Fighting CUI:

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

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ROCKWOOL Technical Insulation

ROCKWOOL

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

39
Countries
45
Manufacturing facilities

11,000+
Team members

Who is RTI?

ROCKWOOL

Industrial insulation segment

ROCKWOOL®
TECHNICAL INSULATION

- 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

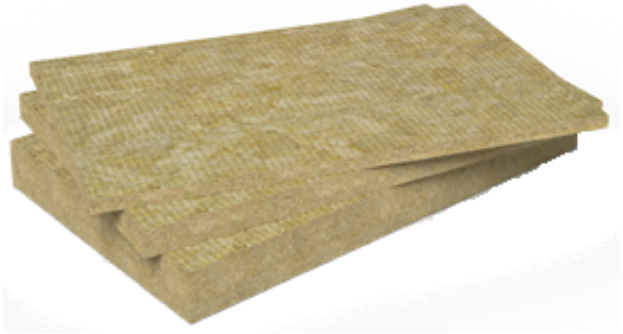
V-groove

Wrap / blanket / mat

Cut pipe

Categories of stone wool insulation

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

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

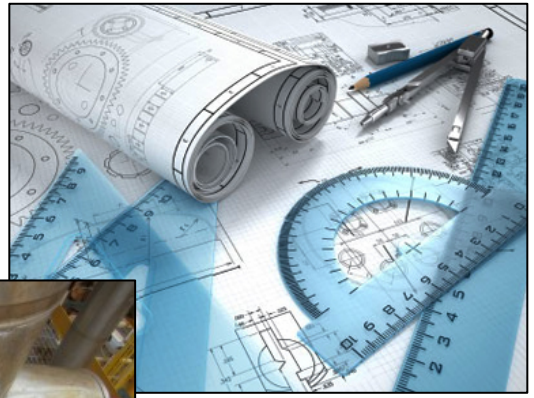
Why is CUI Important?

CUI = Corrosion Under Insulation

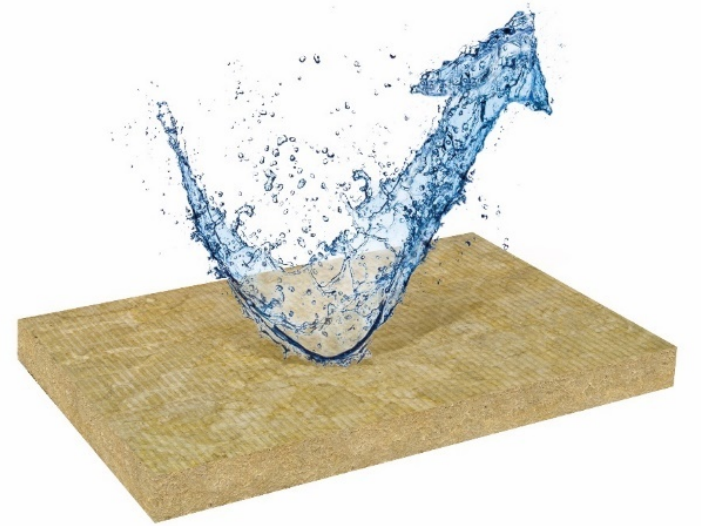
CUI is a Problem….CUI is Complex

- 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?



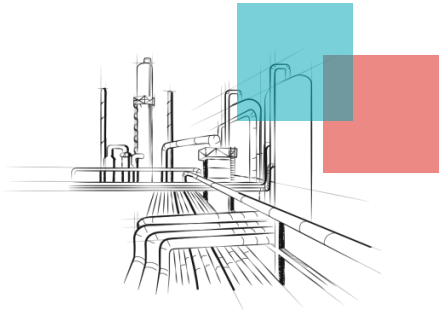
"Because CUI is a product of wet metal exposure duration, the insulation system that ***holds the least amount of water*** and ***dries most quickly,*** should result in the least amount of corrosion damage to equipment"

NACE INTERNATIONAL

NACE SP0198-2016 (2.1.2)

Corrosion can be reduced by the careful selection of insulation materials

The purpose of water repellency



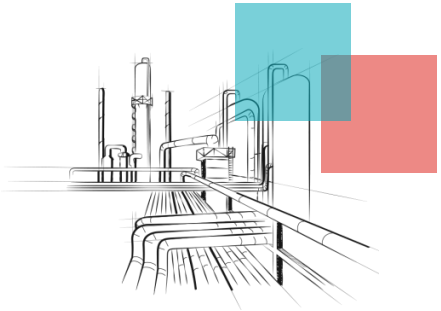
For industrial insulation products:

- 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%

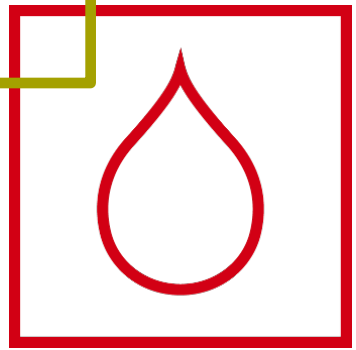
How is water repellency achieved in mineral wool?



