

ASPEN AEROGELS
Best Practice in Managing Corrosion under Insulation
(CUI) and Corrosion Under Fire Protection CUI

Altaf Rahman – EMEA Commercial Director

10th December 2020

Today's Agenda

- An Introduction to Aerogel Technology focused on Pyrogel and Cryogel.
- Evidence based Discussions and Independent Testing
- CUI Types and their Origins
- How Exxon , Shell and Equinor tested Pyrogel and outcomes.
- Proven in Use CUI mitigation : Case Study demonstrating 15 years continuous performance
- 3 Step approach for your company to mitigate CUI
- Alternative Solution to tackle Corrosion Under Fire Protection CUF.
- Open Forum and Questions

More than US\$1 billion Installed around the world

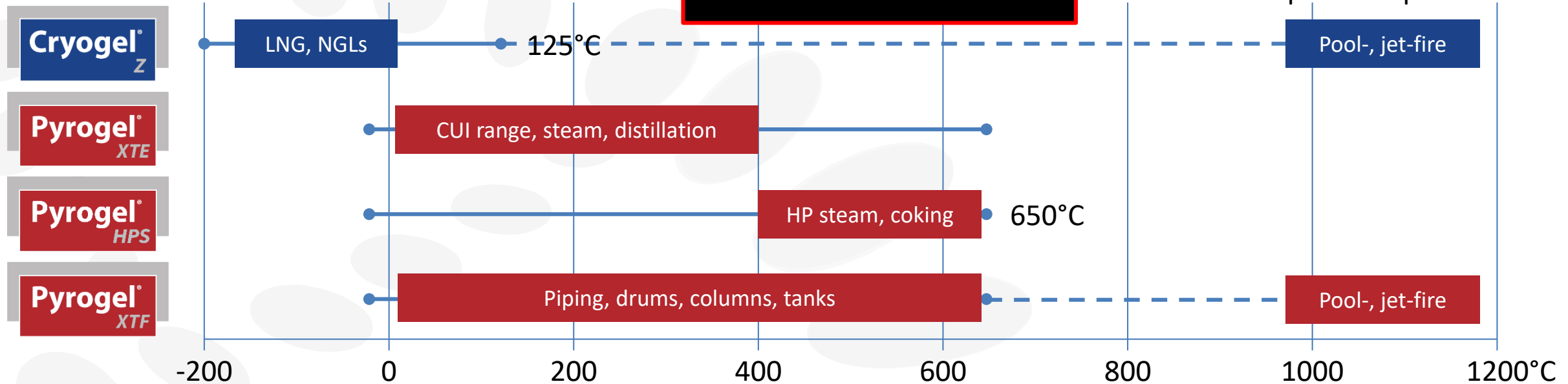
As the world's leading manufacturer of aerogel products, Aspen Aerogels has:

- Been in business since 2001
- 3-line factory in Providence, RI (USA)
- 250 employees & sales of US\$130MM/yr
- Over US\$1 billion installed

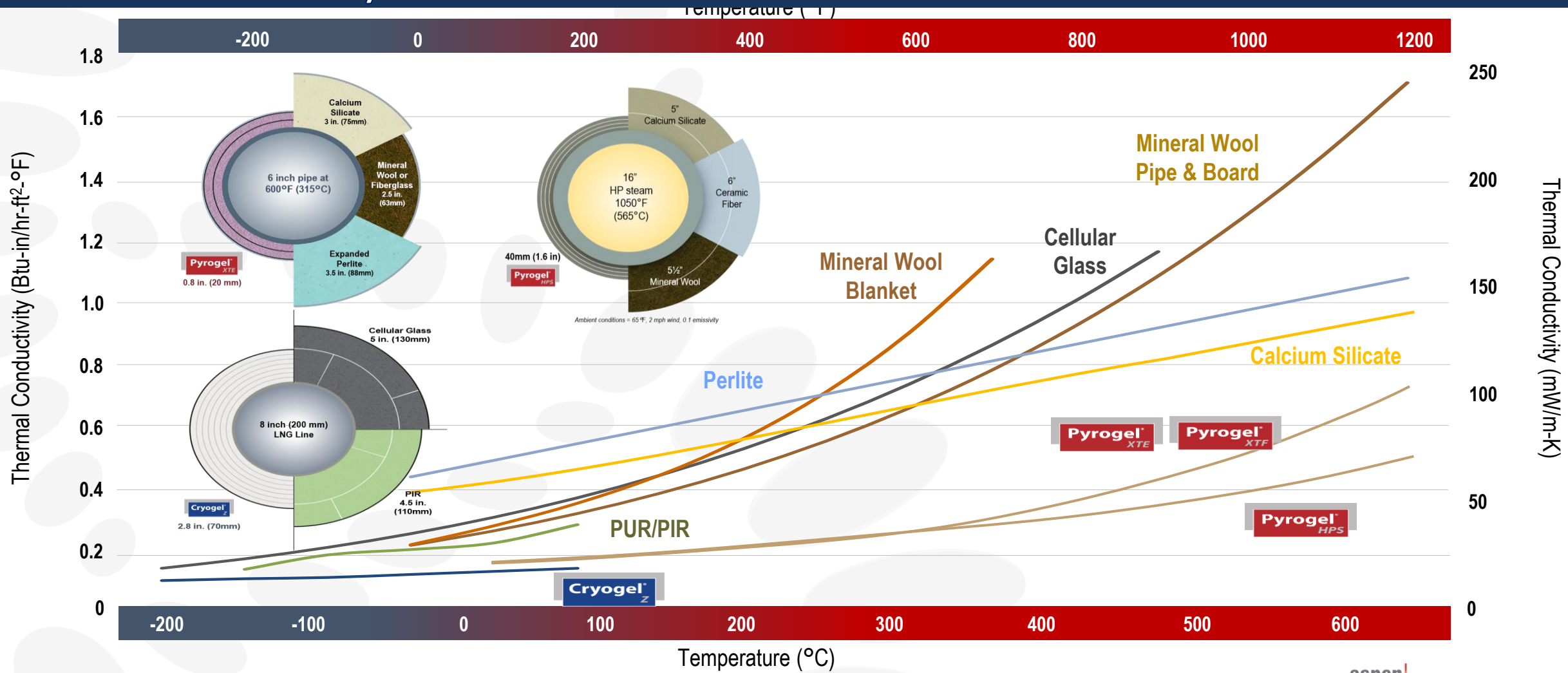


Cryogel & Pyrogel:

- Thinnest insulation on Earth
- Tough, flexible format
- Helps prevent CUI
- Faster to install
- Insensitive to workmanship
- Jet- and pool-fire protection



The Lowest k-Value of Any Industrial Insulation



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CUI – A BRIEF HISTORY



Evidence based discussion

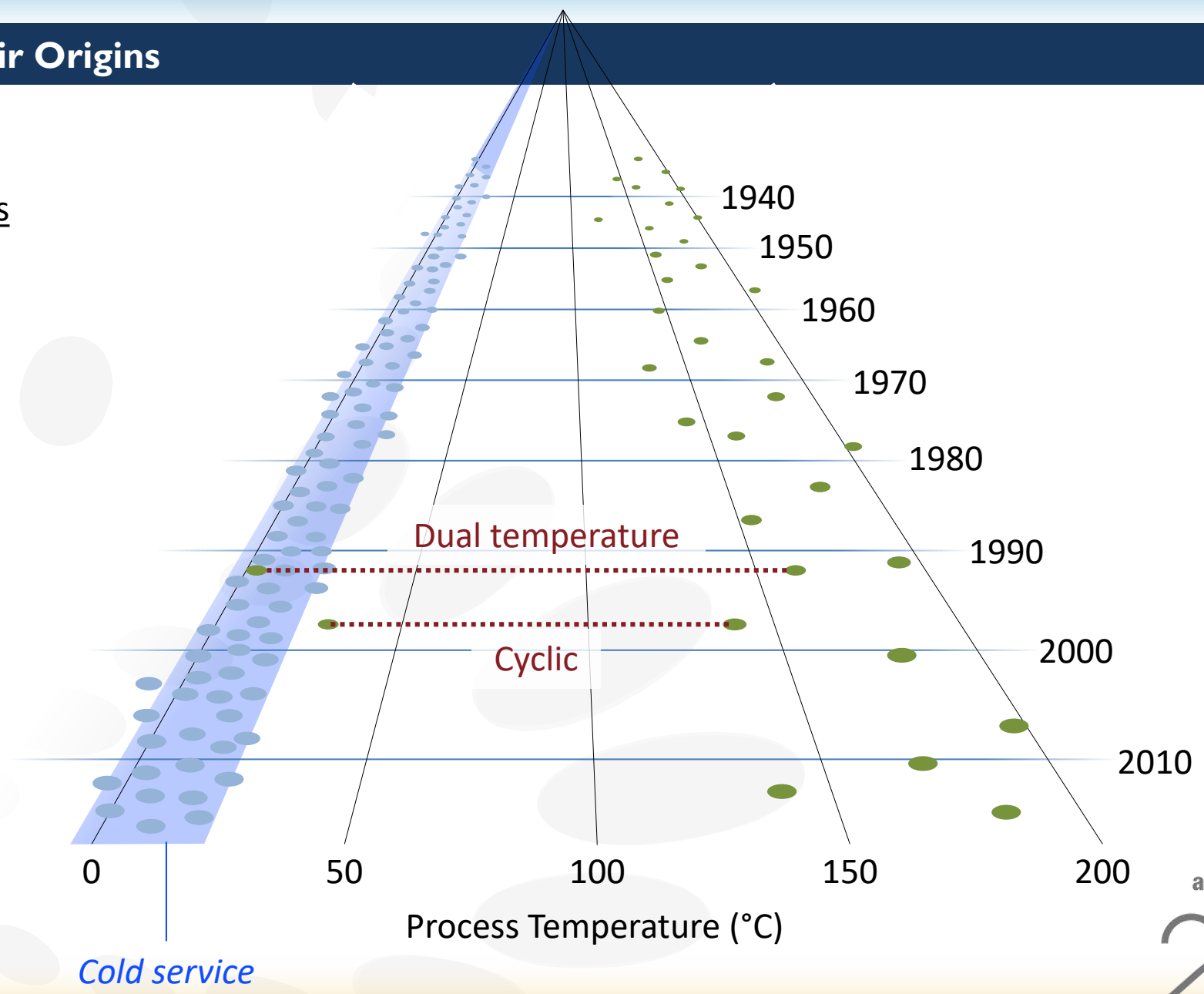
- Our CUI mitigation defense is based on the *NACE RP0198 “The Control of Corrosion Under Thermal Insulation and Fireproofing Materials - A Systems Approach”*
- The testing we will present is independent without influence from any insulation manufacturer.
- No Aspen testing is included in this discussion.
- Evidence based case study. Based on 15 year Pyrogel performance mitigating CUI.



