New Thermal Management Raw Materials Platform gives Flexibility to Develop Next Generation Thermal Insulation Coatings (TIC) with Improved Performance

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Thermal insulation coatings (TICs) are an alternative for various applications

Chemical Industry (e.g. Pipes, Storage Tanks, Valves), Oil & Gas, Marine etc.

Easy to apply

- Large areas & complex shapes can be insulated in a short time *via* spray process
- Application possible while equipment is still in service

→ Faster implementation times, reduced shutdown times and increased energy efficiency

TIC provides direct protection of substrate and condensation control

- Good adhesion and low moisture uptake of TIC
- Insulation performance of TIC prevents condensation on cold surfaces

→ Reduced risk of corrosion under isolation (CUI)

Ideal technology for personnel protection

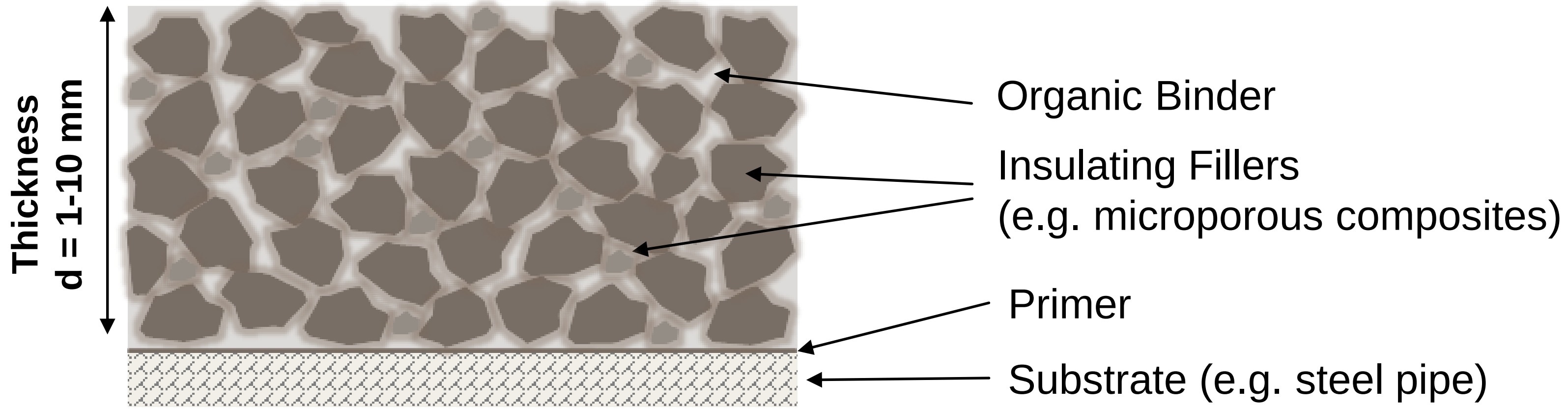
- TIC reduces temperature of hot surfaces and prevents skin burns if touched
- Thickness of TIC could be designed based on individual case

New Generation of Thermal Insulation Coatings (TICs)

What is a TIC?

Schematic cross-section of TIC

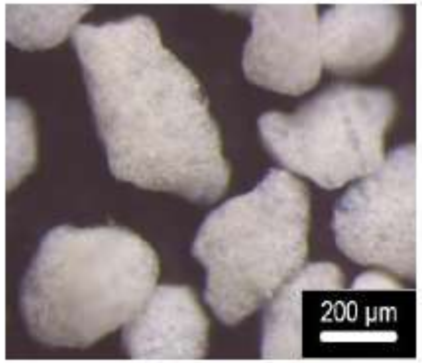
General composition & structure



New Generation of Thermal Insulation Coatings
SIG & SIG synergistic filler

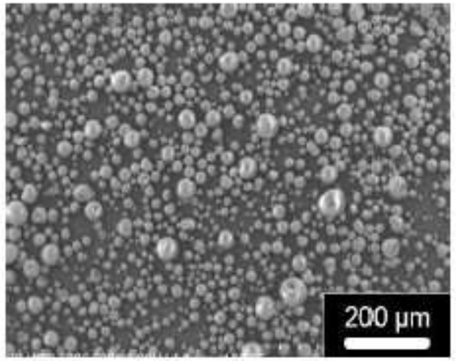
Microporous Composite Granules

SIG



- Particle size d_{50} ~300 µm
- Superinsulation properties from passivated amorphous SiO_2 composite core
- High hydrophobicity
- Non-combustible / non-flammable

SIG synergistic filler



- Particle size d_{50} ~30 µm
- Excellent insulation properties from amorphous SiO_2 core
- Low particle size for smooth coating surfaces
- Excellent dimensional stability

Raw Material TIC Platform (SIG, SIG Synergist, WBSHB)

SIG	
carbon content	< 2.5 % (without opacifier)
delivery form	free-flowing powder
loss on drying	< 0.5 %
particle size, d_{50}	~ 300 µm
particle size, d_{95}	< 1000 µm
pH- value	6.5 - 8.5
specific surface area (BET)	~ 115 m²/g
tamped density	~ 225 g/l
thermal conductivity at 10°C	~ 0.024 W/m/K