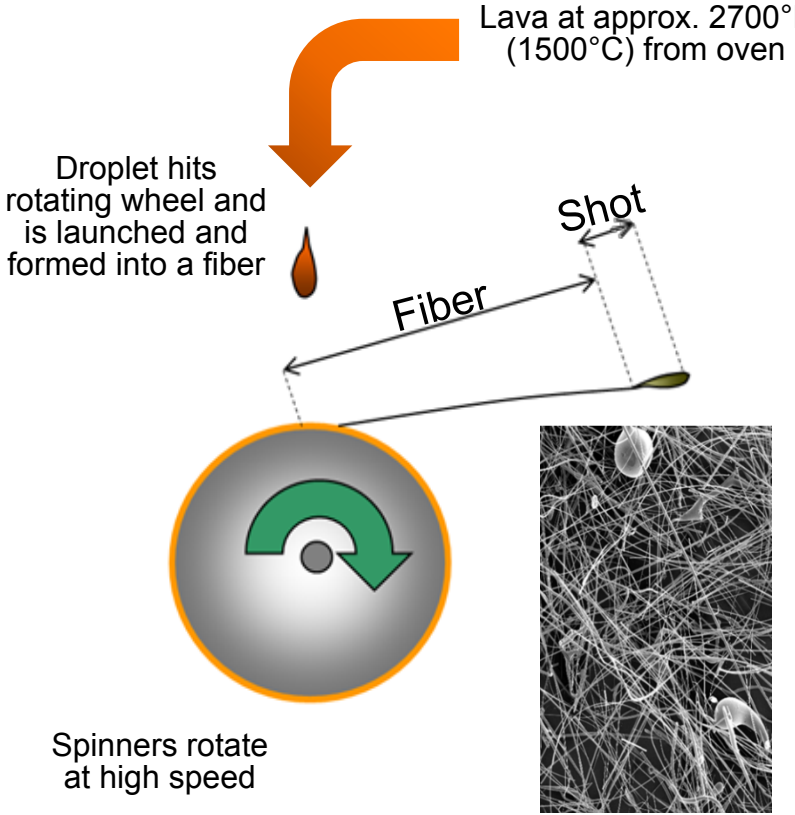
Difference in performance is achieved depending on:

- **Type** of additive
- **Amount** of additive
- **Application** of additive

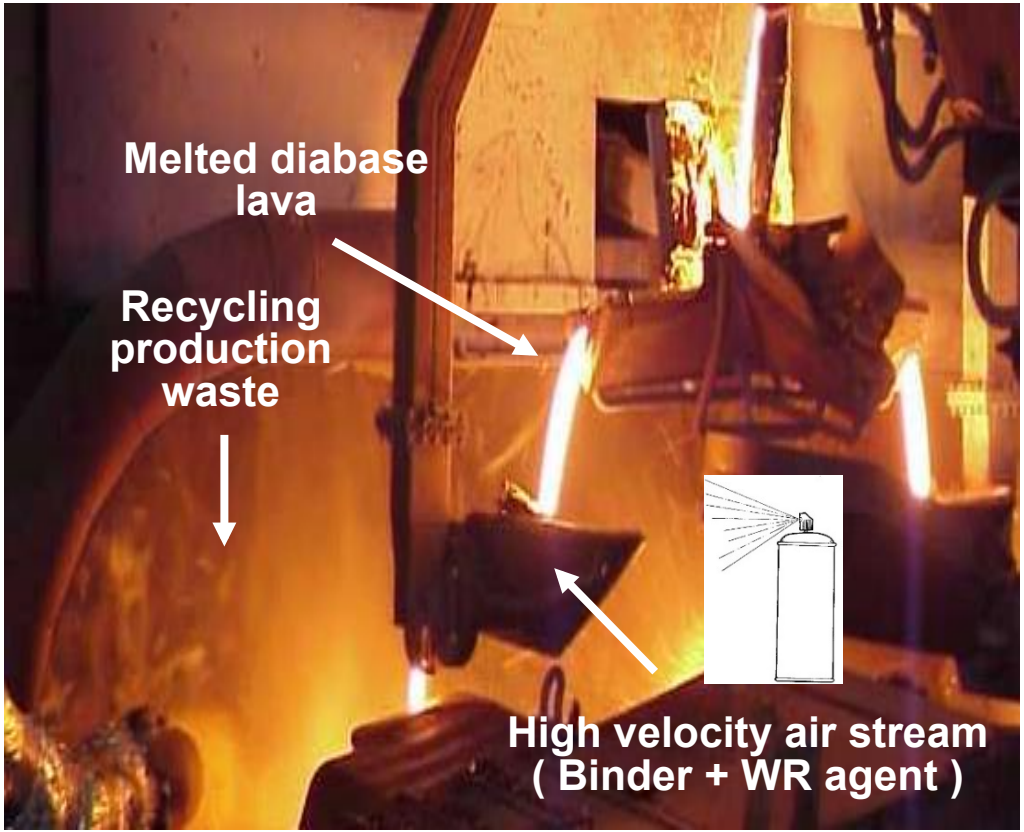
Water repellency is obtained via treatment with additives