Three Types of CUI, and Their Origins

Types of CUI Incidents

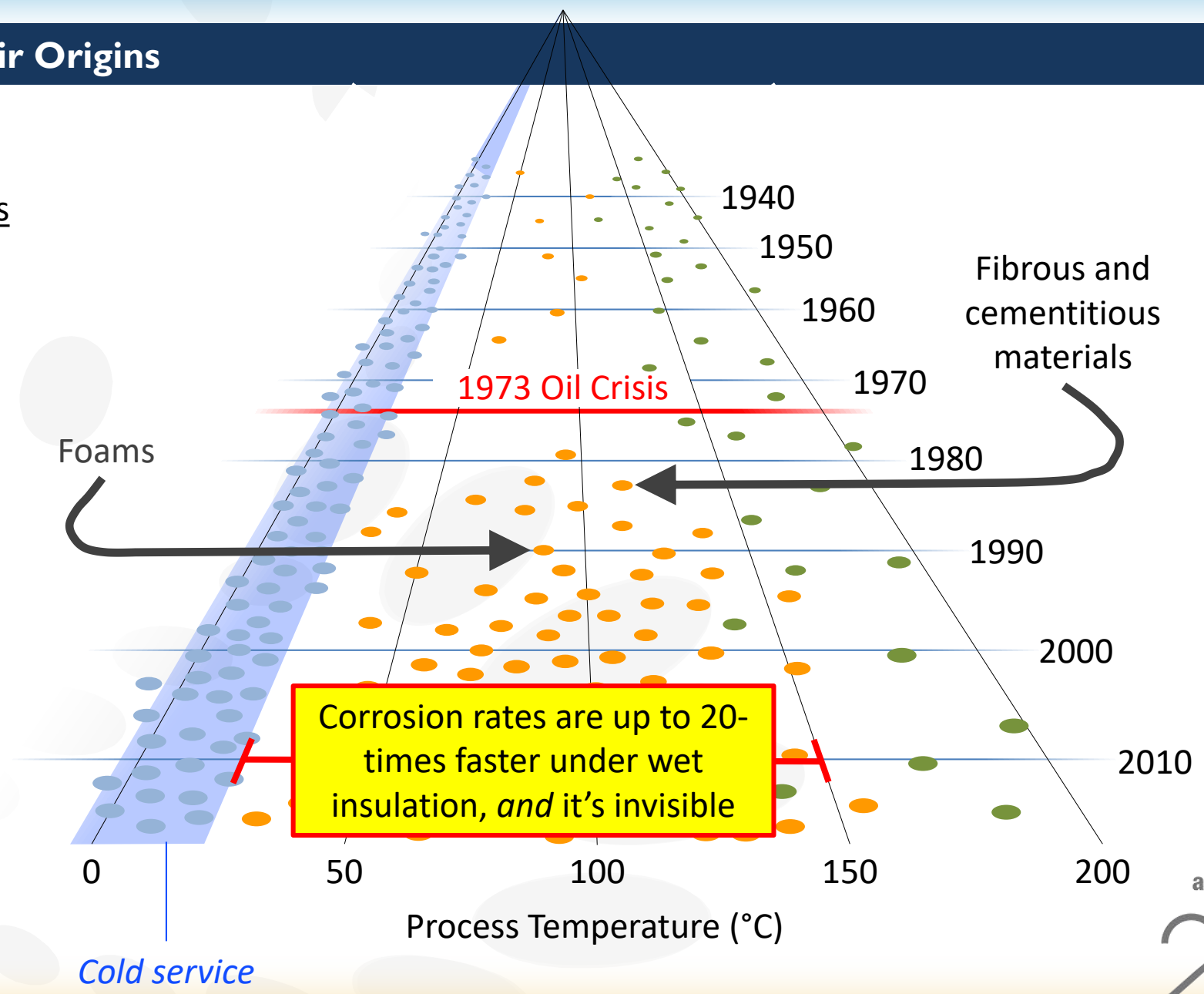
- 1 Cold service
- 2 Cyclic service



Three Types of CUI, and Their Origins

Types of CUI Incidents

- 1 Cold service
- 2 Cyclic service
- 3 Hot service



**“By the time we’re done,
we will have spent over \$650 million
globally on CUI remediation.”**

– A major European IOC

**“At one site alone, we had over
50 CUI-related incidents in 2016.”**

– A German petrochemical company

**Many refineries and petrochemical plants
are now spending 10-30% of their
maintenance budgets fighting CUI**

**“CUI causes one
loss-of-containment
event every day.”**

*– A major US international oil
company (IOC) speaking of
their global operations*

Hydrophobic



Vapor
Permeable



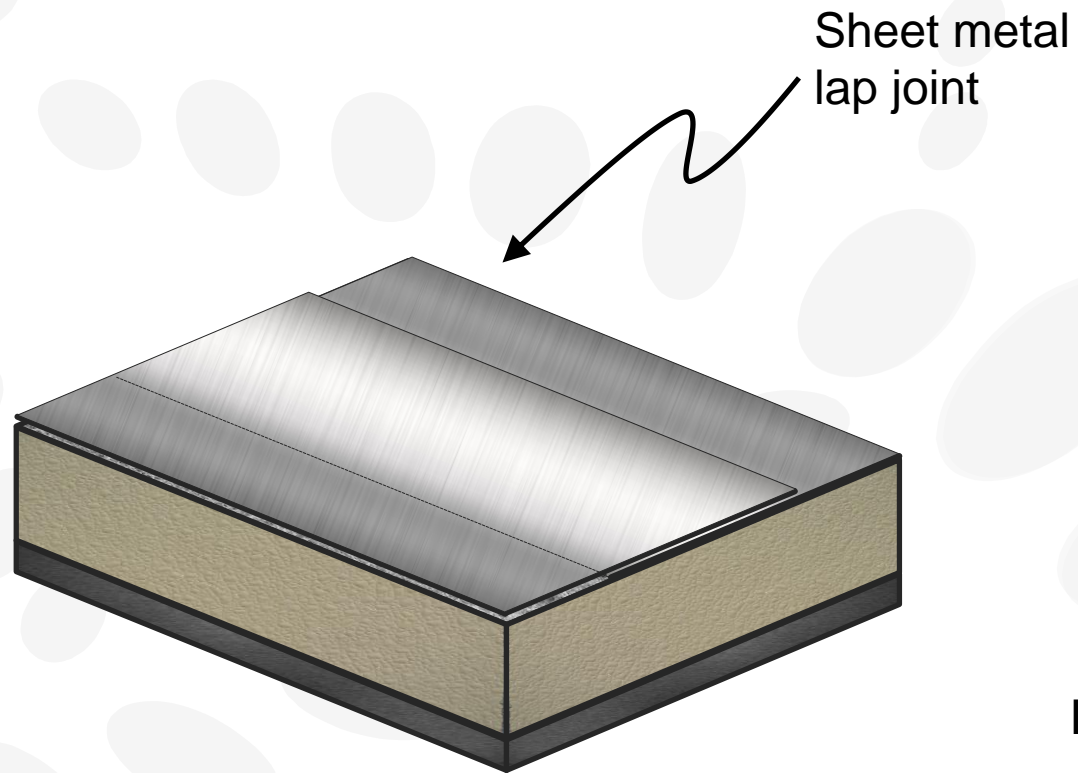
SUPERIOR CUI DEFENCE

- Breathable design allows introduced moisture to escape
- Minimize 'time in contact' with water

