Ammonia-salt thermal cycling rig

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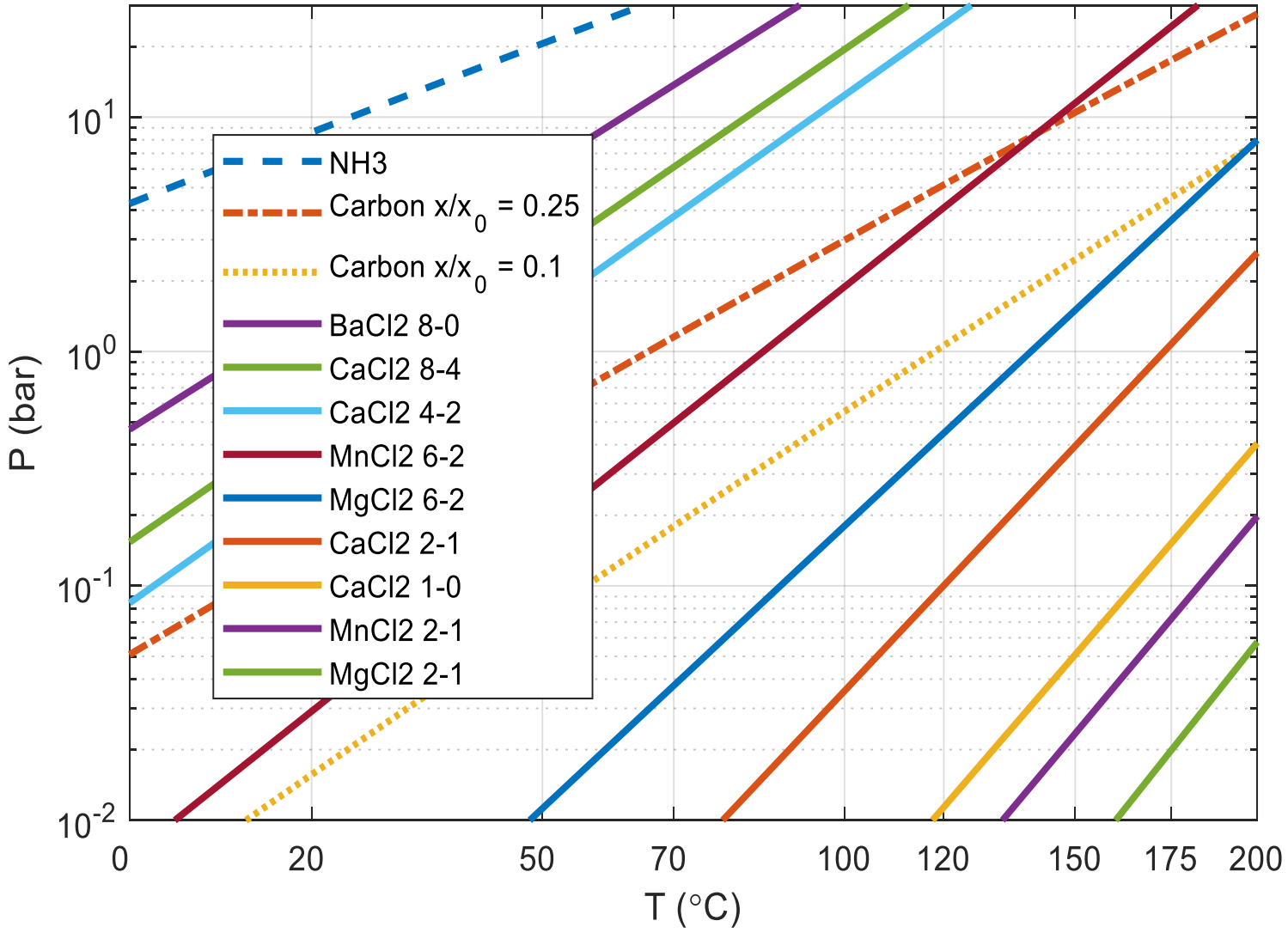
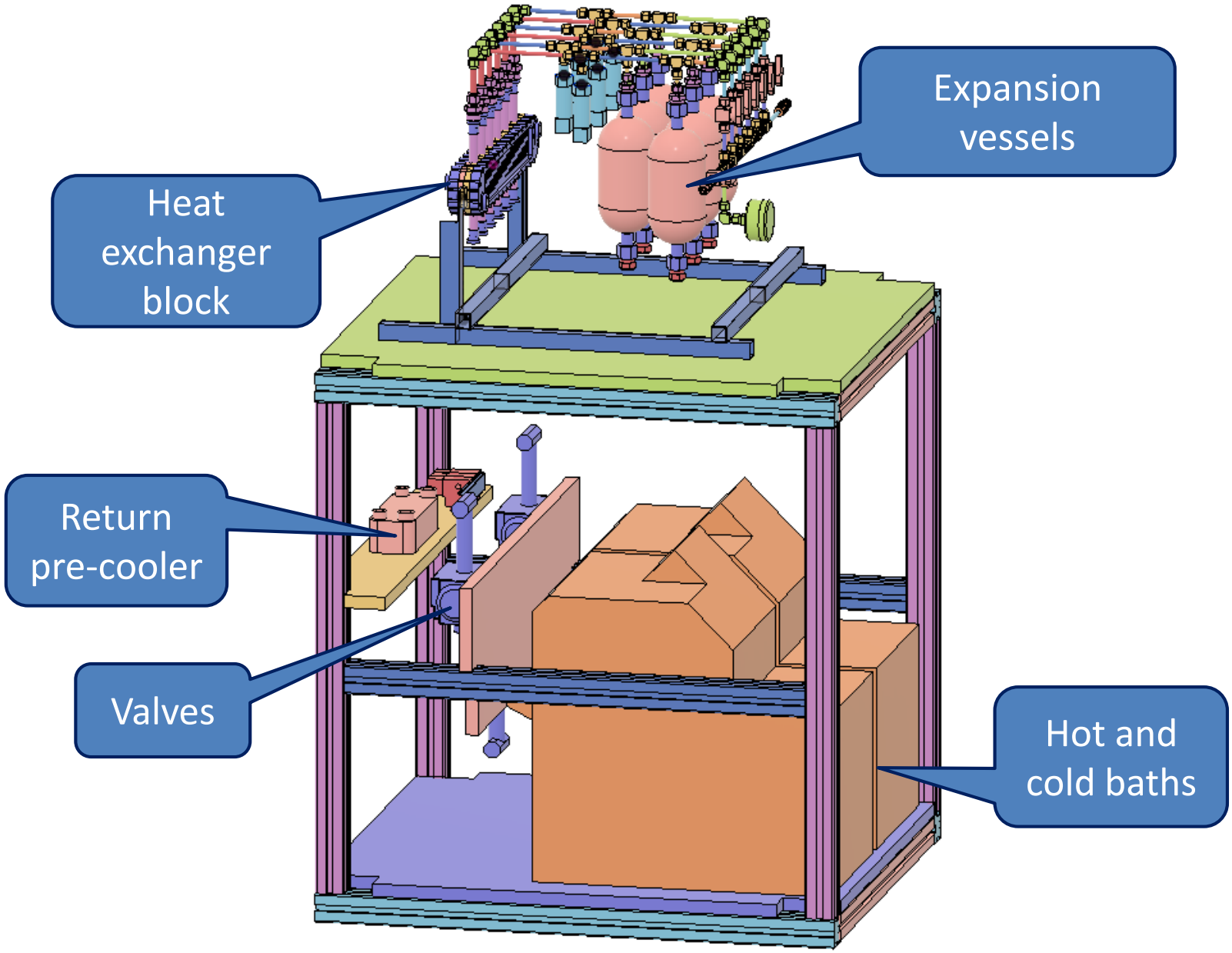
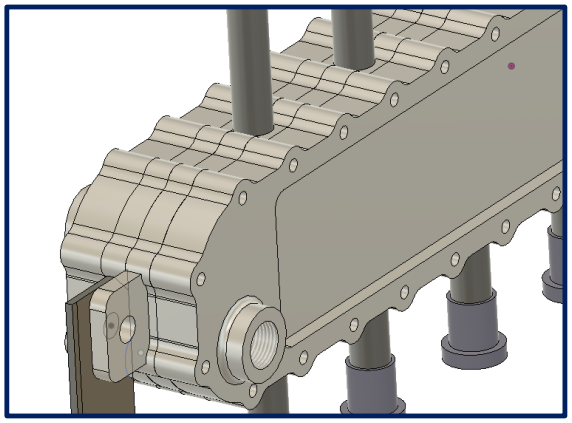
Aims:

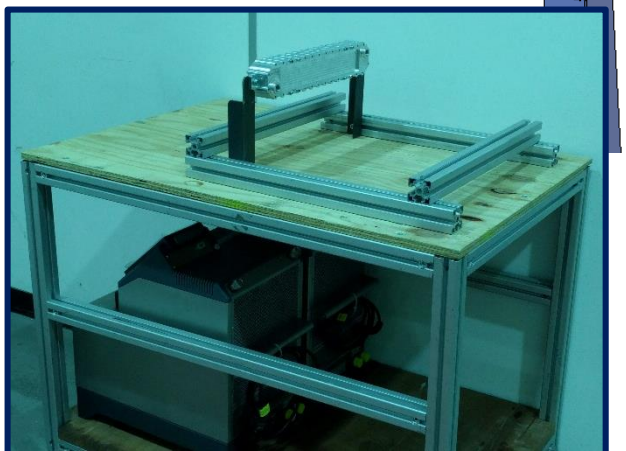
- Demonstrate the longevity of salt/ENG composites under repeated adsorption and desorption for typical heat pump pressure & temperature cycles
- Quantify any reduction in adsorption rates
- Investigate the influence of salt concentration on life and adsorption rates.

