Development of Phase Change Materials to Reduce Power Plant Emissions

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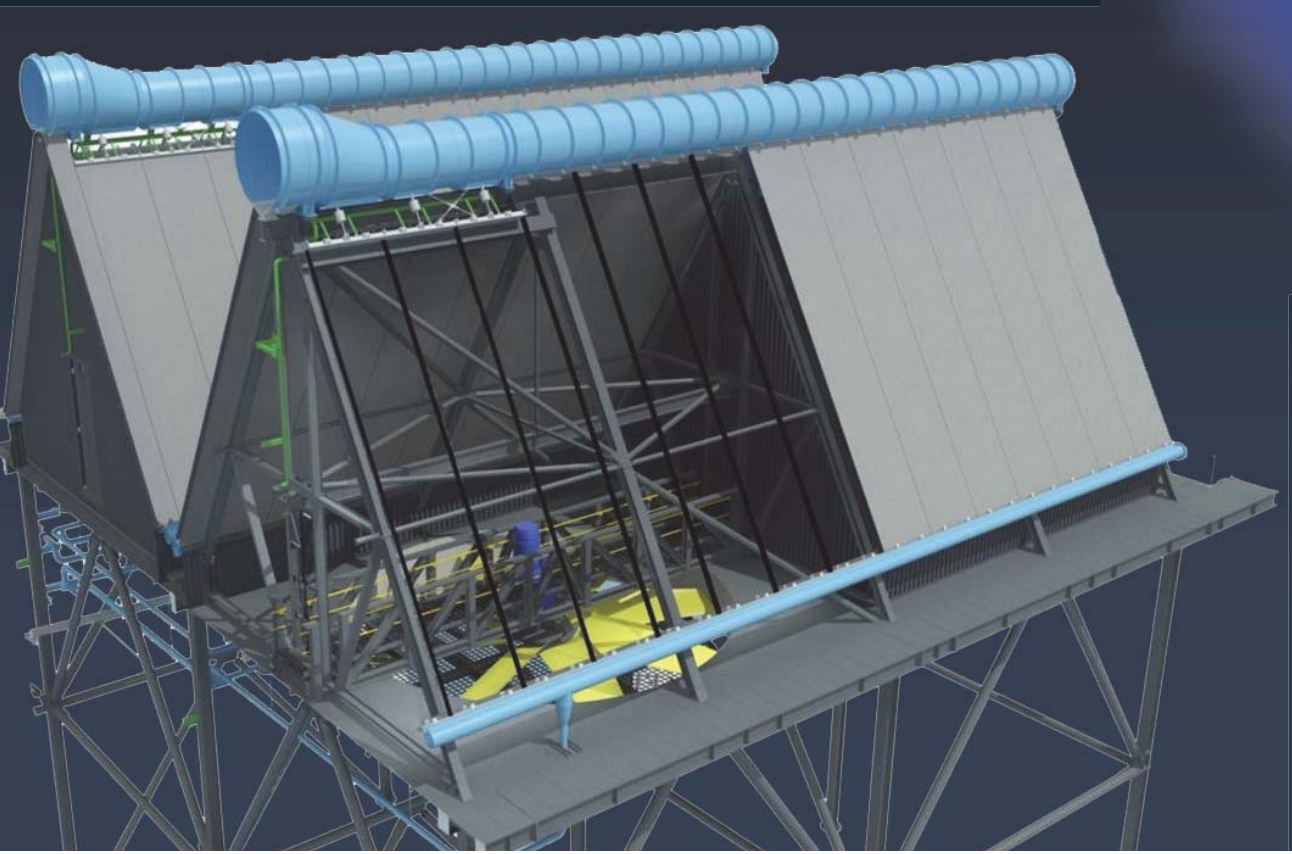
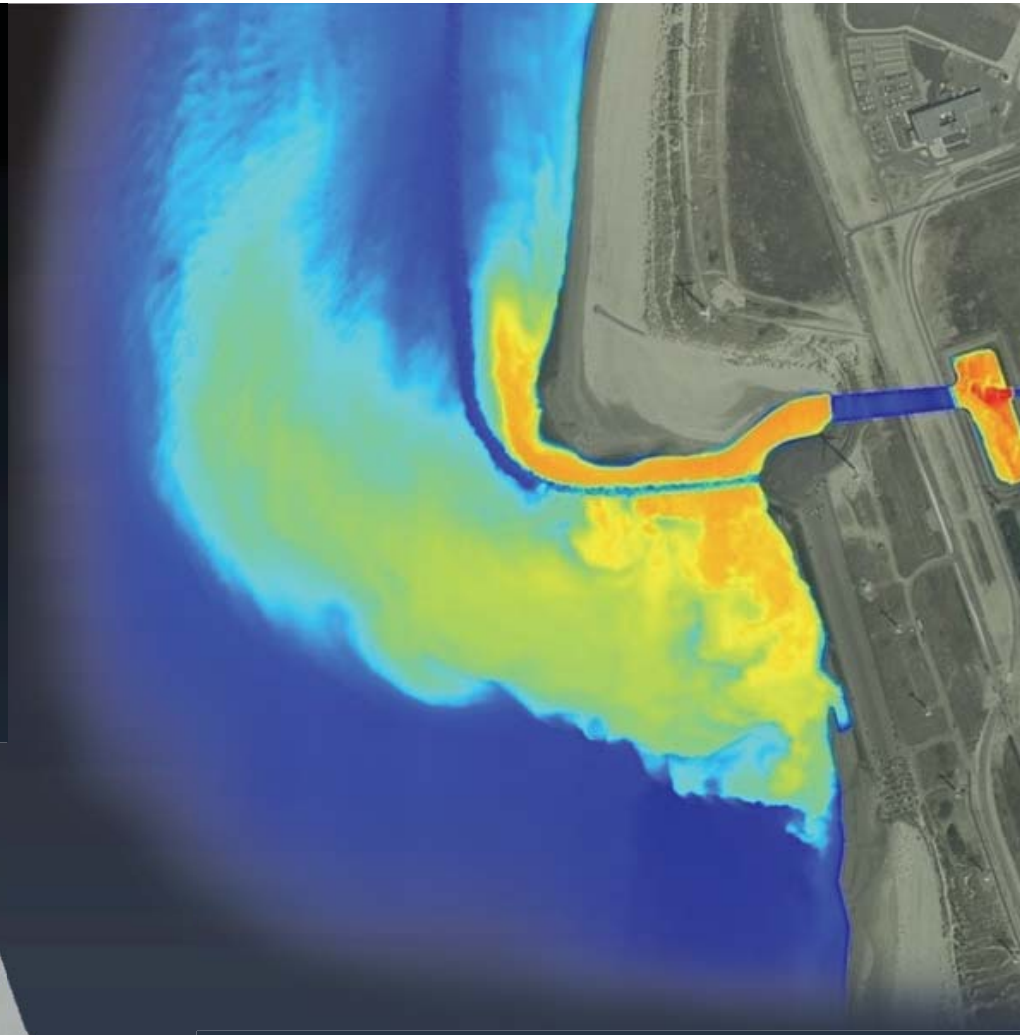
Typical Coal-Fired Power Plant

Efficiency limited by temperature difference between hot and cold reservoirs of the thermodynamic cycle.

Cooling Limitations

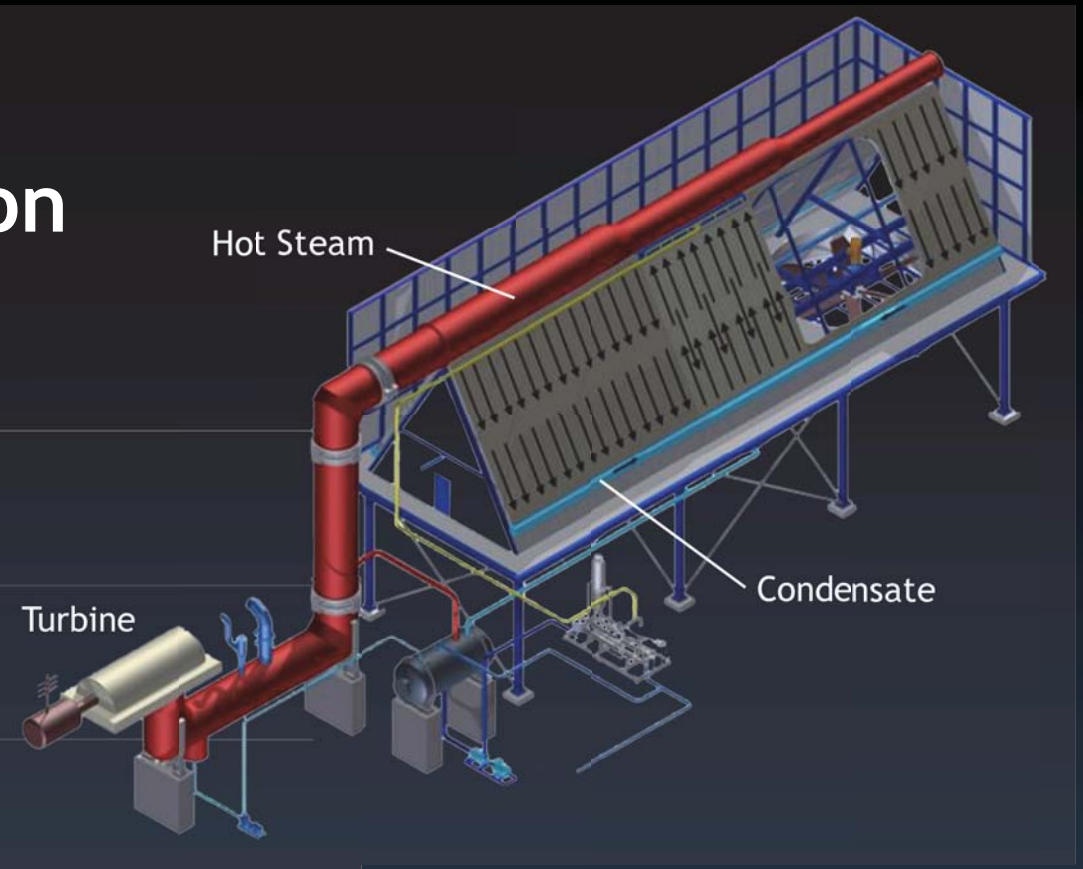
Air cooled condensers can be severely limited when ambient temperatures rise.