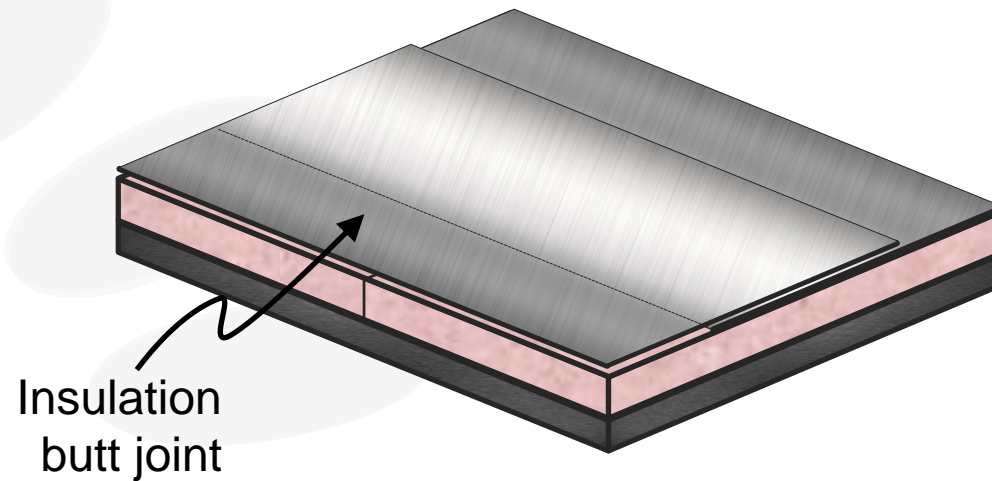


Vapor escapes through PyroGel

A Tale of Two Surfaces – Newly Installed

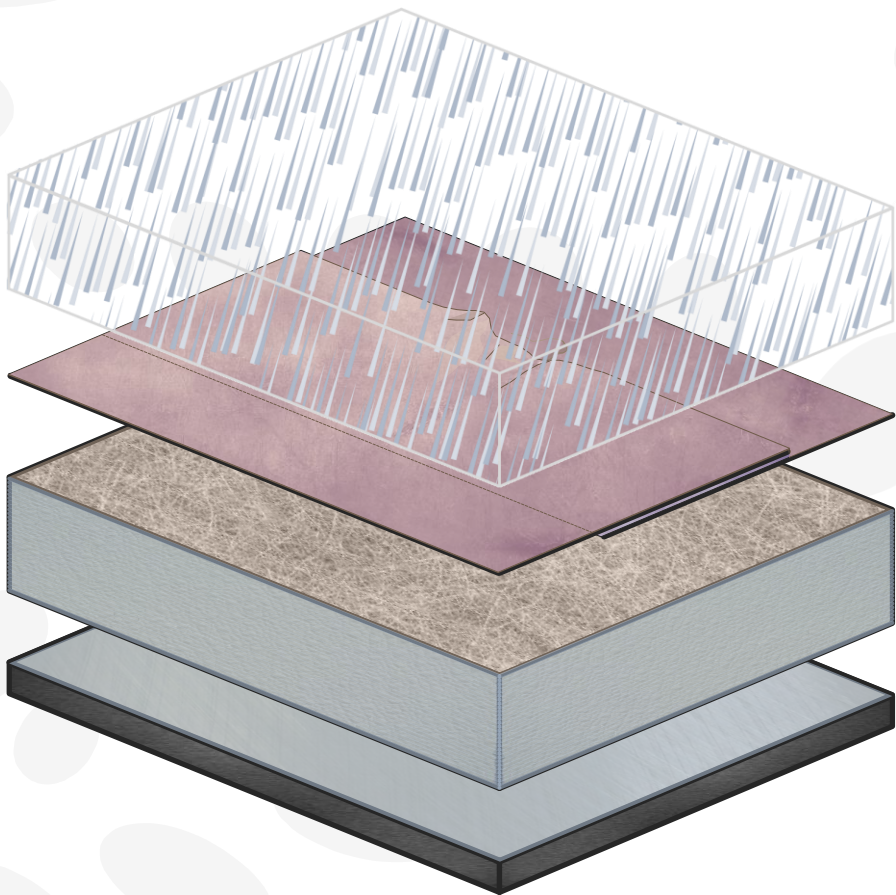


Water-Absorbent Insulation

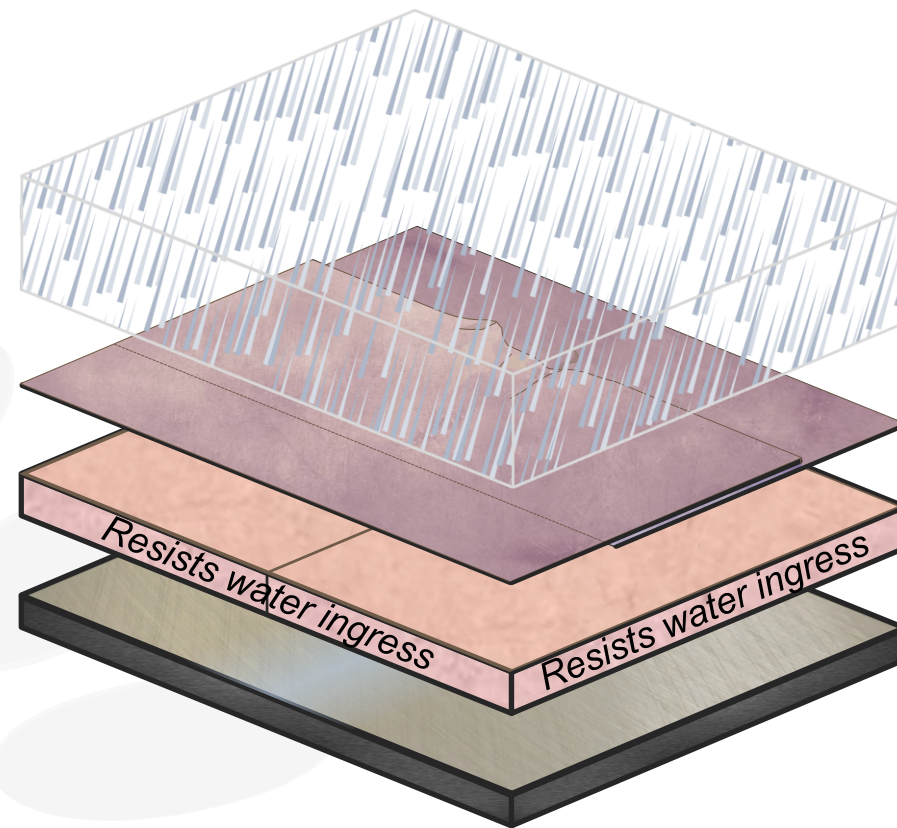


Hydrophobic Insulation

A Tale of Two Surfaces – Aged and Weathered



Water-Absorbent Insulation

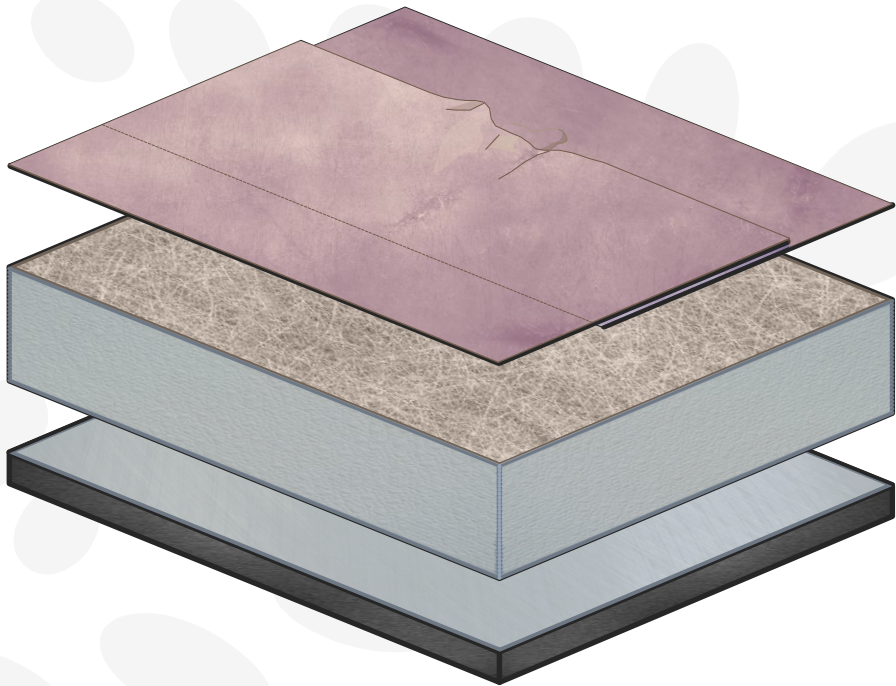


Hydrophobic Insulation

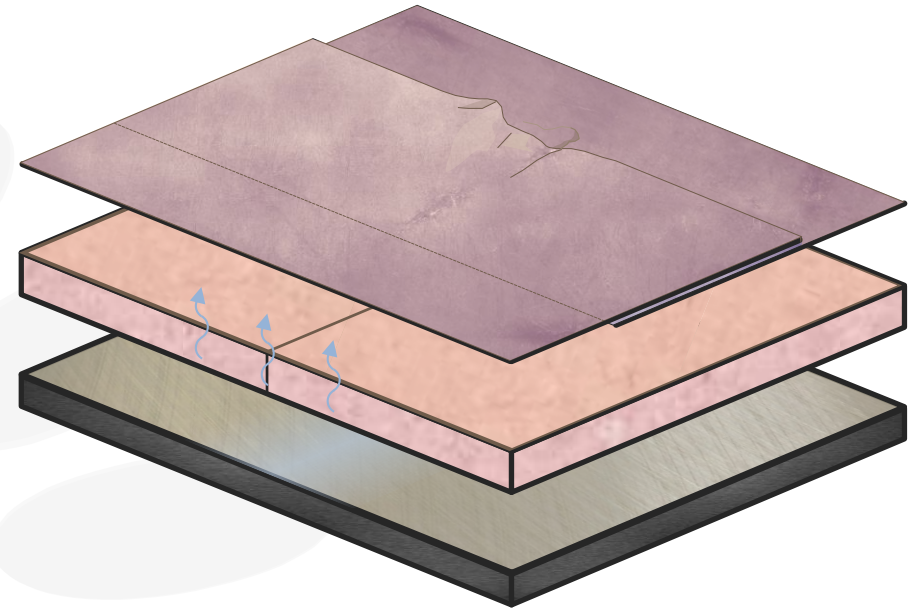
Water Weight

98%
Less

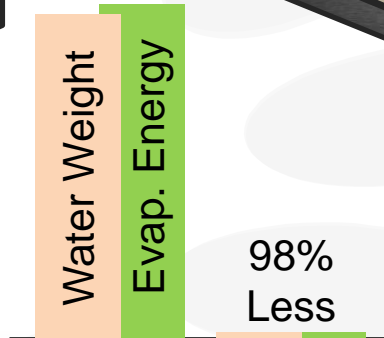
A Tale of Two Surfaces – After the Rain Stops



