VERSILINE™

SPECIALITY COATINGS BY HEMPEL

Corrosion technologies for under insulation

What you can't see can hurt you!

HEMPEL

Contents

Physical problems facing users

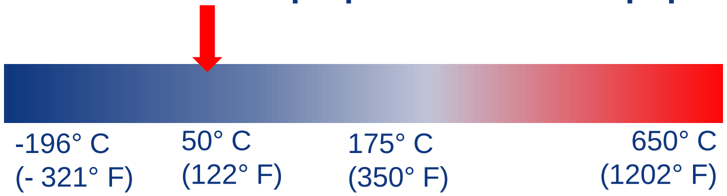
- Amount of insulated surfaces
- Moisture & wet insulation
- Coating breakdown
  - Incorrect surface preparation
  - Incorrect coating specification (heat)
  - Insufficient coating resistance (immersion)
- Limited alternatives

Real problems facing users

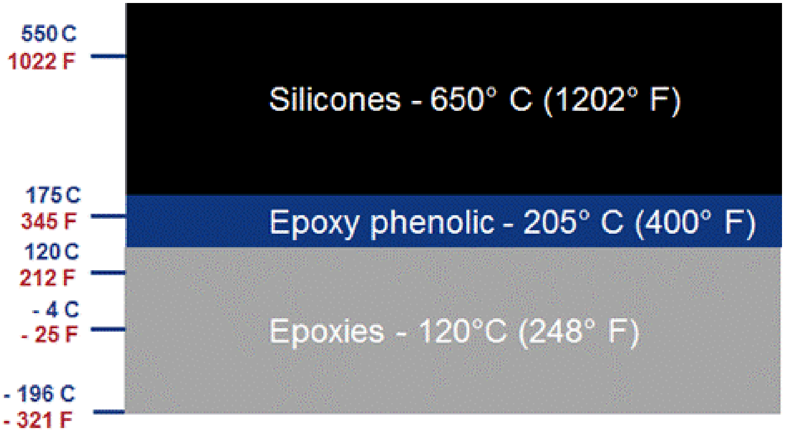
- Budgetary pressures
- Increasingly complex production processes
- Reduced turnaround opportunities and durations
- Better understanding of coatings limits (adds complexity)
- Numerous coating options (more recent years)
- Lack of definitive guidance
  - Recommendation
  - Testing
- **It's a complex issue!**

Three target areas

- Insulated equipment and pipework

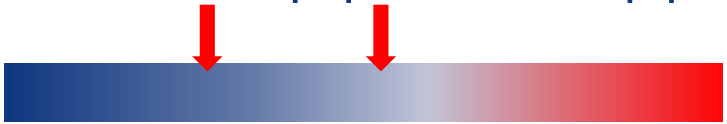


- Operating temperature below Dew point (‘sweating’)
- Lower temperature reduced corrosion rate