SIG Synergist	
carbon content	~ 3.0 % (without opacifier)
delivery form	free-flowing powder
loss on drying	< 1.0 %
particle size, d_{50}	~ 30 µm
pH- value	7.0 - 9.5
specific surface area (BET)	~ 190 m²/g
tamped density	~ 300 g/l
thermal conductivity at 10°C	~ 0.030 W/m/K

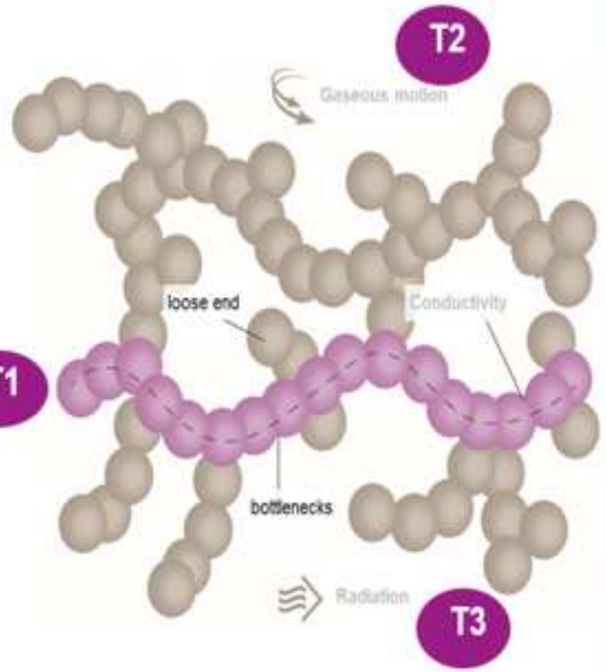
WBSHB	
appearance	milky liquid
delivery form	dispersion
non-volatile content	46-54%
pH-value	4,5 - 7,0
viscosity at 23°C (as supplied)	50-500 mPas

Basics of Thermal Insulation and snapshot of current TIC filler landscape

How is heat transferred?

Heat can travel from one place to another in three ways:

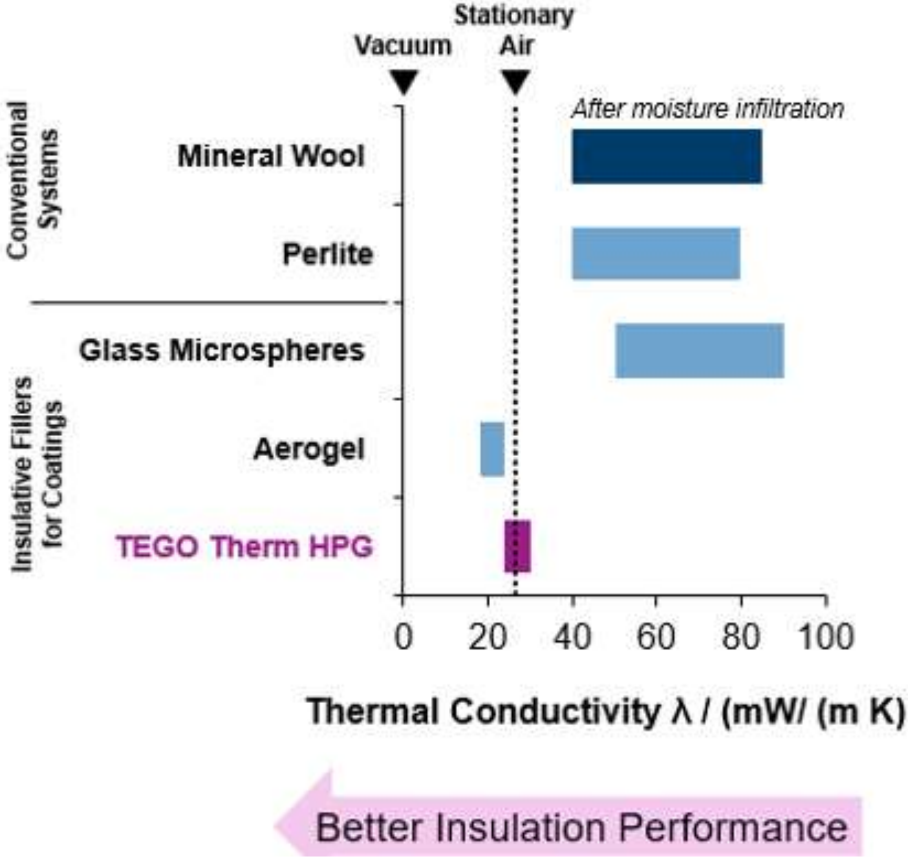
1. Conduction: between substances that are in direct contact with each other.
2. Gaseous motion: by the movement of fluids (liquid or gases), but no convection due to pore sizes
3. Radiation: transmitted through empty space by thermal radiation (often called IR radiation)