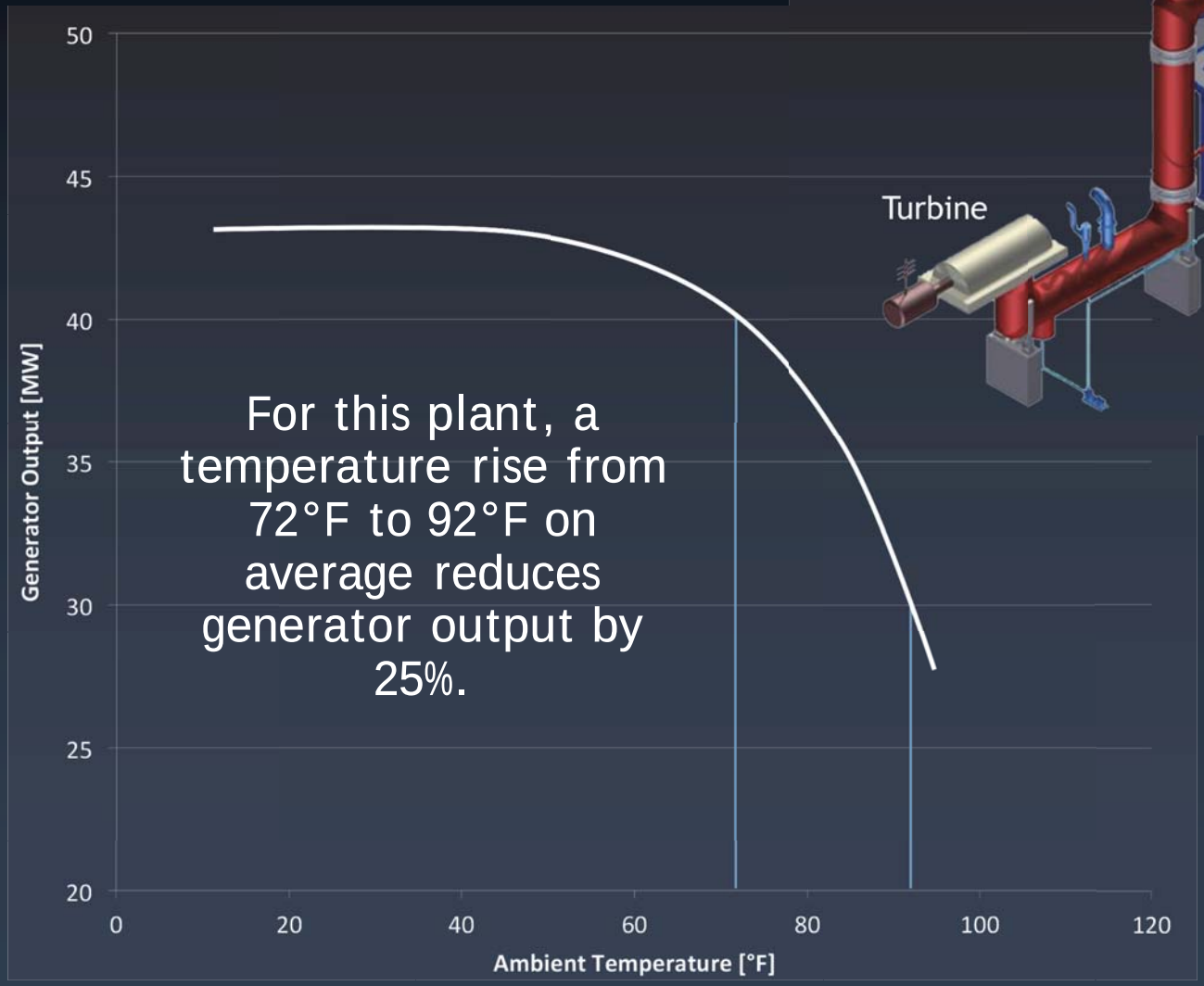




Water discharge rates are limited for once-through cooled plants.

Impact on Air Pollution

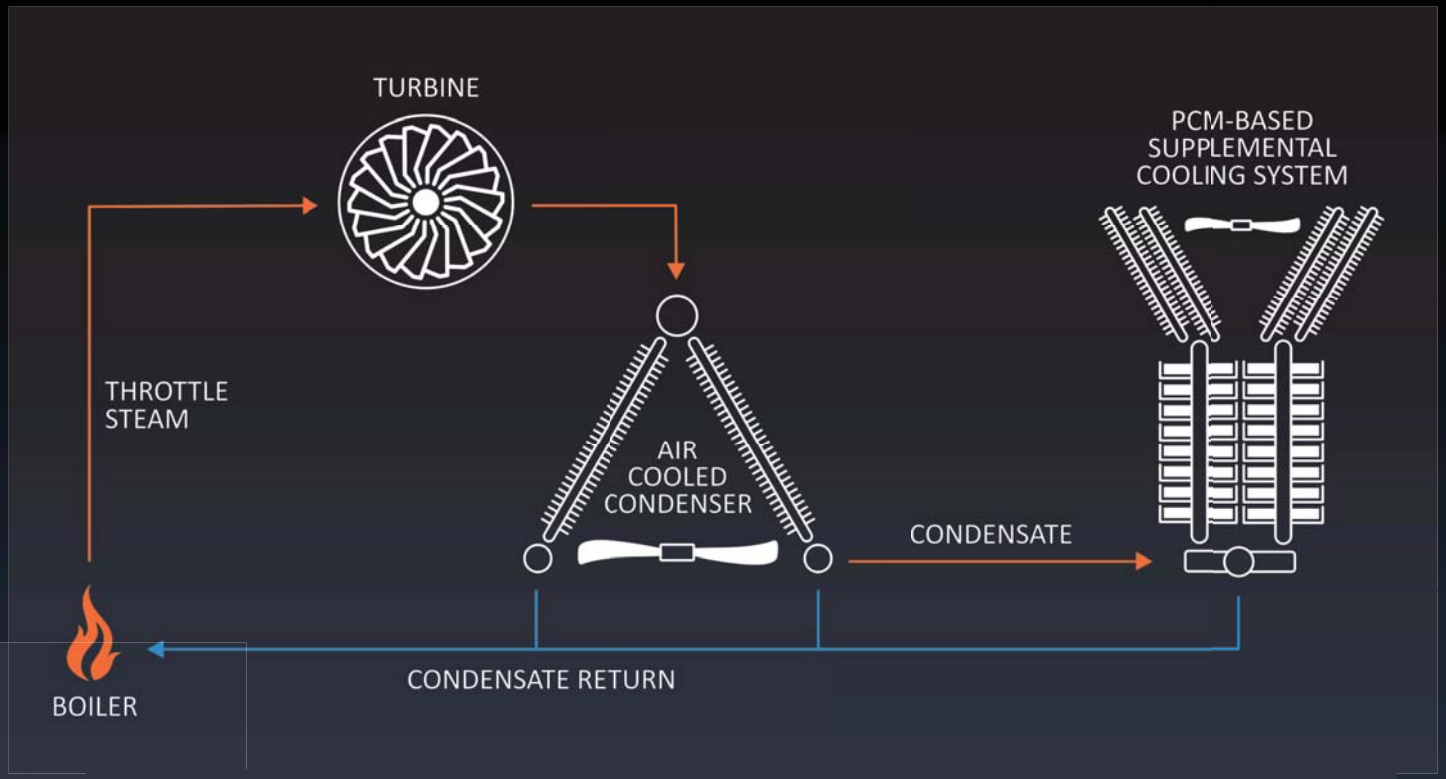


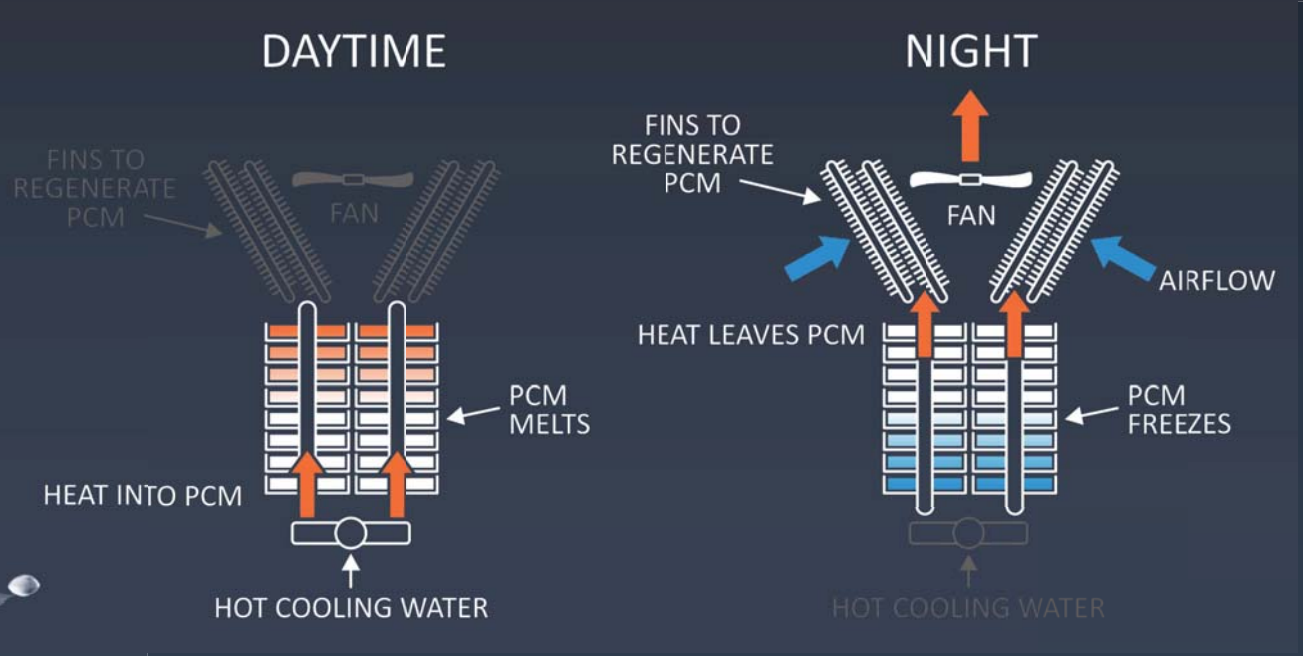


For this plant, a temperature rise from 72°F to 92°F on average reduces generator output by 25%.

