

FINAL REPORT INITIAL TEST RAL GZ 896

PCM t-t 5.5 CH 07-2020

Customer:

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Contractor:

Wärme- und anwendungstechnische Prüfungen
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1. preliminary remark

Axiotherm GmbH commissioned the company w&a, wärme- und anwendungstechnische Prüfungen Andreas Laube, as a RAL GZ 896 approved test centre, to carry out a cycling test 500 cycles of the PCM t-t 5.5. The PCM is an organic substance with additives for thickening. Segregation is therefore not important.

This is the final report of the test.

The test was carried out in accordance with the quality and testing regulations of the PCM Quality Association (March 2018 edition).

2. phase transition temperature range and stored thermal energy (quality criterion 1)

2.1 Sampling

4 samples of 100ml (77g) each from the PCM t-t 5.5 sample were filled in an aluminium composite foil airtight and sealed.

Sample 4 is for external measurement, this sample was not cycled.

2.2 Density

The density of PCM t-t 5.5 is 0.75 kg/l at 20 °C

2.3 Measurement method

The determination of the heat storage capacity was carried out using 3-layer calorimeters from the company w&a. A Binder KB53 cooled incubator was used to provide the required temperature levels.

2.4 Calibration of the device

Calibration of the device is done by means of C16-99.

The calibration of the device is carried out every 6 months

Last control measurement took place on 20.05.2020

Heat quantity C16-99: 265 J/g (10 - 25°C)

Measurement accuracy +/- 5%.

2.5 Measuring range / measuring programme

Starting temperature of the sample: 20°C

Climatic chamber : 17 hours 20°C

17 hours -10°C

2.6 Evaluation range

The evaluation range is -2 - 13°C

3. individual results enthalpy - temperature curve

3.1 PCM t-t 5.5

3.1.1 measured samples

sample 1: 100ml - 77,42g

sample 2: 100ml - 77,29g

sample 3: 100ml - 77,11g

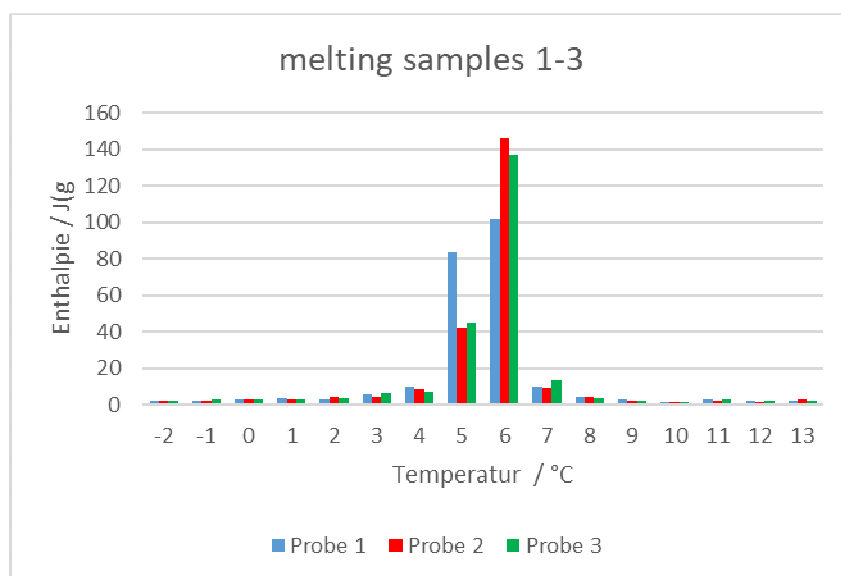
Retention sample 4: 100ml - 77.22g (uncycled sample)