Surface treatment vs. individual fiber treatment



Application of the additive



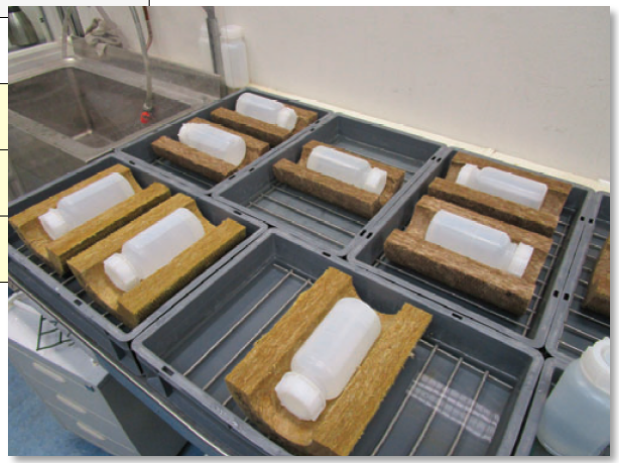
Advantages and disadvantages of different types of additives

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

Inorganic resins are the superior additive for water repellency… and are **silicone oil free!**

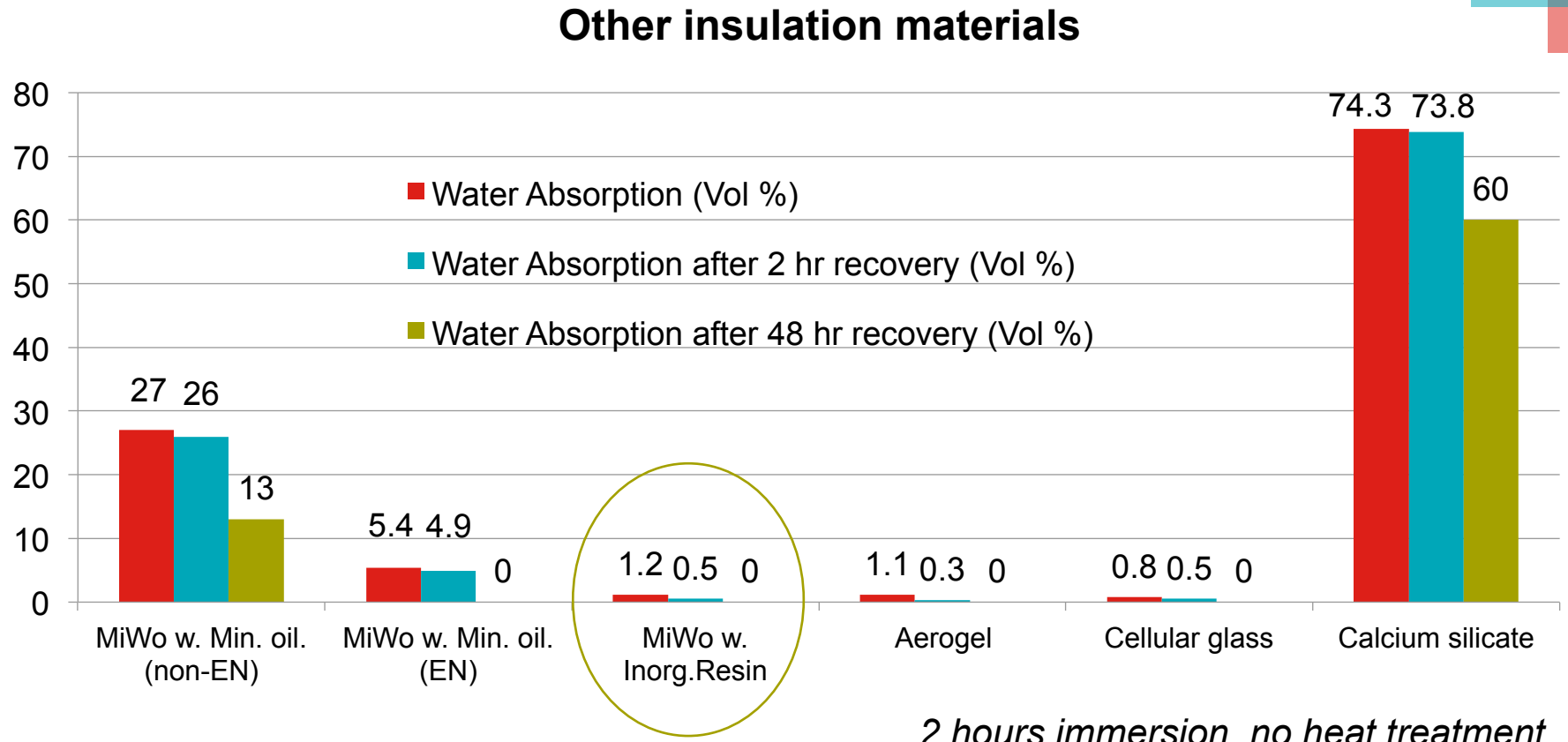
Water absorption (partial immersion) according to EN 13472

Type of additive	Water absorption after 24 hr, (kg/m^2)	Water absorption after 24 hr, **heat aged** material (24h at 250°C / 482°F)
A. **Mineral oil** based (EN)	0.5	30
B. **Mineral oil** based (EN)	1.4	44
C. **Mineral oil** based (non-EN)	8.2	51
D. **Mineral oil** based (non-EN)	0.6	70
E. **Mineral oil** based (non-EN)	3.5	61
F. **Silicone oil** based (EN)	0.1	0.1
G. **Silicone oil** based (EN) *	0.1	46
H. **Inorganic resin**	0.1	0.1