To meet grid demand, this lost generation must come from other generation sources. Fossil generation has a 1:1 relationship with emissions.

The Proposed Solution



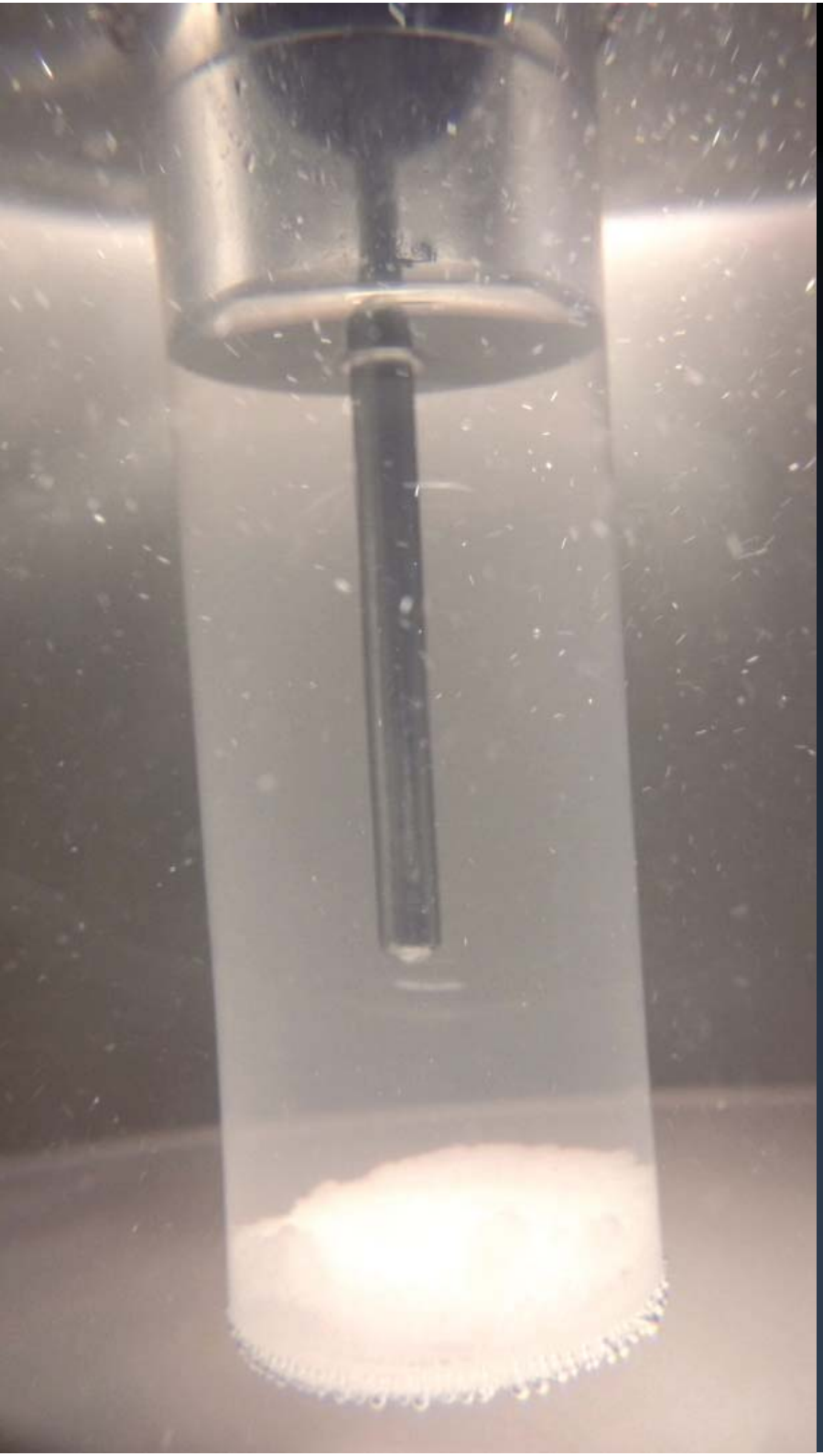


The Phase Change Materials

	T_m [°C]	H_f [kJ/kg]	$/kg	$/MJ
Hydrated Salts				
$KF \cdot 4H_2O$	18.5	231	1	4
$CaCl_2 \cdot 6H_2O$	29.0	180	0.3	1.5
$Na_2SO_4 \cdot 10H_2O$	32.5	250	0.1	0.5
Hydrated Salt Mixtures				
	25	120	0.3	2
	25	127	0.1	0.7

Selection Criteria

- Correct Phase Change Temp. (15-30°C)
- High Latent Heat
- No Health Hazards
- Long-Term Stability/Performance
- Low Cost



$CaCl_2 \cdot 6H_2O$

Phase Change Temp: 29°C

Latent Heat: 180 J/g

The Good

Low Cost (it's Road Salt)