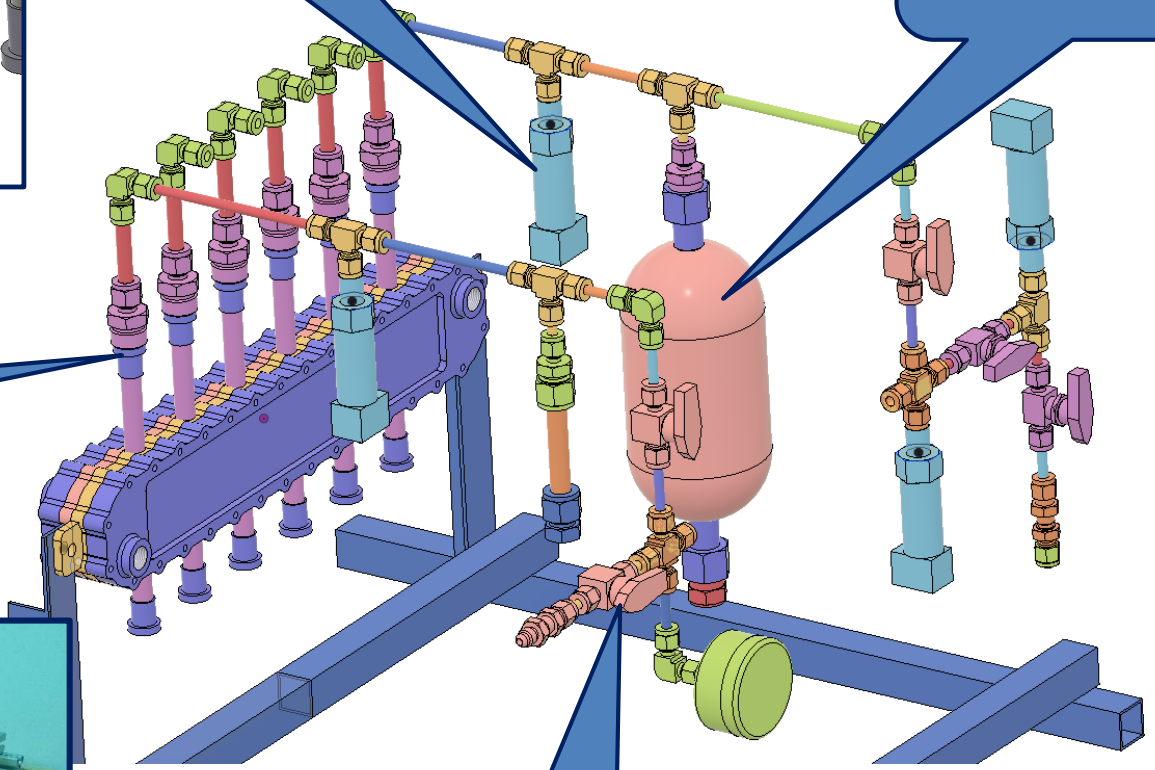
Adsorption/desorption lines

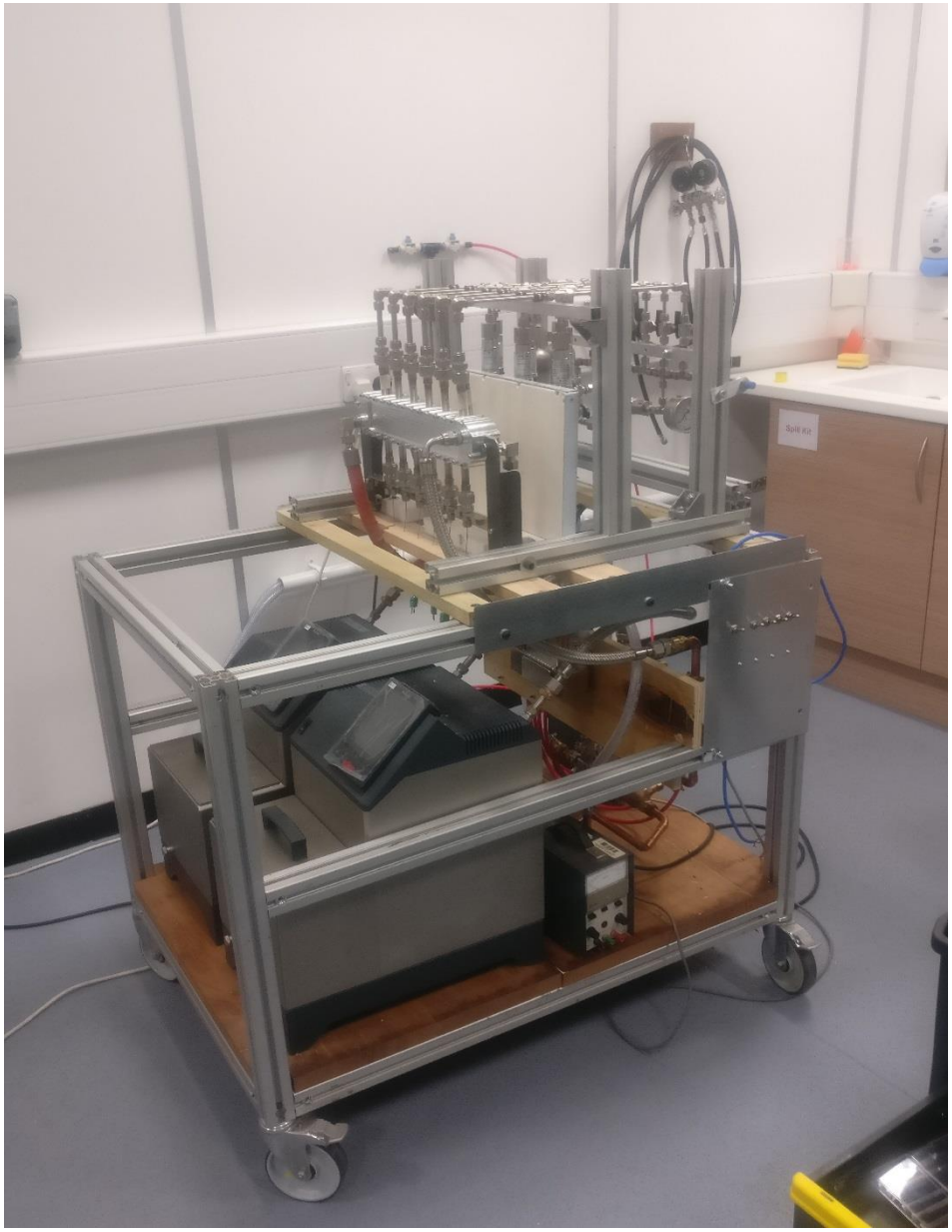


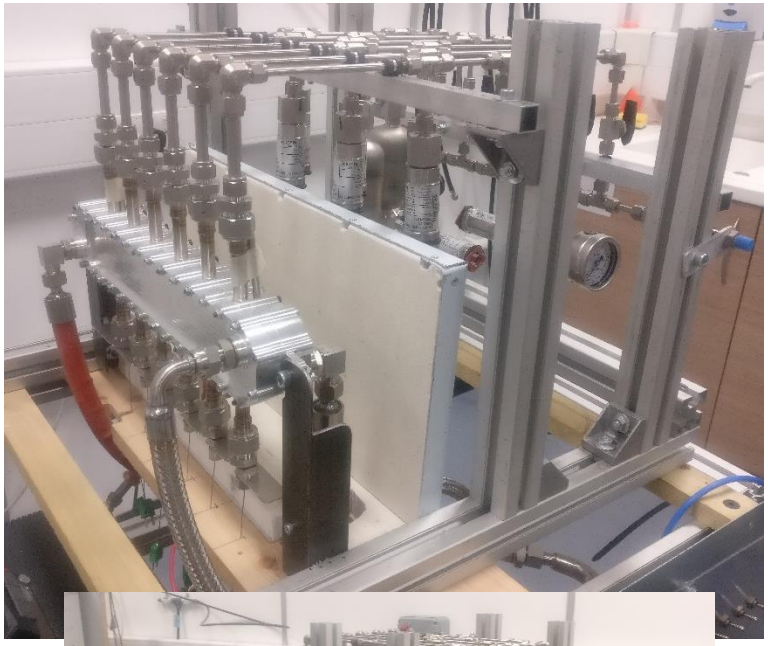

Expansion vessels
Heat exchanger block
Return pre-cooler
Valves
Hot and cold baths

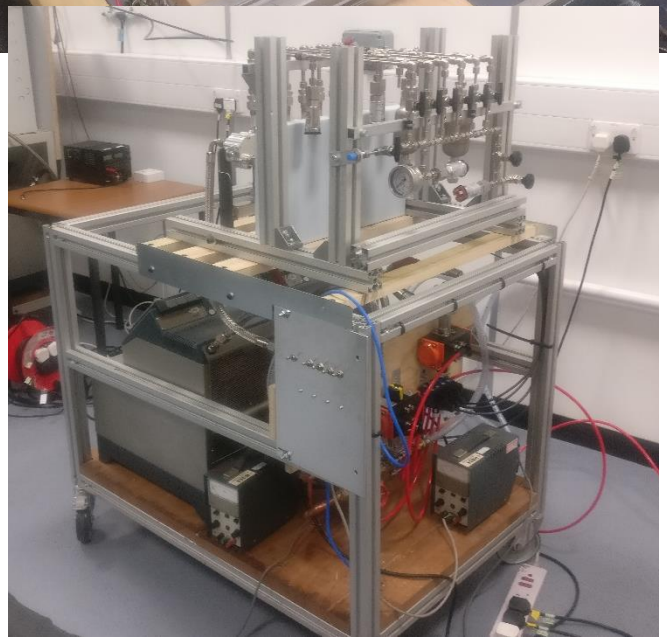


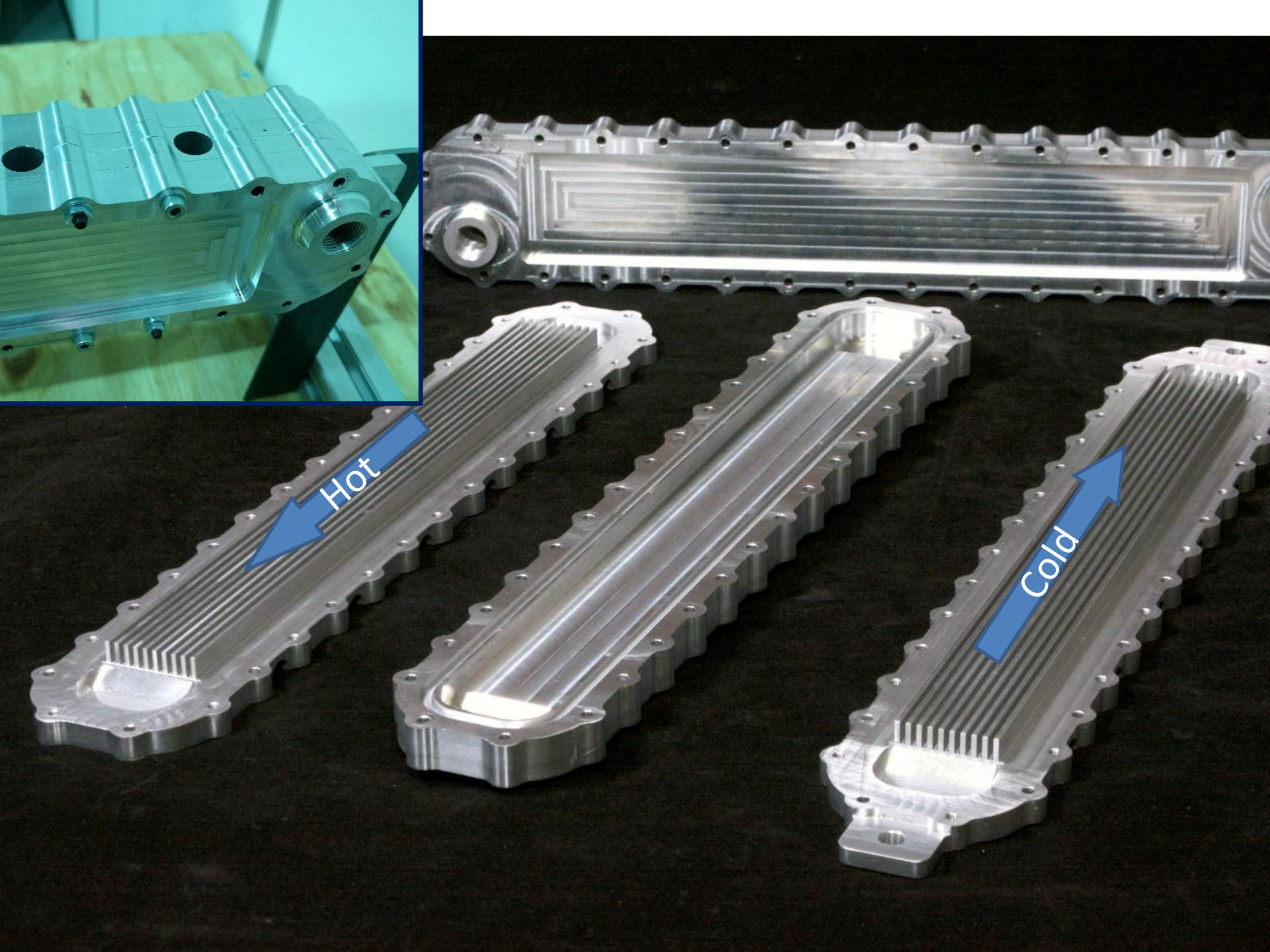



Pressure transducers
Expansion vessels (34 – 800 cm³)
Sample tubes (VCO seals)
Filling line