Water-Absorbent Insulation



Hydrophobic Insulation

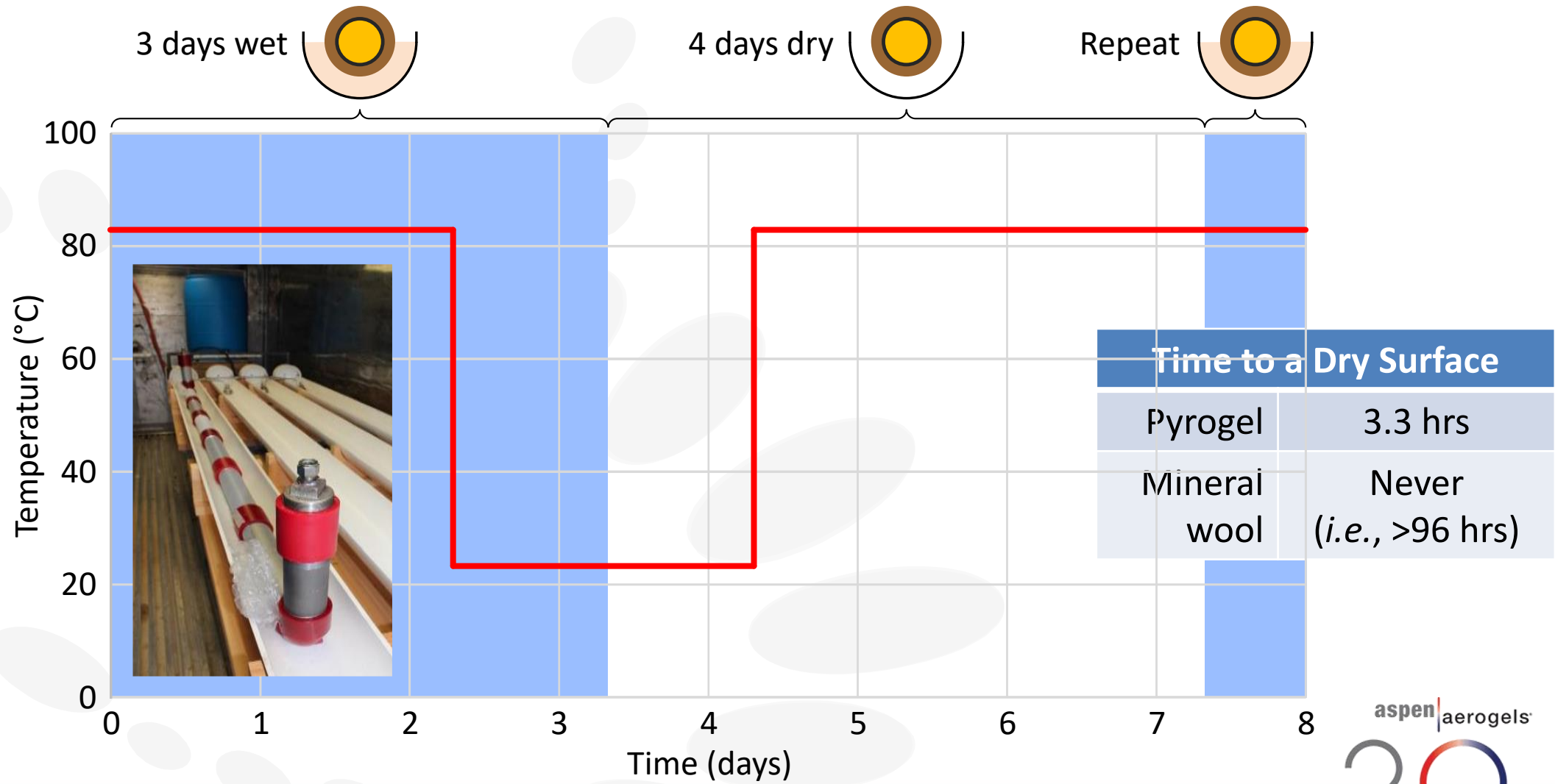


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APPROVED AND TESTED BY THE INDUSTRY LEADERS.



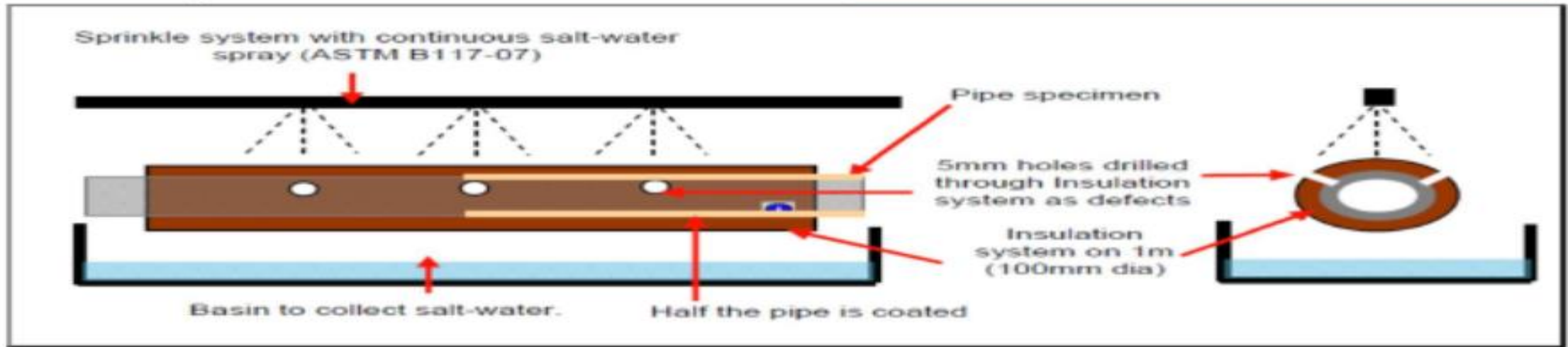
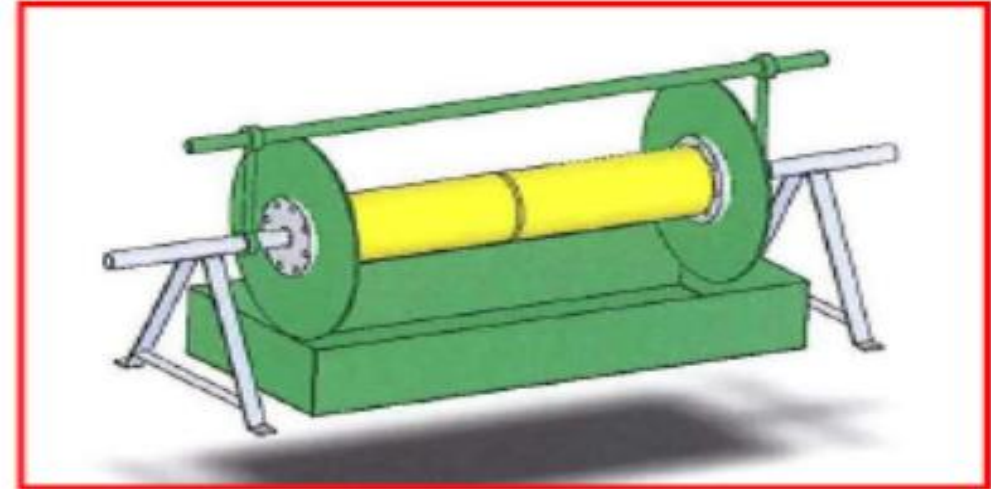
Dryout Testing by An Oil & GAs Major



TESTING OF VARIOUS INSULATION MATERIALS BY A MAJOR REFINER

Recent independent testing compared different insulation systems to conditions known to promote CUI:

- Uncoated carbon steel pipe
- Heated water at 80°C is channeled thru a closed controlled circulation system.
- 180-day exposure to a salt water drip



Test Results

MW

1A(Coated) Corrosion rate 0.06mm/year



1B(non-coated) 0.09mm/year



Cellular Glass

2A(Coated) Corrosion rate 0.14mm/year

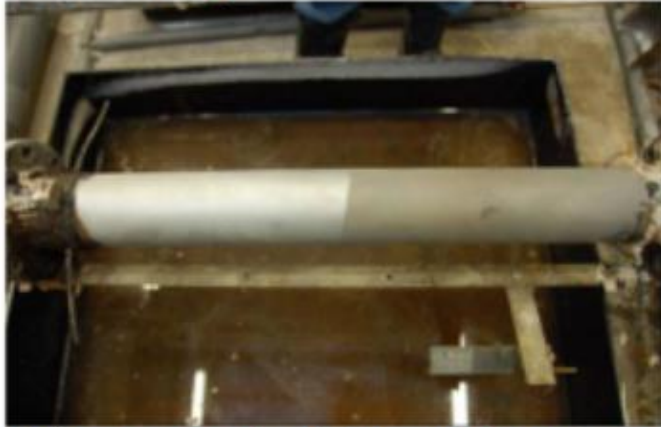


2B(non-coated) 0.15mm/year



Aerogel Test Results

3A(Coated) Negligible Corrosion



3B(non-coated) Negligible Corrosion



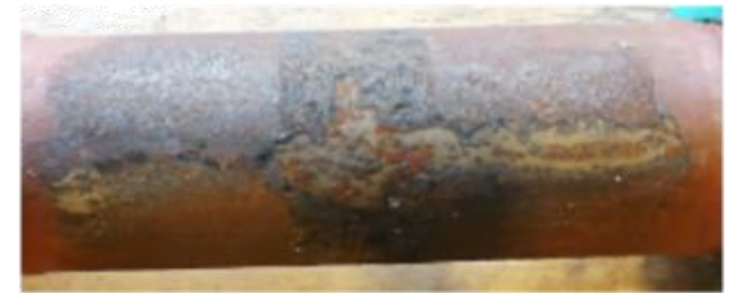
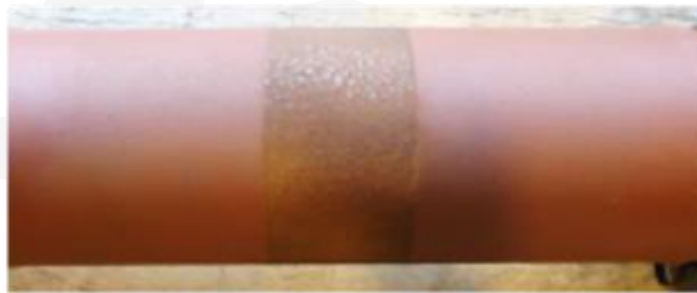
The insulation test