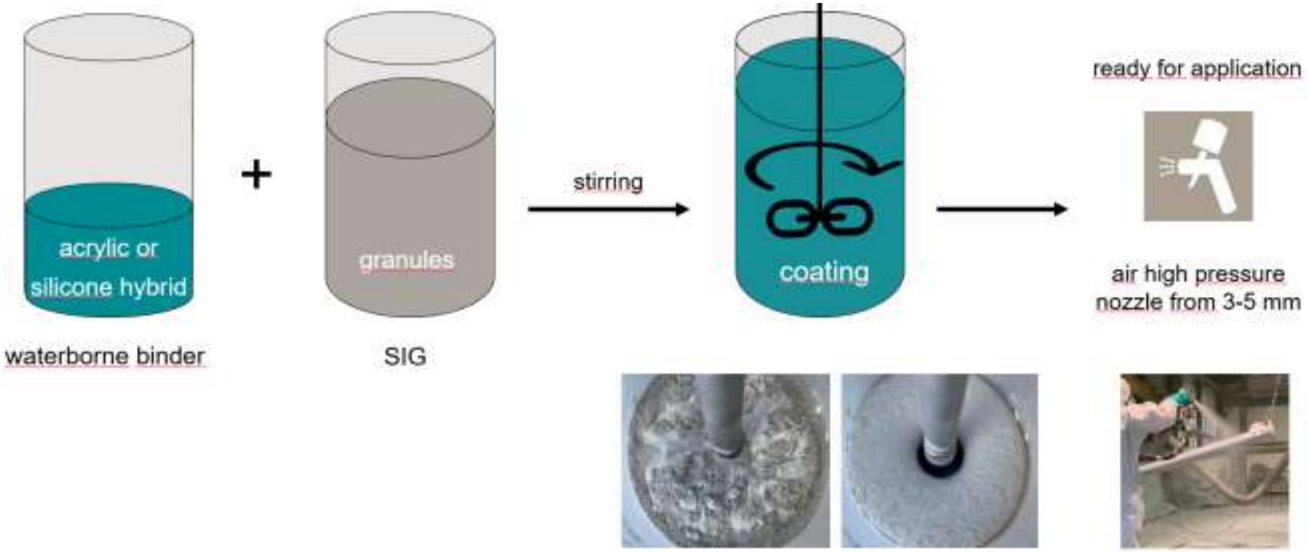
Correlation between Effect and TIC properties:

↑ Thickness d	→	↑ Improved Thermal Insulation
↓ low λ value	→	↑ Improved Thermal Insulation

λ value of „conventional“ insulation systems and Insulation Fillers for TICs



Incorporation of TIC Platform into a coating and Formulating Hints



- Liquid components weighed in and homogenized 5‘ with a prop stirrer (300 rpm)
- Insulating material is added to the formulation in small quantities while stirring
- Speed of rotation must be increased continuously in small steps up to 1200 rpm.

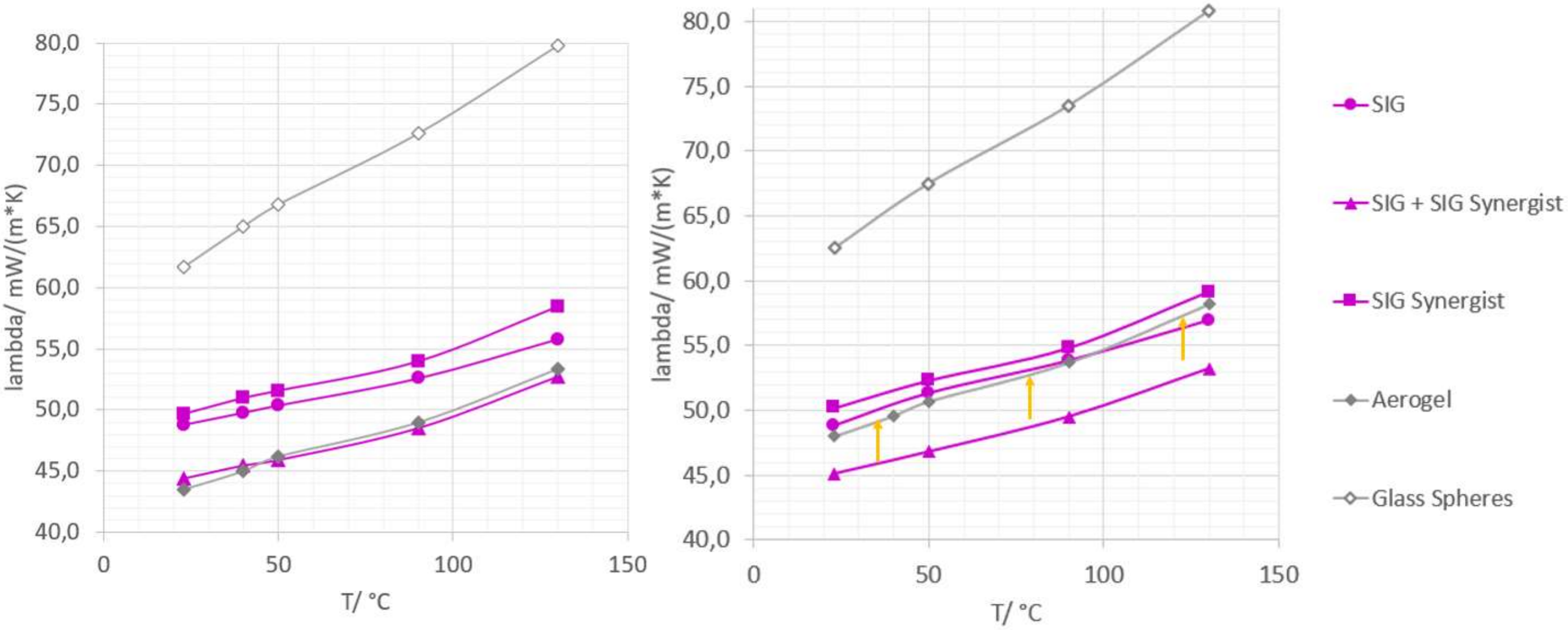
- Defoamer and deaerators will destroy the structure of the foam which is necessary for stability and insulation properties
- Substate wetting and dispersion additives tend to wet out the hydrophobic particles and lead to a strong thickening of the whole formulation.