Safe

Well-researched

The Bad

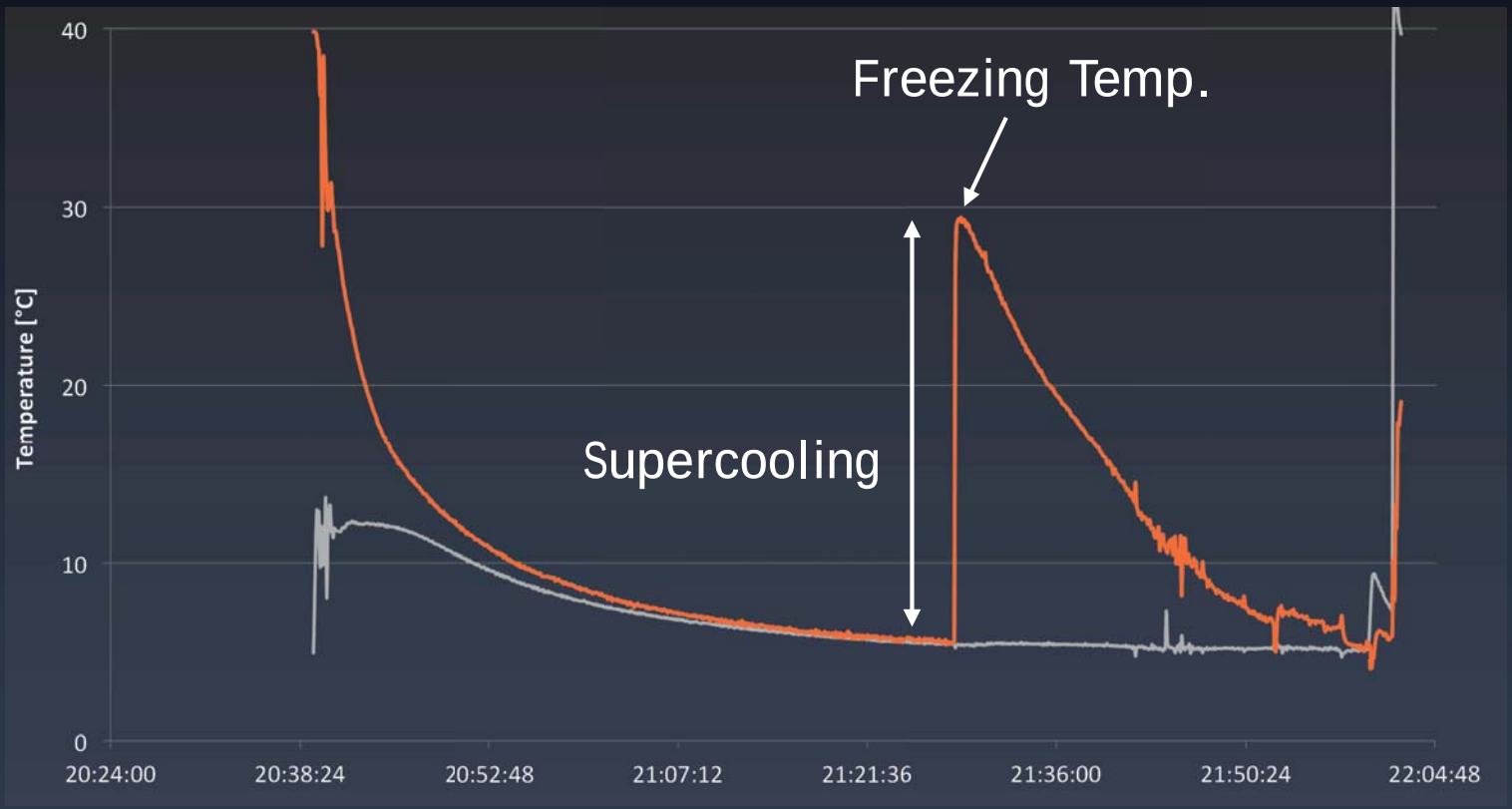
Supercooling

Corrosive

Long-term Phase Instability

Supercooling

Must lower temperature below freezing temperature before freezing begins



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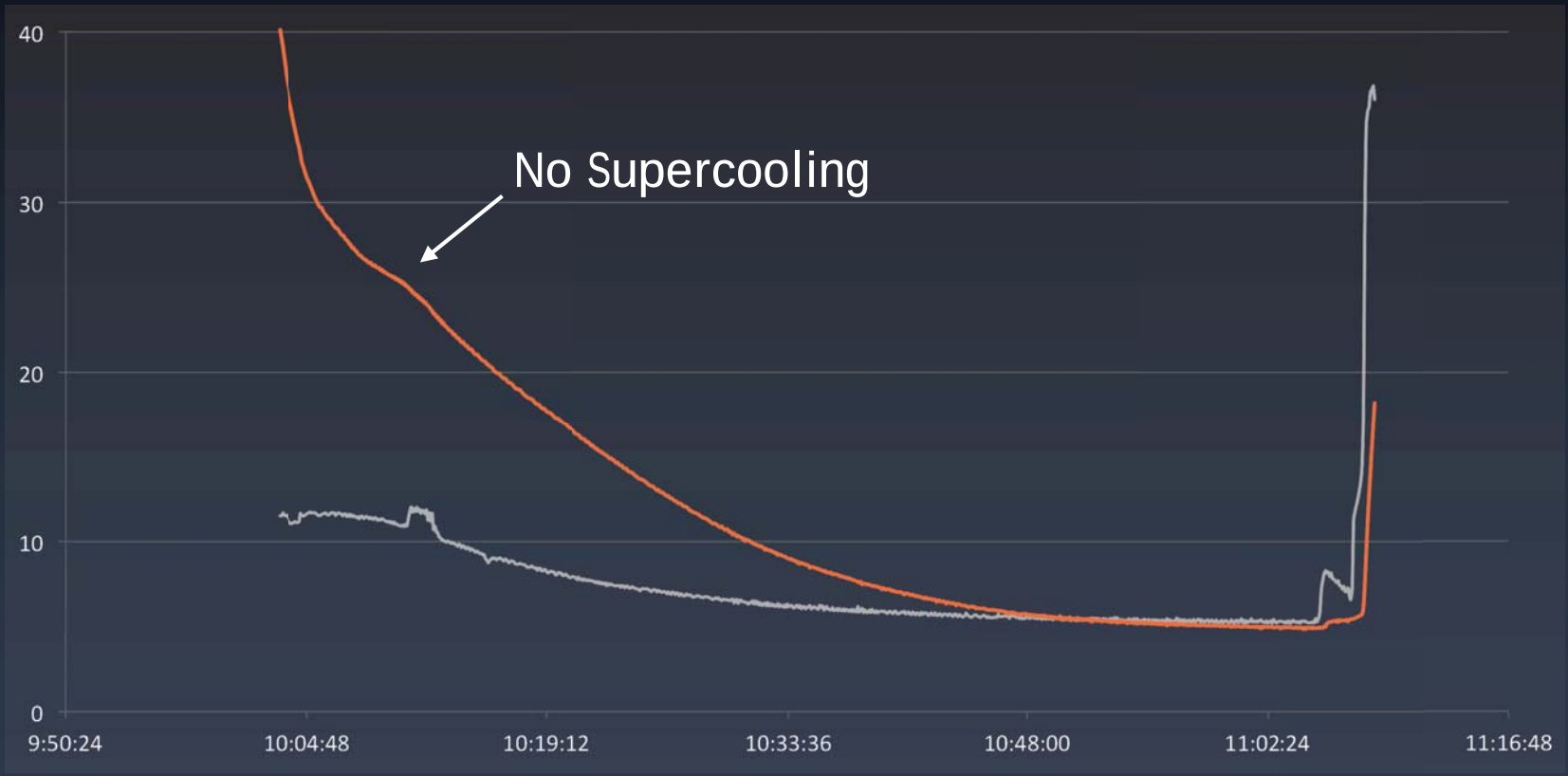
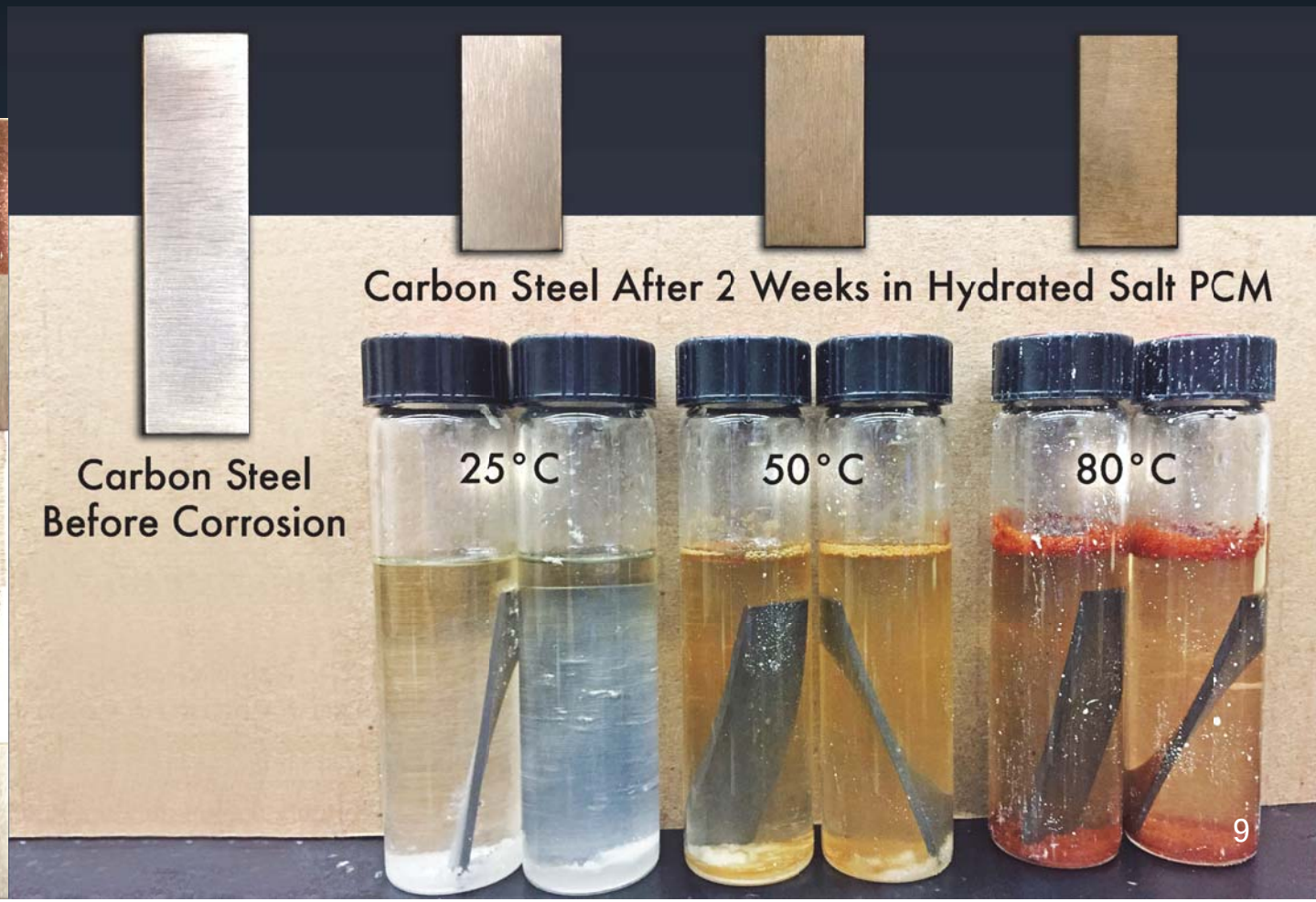