Porsgrunn 2014

**Tested different solutions
and available insulation
systems to verify effect on
CUI**

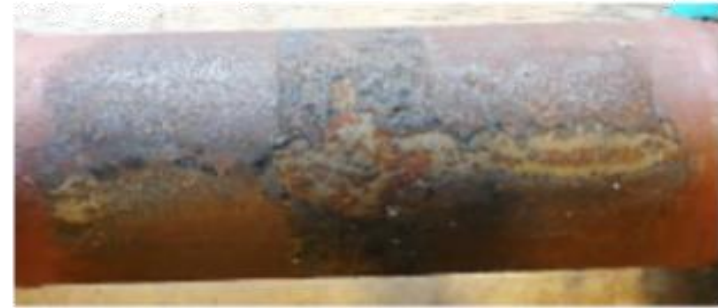
Results

Here are the final conditions:

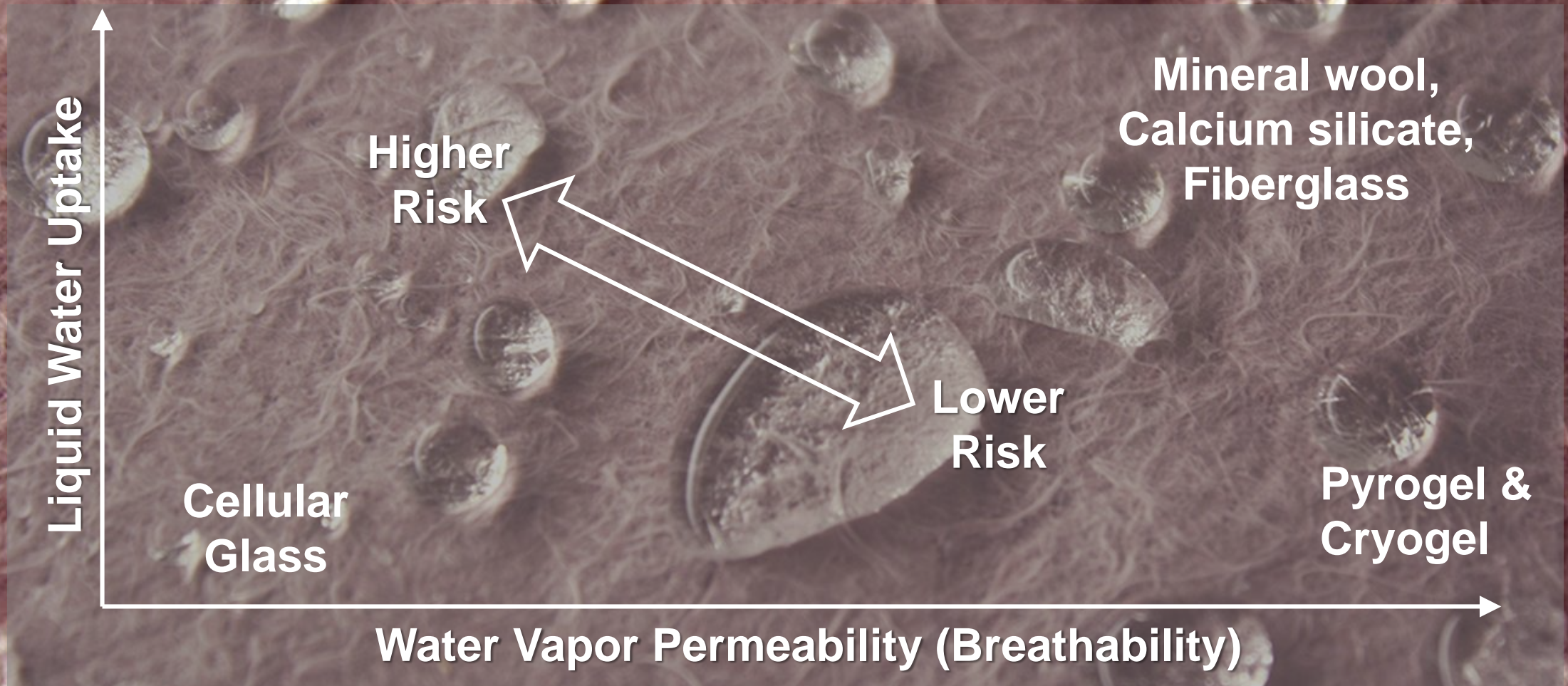


Cellular glass solutions

Not completely resistant towards humidity.



WHAT TO LOOK FOR? HYDROPHOBIC & BREATHABLE



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CUI – CASE STUDY



A decade of superior protection

- **HuChems** first adopted Pyrogel for its MNB plant in 2008.
- Pyrogel was used to insulate piping, equipment and vessels for heat conservation in Phase II of MNB plant.
- Pyrogel protects against CUI
- Pyrogel allows the HuChems team to focus on their process not the weather

Watch the video - [A Decade of Superior protection](#)

Service Classes

Process Temp.	4" - 10"	> 12"	Equipment or Vessel
50-175°C ¹	Case 1 Case 8	Case 3 Case 7	
>180-300°C	Case 2 Case 6		
>300°C ²		Case 4	Case 5

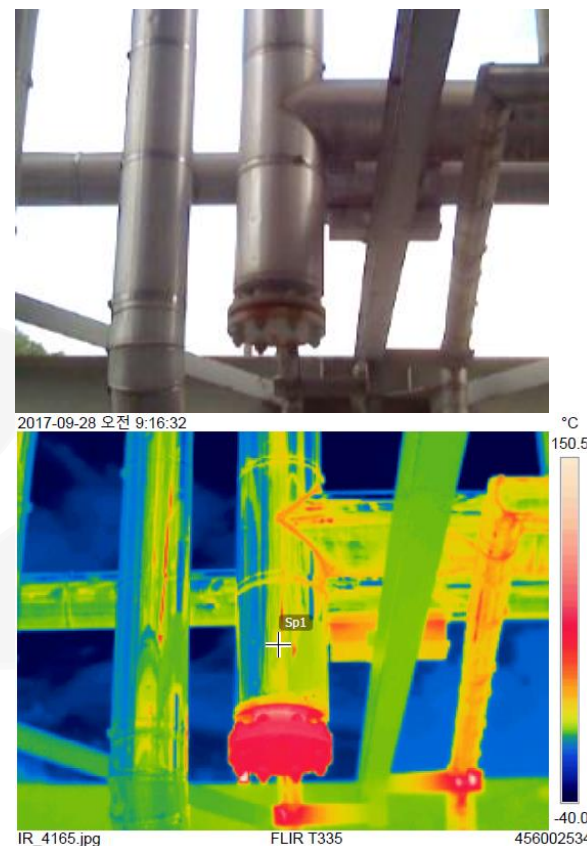
¹ *High risk of CUI category*

² *Hydrophobic durability. The hydrophobe of Mineral wool and perlite will degrade over time under such high temp.*



Case 1: 4" (Nitric ACID FACILITY)

NPS	4" Low Pressure Steam Pipe
Process Temp.	135°C
Ambient Temp.	22.7°C
Wind Speed	1.2 m/s
Material	Pyrogel XT 20mm
Surface Temp. Measured	32°C (Probe) 33.8°C (FLIR)
Surface Temp. Calculated	31.2°C Emissivity 0.3

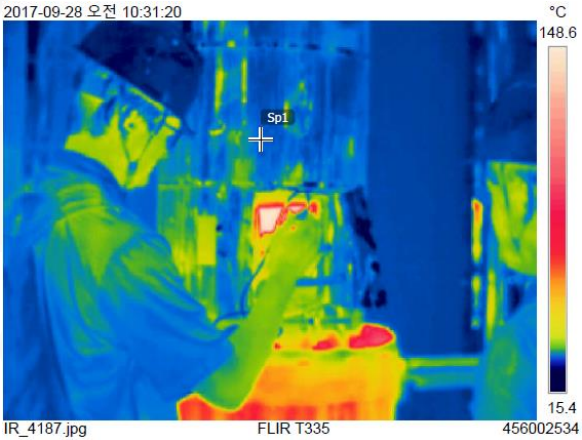


Case 7: 14" (MNB FACILITY)

NPS	14"
Process Temp.	90°C
Ambient Temp.	26.5°C
Wind Speed	0.7 m/s
Material	Pyrogel XT 20mm
Surface Temp. Measured	35.0°C (Probe) 33.7°C (FLIR)
Surface Temp. Calculated	36.3°C Emissivity 0.1



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IR_4187.jpg

FLIR T335

456002534

Case 7: 14" (mnb FACILITY)