WB Acrylic Binder Formulations (in w%) w/ Different Thermal Insulation Particles

	1	2	3	4	5
WB acrylic binder*	45.58 %	43.11 %	39.72 %	72.73 %	63.88 %
WB silicone emulsion*	0 %	0 %	0 %	0 %	0 %
Water	24.15 %	22.84 %	21.03 %	12.56 %	18.63 %
Viscosity modifier**	0.04 %	0.04 %	0.04 %	0.07 %	0.06 %
Glass fibers	0.61 %	0.58 %	0.53 %	0.97 %	0.85 %
Particle stabilizer (PVOH)	0.98 %	0.93 %	0.85 %	1.55 %	1.37 %
SIG	28.65 %	26.01 %			
SIG syn		6.50 %	37.83 %		
Aerogel				12.12 %	
Glass spheres					15.21 %
Calculated PVC	77.8 v%	79.9 v%	79.5 v%	72.2 v%	78.8 v%

- *Approx. 50 % water content in used binder systems; ** nature-based (xantham gum) rheology modifier (thixotropic liquid)
- Note: Formulations were optimized for lambda performance and not for long term stability

WB Acrylic Binder Formulations (in w%) with Different TIC Particles @ T=0 & T=10 days @ 140C



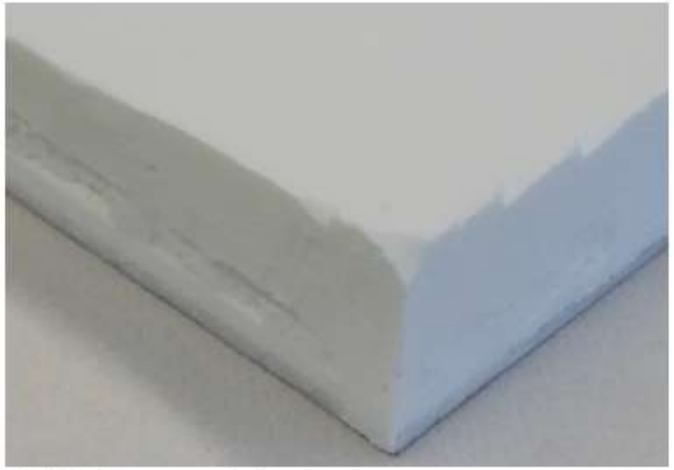
Photos of WB Acrylic with TIC fillers after heat aging for 10 d @ 140C