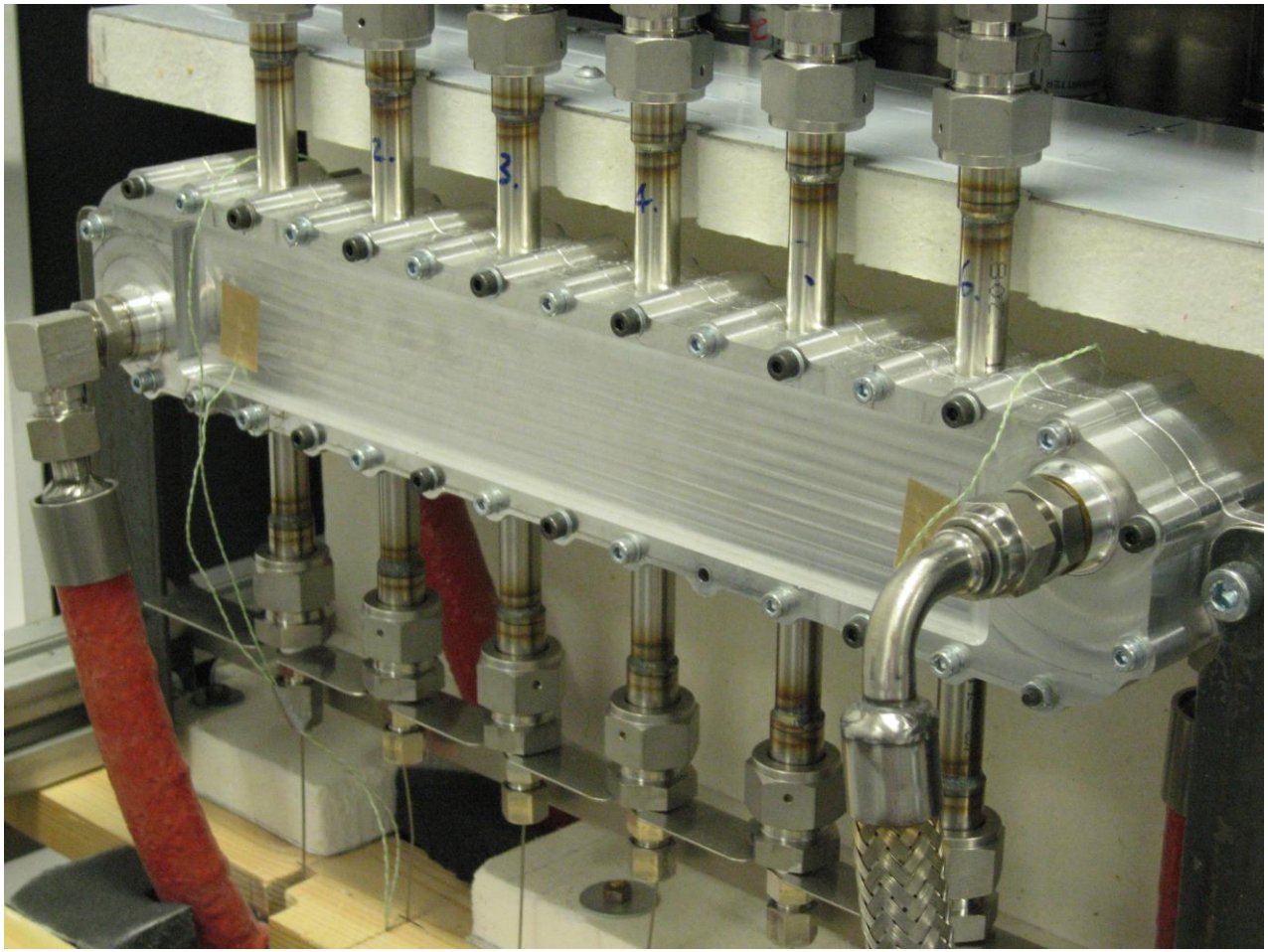


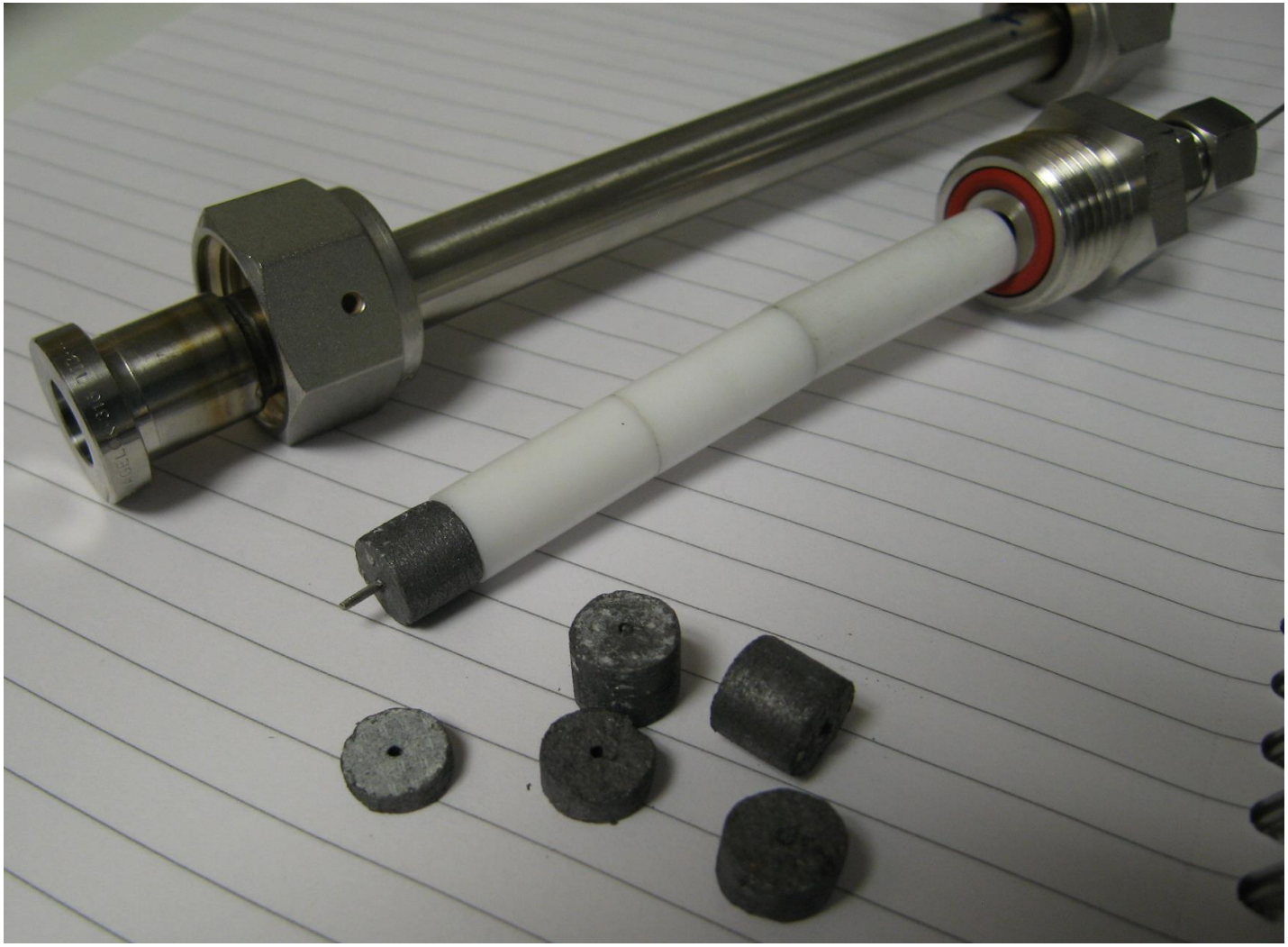



Hot
Cold

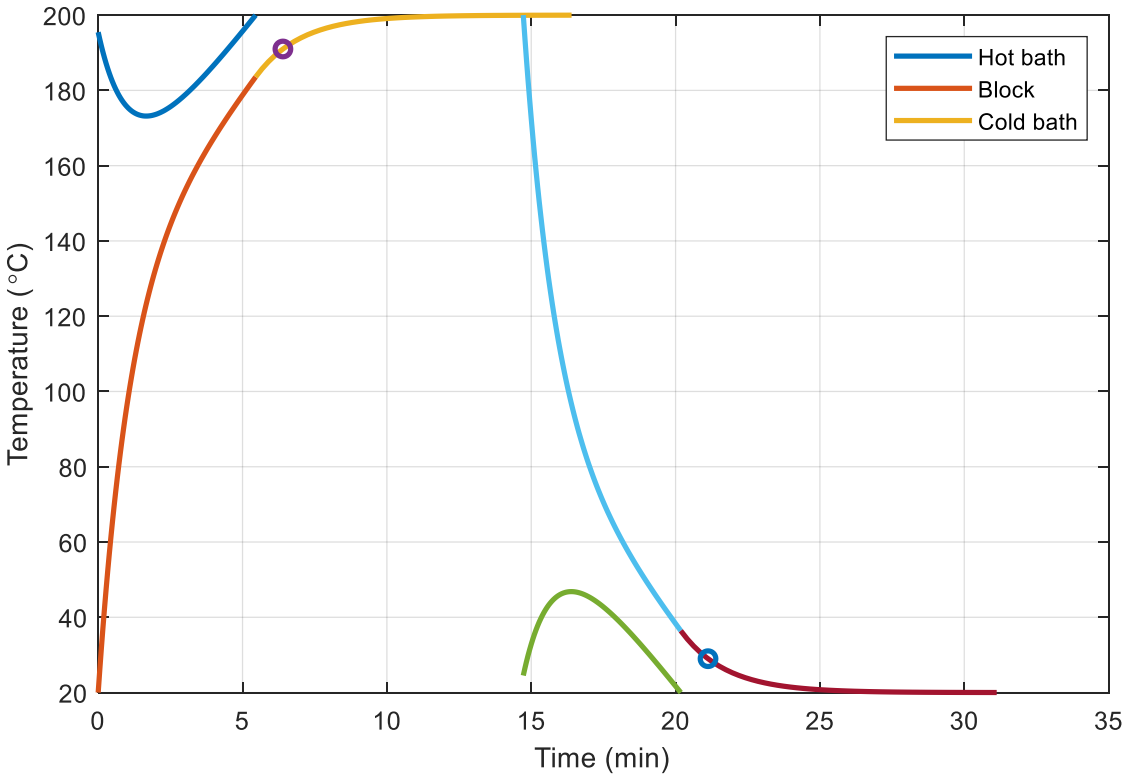
Outer casing

“Inner” insulated box

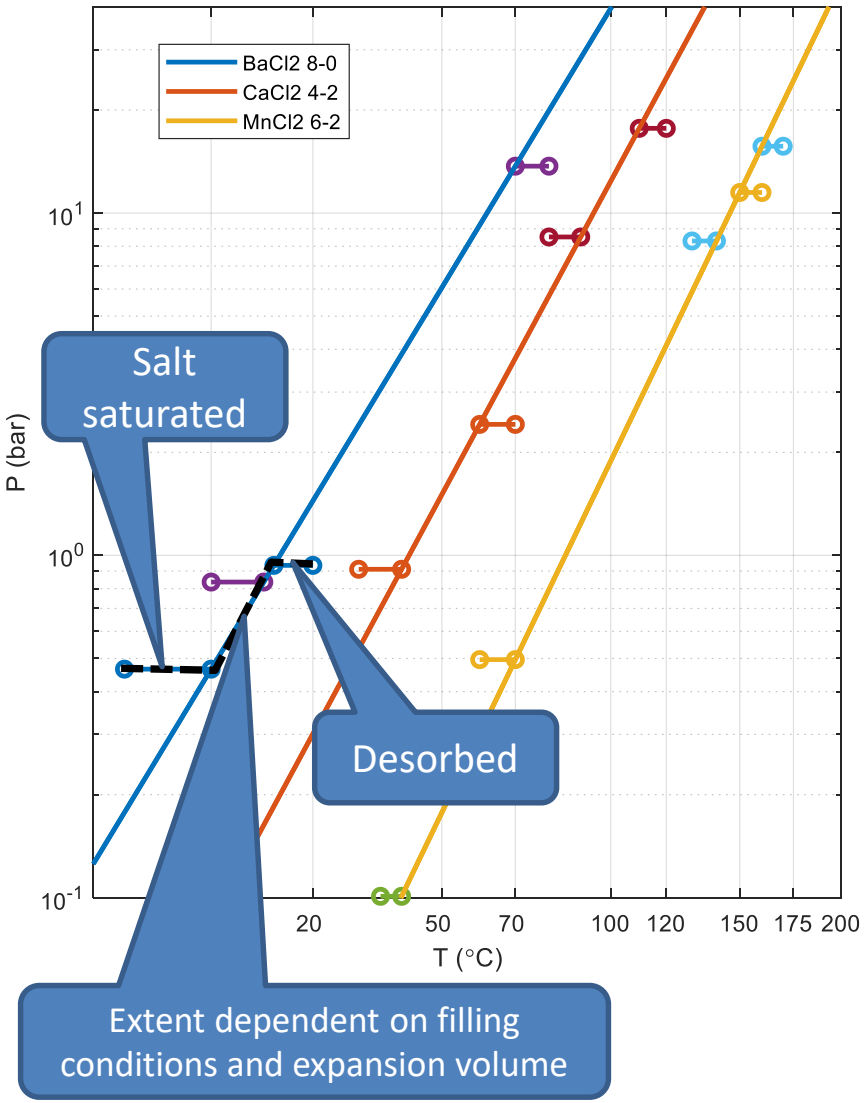


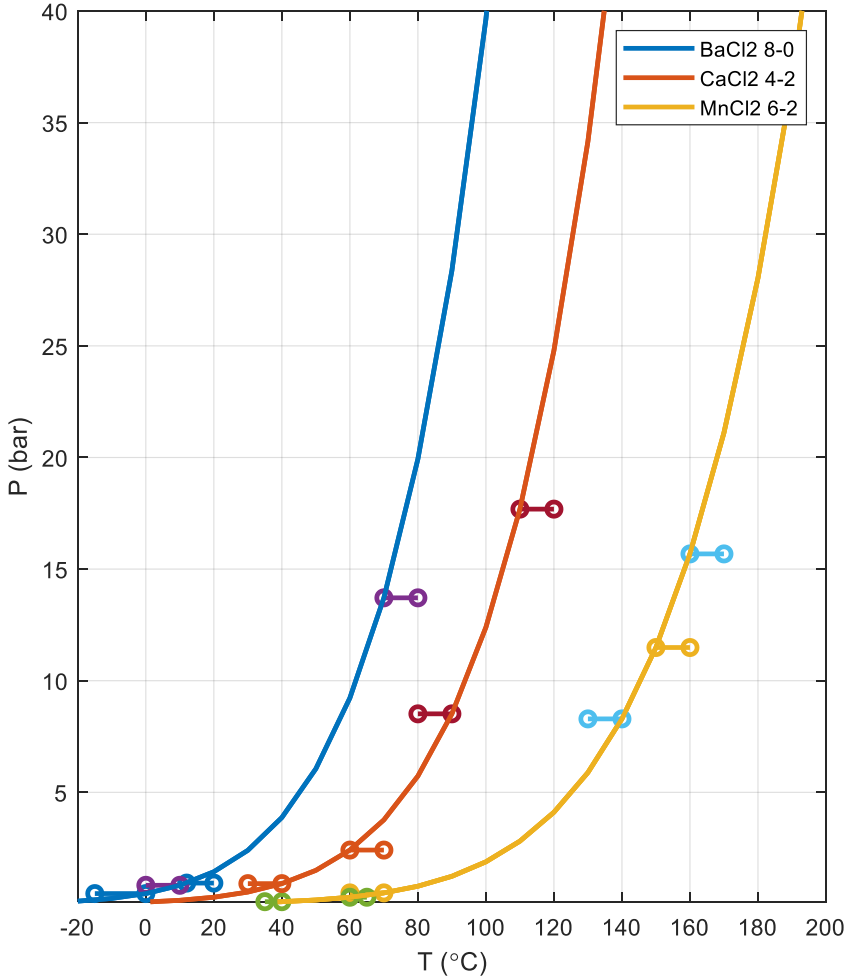