**Insulated with
20mm Pyrogel XT**

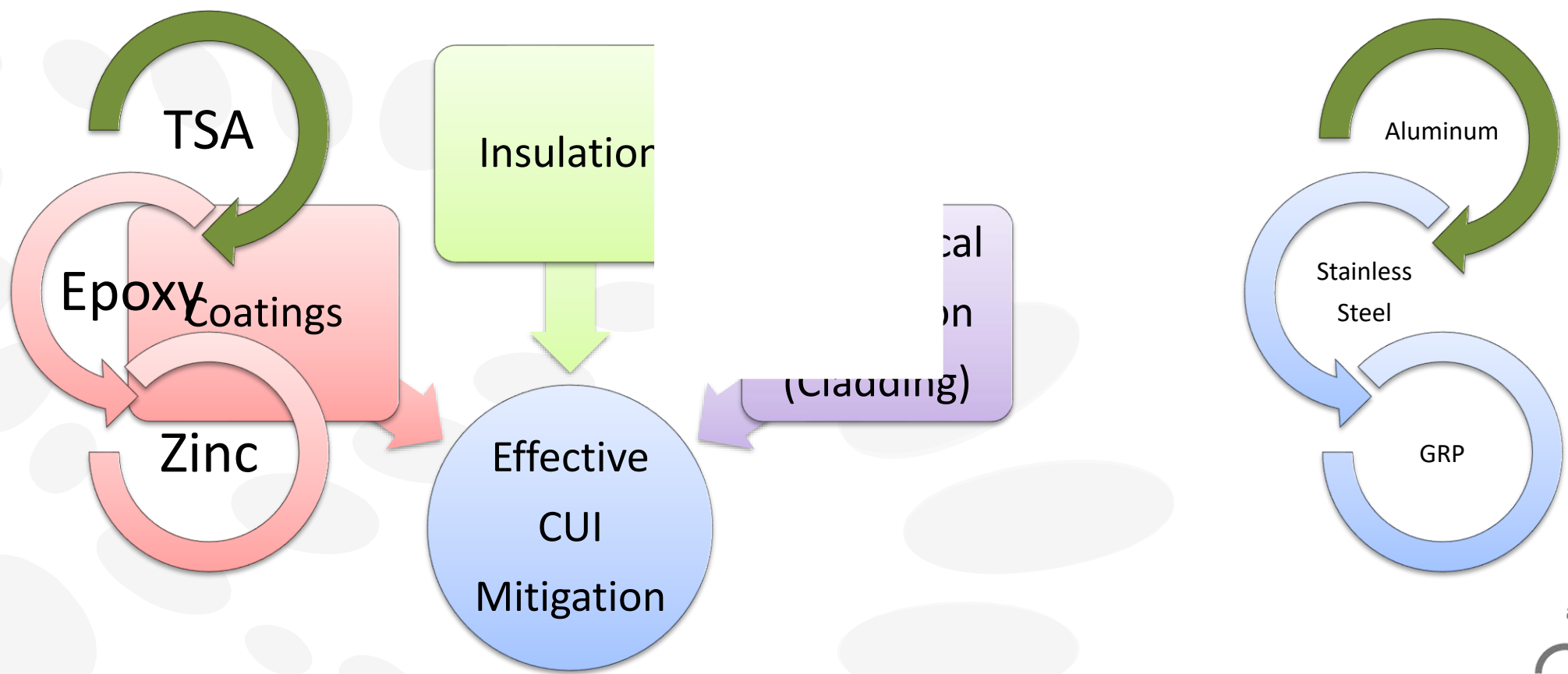


NO CORROSION!

10 Years of Service in a Marine Environment



Traditional approach based on coatings and cladding



A comprehensive 3 Prong effective CUI mitigation





CORROSION UNDER FIRE PROTECTION

Corrosion Under Fire protection

- When fire protection is applied on-top of insulation in a service where hot / cold conservation is required along with fire protection.
- Typical Fire Protection certification standards
 - UL1709 for Hydrocarbon Pool Fire
 - Jet Fire Protection ISO 22899-1
 - ISO 20088-3 Protection Against Cold Spillage

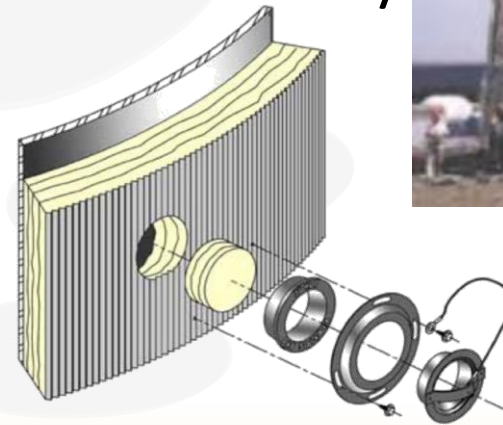
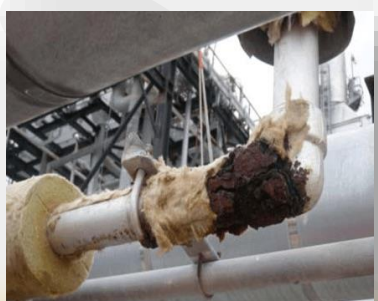


	Page	1 of 10
	Certificate No:	LR20024205F
	Issue Date:	11/03/2020
	Expiry Date:	10/03/2025
Certificate Of Fire Approval		
<small>This is to certify that the product(s) detailed below will be accepted for compliance with the applicable Lloyd's Register Rules and Regulations for use on offshore units classed with Lloyd's Register, and for use on offshore units and onshore facilities when authorised by contracting governments to issue the relevant certificates, licences, permits etc.</small>		
Manufacturer	Aspen Aerogels Inc.	
Address	30 Forbes Road, Northborough, MA 01532 United States of America	
Type	Jet Fire Resisting Protection Systems	
Description	Steel protected with "Flexible Aerogel Blanket - Cryogel® Z" insulation system, for jet fire exposures up to 90 minutes	
Trade Name	Cryogel® Z	
Specified Standard	ISO 22899-1:2007 "Determination of the resistance to Jet Fires of Passive Fire Protection Materials - Part 1: General Requirements"	



What are the challenges facing Inspection team using traditional fire protection materials

- CUI Hidden enemy under the Fire Protection
- Access for inspection to the Pipe / Vessel surface is very difficult.
- Inspection windows cannot be used because it affects the integrity of the fire protection.
- NDT inspection tools not reliable.
- Inspection can only be carried out during a shutdown / TA event.
- Process is complex and time consuming .



Most Common Traditional Types of Fire protection over Insulation

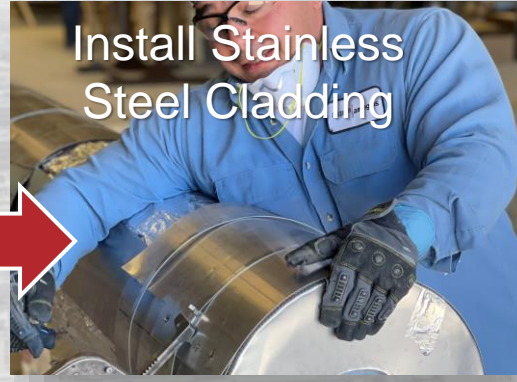
- Intumescent Application
- Applied over the top of the cladding (mechanical protection)
- Requires blasting if applied to existing piping / equipment.
- Up to 3 coat application



- Cementitious Application
- Mainly used to provide fire protection on structures.
- Rarely used on top of insulation.

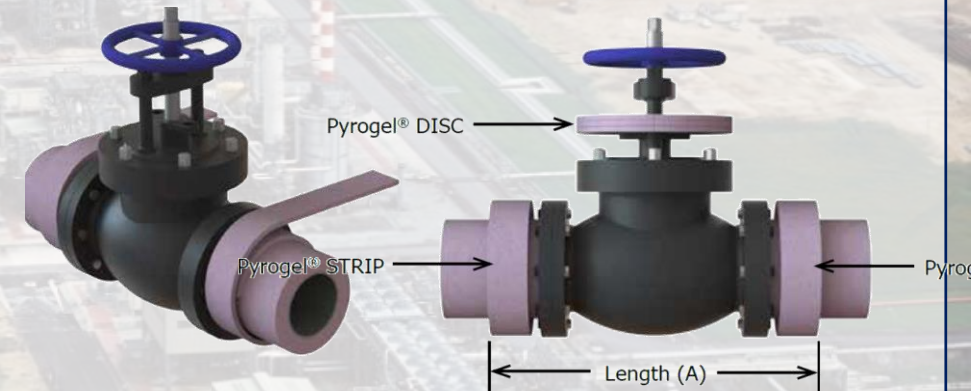


Installing Pyrogel XTE and Pyrogel XTF



Easy to install on complex
shapes

aspen aerogels®



Pyrogel®
XTE

Pyrogel®
XTF



Pyrogel[®]
XTF

Cryogel[®]
Z

PFP /CSP STANDOUT PERFORMANCE
COMPREHENSIVELY TESTED FOR USE IN
LNG, OIL & GAS AND PETROCHEM
FACILITIES.



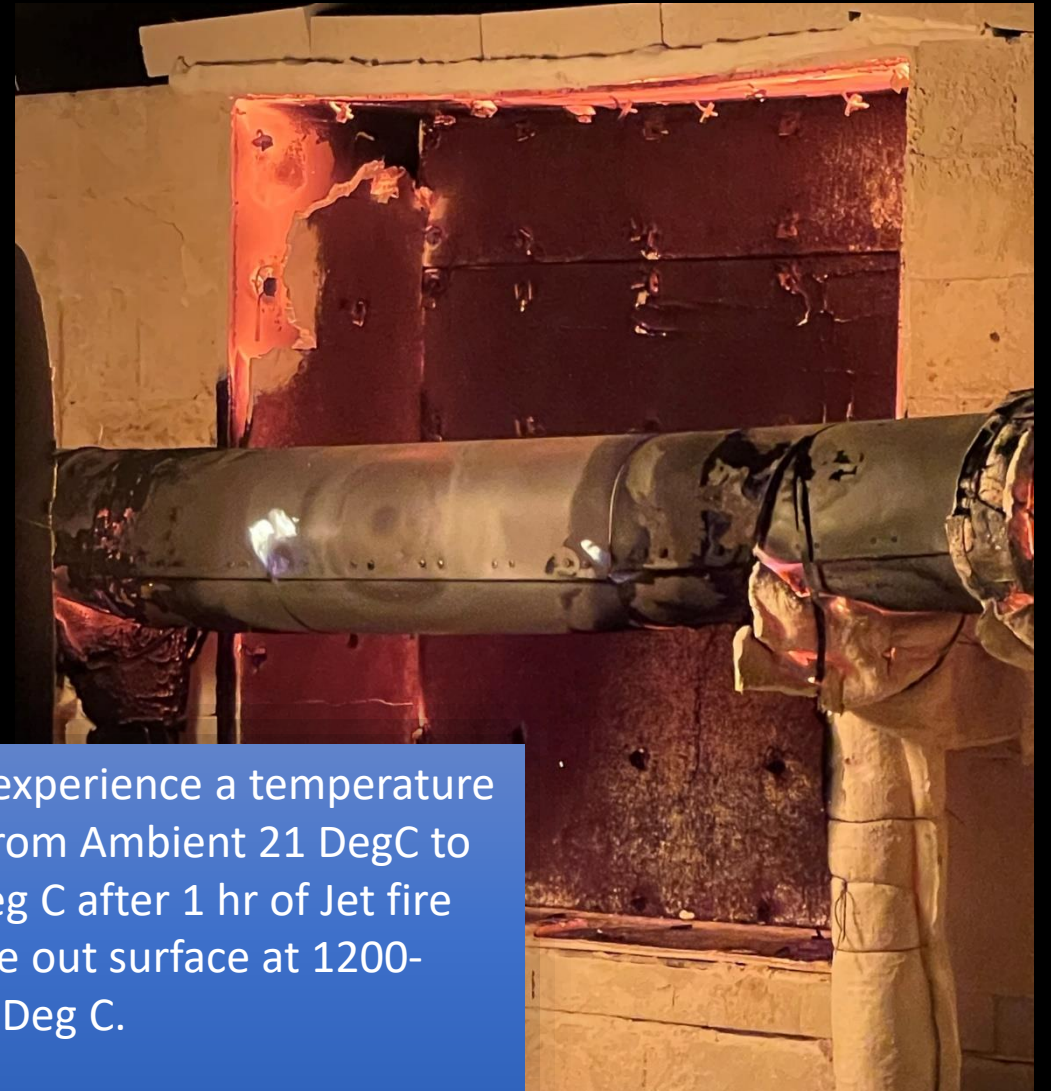
- Cryogenic Spill Test ISO 20088-3.
- -196°C LN2 Jet at 8bar through a 10mm Orifice for 1 Hr.