- To meet the EN standard….the **non-heated** must be < 1 kg/m2

Water absorption (full immersion) according to ASTM C1763

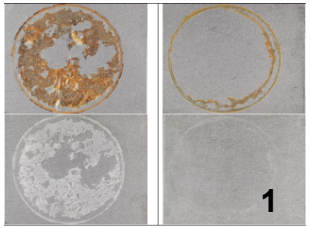


2 hours immersion, no heat treatment

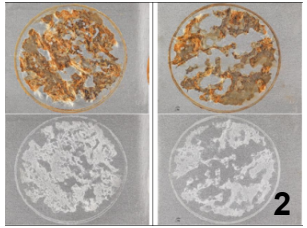
Results of simple corrosion testing

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

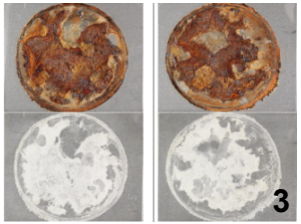
Mineral oil



- EN
- no heat aging
- Weight loss = 6 mg

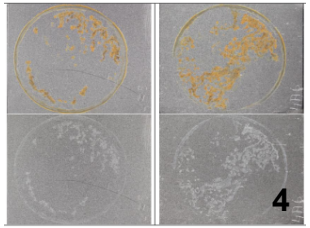


- Non-EN
- no heat aging
- Weight loss = 70 mg

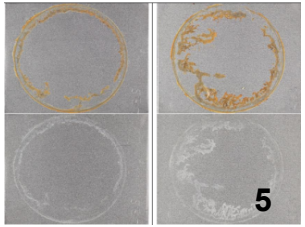


- EN
- **heat aged** 24 hr at 250°C
- Weight loss = 242 mg

Inorganic resin



- 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

Mineral wool with an inorganic resin additive

Changing Perception: Open-Cell Insulation vs. Water Absorption

OLD

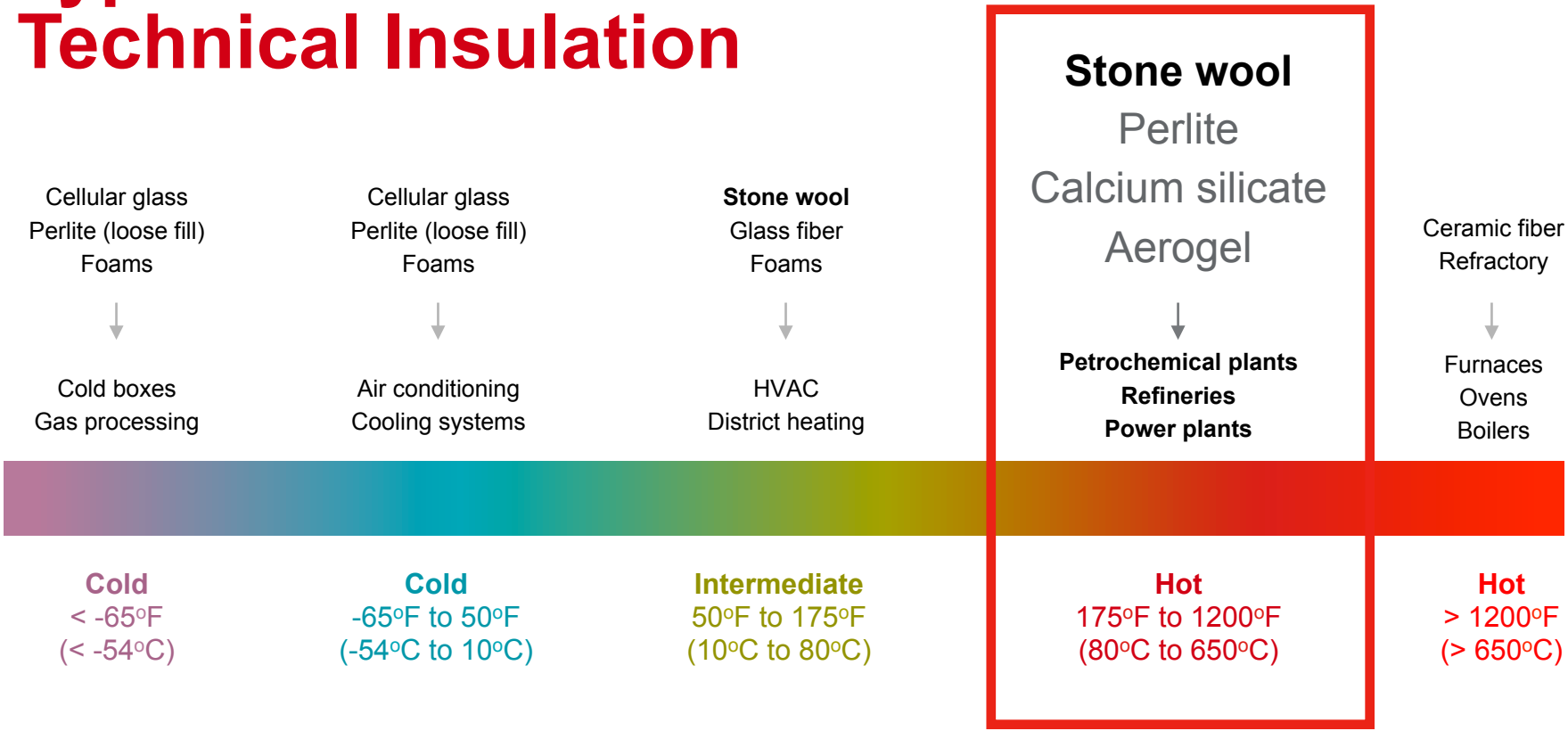
The industry perception is that open-cell insulation absorbs water……high risk of CUI

NEW

"Class of it's own"