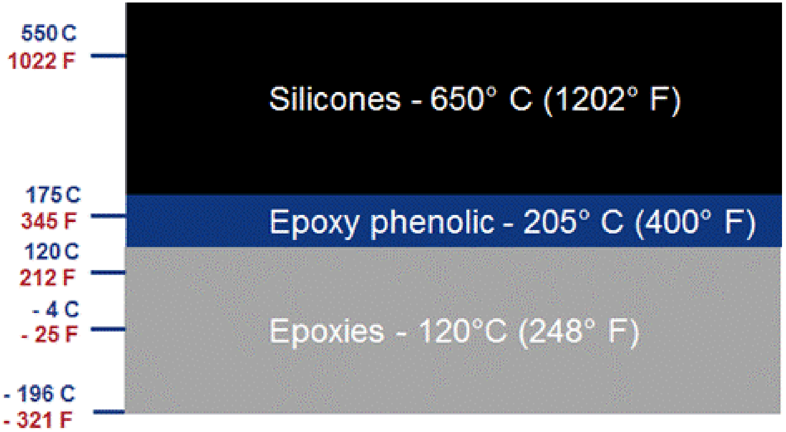


Three target areas

- Insulated equipment and pipework

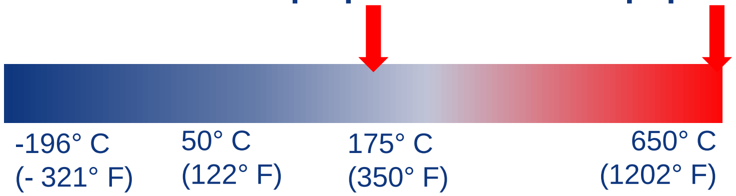


- Operating temperature in CUI range
- Increased corrosion rates

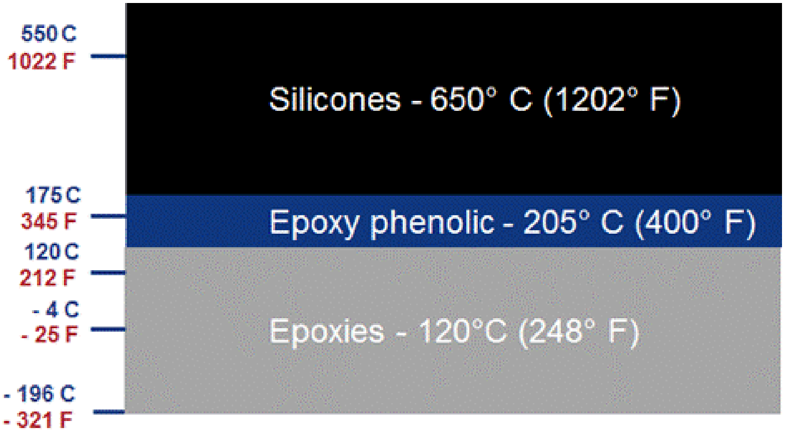


Three target areas

- Insulated equipment and pipework

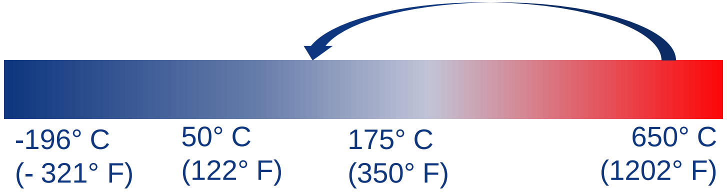


- Operating temperature above CUI range
- Reduced corrosion rates

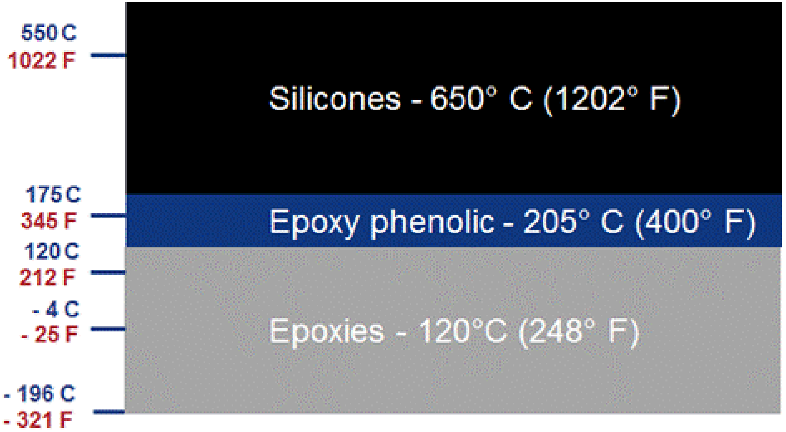


However, conditions are rarely constant