- Ignited Gas from Pressurized Asset Failure
- Rapid High Temperature Exposure 1200°C to 1300°C
- Jet Fire Exposure ISO 22899-1
- Critical Temperature 400°C or as Provided
 - Looking for Risk of Mechanical Failure through Thermal shock

Pyrogel[®]
XTF

Cryogel[®]
Z



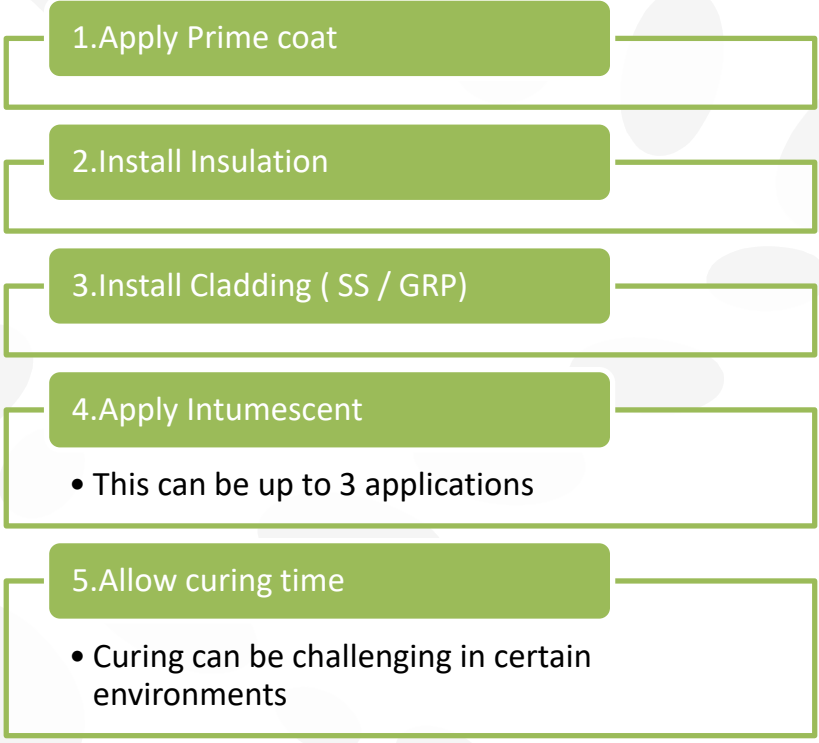
- Pipe experience a temperature rise from Ambient 21 DegC to 41 Deg C after 1 hr of Jet fire on the out surface at 1200-1300 Deg C.

Pyrogel[®]
XTF

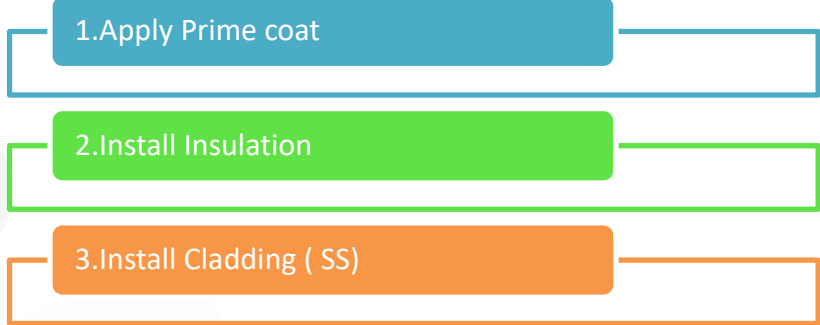
Cryogel[®]
Z

Installation Challenges during construction phase

• Intumescent Paint Fire Protection over Insulation

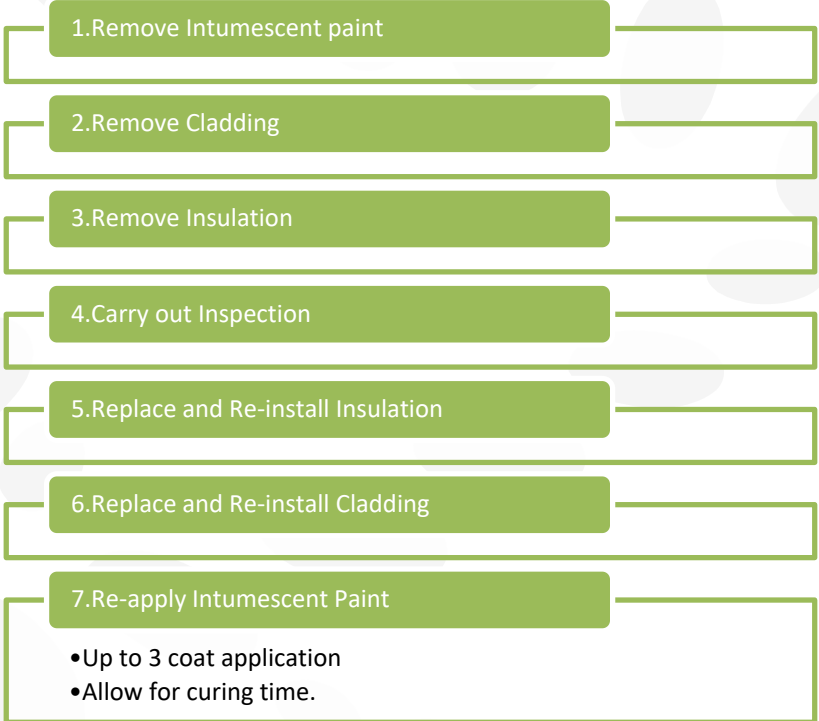


• Using PFP Blankets Pyrogel XTF or Cryogel Z



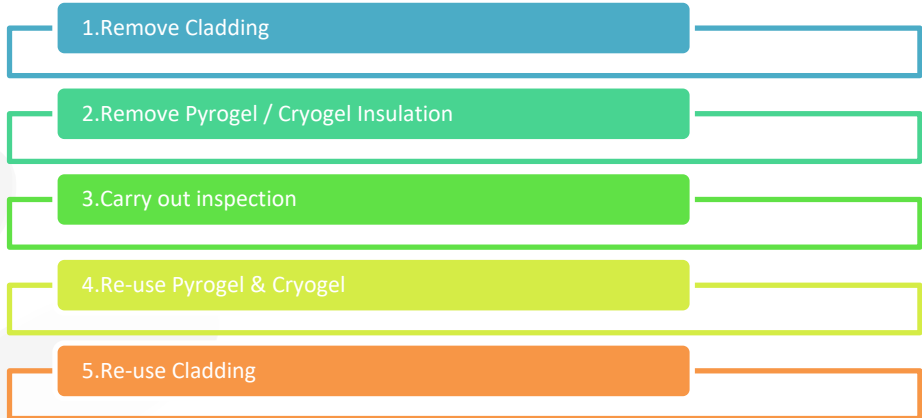
Inspection challenges during operational phase

• Intumescent Paint Fire Protection over Insulation



Majority Of time Spent here.

• Using PFP Blankets Pyrogel XTF or Cryogel Z

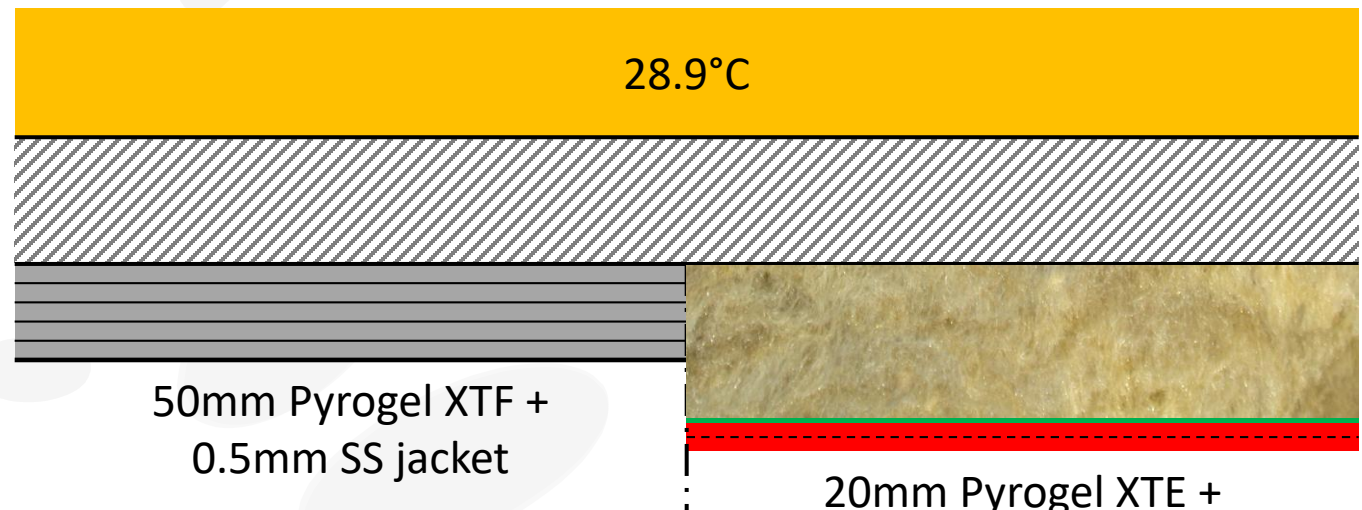


- Re-use existing material.
- Save time / Money
- Carry out inspection anytime, shutdown event is not necessary.