What did we do? $CaCl_2 \cdot 6H_2O$ + 3% $SrCl_2 \cdot 6H_2O$

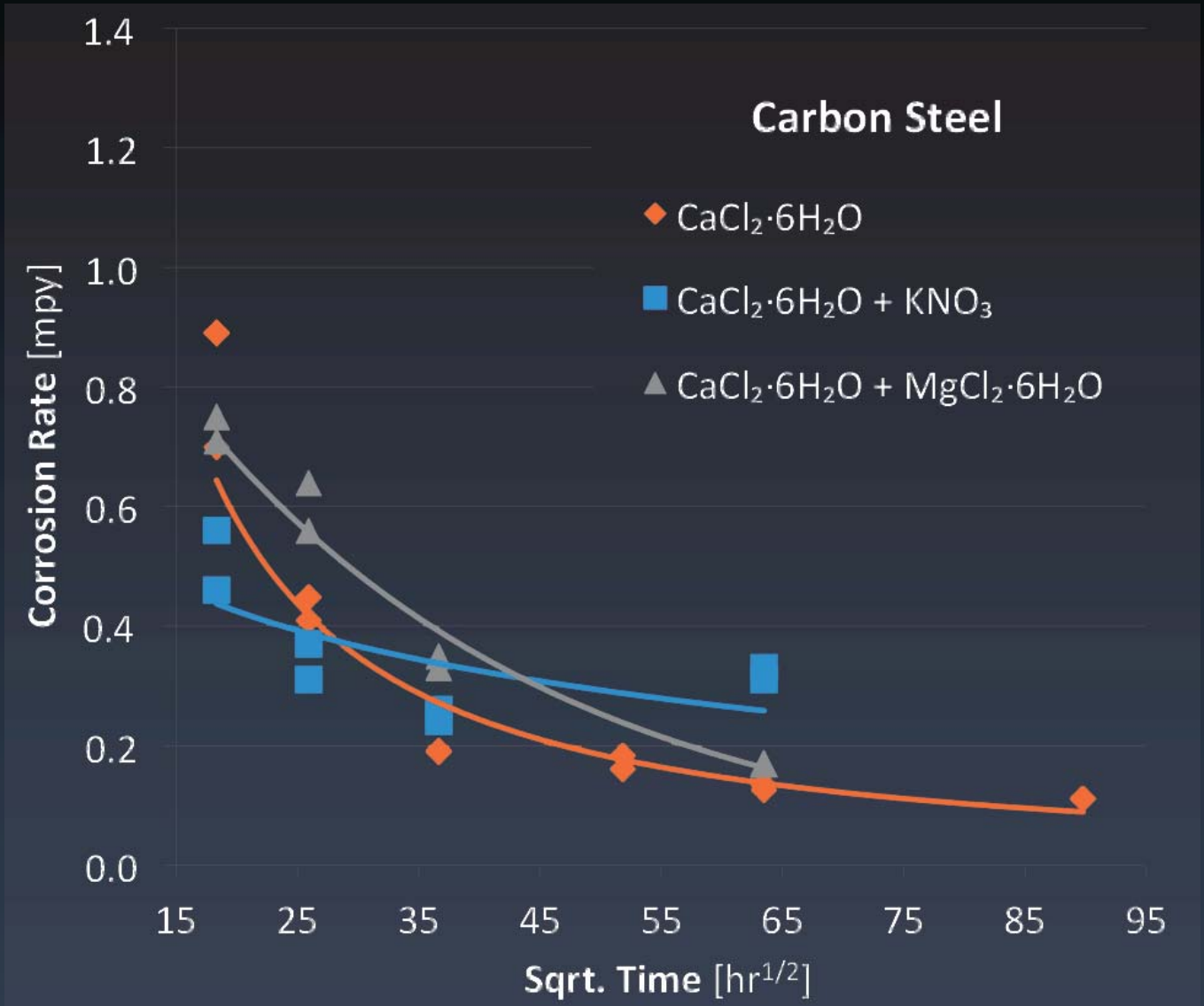
Corrosion Testing

5 Metals were Corrosion Tested in all 3 PCM's

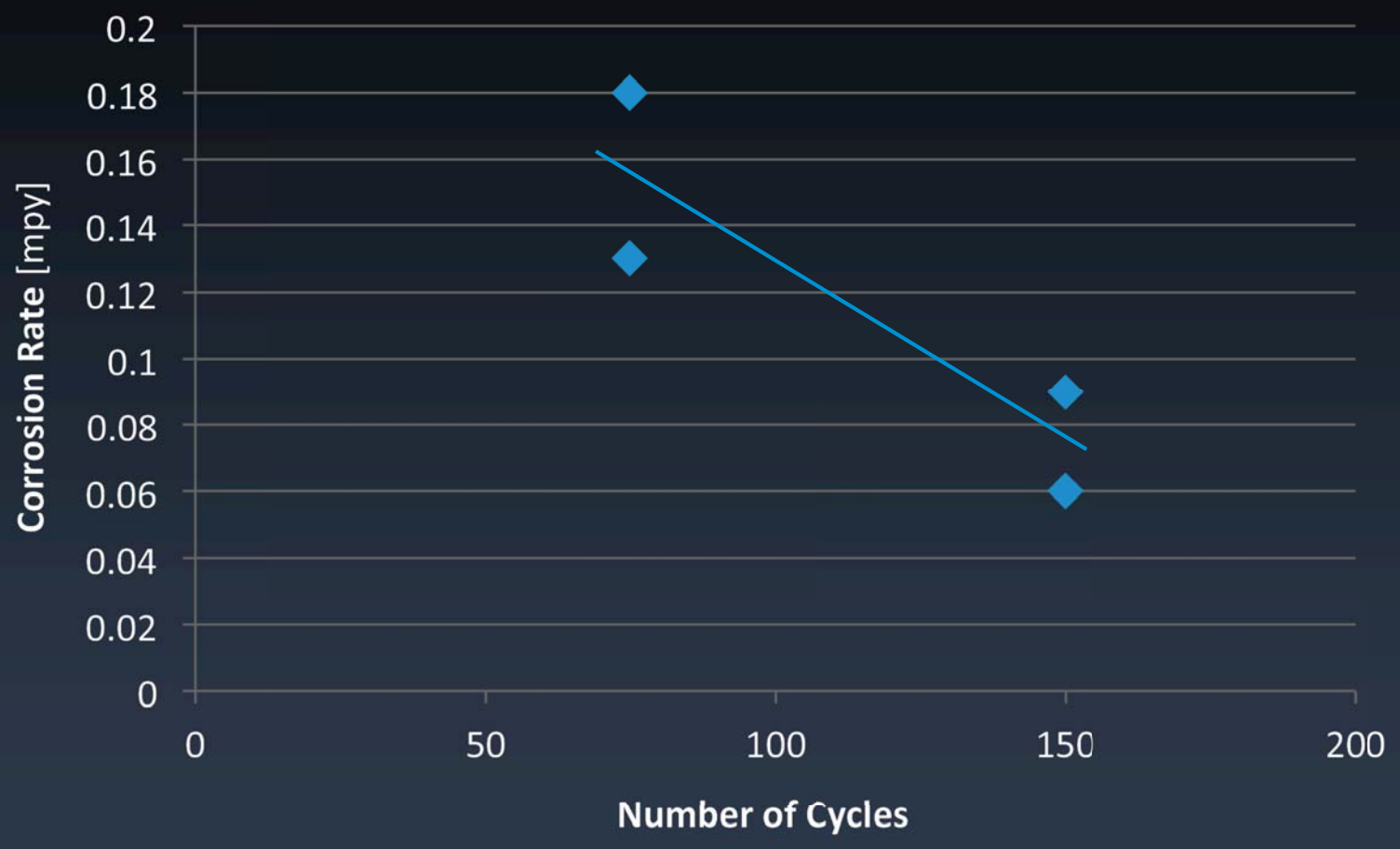


Corrosion Testing

Carbon steel had good long-term corrosion performance while in contact with all 3 PCMs

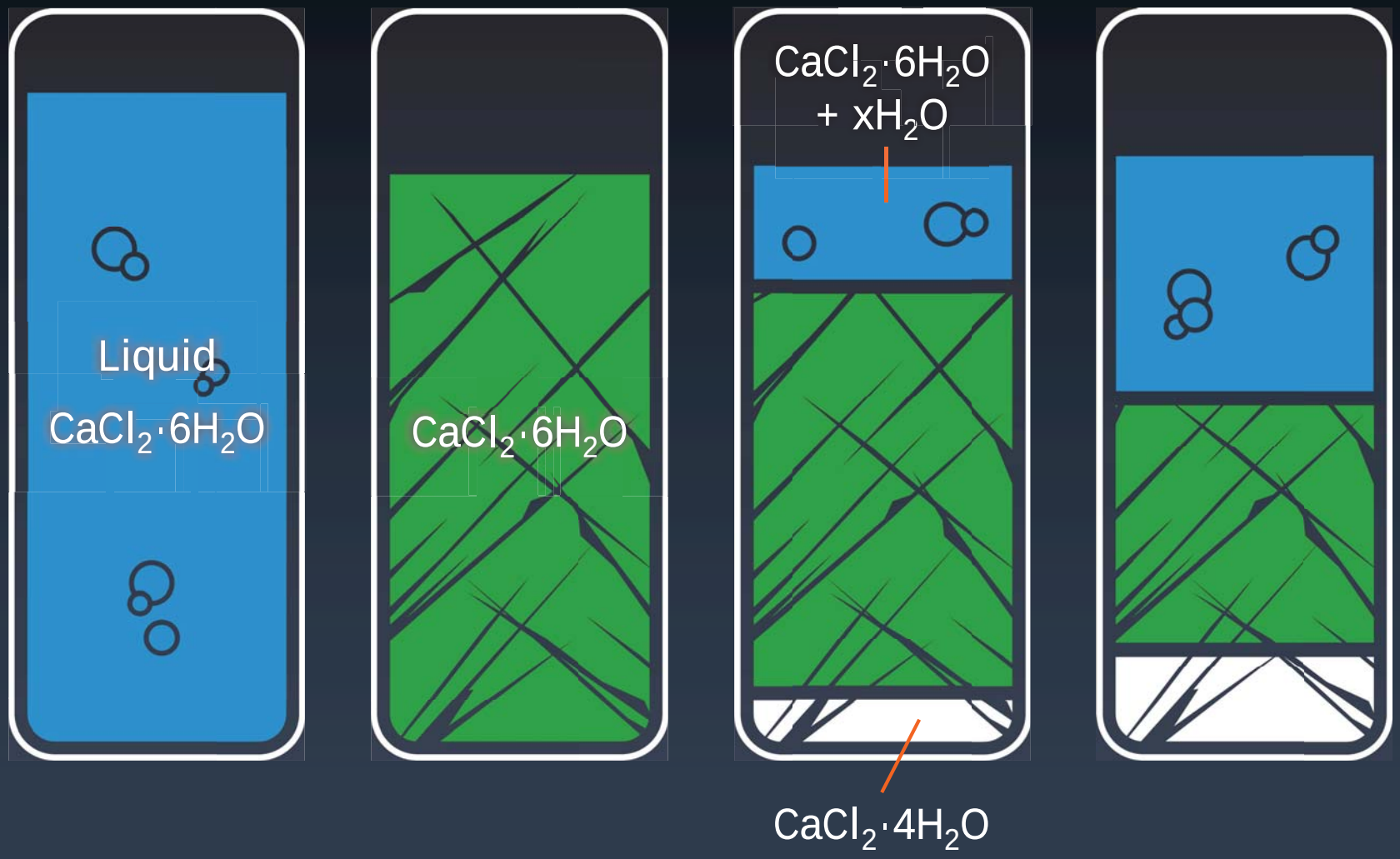


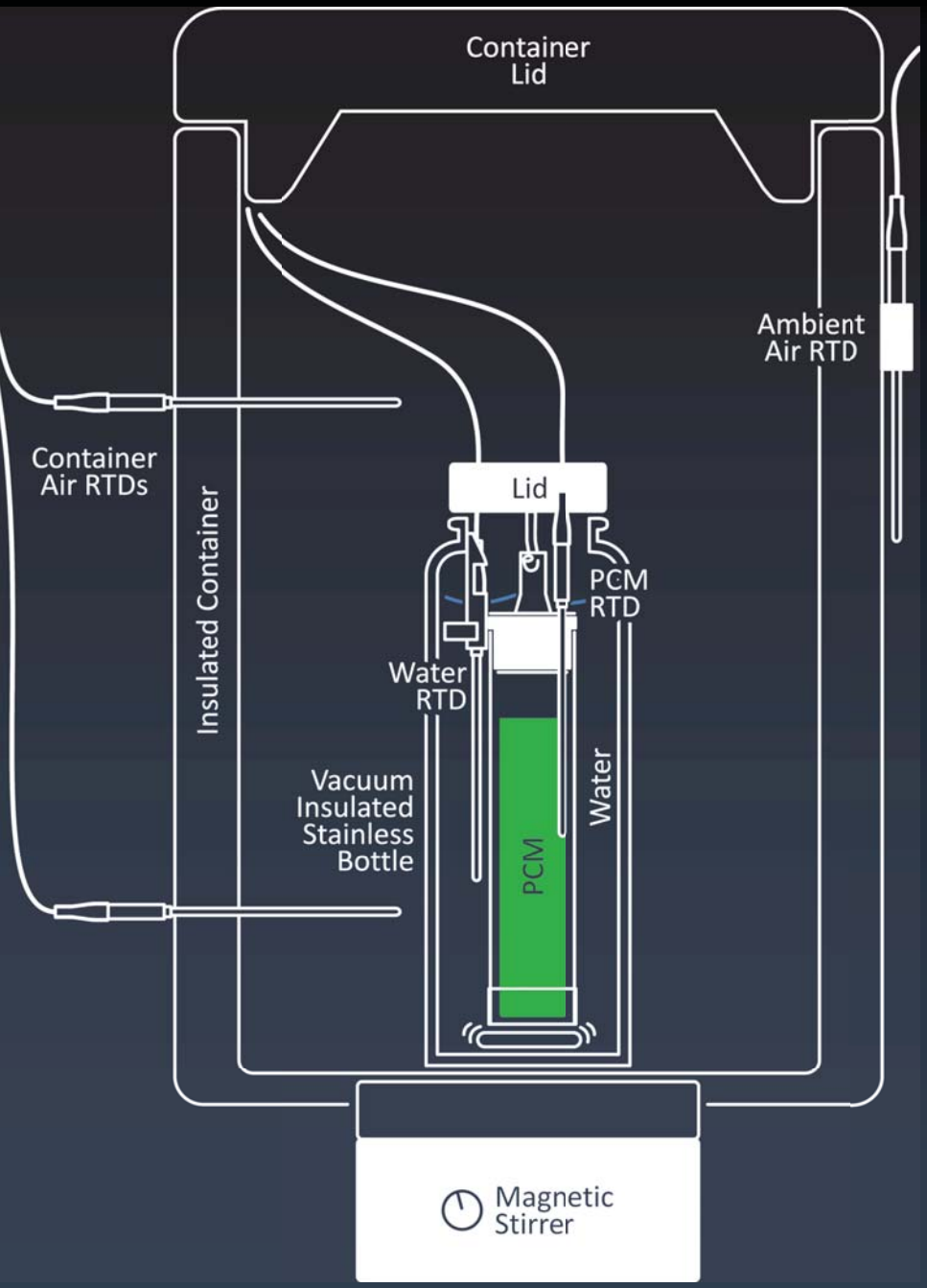
Corrosion Testing



Al 5086 in $CaCl_2 \cdot 6H_2O$ During Thermal Cycling (5 hr cycles)