- Insulated equipment and pipework

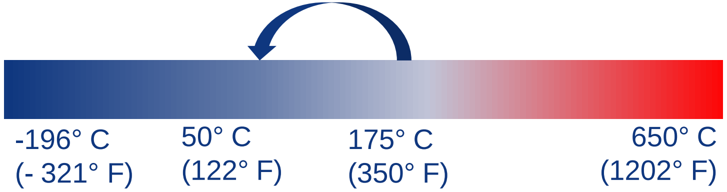


- Loss of heat on process equipment

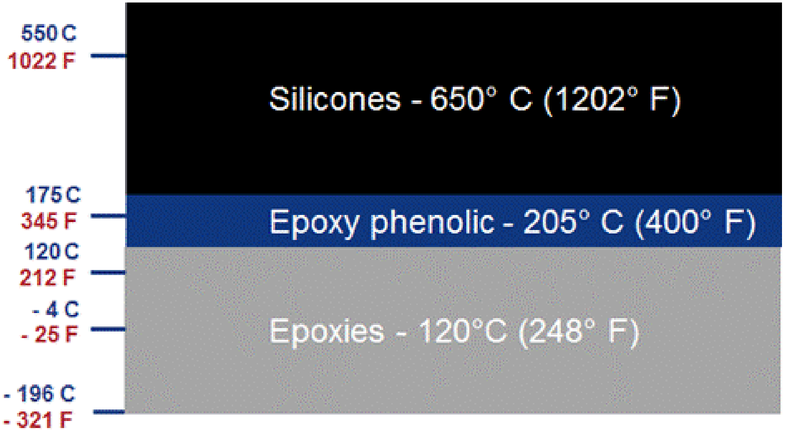


Example 2

- Insulated equipment and pipework

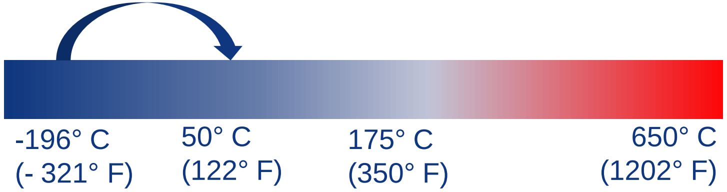


- Process regeneration (absorbers, driers etc.)

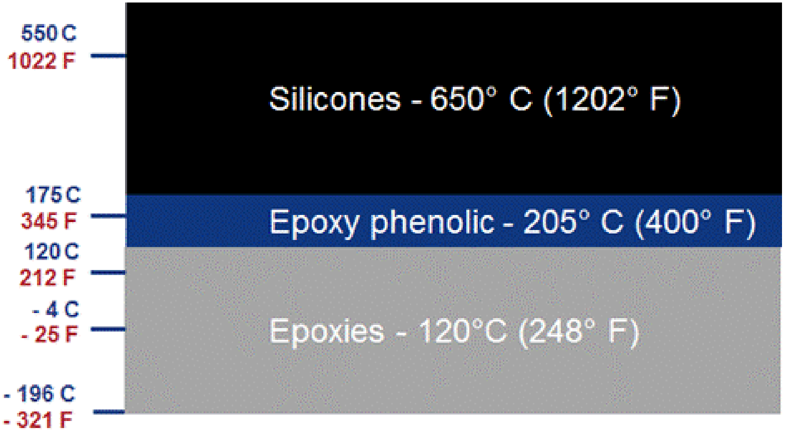


Example 3

- Insulated equipment and pipework

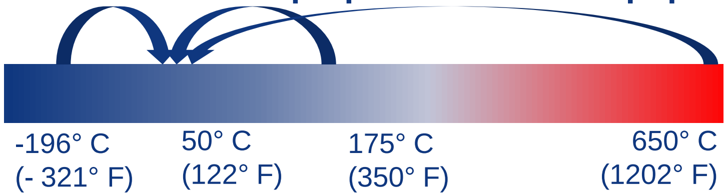


- Outage on cryogenic equipment (e.g. BOG compressors)