Commercial aerogel


SIG + SIG Synergist


Commercial glass hollow spheres


SIG

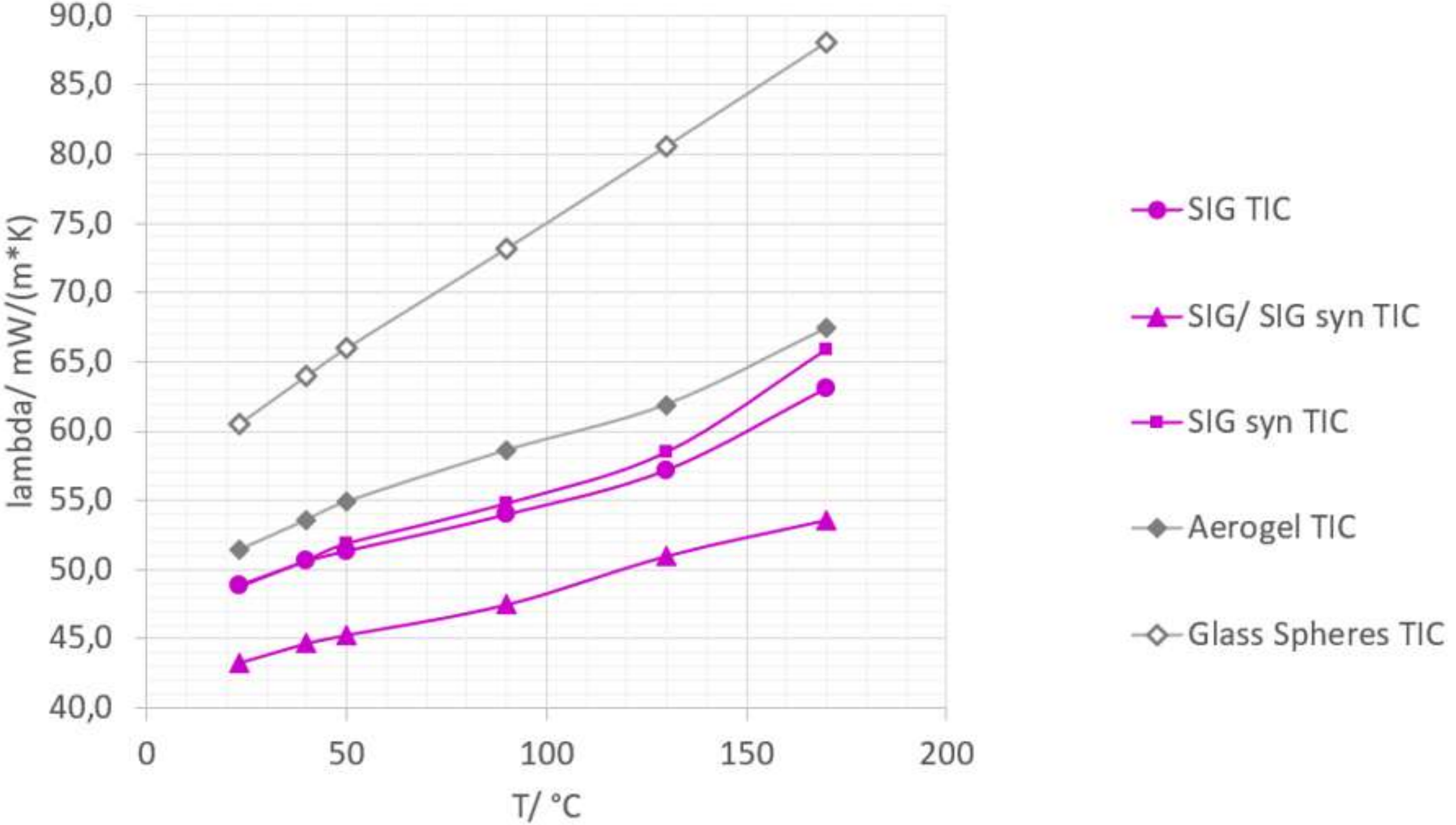

SIG Synergist

Hybrid Formulations with WB Acrylic & WB Silicone Emulsion (in w%) w/ Different Thermal Insulation Particles

	6	7	8	9	10
WB acrylic binder*	14.04 %	12.34 %	12.03 %	20.45 %	19.08 %
WB silicone emulsion*	29.64 %	26.05 %	25.39 %	43.18 %	40.28 %
Water	26.37 %	20.87 %	20.35 %	23.26 %	21.70 %
Viscosity modifier**	0.04 %	0.04 %	0.04 %	0.06 %	0.06 %
Glass fibers	0.58 %	0.51 %	0.50 %	0.85 %	0.79 %
Particle stabilizer (PVOH)	1.87 %	1.64 %	1.60 %	2.73 %	2.54 %
SIG	27.46 %	30.84 %			
SIG syn		7.71 %	40.09 %		
Aerogel				9.47 %	
Glass spheres					15.55 %
Calculated PVC	76.4 v%	83.0 v%	80.1 v%	68.2 v%	79.1 v%

- *Approx. 50 % water content in used binder systems; ** nature-based rheology modifier (thixotropic liquid)
- Note: Formulations were optimized for lambda performance and not for long term stability