MRI Receiver C60 J60 H60



	Baseline	Pyrogel
Thk (mm)	93	50 -46%
Labor (hrs)	4,900	800 -84%
Hold Points	8	3 -63%
Cost (USD)	\$140k	\$110k -16%



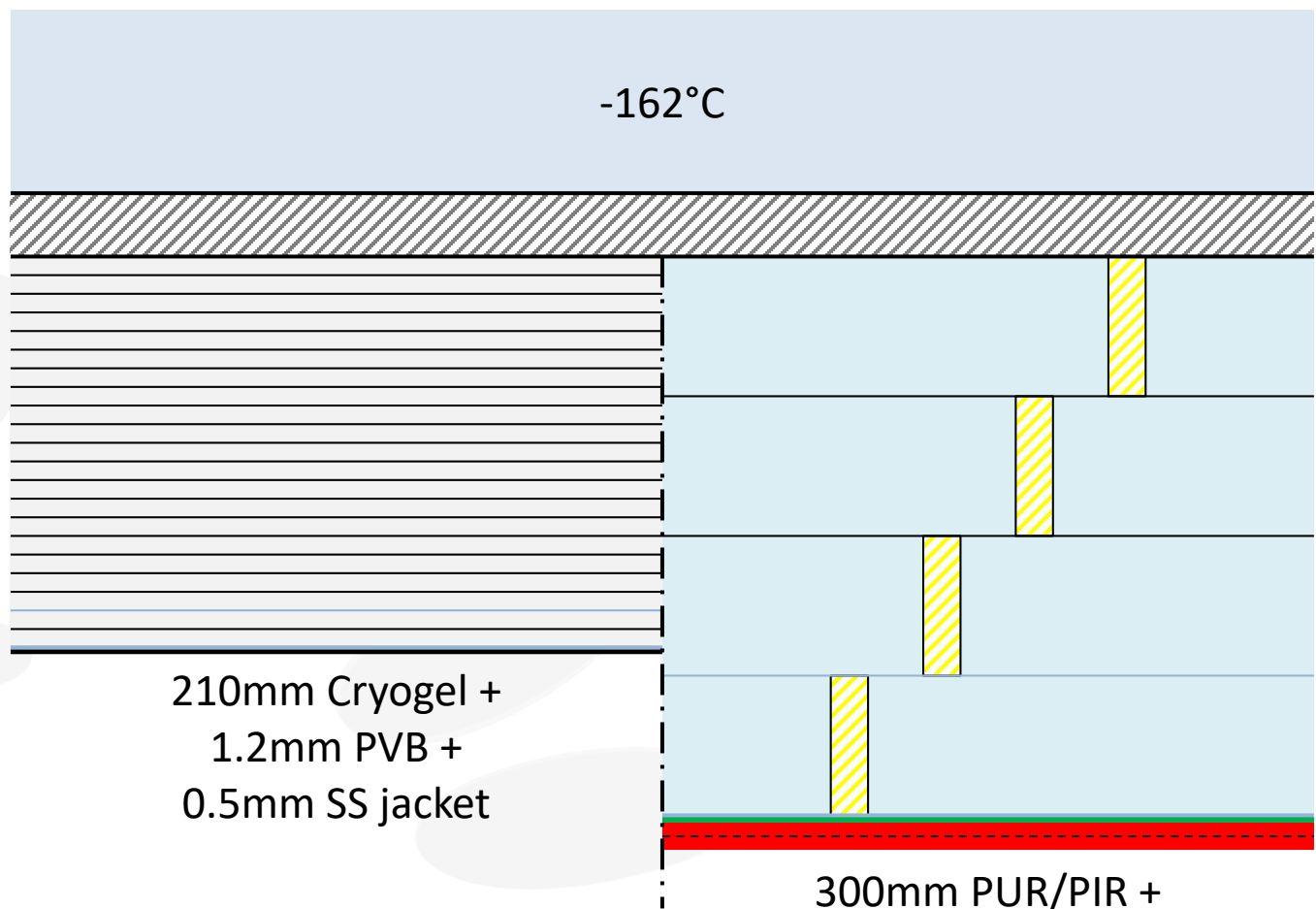
50mm Pyrogel XTF +
0.5mm SS jacket

20mm Pyrogel XTE +
100mm mineral wool +
3mm GRP +
10mm Chartek

SubCooler C60 J60 H60



	Baseline	Cryogel
Thk (mm)	320	210 <i>-34%</i>
Labor (hrs)	38,000	7,300 <i>-81%</i>
Hold Points	12	5 <i>-58%</i>
Cost (USD)	\$760k	\$870k <i>+15%</i>



210mm Cryogel +
1.2mm PVB +
0.5mm SS jacket

300mm PUR/PIR +
1.2mm PVB +
3mm GRP +
15mm Chartek

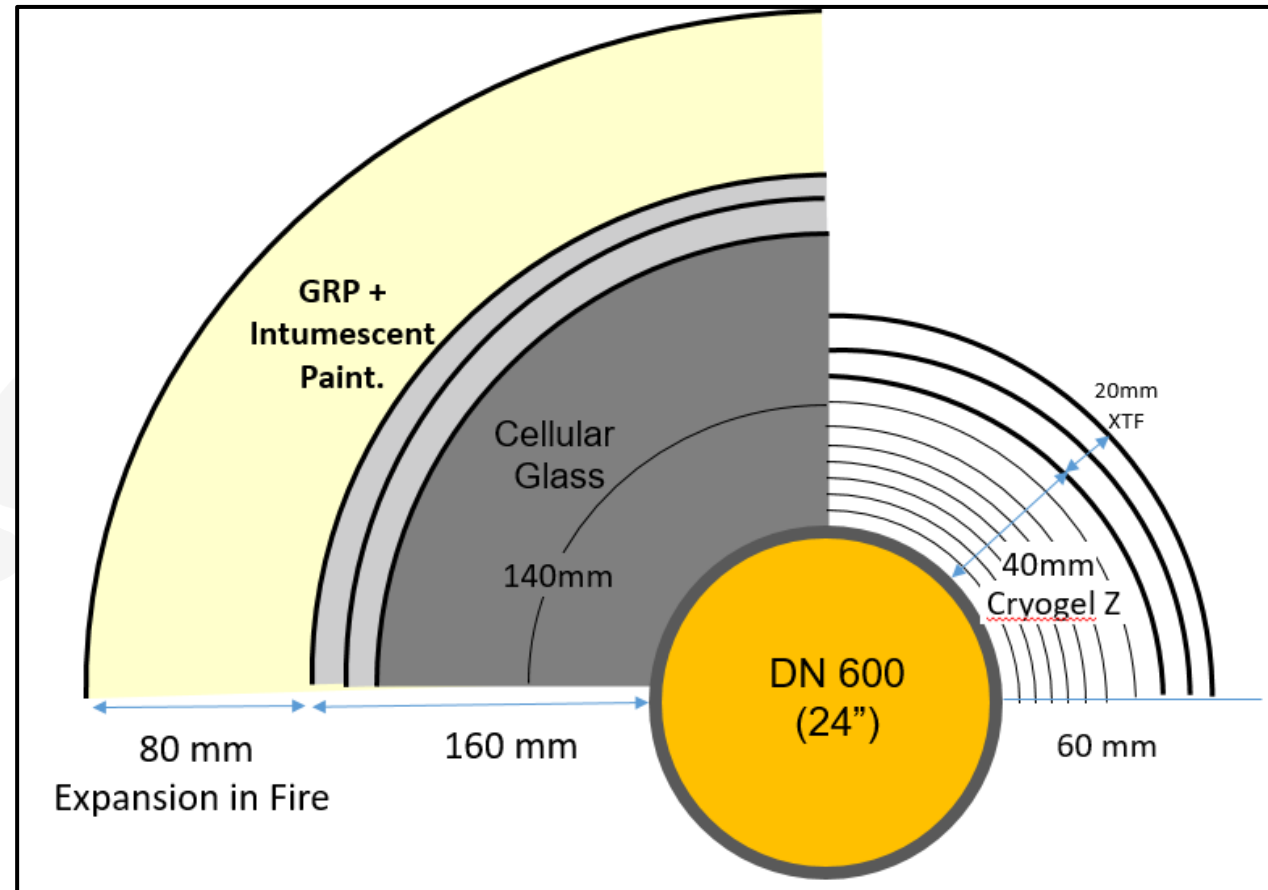
Combined Cold Conservation + Jet Fire

Pyrogel[®]
XTF

Cryogel[®]
Z

CASE STUDY

- Refrigerated Propane Line
- Operating at -44°C
- Thermal Protection and Passive Fire Protection
- 4 X Thinner Cryogel Z Solution for Equivalent Performance
- Add Acoustic? – No Problem
 - Cryogel Z vs 100mm of Mineral Wool
- Lower Total Install Cost



Proven Value in Jet Fire & Cold Spill Protection

- All-in-One Protection
 - Thermal + Acoustic + CSP + Fire & CUI Prevention
- Pre-Insulate
 - Reduce Scaffolding, Installing on Horizontal and Lift Into Position
 - Takes the Insulation off the Project Critical Path
- Thinner & Lighter Solutions
 - Save on Space: Reducing Sail and Blast Area
 - Saving Weight: Critical for Floating Assets
- Durable & Re-Usable - Remove, Inspect, Re-Install
- Low Total Cost Solution
- World Class Support
 - Technical Support for Unique System Challenges
 - Digital and Onsite Training by Experienced Field Experts



THANK YOU FOR YOUR TIME



Altah Rahman
EMEA Commercial Director
Aspen Aerogels
Tel: +44 (0)7976 924767
arahman@aerogel.com



Headquarters

30 Forbes Rd, Building B
Northborough, MA 01532
USA



Manufacturing

3 Dexter Road
East Providence, RI 02914
USA



Phone

+1 (888) 481 5058
+1 (508) 691 1111



Email / Website

info@aerogel.com
www.aerogel.com