3.1.2 Results of the single zero measurements

melting

	melting sample 1		melting sample 2		melting sample 3	
Temperatur (°C)	Enthalpie (J/g)	Enthalpie (J/ml)	Enthalpie (J/g)	Enthalpie (J/ml)	Enthalpie (J/g)	Enthalpie (J/ml)
-2	2,4	1,9	2,6	2,0	2,2	1,7
-1	2,2	1,7	2,3	1,8	3,0	2,3
0	3,0	2,3	3,0	2,3	3,2	2,5
1	3,5	2,7	2,7	2,1	2,9	2,3
2	3,2	2,5	4,1	3,2	3,5	2,7
3	6,1	4,7	4,6	3,5	6,3	4,8
4	10,0	7,7	8,6	6,7	7,3	5,6
5	83,5	64,3	42,0	32,3	44,7	34,5
6	102,0	78,6	146,5	112,8	137,3	105,7
7	10,1	7,8	9,1	7,0	13,8	10,6
8	4,6	3,6	4,1	3,2	3,7	2,8
9	3,0	2,3	2,5	1,9	2,2	1,7
10	1,6	1,2	1,6	1,2	1,4	1,0
11	2,9	2,3	2,5	1,9	3,1	2,4
12	2,3	1,8	1,6	1,2	2,1	1,6
13	2,3	1,8	2,7	2,1	2,2	1,7
Summe:	243,0	187,1	240,6	185,2	238,9	183,9