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

Typical Products for Technical Insulation



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

Key Selection Criteria for Technical Insulation

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

Circularity

Thermal Properties

Water Properties

Acoustic Capabilities

Robustness

Fire Resilience

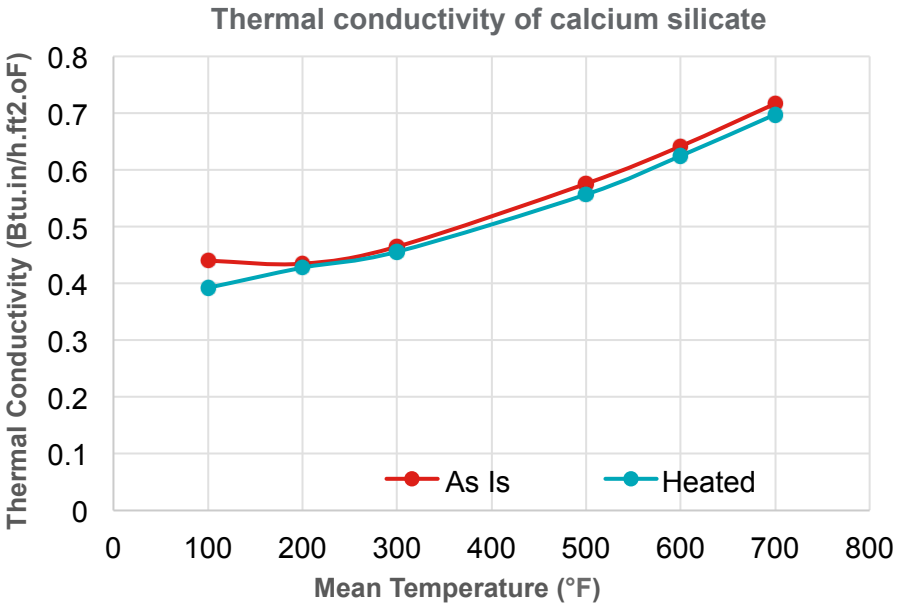
- Extremely resilient to fire
- Remains stable at very high temperatures
- Non-combustible
- Works to contain fire and prevent it from spreading
- Does not contribute to the development and spread of fire or the release of toxic gases
- 1200°F + maximum service temperature
- < 25/50 flame/smoke (ASTM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

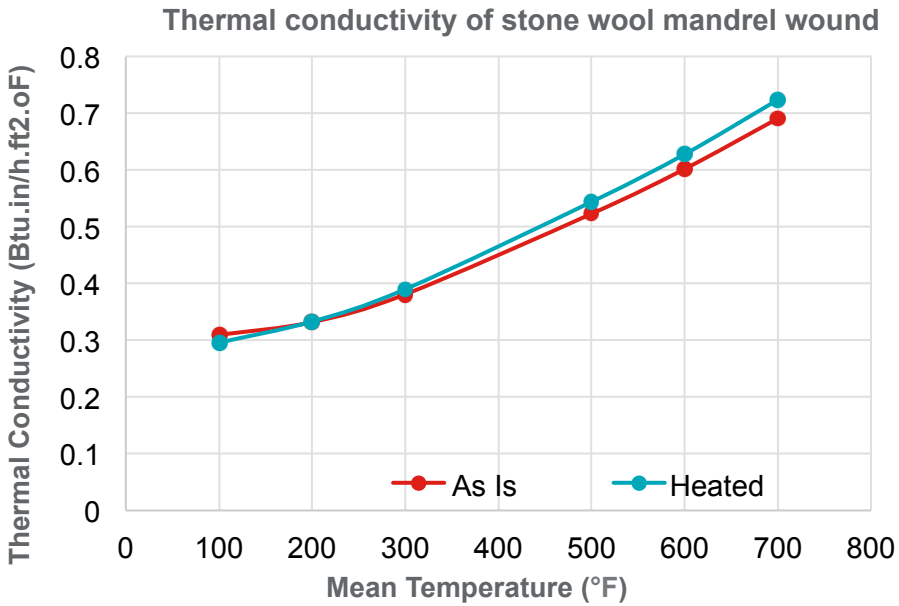
Stone wool and calcium silicate

Thermal Properties

Effects of High Temperature on Thermal Conductivity

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





Thermal Properties

Thickness Needed

Stone wool mandrel wound + 0.5”

Material	2” pipe			4” pipe			6” pipe			12” pipe			24” pipe		
	400°F	600°F	1000°F	400°F	600°F	1000°F	400°F	600°F	1000°F	400°F	600°F	1000°F	400°F	600°F	1000°F
Stone wool	1.5”	2”	4.5”	1.5”	2.5”	5”	1.5”	3”	5.5”	1.5”	3”	6.5”	2”	3.5”	7.5”
Calcium silicate	1.5”	2.5”	4.5”	2”	3”	5.5”	2”	3”	6”	2”	3.5”	7”	2.5”	4”	8”