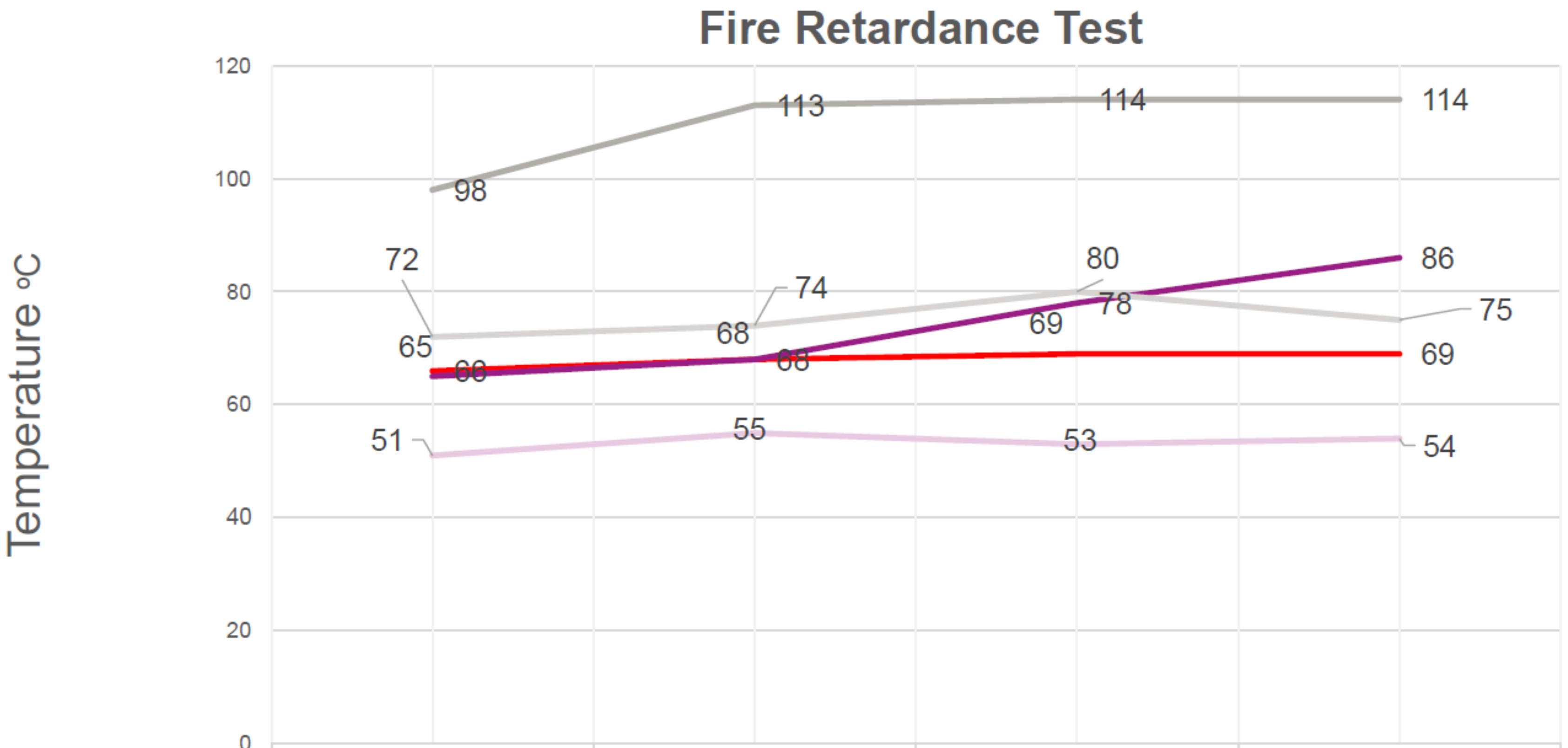
Hybrid WB Acrylic Binder & Silicone Emulsion (in w%) w/ Different Thermal Insulation Particles



High Temperature WB Silicone Emulsion w/ TIC fillers

Formulation	80/20 SIG / SIG SYN	SIG	50/50 SIG / SIG SYN	SIG SYN	Glass Sphere	Aerogel
	#15	#16	#17	#18	#19	#20
WB Silicone emulsion	42.36%	45.17%	43.22%	44.34%	54.38%	54.38%
PVA (20% in water)	12.45%	13.30%	12.70%	13.00%	13.52%	13.52%
Visc. modifier 0,5%	0.37%	0.40%	0.38%	0.39%	0.37%	0.37%
Water	18.68%	19.92%	19.05%	19.55%	20.57%	20.57%
Fibers	3.57%	1.86%	1.78%	1.82%	3.57%	3.57%
SIG	18.04%	19.38%	11.43%	0.00%	0%	0%
SIG Synergist	4.53%	0.00%	11.43%	20.86%	0%	0%
Glass Sphere	0.00%	0.00%	0.00%	0.00%	7.6%	0%
Aerogel	0.00%	0.00%	0.00%	0.00%	0%	7.6%
Total%	100%	100%	100%	100%	100%	100%

