the risk of CUI

Don’t let water take hold of your pipes

Thank You