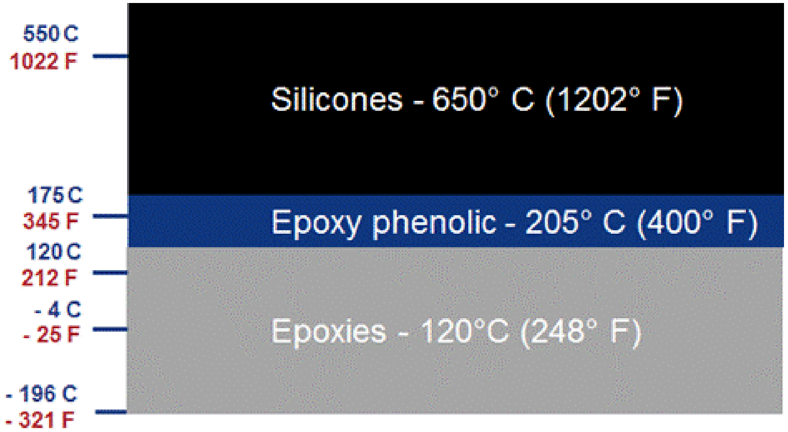
Example 4

- Insulated equipment and pipework



- Shutdowns
- Unexpected outages

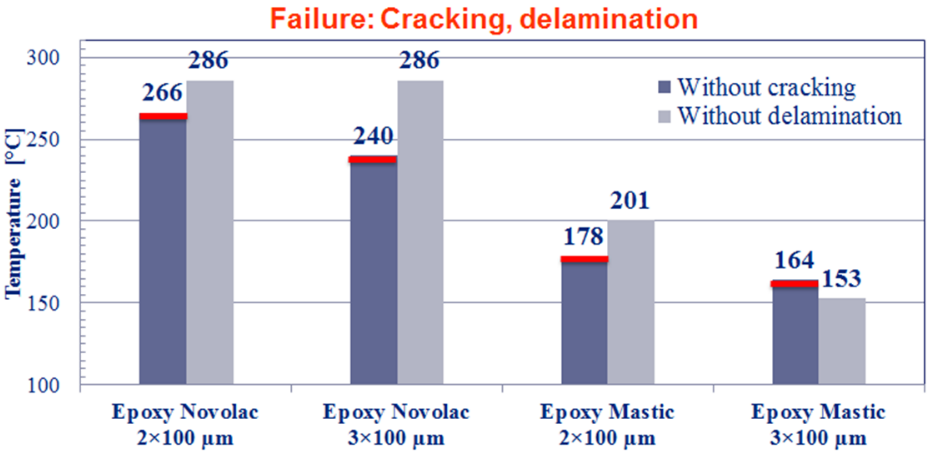
Coatings must have the ability to withstand these cycles



What matters most?

Immersion linings - lack of heat resistance

Epoxy Novolac versus epoxy



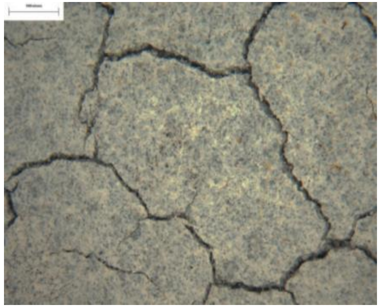
What matters most?

High temperature coatings – lack of corrosion resistance

- Silicones at high temperature
- Micro-cracking issue
- Subsequent corrosion

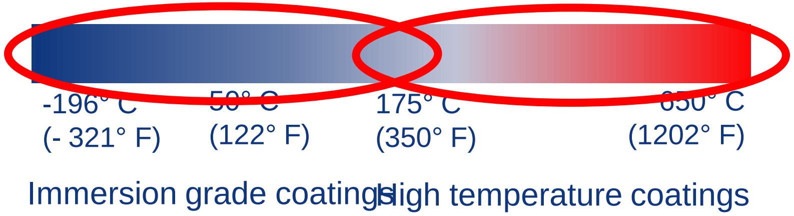
- Incomplete cure
- Lack of corrosion resistance
- Handleability

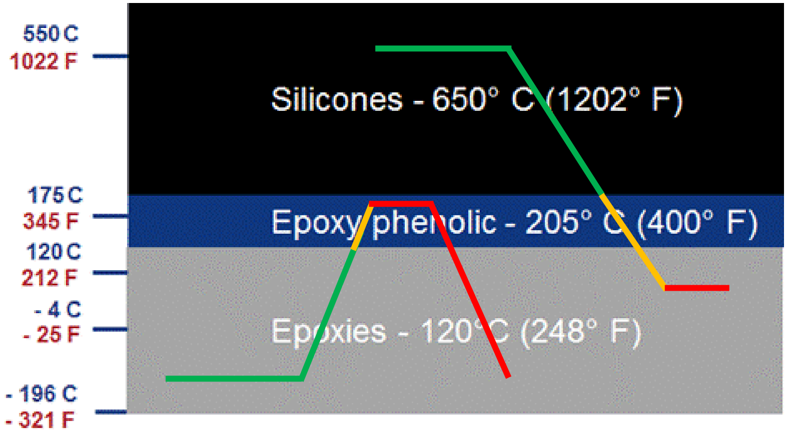
Historic thin – film Silicones



Summarise coatings types

- Insulated equipment and pipework





Cycling

- Limited to narrow temperature range
- Effects permanent change in coating

NACE SP0198 : 2010

Stainless steel

System	Temperature range	Surface preparation	Coating type
SS-1	-45 to 60ºC	SSPC-SP-1 / abrasive blast	Epoxy
SS-2	-45 to 150ºC	SSPC-SP-1 / abrasive blast	Epoxy phenolic
SS-3	-45 to 205ºC	SSPC-SP-1 / abrasive blast	Epoxy Novolac
SS-4	-45 to 540ºC	SSPC-SP-1 / abrasive blast	Silicone or modified silicone
SS-5	-45 to 650ºC	SSPC-SP-1 / abrasive blast	Inorganic copolymer / Inert multi-polymer matrix