Fire Retardance Results w/ TIC Fillers

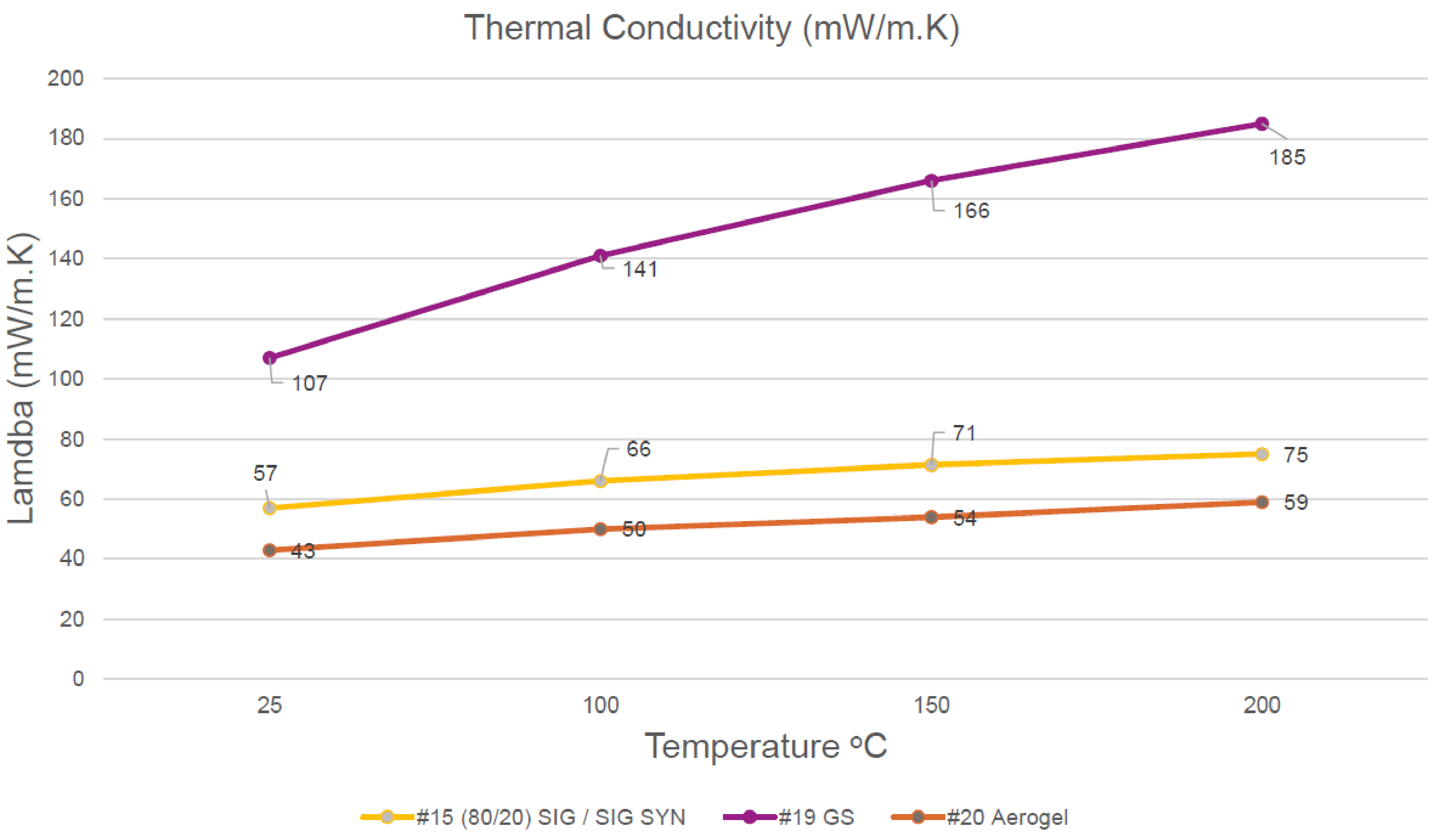


	5	10	15	20
#16 SIG	66	68	69	69
#17 SIG / SIG SYN	65	68	78	86
#18 SIG SYN	98	113	114	114
#19 GS	72	74	80	75
#20 Aerogel	51	55	53	54

Time (Min)