Linked ODE solution for oil bath and heat exchanger block temperatures.

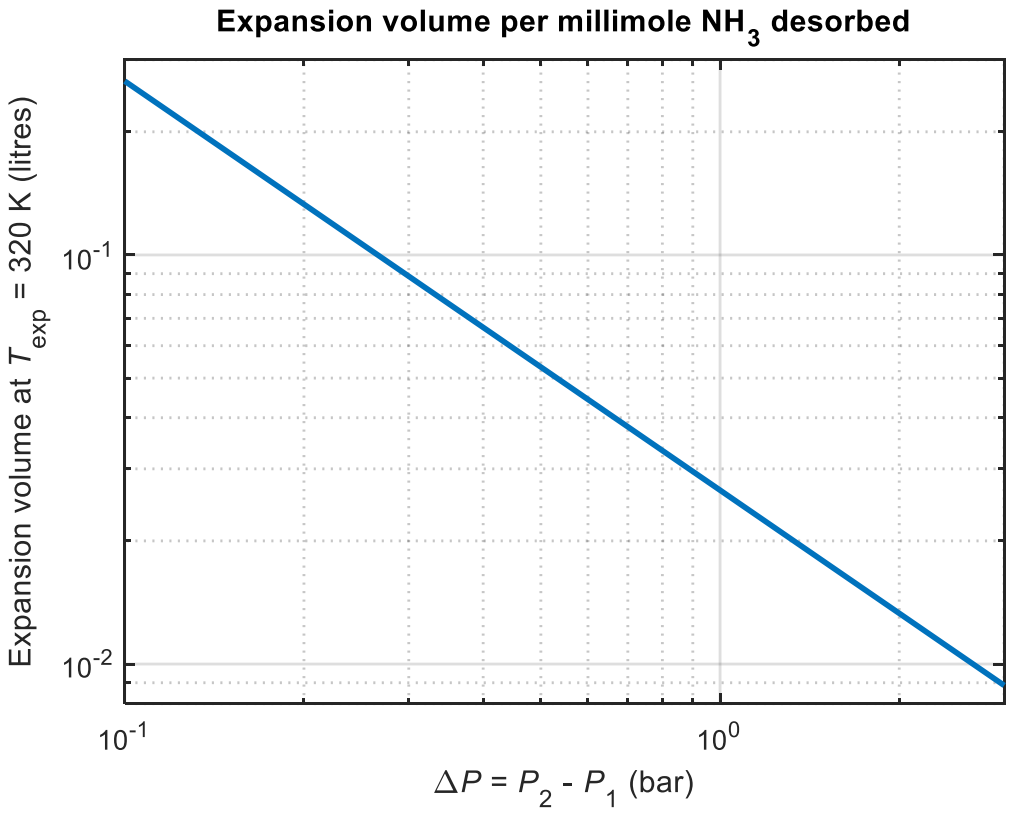


Regions of interest





Expansion volume requirements.

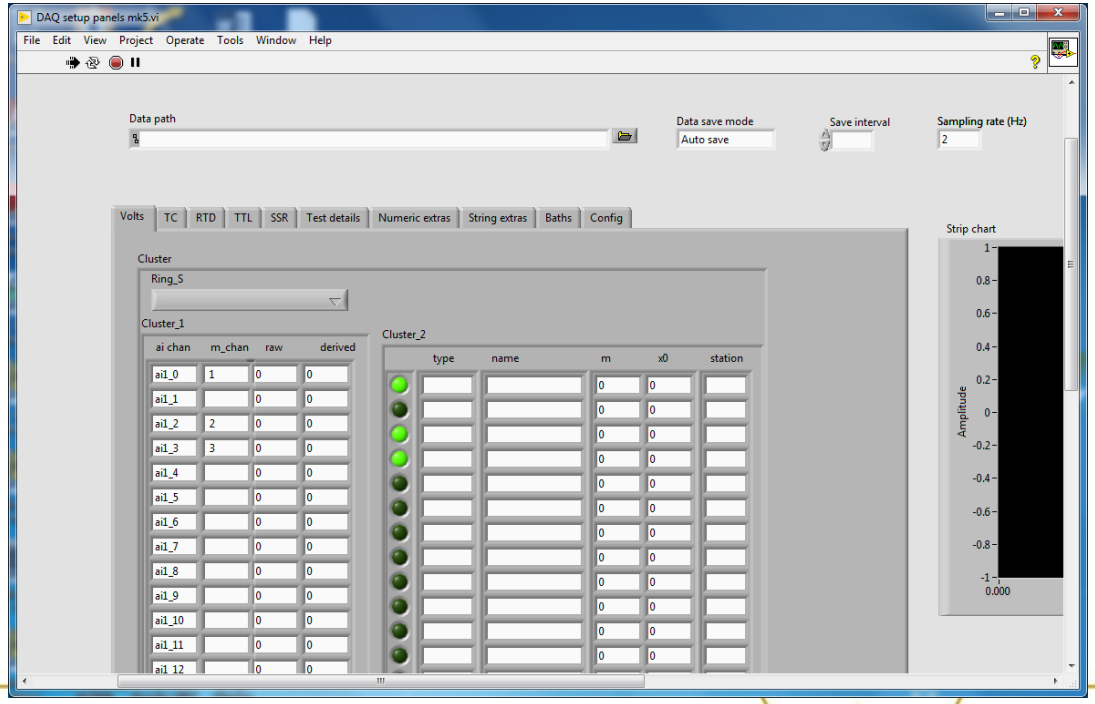


Per disk:

	Salt (g)	NH_3 (mMol)
$BaCl_2$ 8-0	0.16	6.1
$CaCl_2$ 4-2	0.24	4.3

LabView control program controlling NI cDAQ chassis:

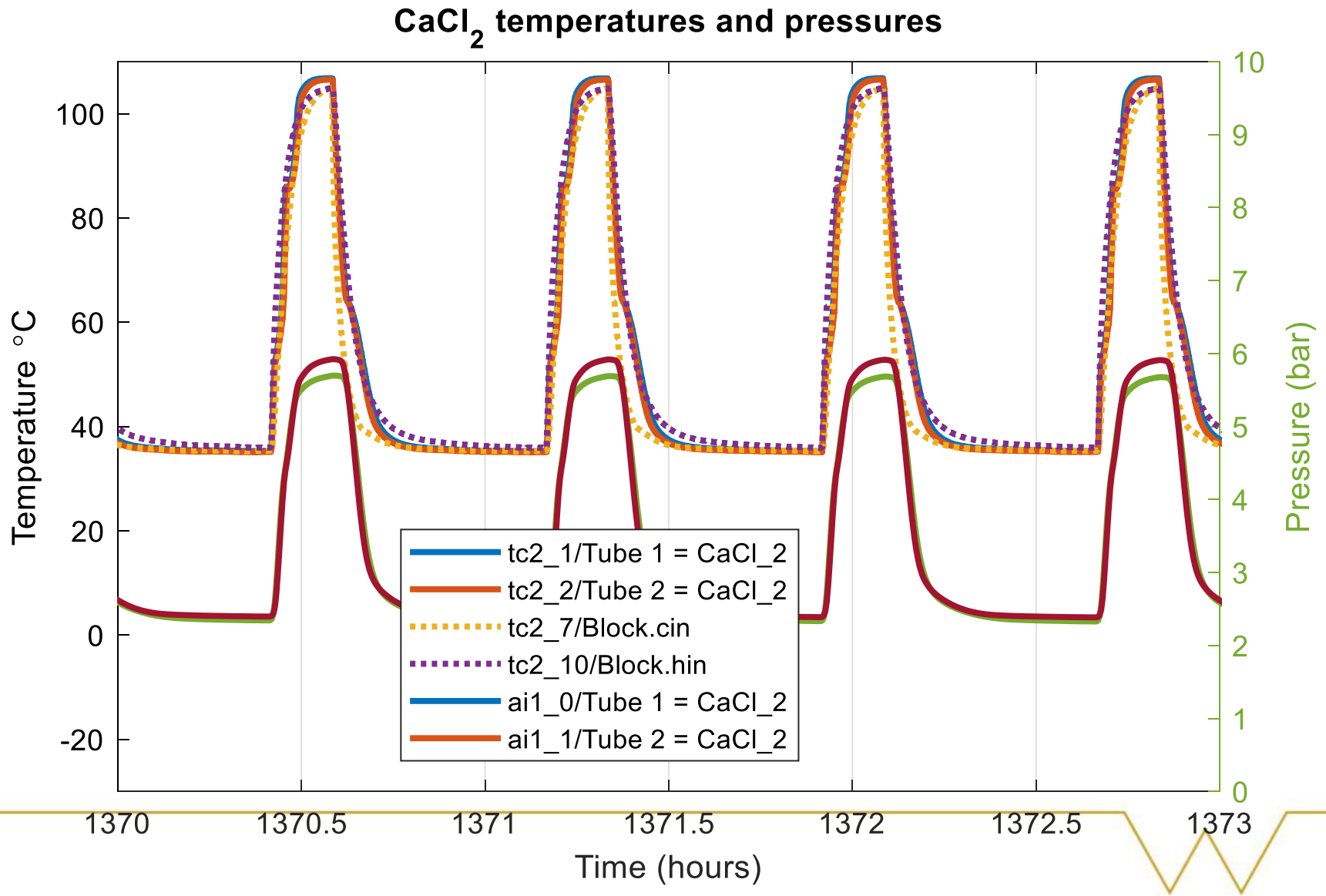
- Valve control for hot/cold baths via pneumatic relays
- Pressure and temperature monitoring and logging
- Saves data automatically to Matlab binary files to allow analysis during the test period.



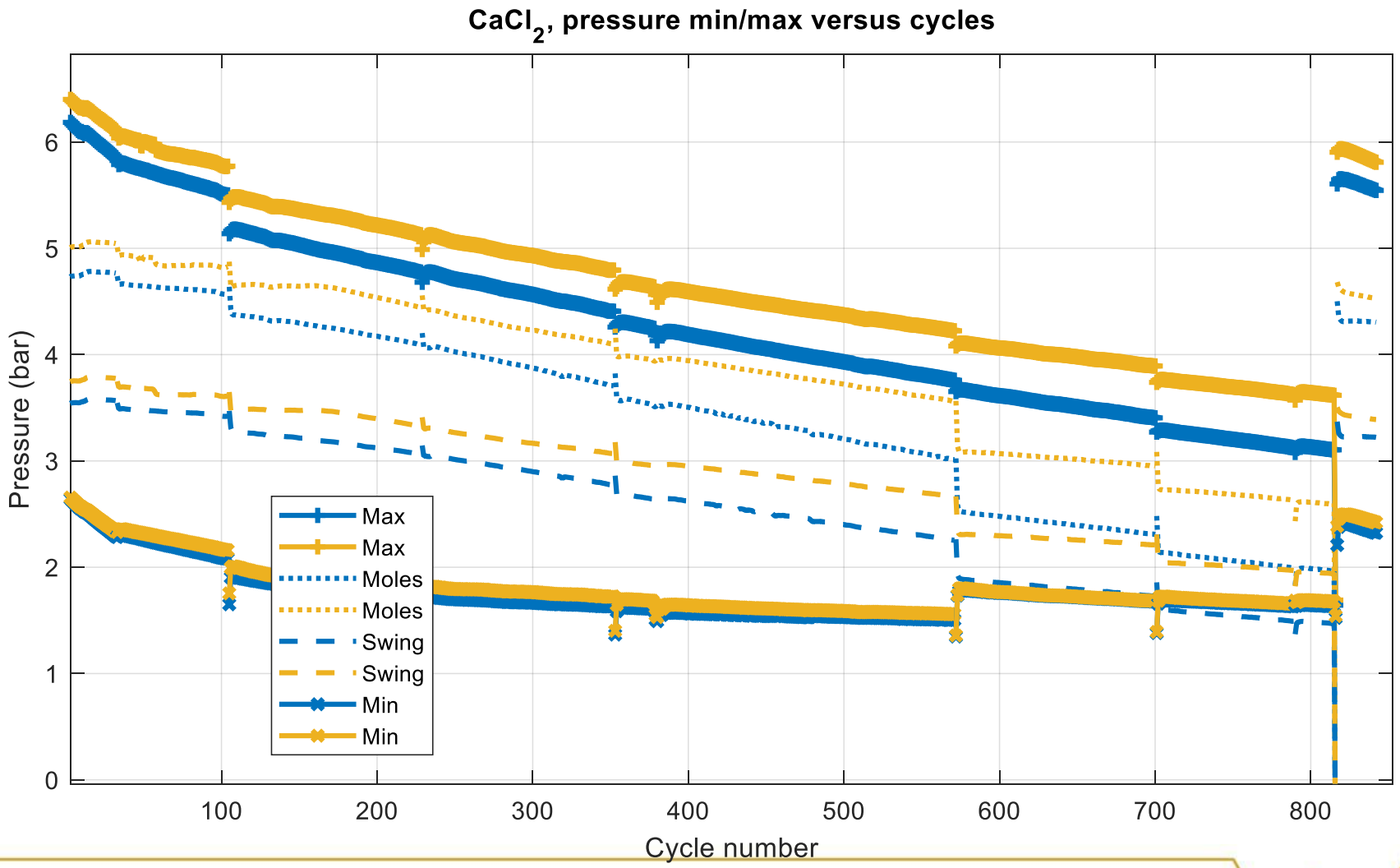
Test history

	cycles	total	Tmin	Tmax	
190807d	31	32	35	110	45 min
190810a	72	104	35	110	
190819b	124	228	35	110	
recharge					
190823c	124	352	35	110	
190829c	219	571	35	110	
190916b	129	700	35	110	
190927b	89	789	35	110	
190930a	27	816	35	150	
recharge					
191001b	26	842	35	110	
191002a	2	844	35	110	2 hr cycle
Suck down and recharge					
191002d	24+	887	35	110	