— 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

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)

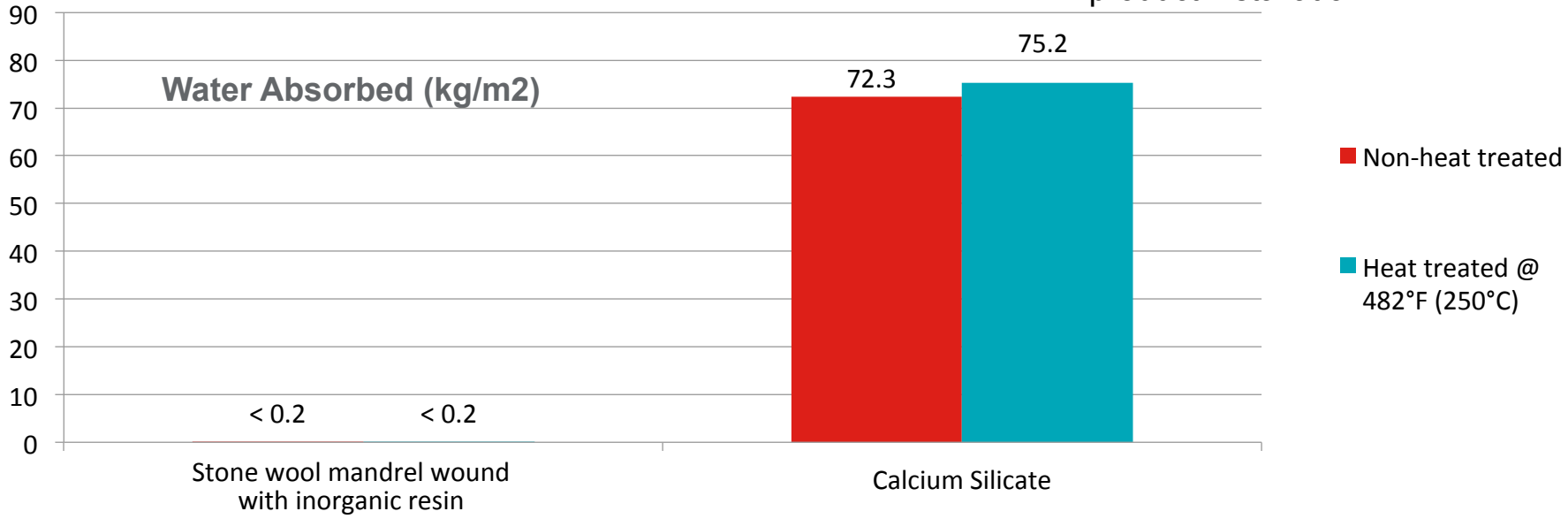
Product Property	Standard	Stone Wool Mandrel Wound	Calcium Silicate
Insertion loss	ISO 15665 Class A, B, & C	✓	X
	ISO/Shell Class D	✓	X