#16 SIG #17 SIG / SIG SYN #18 SIG SYN #19 GS #20 Aerogel

Thermal Conductivity (mW/m*K) of Silicone Formulations w/ TIC Fillers

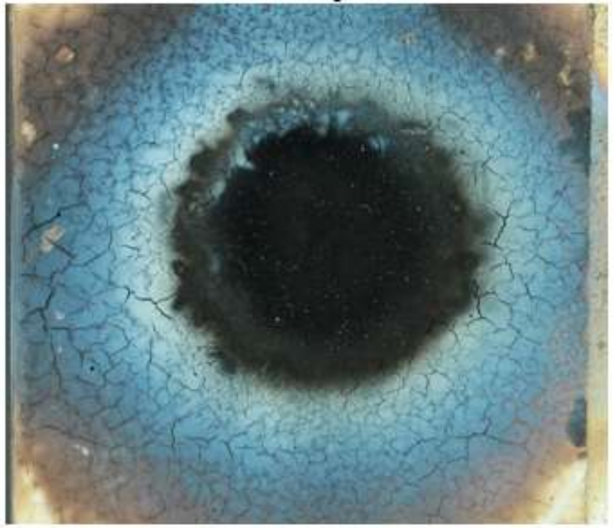


Photos of Flame testing with TIC Fillers in WB Silicone

SIG

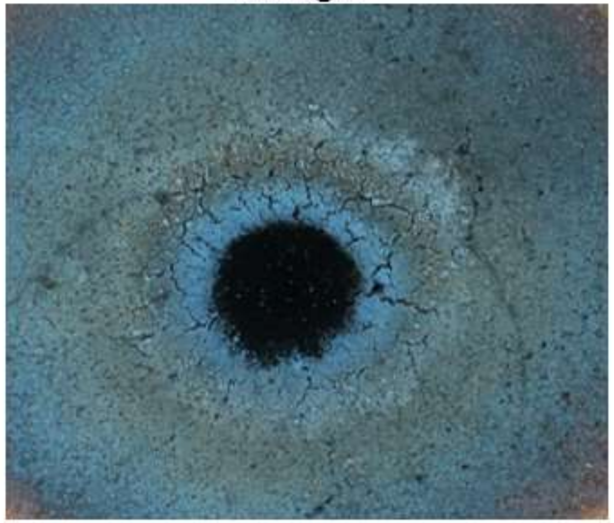
SIG/ SIG Syn

SIG Syn

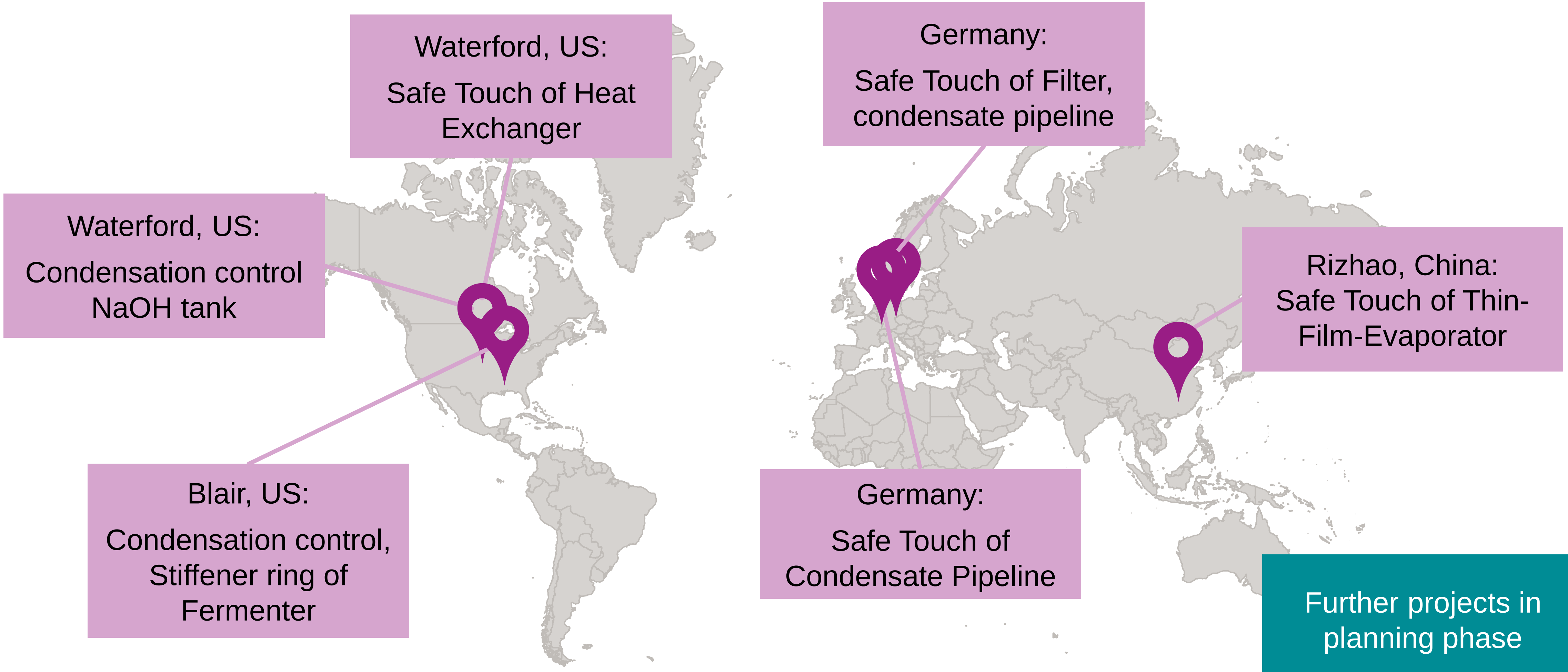


Glass Spheres

Aerogel



First commercial TIC successfully tested in various “use cases” within production landscape



Further projects in planning phase

Prevention of Corrosion under Insulation (CUI)

Caustic soda tank

Before

VS

After

5 mm prevent condensation and ensures thermal management

Cost savings for implementation
~ 28 %

Reduced life cycle costs
~ 35%

Conclusions

- TIC made with new SIG demonstrate high performance efficiency due to improved lower thermal conductivity combined with higher hydrophobicity imparting a balanced condensation protection, especially at temperatures above 100°C.
- TIC made with new SIG demonstrates improved durability due to the improved 3D stability showing less shrinkage after exposure to heat stress.
- For safe touch and Thermal break enhancement driving Dew point shift, TIC made with SIG demonstrates improved thermal stability performance over other TIC filler technology.
- To overcome cracking behavior which can occur in very highly filled coatings, the SIG synergistic filler offers reinforcement and reduces cracking tendencies supported by its spherical morphology and higher internal structure.
- WBSHB offer higher heat resistance than standard TIC binder types and can be co-blended with other typical water-based binder technologies to extend the heat resistance of the over coating.
- The new TIC platform of raw materials consisting of two fillers and a binder can be leveraged together or independently to improve an existing formulation whether the desire is to have a lower thermal conductivity, reduced cracking and improved dimensional stability or increase temperature resistance of classic water-based TIC formulations.

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