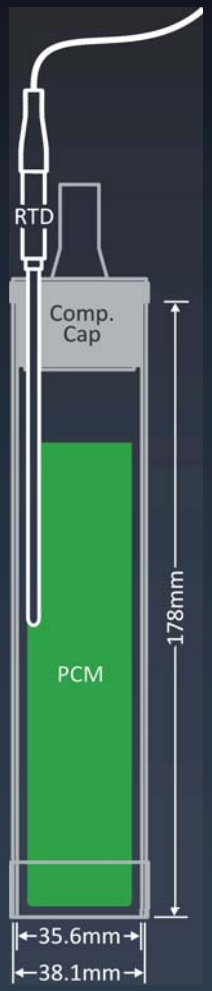
Phase Separation of $CaCl_2 \cdot 6H_2O$





Long-Term Stability

200g PCM samples were prepared along with a drop calorimeter to measure their latent heat



Cycling

Over 20 of these samples were cycled with 1 heating or cooling period lasting 75 minutes.

Each sample was calorimetry tested before and after cycling to note any change in the latent heat.

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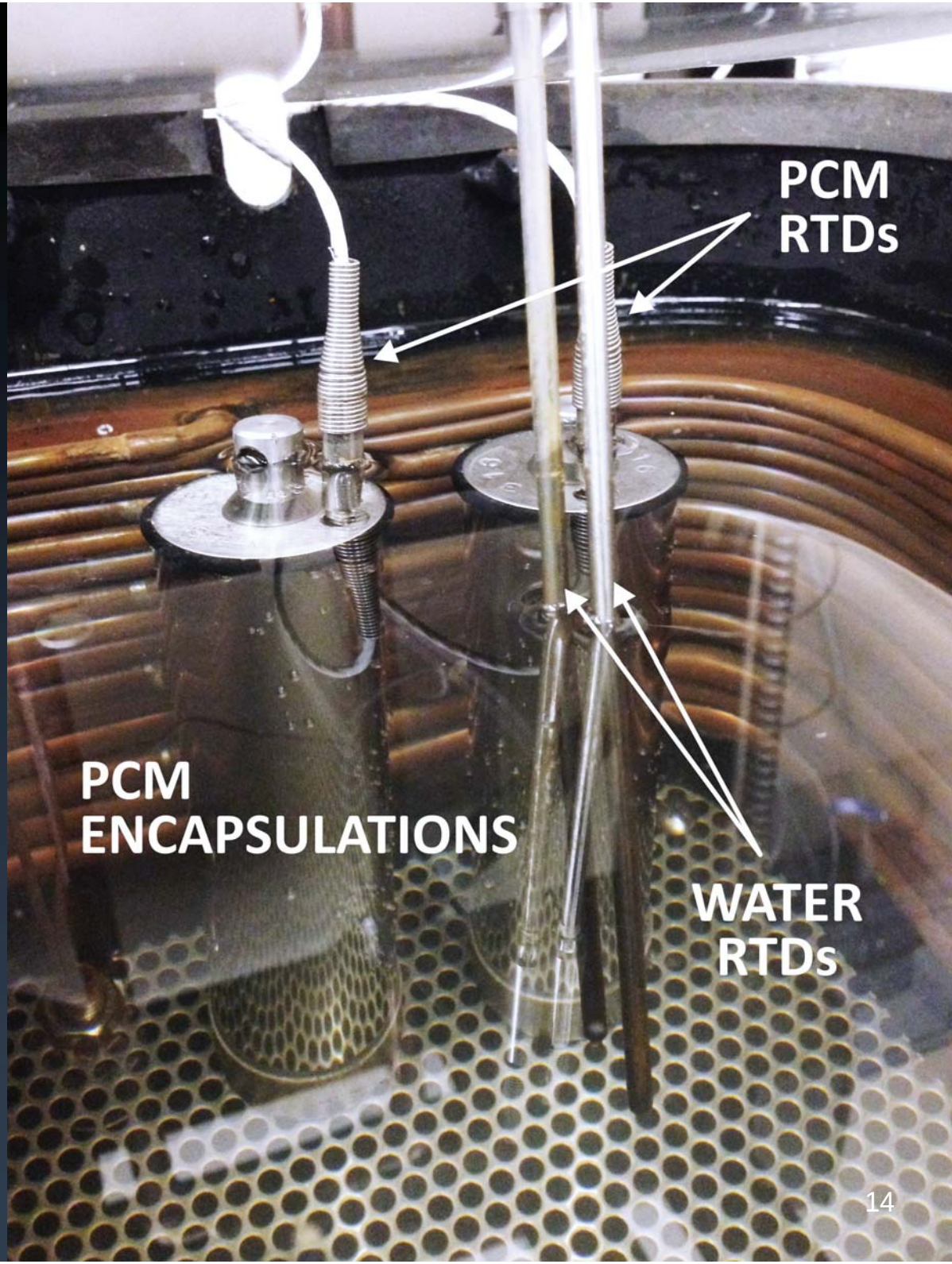
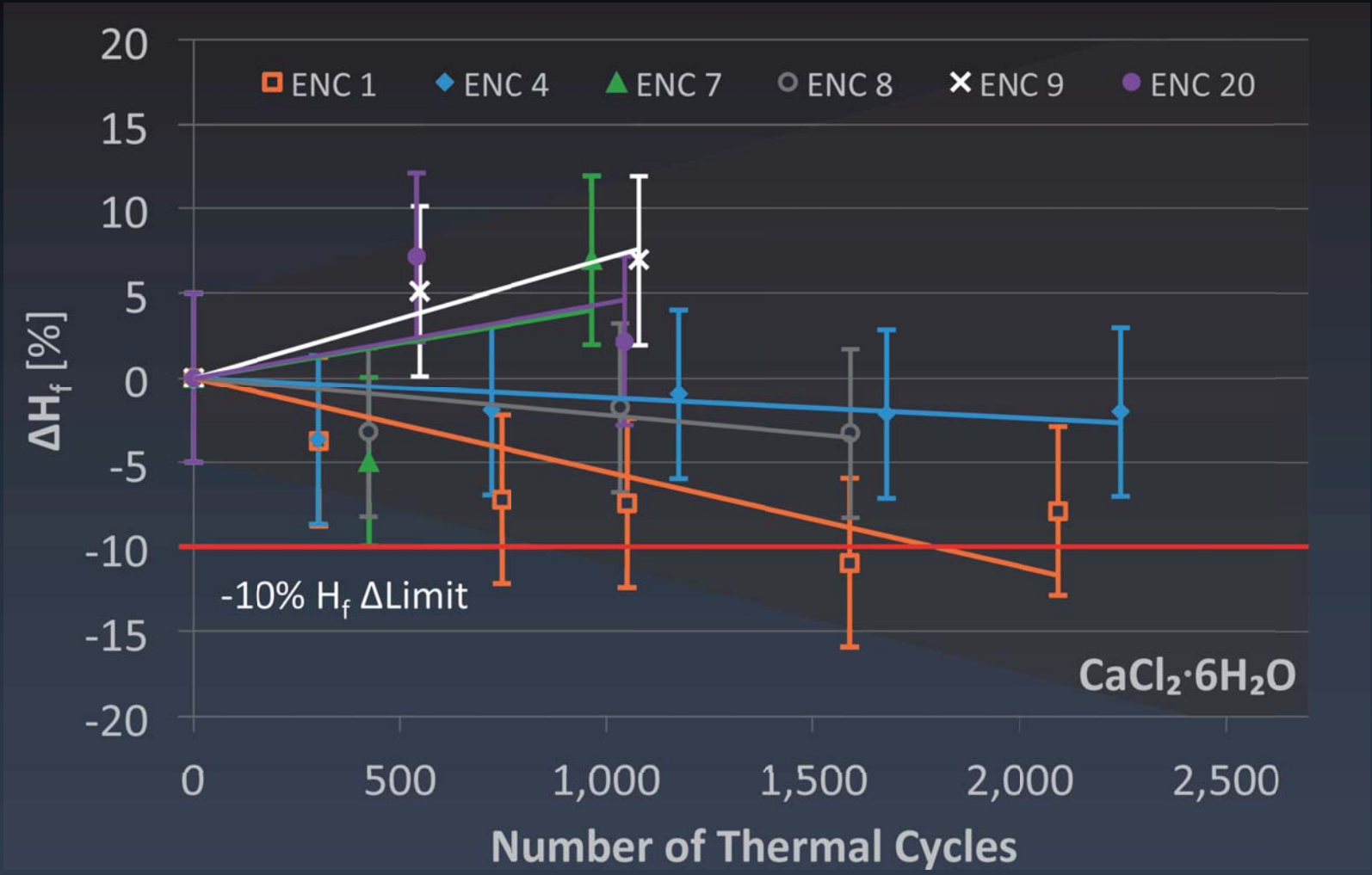