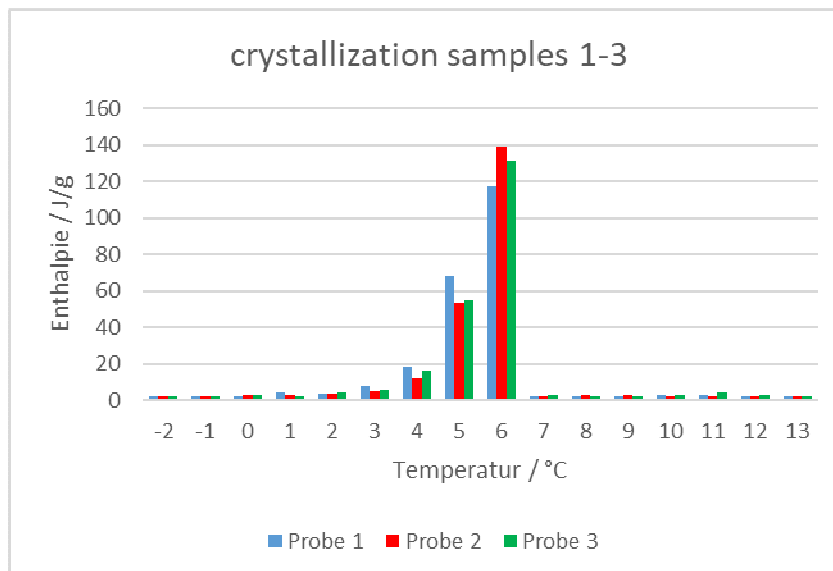
mean value: 240,8 J/g, 185,4 J/ml



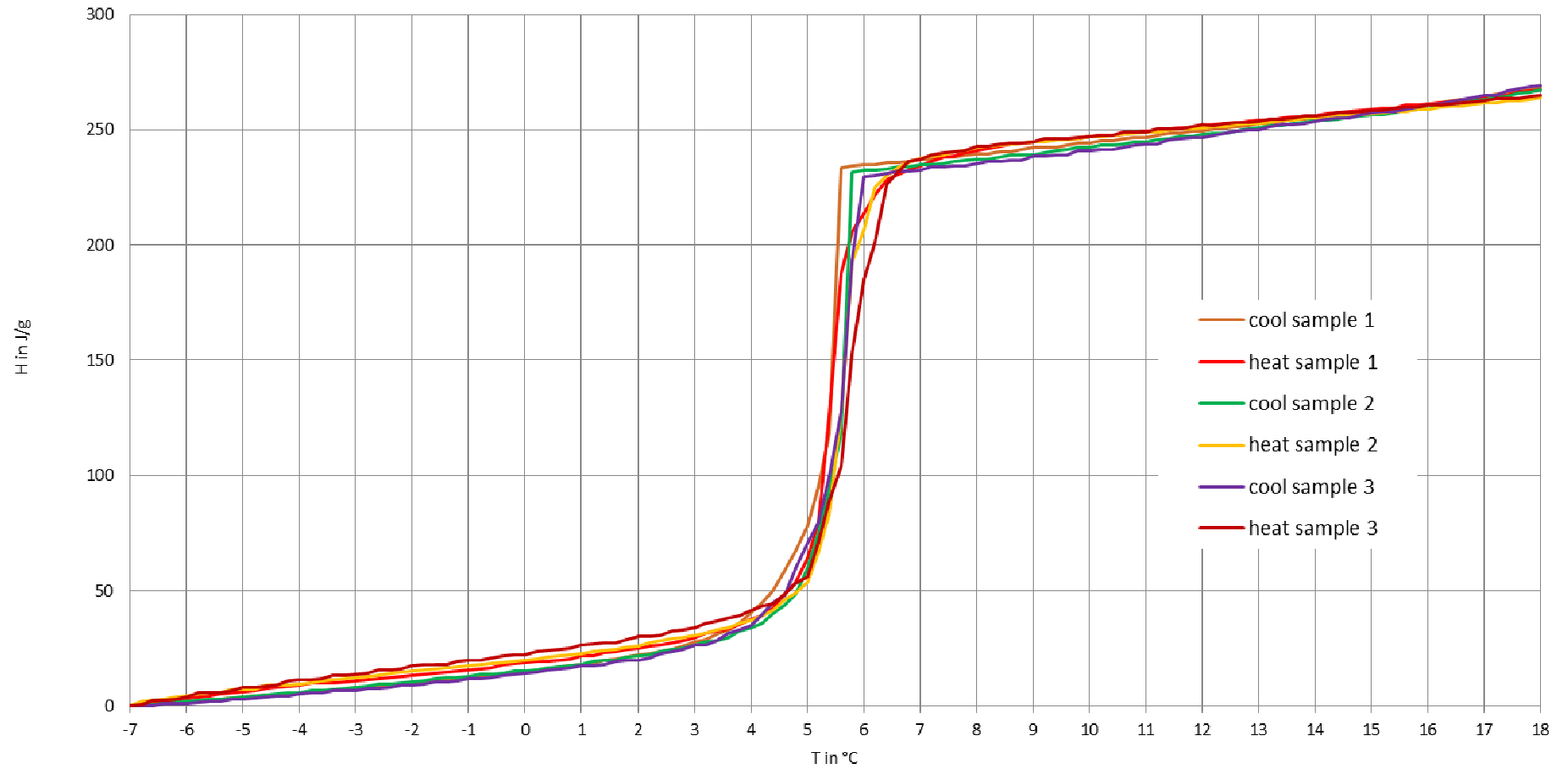
crystallization

	crystallization sample 1		crystallization sample 2		crystallization sample 3	
Temperatur	Enthalpie	Enthalpie	Enthalpie	Enthalpie	Enthalpie	Enthalpie
(°C)	(J/g)	(J/ml)	(J/g)	(J/ml)	(J/g)	(J/ml)
-2	2,4	1,9	2,4	1,9	2,5	1,9
-1	2,3	1,8	2,1	1,6	2,2	1,7
0	2,5	1,9	2,6	2,0	3,2	2,4
1	4,0	3,1	3,2	2,5	2,4	1,9
2	3,6	2,8	3,8	2,9	4,4	3,4
3	7,5	5,8	4,9	3,8	5,6	4,3
4	18,7	14,4	11,9	9,1	16,5	12,7
5	68,4	52,7	53,4	41,1	54,8	42,2
6	117,3	90,3	139,5	107,4	131,6	101,3
7	2,4	1,8	2,0	1,6	2,9	2,2
8	2,5	1,9	2,8	2,2	2,4	1,8
9	2,0	1,6	3,0	2,3	2,5	1,9
10	2,8	2,2	2,4	1,8	2,6	2,0
11	2,9	2,3	2,5	1,9	4,2	3,3
12	2,3	1,8	2,6	2,0	2,8	2,2
13	2,3	1,8	2,3	1,8	2,3	1,8
Summe:	244,2	188,0	241,4	185,9	243,0	187,1