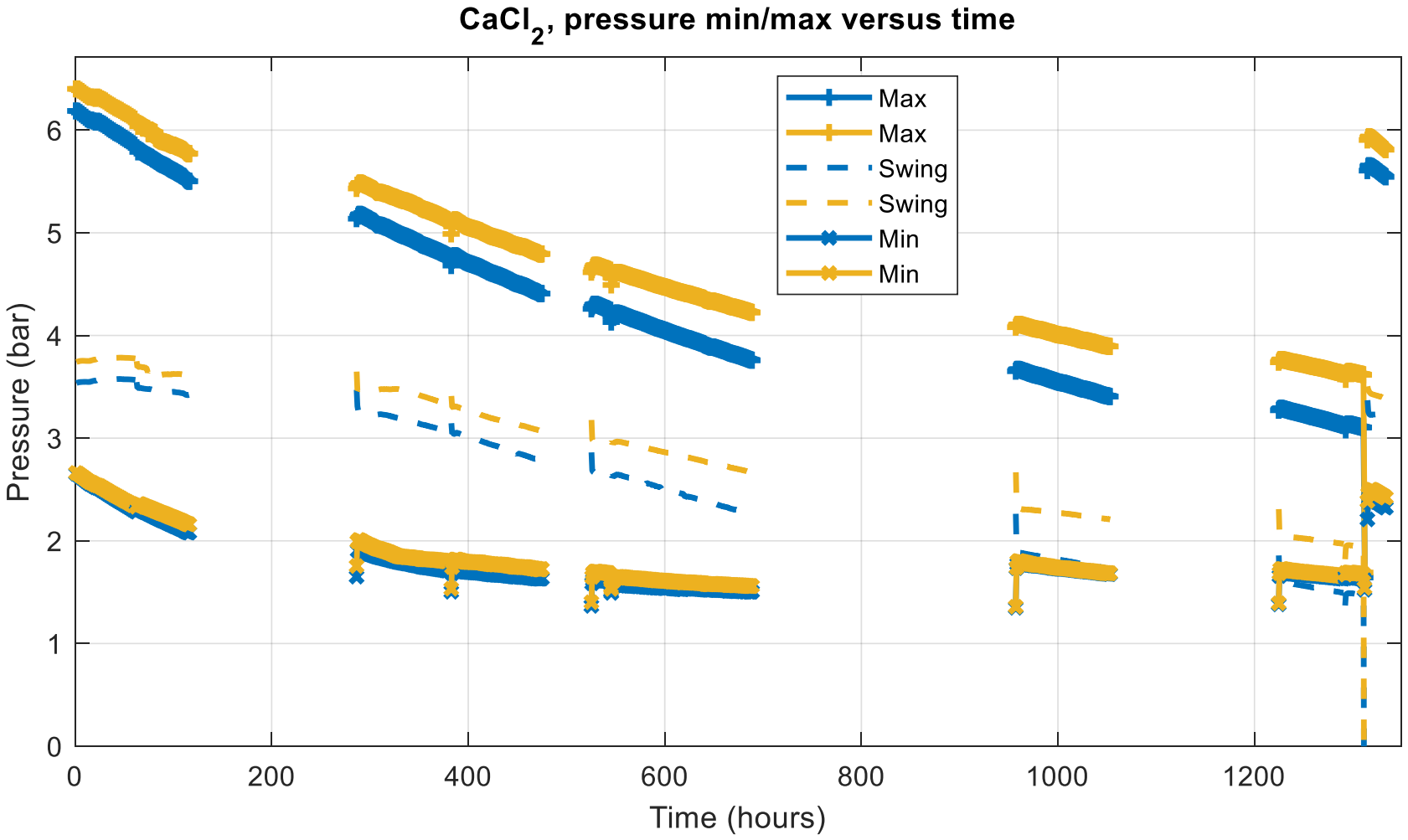
Calcium chloride



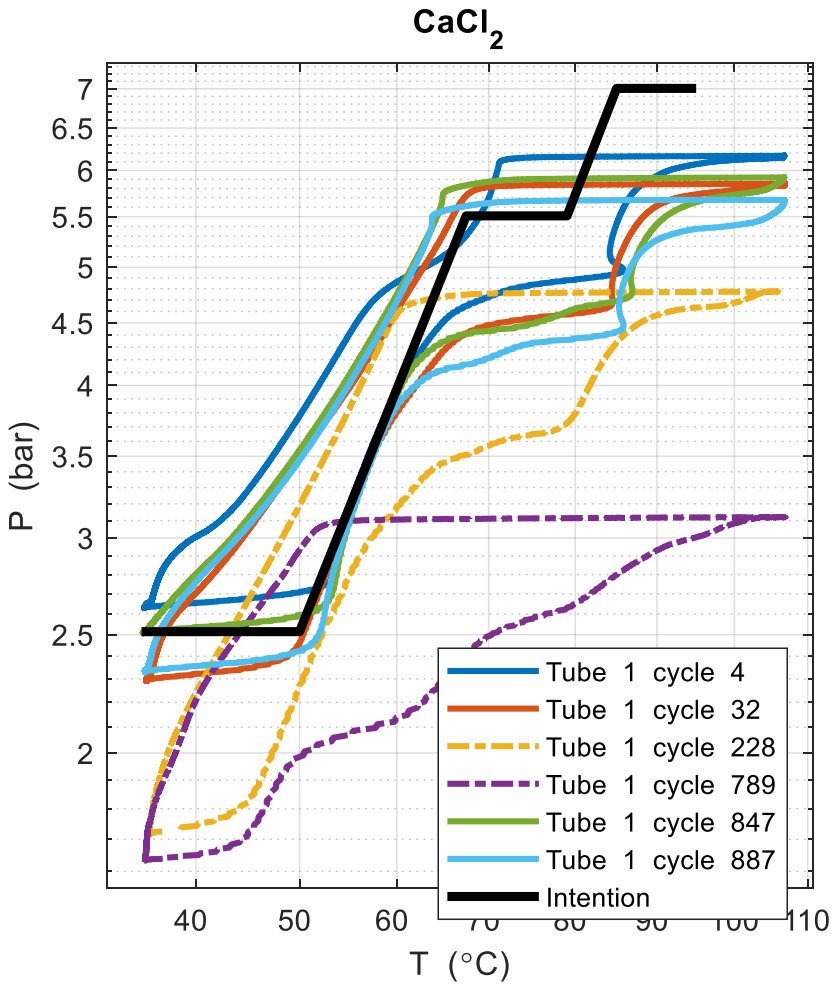
Calcium chloride

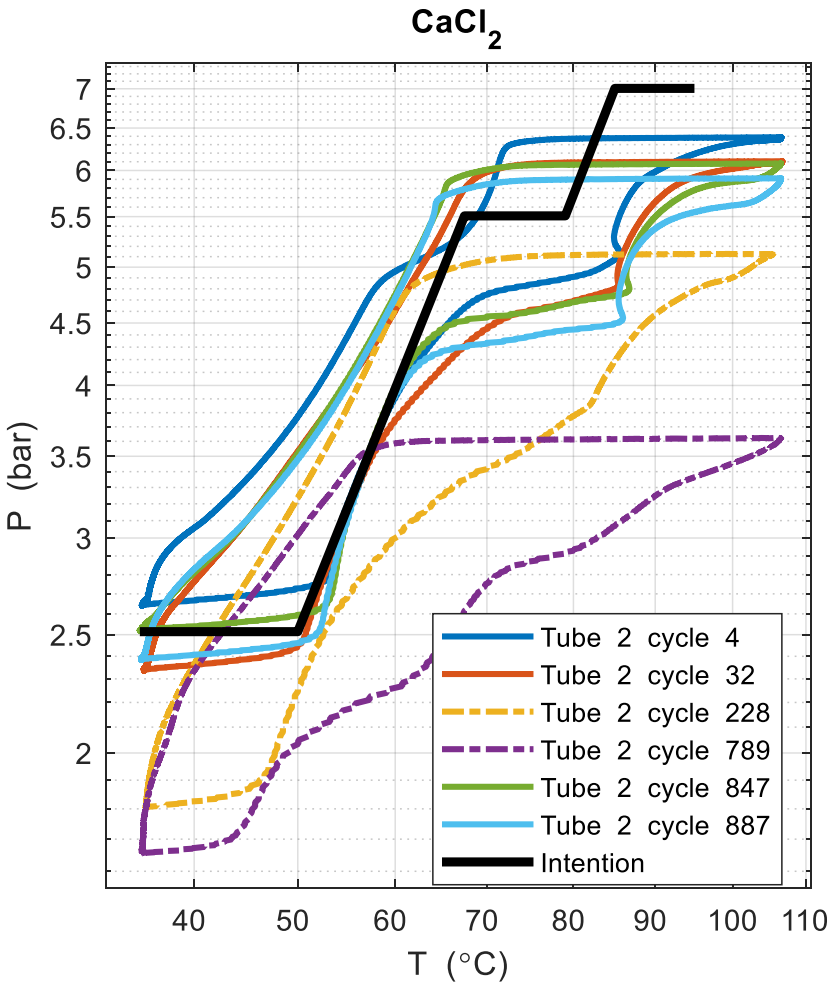


Tubes 1&2

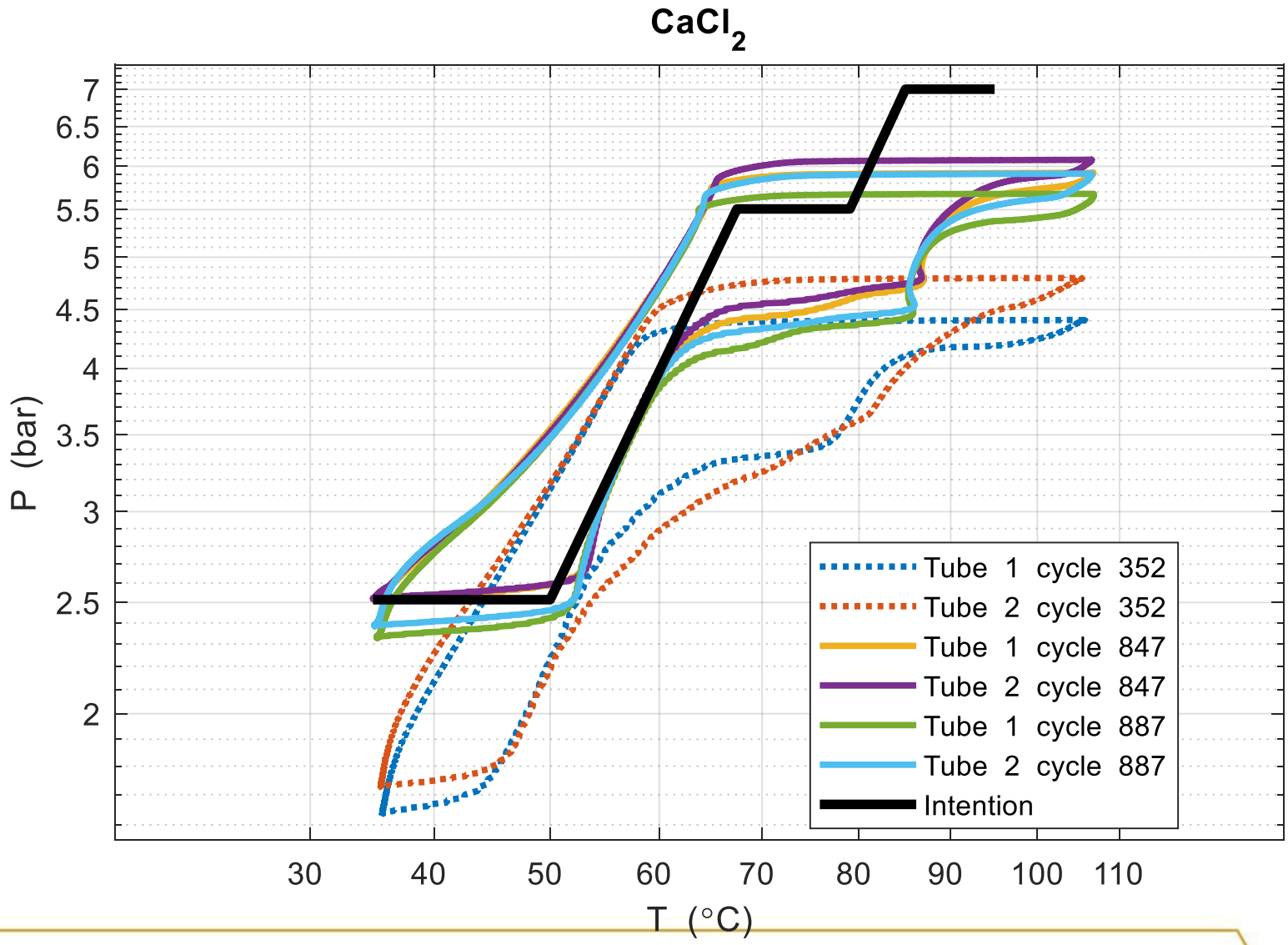

CaCl2, pressure min/max versus time
Max
Max
Swing
Swing
Min
Min
Pressure (bar)
Time (hours)
0
1
2
3
4
5
6
0
200
400
600
800
1000
1200