Carbon steel

System	Temperature range	Surface preparation	Coating type
CS-1	-45 to 60ºC	NACE No. 2 / SSPC-SP-10	Epoxy
CS-2 (shop only)	-45 to 60ºC	NACE No. 2 / SSPC-SP-10	Fusion bonded epoxy (FBE)
CS-3	-45 to 150ºC	NACE No. 2 / SSPC-SP-10	Epoxy phenolic
CS-4	-45 to 205ºC	NACE No. 2 / SSPC-SP-10	Epoxy Novolac or silicone hybrid
CS-5	-45 to 595ºC	NACE No. 2 / SSPC-SP-5	Thermally sprayed aluminium (TSA)
CS-6	-45 to 650ºC	NACE No. 2 / SSPC-SP-10	Inorganic copolymer / Inert multi polymer matrix
CS-7	To 60ºC	SSPC-SP2 or SSPC-SP3	Petrolatum / petroleum wax tape
CS-8 (bulk or shop primed pipe coated with inorganic zinc)	-45 to 150ºC	Low pressure water cleaning	As CS-3/4/6

Do we need to choose?

Effective heat resistance

- Wide range
- Change in temperatures (Cycling)
- No micro-cracking
- Cryogenic capability

Corrosion resistance

- Before exposure
- After heat exposure
- CUI environment

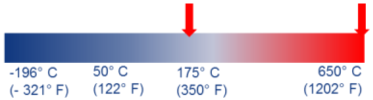
Practical

- Physically durable
- M & R friendly

Things to consider

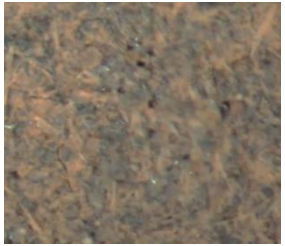
- Heat resistance
- Corrosion resistance after heat exposure
- Effect of thermal cycling
- Corrosion under insulation resistance
- Cryogenic resistance
- Resistance to damage (CS-8)

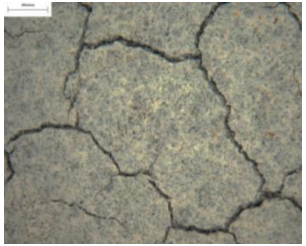
Heat resistance



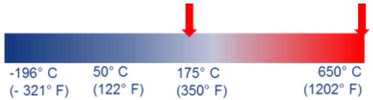
DFT	Temperature
1 x 150 µ (6 mils)	650° C (1202° F)
2 x 150 µ (6 mils)	625° C (1157° F)
3 x 150 µ (6 mils)	600° C (1112° F)
2 x 300 µ (12 mils)	450° C (842° F)

- Modified ASTM D2485 – Method B
- Exposure 300 - 650° C (572 - 1202° F) 50° C (122° F) steps)
- Can be noticeable at 450° C (842° F)