Water Properties

Water Absorption

EN 13472 Test "Rain" – 24 hrs

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

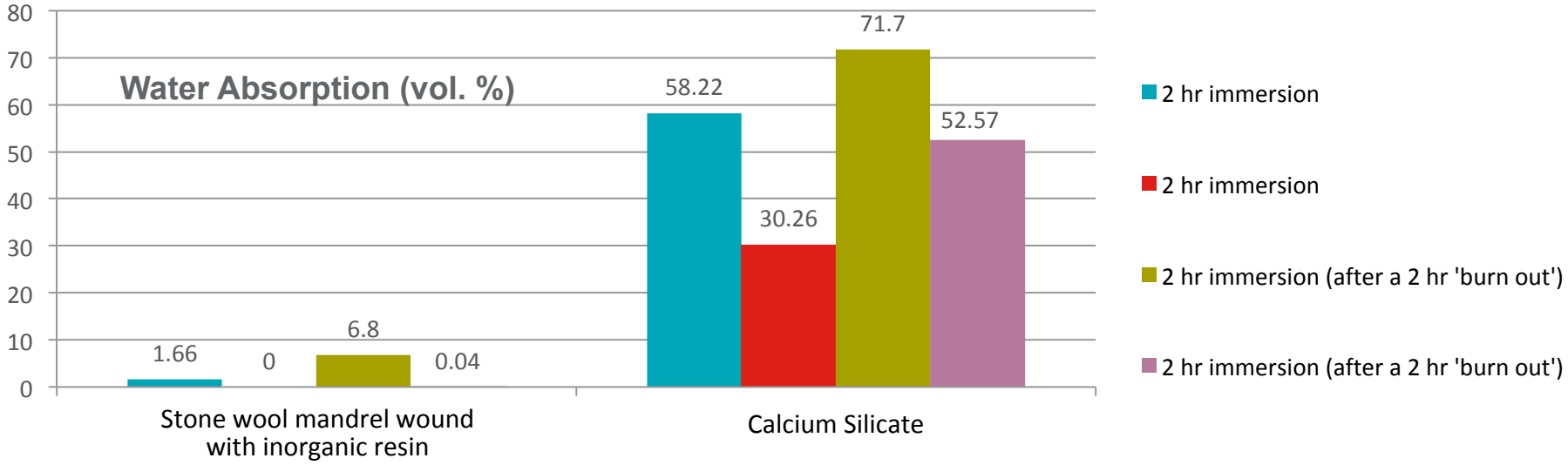


Water Properties

Water Absorption

ASTM C1763
“Immersed” – 2 hrs

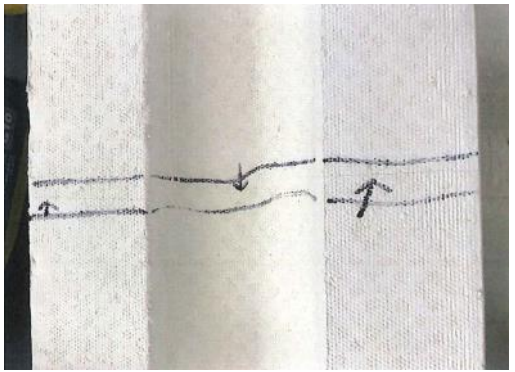
Measuring the water absorption as a result of direct immersion in liquid water



Robustness

Walkability Testing – a function of durability

Sample	Jacketing	Thickness Recovery	Observation
Stone wool mandrel wound pipe section	None	97%	No cracks/damage
Calcium silicate		99%	Cracks evident
Stone wool mandrel wound pipe section	0.016” aluminum	98%	Jacketing sprang back 100%
Calcium silicate		99%	No cracks or deformation



Robustness

Cellulosic Fiber Oxidation vs. Binder Oxidation

— 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

Calcium silicate after high temp exposure

Stone wool after high temp exposure

Circularity

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

Insulation is the most profitable cost savings opportunity for emissions reduction

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

V-groove **Mandrel wound** **Cut pipe**

C547 – 12

TABLE 1 Requirements of Mineral Fiber Pipe Insulation (Grades A & B)

Property	Type I (Grades A andB)	Type II (Grades A and B)	Type III (Grades A and B)	Type IV (Grades A and B)	Type V (Grades A and B