Cycling Results



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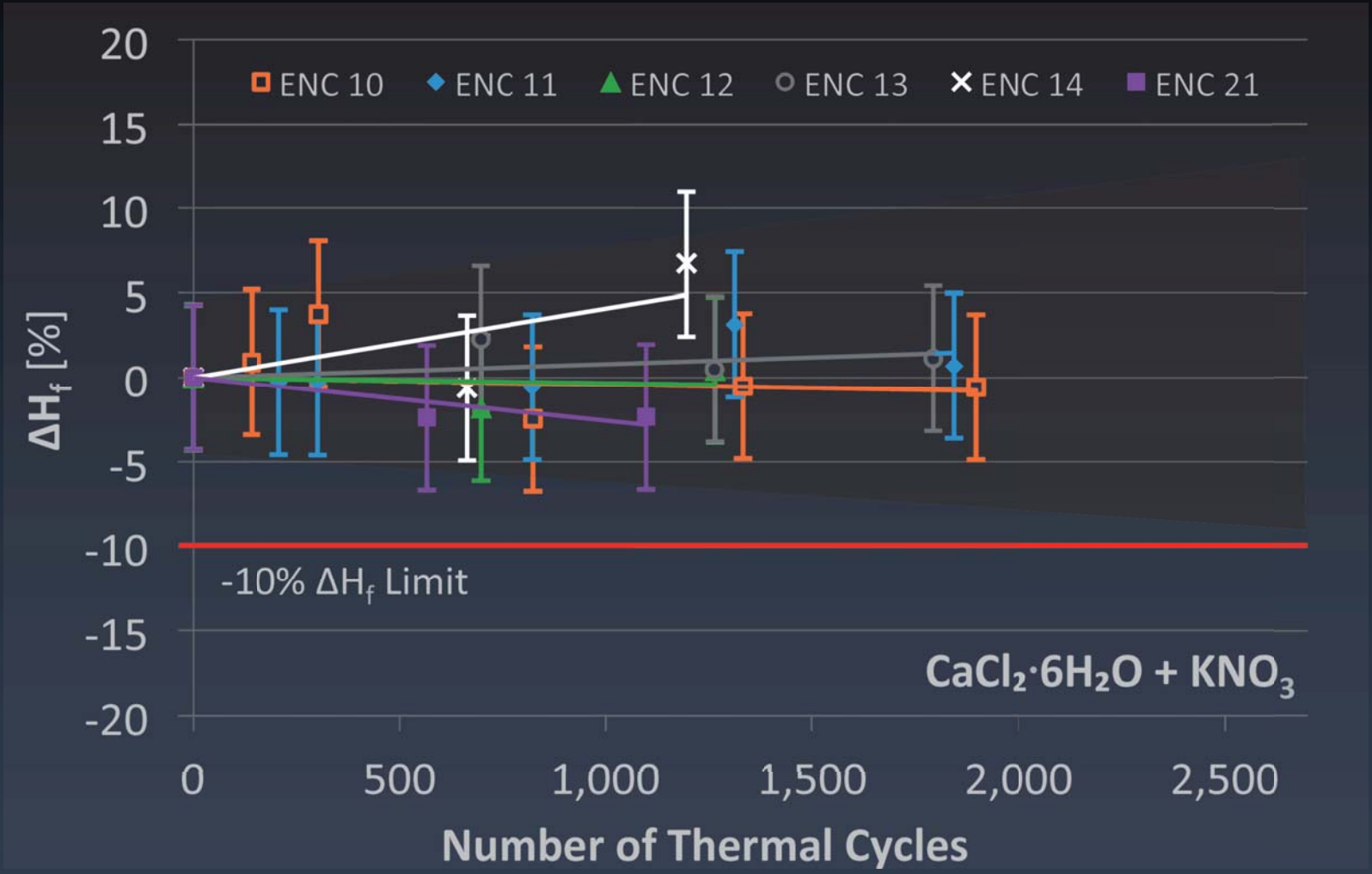

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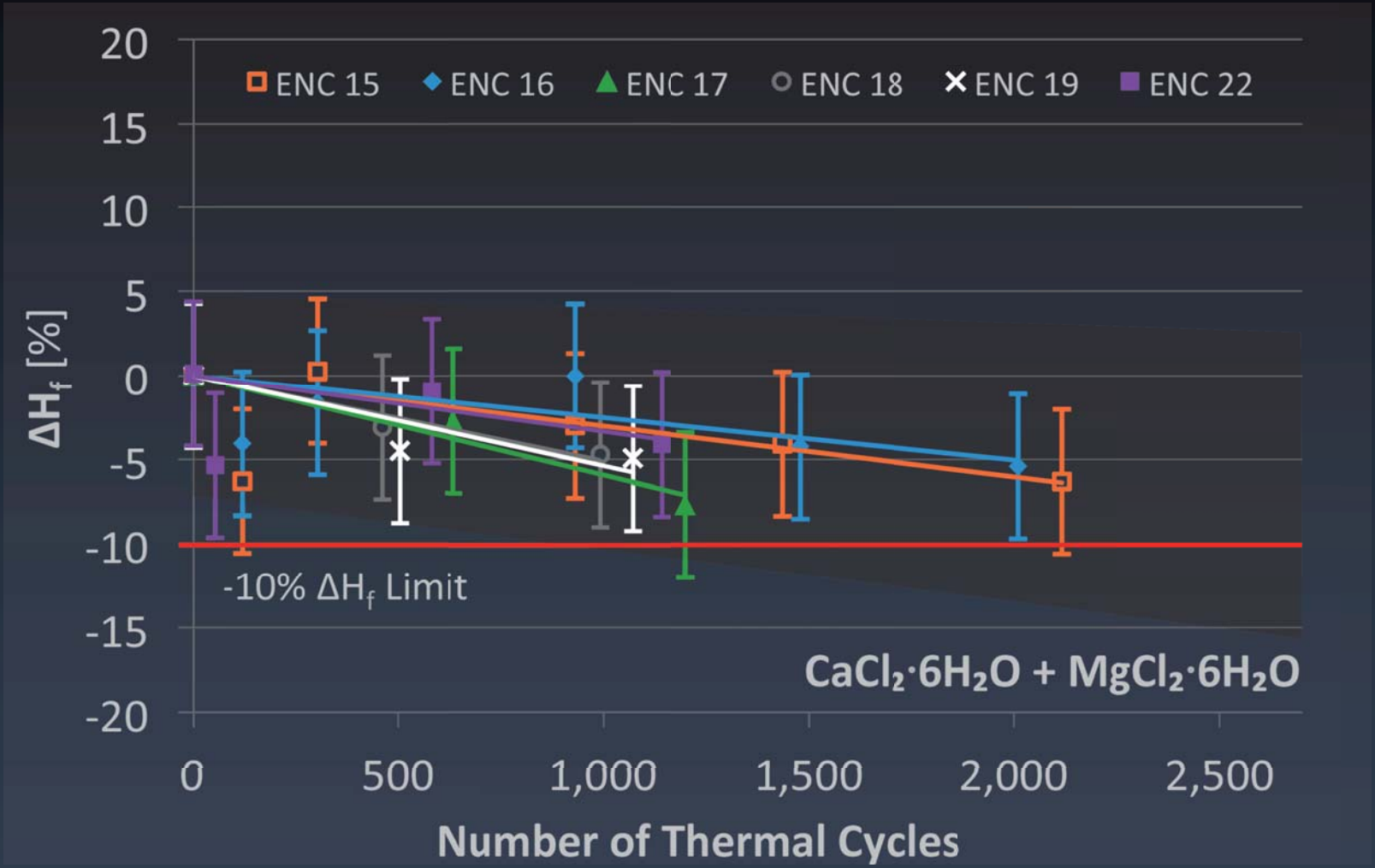
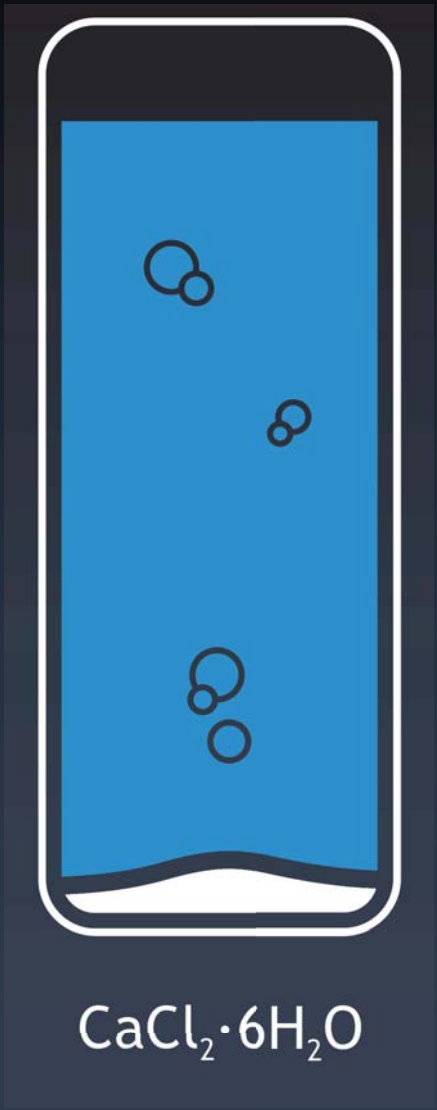
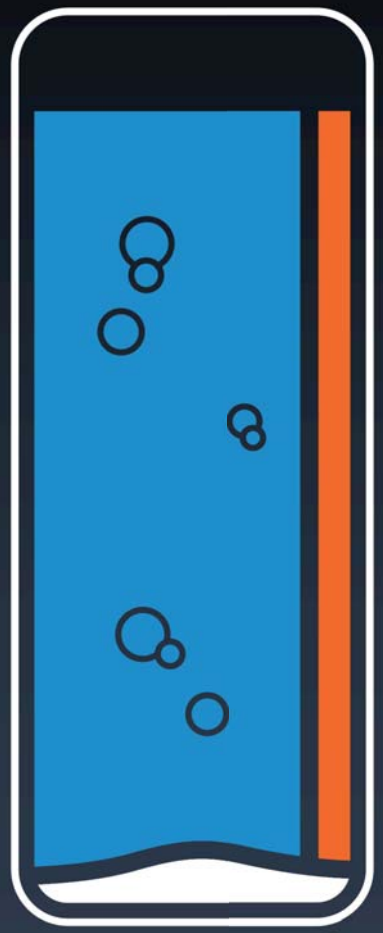


What We Learned



Has some separation over time.