Tubes 1 & 2

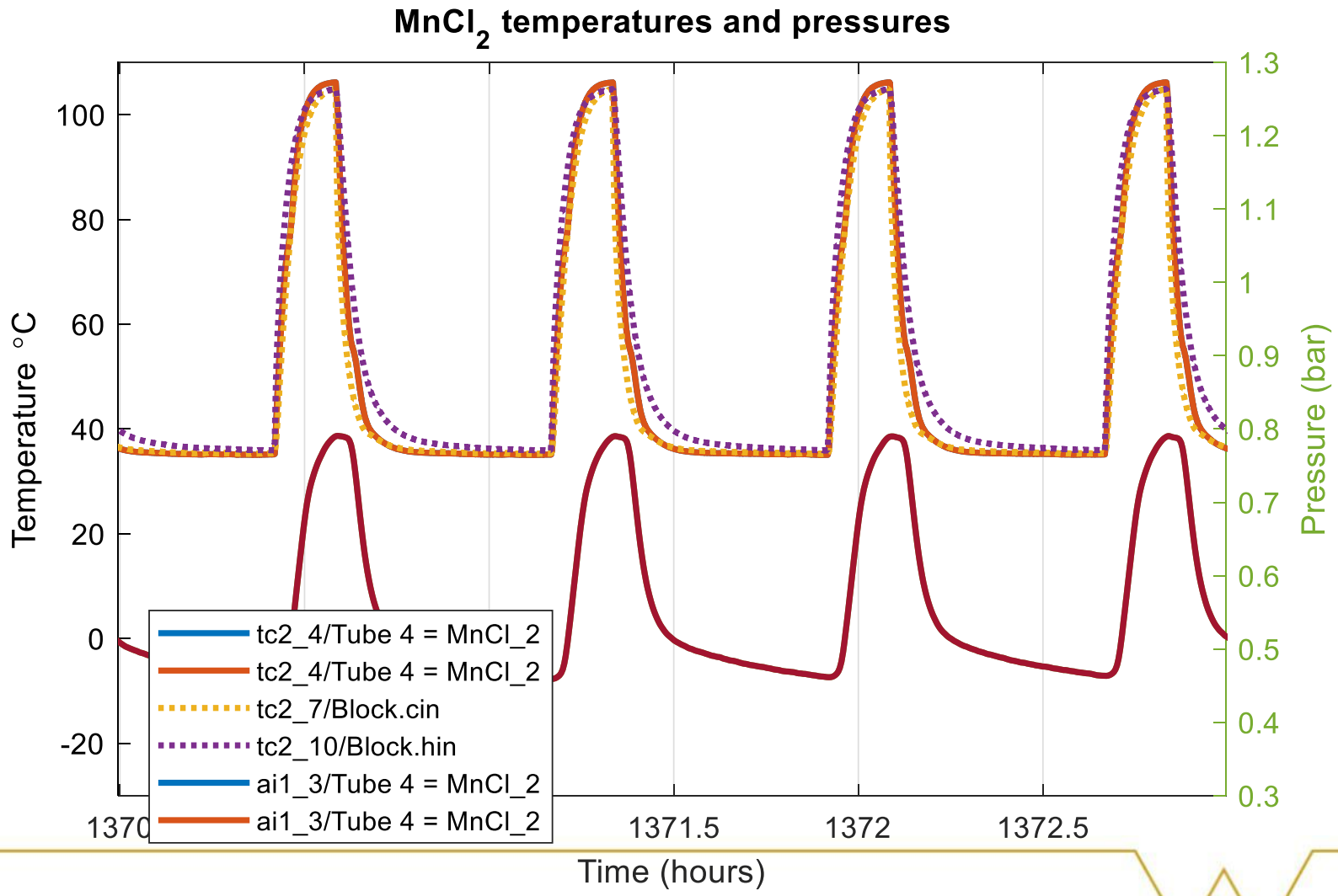

CaCl2
P (bar)
T (°C)
Tube 1 cycle 4
Tube 1 cycle 32
Tube 1 cycle 228
Tube 1 cycle 789
Tube 1 cycle 847
Tube 1 cycle 887
Intention


CaCl2
P (bar)
T (°C)
Tube 2 cycle 4
Tube 2 cycle 32
Tube 2 cycle 228
Tube 2 cycle 789
Tube 2 cycle 847
Tube 2 cycle 887
Intention

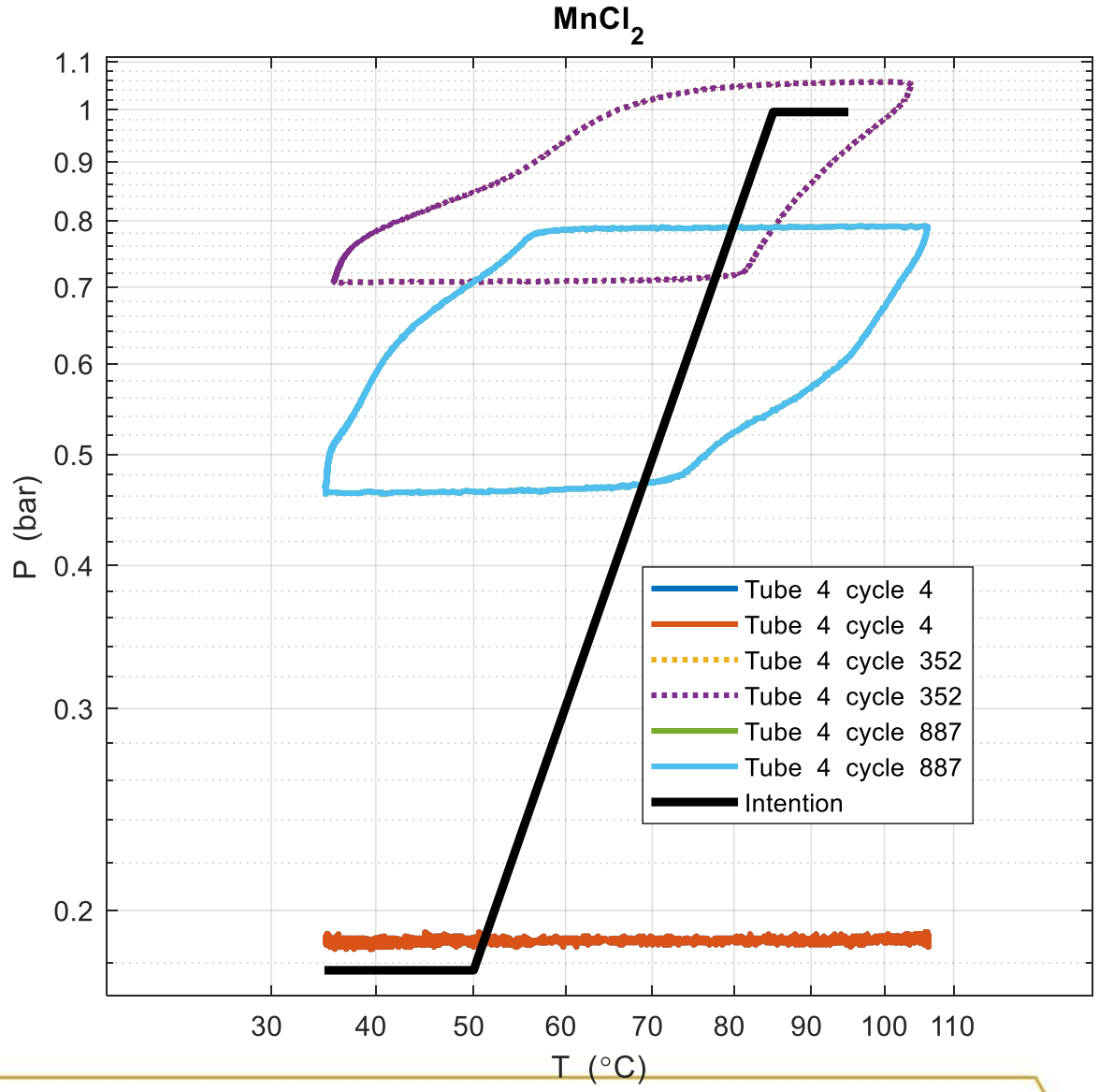
Tubes 1&2


CaCl2
P (bar)
T (°C)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
30
40
50
60
70
80
90
100
110
Tube 1 cycle 352
Tube 2 cycle 352
Tube 1 cycle 847
Tube 2 cycle 847
Tube 1 cycle 887
Tube 2 cycle 887
Intention