Use temperature, max, °F (°C)	850 (454)	1200 (650)	1200 (650)	1000 (538)	1400 (760)
Sag resistance, max, % thickness change	5	5	5	5	5
Linear shrinkage (length), max, % change after change after soaking heat at maximum use temperature	2	2	2	2	2
Water vapor sorption, max, % by weight	5	5	5	5	5
Surface burning characteristics, max					
Flame spread index	25	25	25	25	25
Smoke developed index	50	50	50	50	50
Apparent thermal conductivity, max, Btu.in./h,ft^2, °F(W/m.K) Mean temperature[A]					
°F (°C)					
100 (38)	0.25 (0.036)	0.25 (0.036)	0.25 (0.036)	0.25 (0.036)	0.25 (0.036)
200 (93)	0.31 (0.045)	0.31 (0.045)	0.31 (0.045)	0.31 (0.045)	0.31 (0.045)
300 (149)	0.40 (0.058)	0.37 (0.053)	0.37 (0.053)	0.37 (0.053)	0.37 (0.053)
400 (204)	0.51 (0.074)	0.45 (0.065)	0.45 (0.065)	0.45 (0.065)	0.45 (0.065)
500 (260)[†]	0.64 (0.092)	0.54 (0.078)	0.54 (0.078)	0.54 (0.078)	0.54 (0.078)
600 (316)		0.65 (0.094)	0.65 (0.094)	0.65 (0.094)	0.65 (0.094)
700 (371)		0.77 (0.111)	0.77 (0.111)	0.77 (0.111)	0.77 (0.111)

[A] 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.
[†] Editorially corrected in January 2012.

Surface burning

Thermal conductivity

Water absorption

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

ROCKWOOL