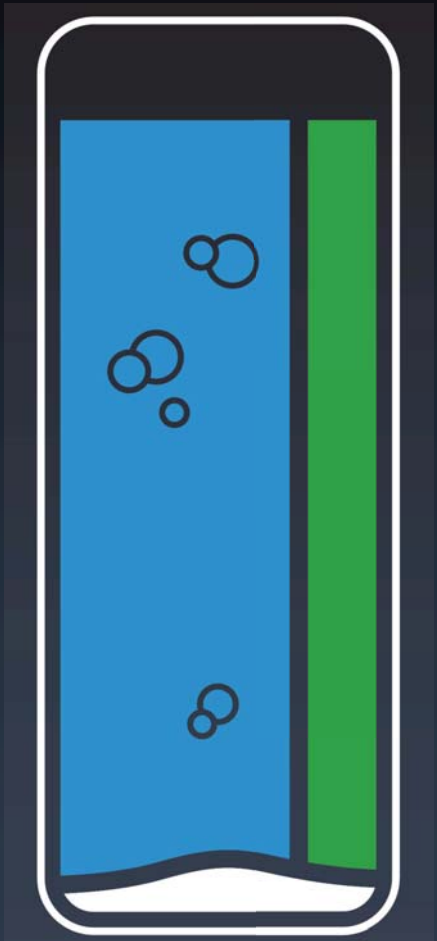
What We Learned



$CaCl_2 \cdot 6H_2O$ +
7% KNO_3

Appears to have no meaningful separation even after 2000 cycles

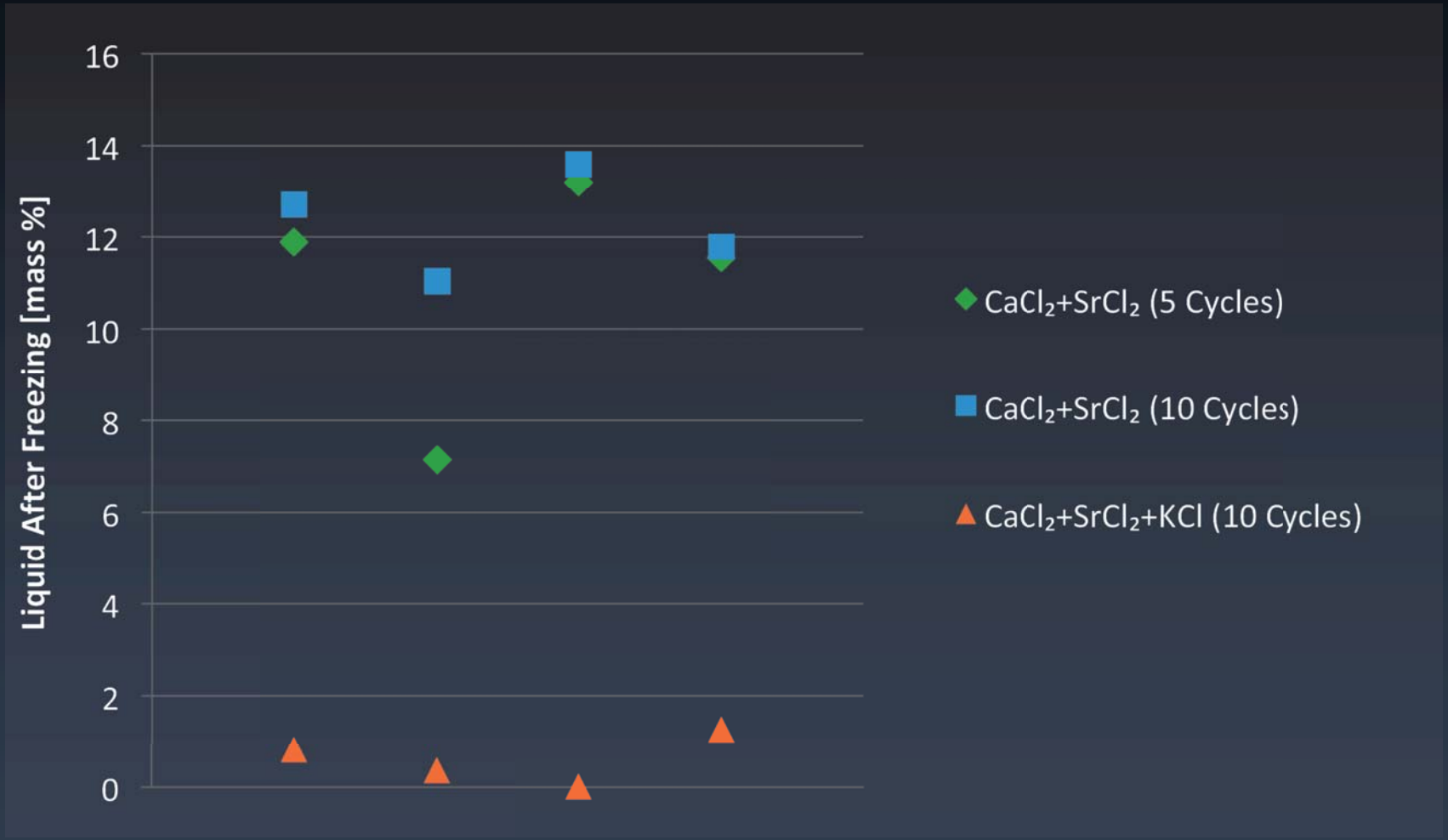
What We Learned



$CaCl_2 \cdot 6H_2O$ +
18% $MgCl_2 \cdot 6H_2O$

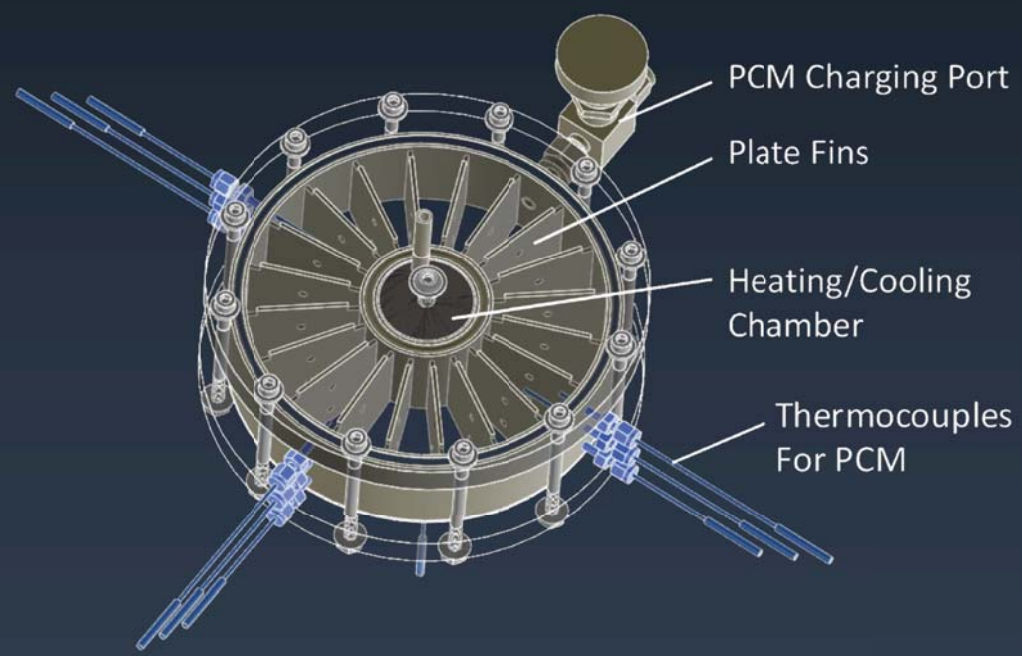
Appears to have some separation over several thousand cycles.

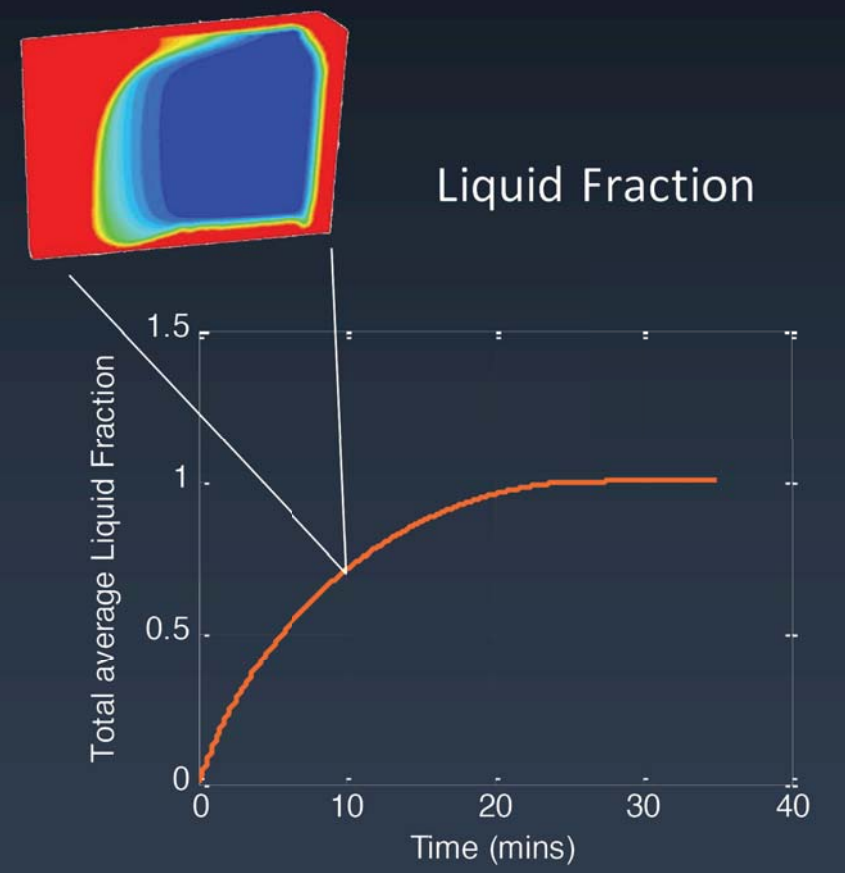
Solving Separation



System Development

ADVANCED
COOLING
TECHNOLOGIES





Thank You!

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CJ Pan

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