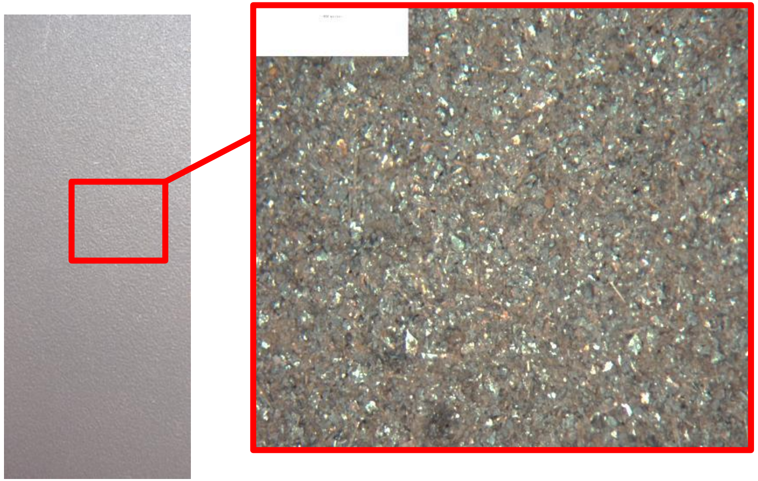




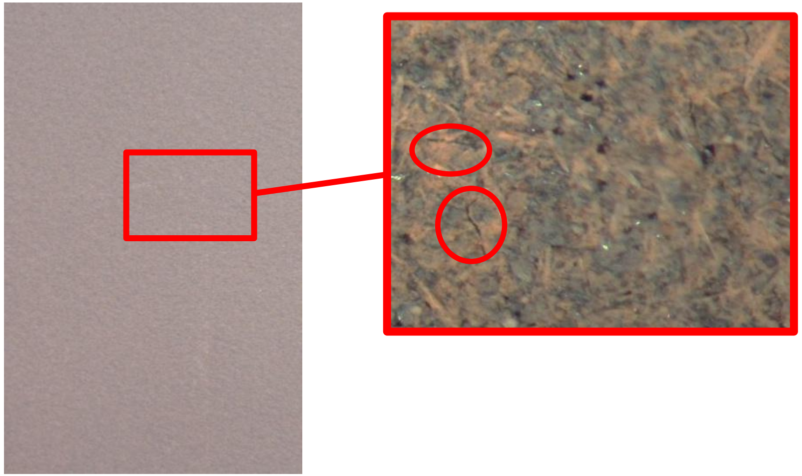
Heat resistance



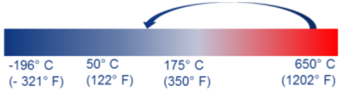
Before heat exposure (650ºC)



After heat exposure (650ºC)



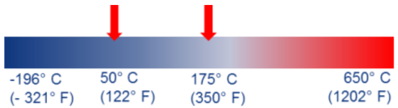
Corrosion resistance



Heat exposure limit	Candidate scheme		
	1 x 150µ	2 x 150µ	3 x 150 µ
650º C (1202 °F)			
450º C (842° F)			

- ISO 7253 / ASTM B117
- Heat exposure limit
  - 650° C
  - 450° C
- Micro cracks form active sites for corrosion

Cyclic CUI corrosion test



- 210ºC dry heat for 16 hours
- Quench in cold water
- Immersion in boiling water for 8 hours

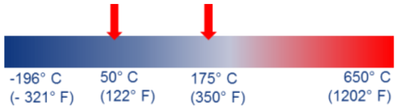
- Results are scheme dependent
- Emphasises barrier effect of pigments

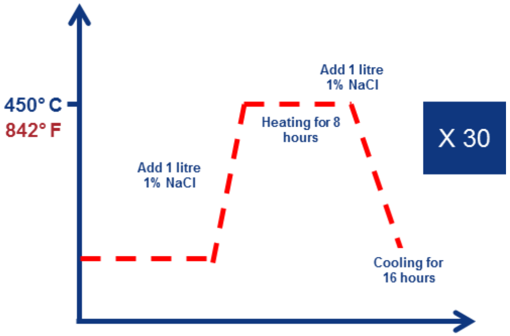
Scheme	Cycles achieved	Before	After
1 x 150 µ	**22**		
2 x 150 µ	**50**		
3 x 150 µ	**80**		

CUI resistance

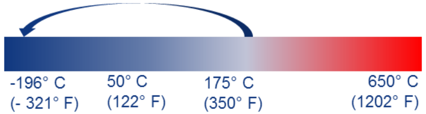
- Houston pipe test
- Multi-temperature evaluation
- Mineral wool insulation
- Repeated cycles
    - Soak-heat-hold-soak-cool

Immersion in salt water to identify presence of micro-cracks





Cryogenic exposure



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- No account for cryogenic conditions
- Minimum temperature - 45ºC
- Typically epoxy phenolics

+ 200ºC - 196ºC

- No cracking or delamination
- Irrespective of substrate

Carbon steel

Stainless steel

Physically durable

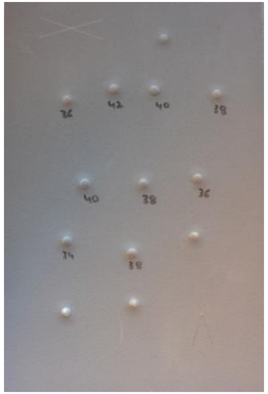
Conventional silicones

- Soft prior to heat exposure
- Easily damaged
- Particularly aluminium variants
- Not ideal for off-site fabrication

SS-5 / CS-6

- Hardness can vary significantly
- Impact resistance / damage resistance should be considered

	Average impact resistance (lb)
Candidate #1	49
Candidate #2	37
Candidate #3	27
Candidate #4	25



CS-8

- Use of Zinc silicate on bulk items
- Conventional schemes
  - If degraded, zinc is exposed
  - Not ideal
- Limits top temperature limit / substrate
- Assists with specification simplification
- Eliminating zinc primer may increase scheme thickness in C5M

No heat exposure

Heat exposure (400ºC)

Conclusions

- Improved materials category → improved durability → reduced lifecycle costs
- No micro-cracking → improved CUI resistance
- Scheme thickness can have significant impact
- Pigment type will affect barrier properties
- Inert multipolymer matrix type materials
  - Improves on current options across ‘High temperatures’
  - Provides resistance to CUI / atmospheric corrosion after high temperature exposure

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Thank you

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