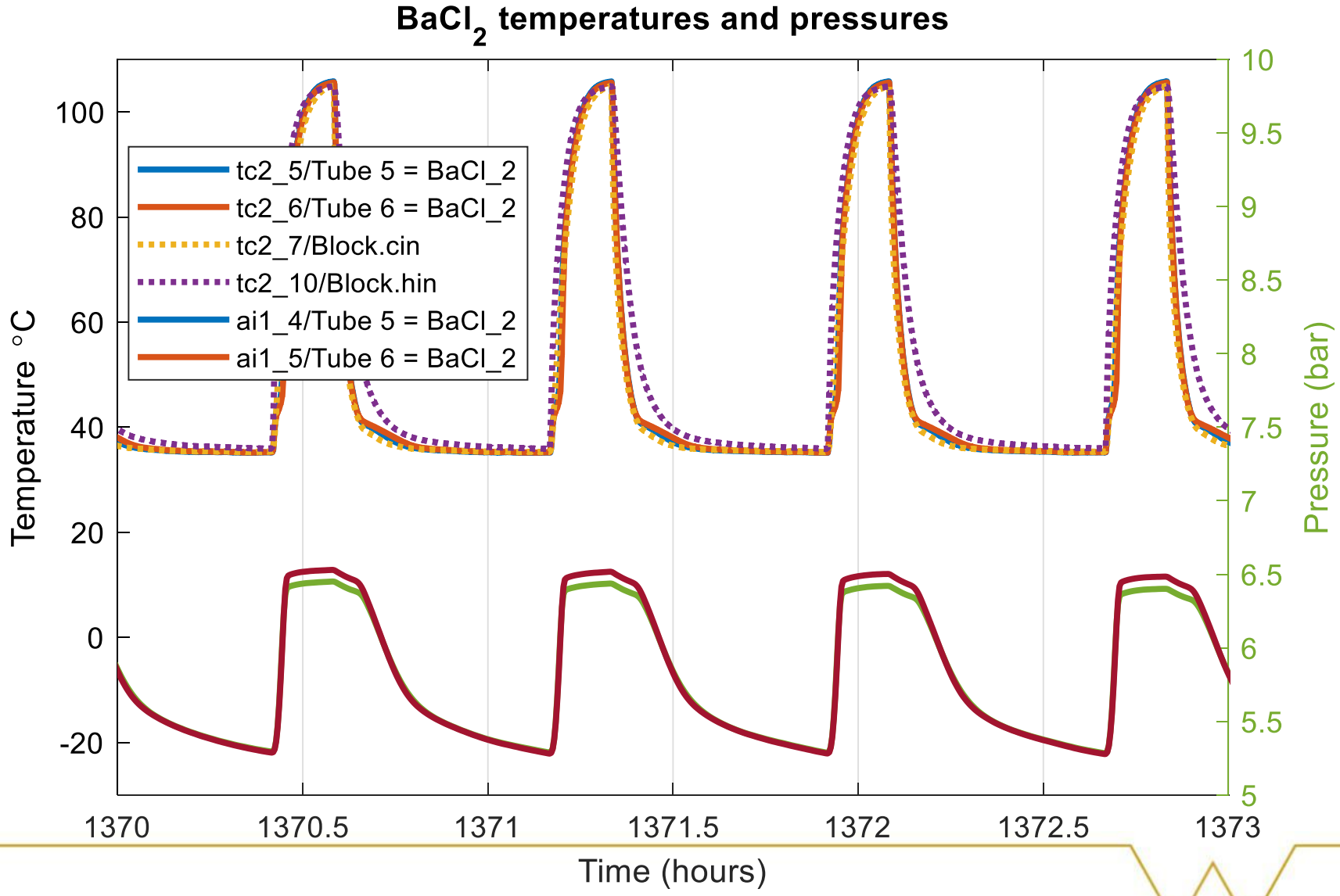
Manganese chloride



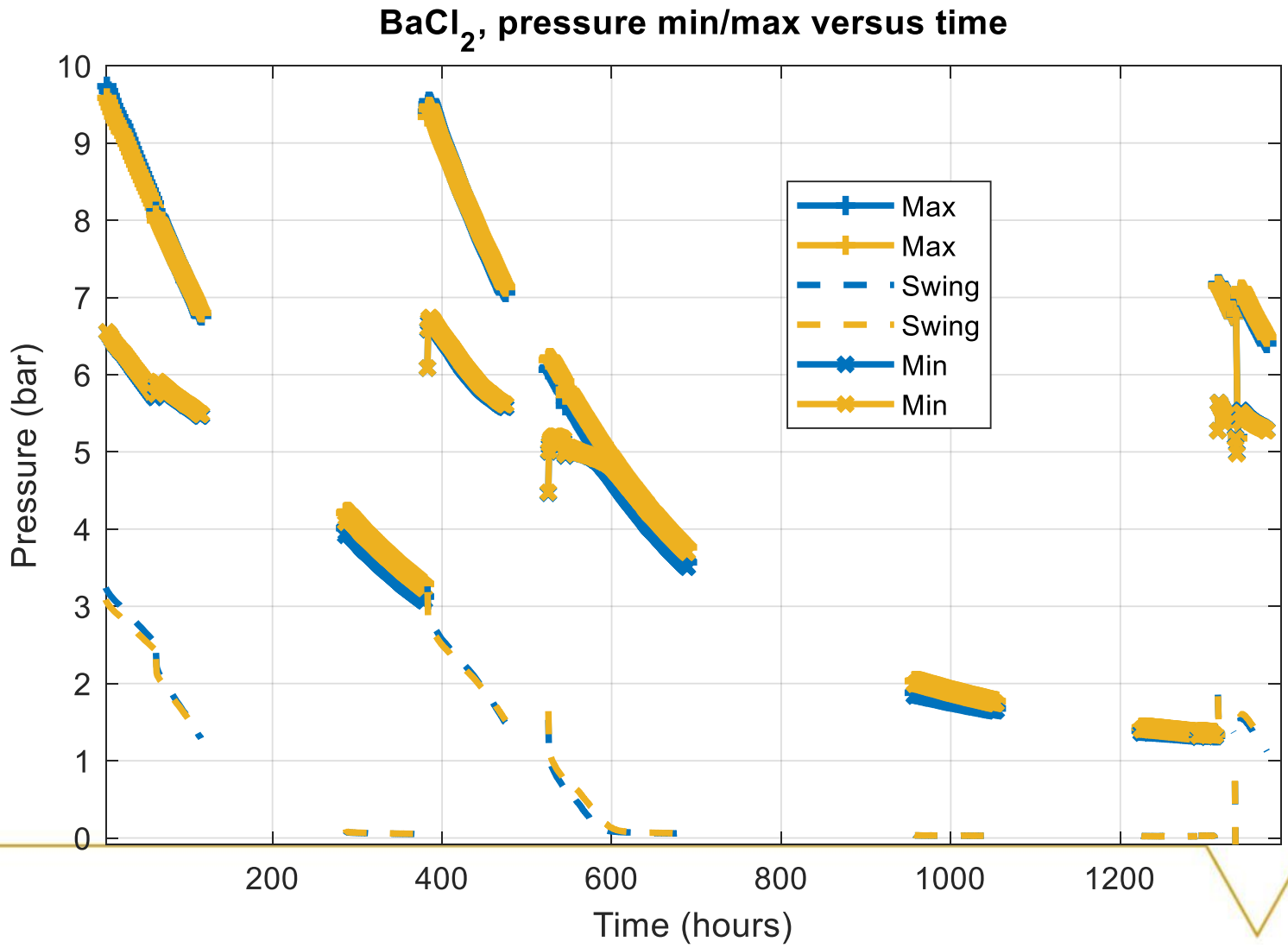
Tube 4


MnCl2
P (bar)
T (°C)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
30
40
50
60
70
80
90
100
110
Tube 4 cycle 4
Tube 4 cycle 4
Tube 4 cycle 352
Tube 4 cycle 352
Tube 4 cycle 887
Tube 4 cycle 887
Intention

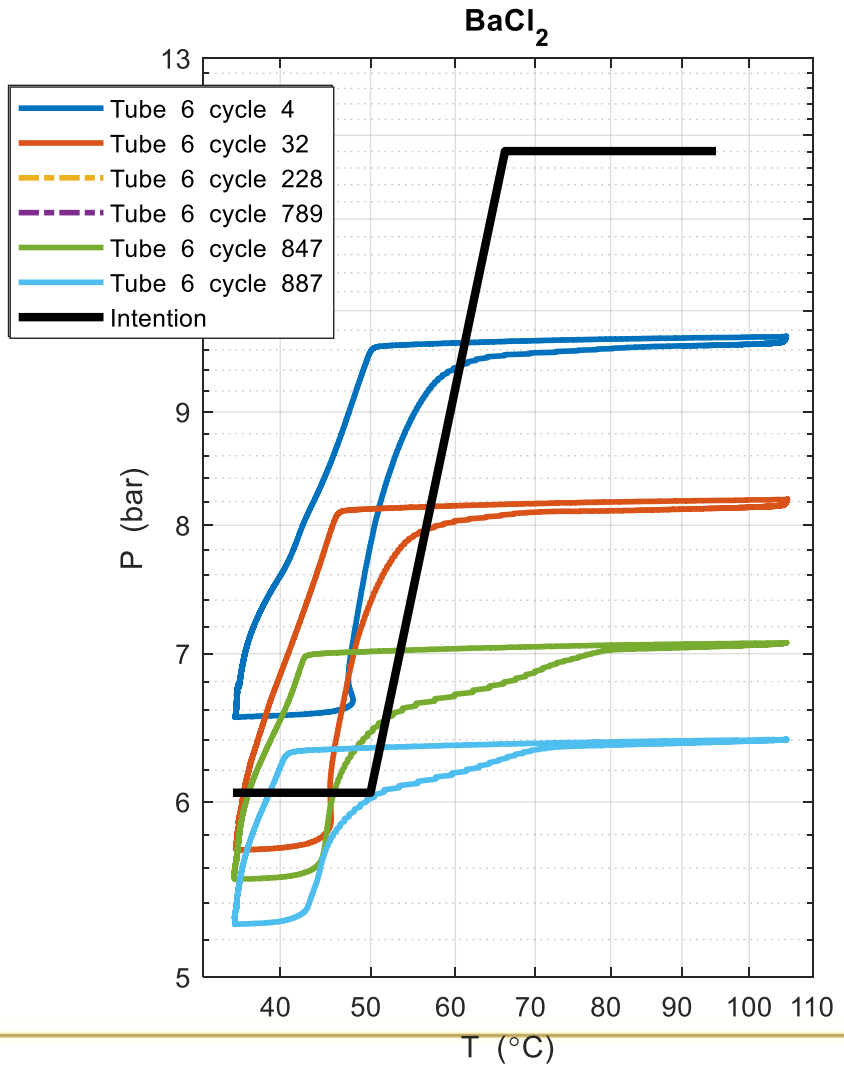
Barium chloride

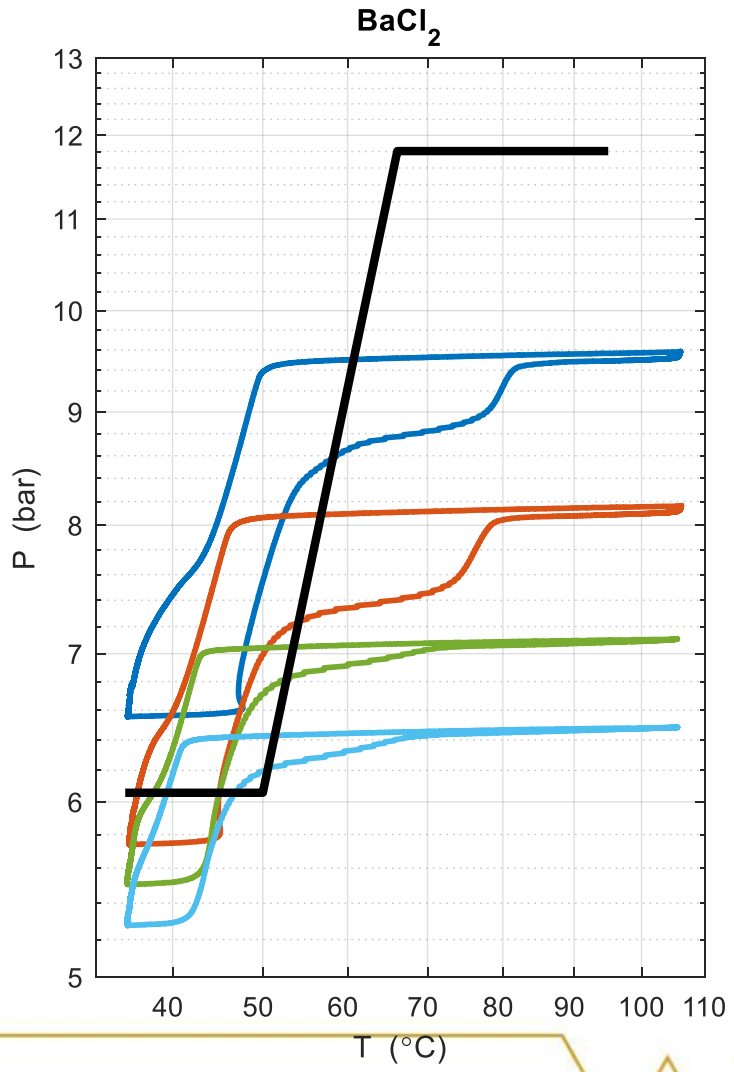


Tubes 5&6


BaCl2, pressure min/max versus time
Pressure (bar)
Time (hours)
0
1
2
3
4
5
6
7
8
9
10
200
400
600
800
1000
1200
Max
Max
Swing
Swing
Min
Min

Tubes 5&6


BaCl2
Tube 6 cycle 4
Tube 6 cycle 32
Tube 6 cycle 228
Tube 6 cycle 789
Tube 6 cycle 847
Tube 6 cycle 887
Intention
P (bar)
T (°C)


BaCl2
P (bar)
T (°C)