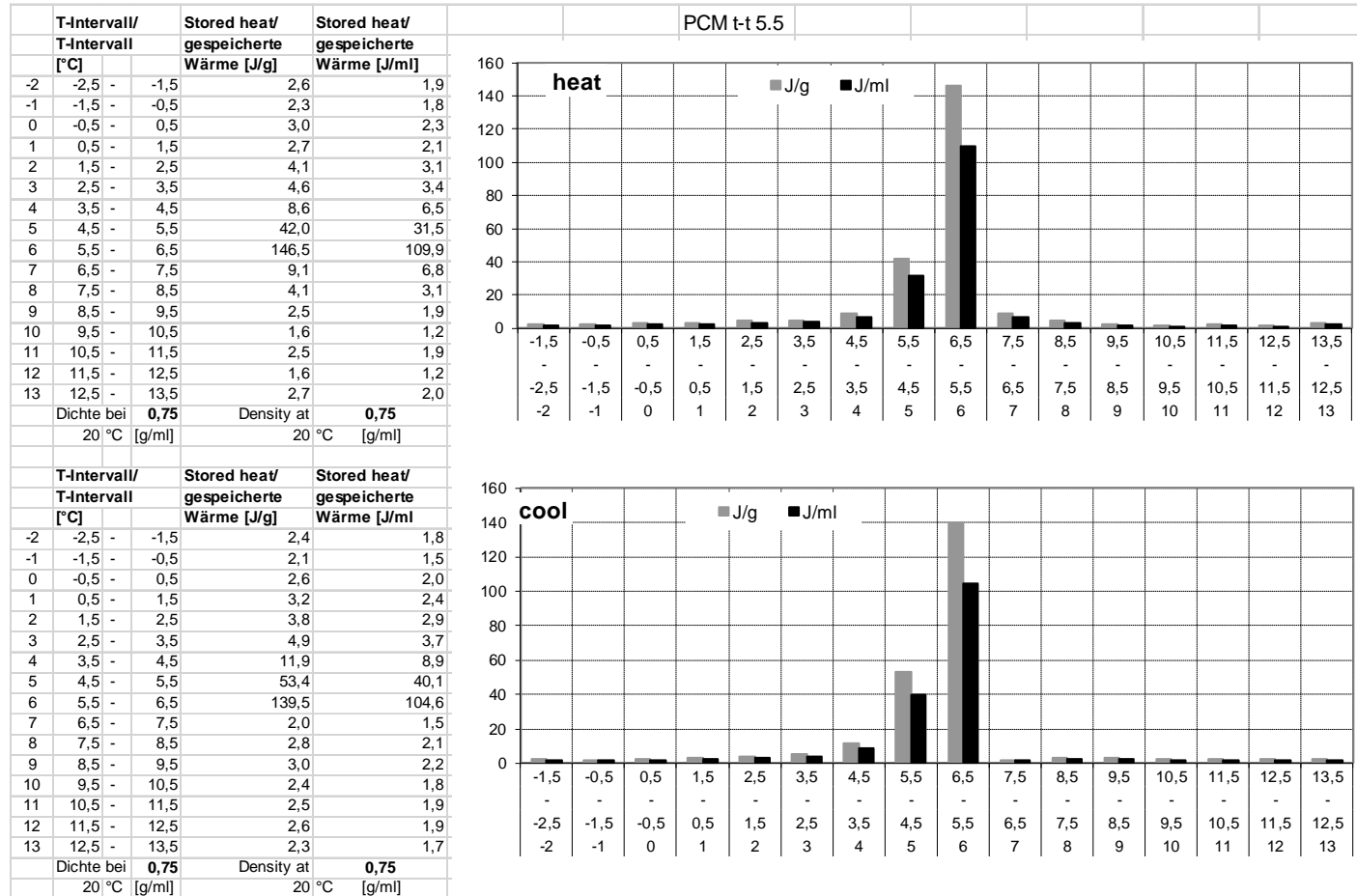
mean value: 242,9 J/g, 187 J/ml

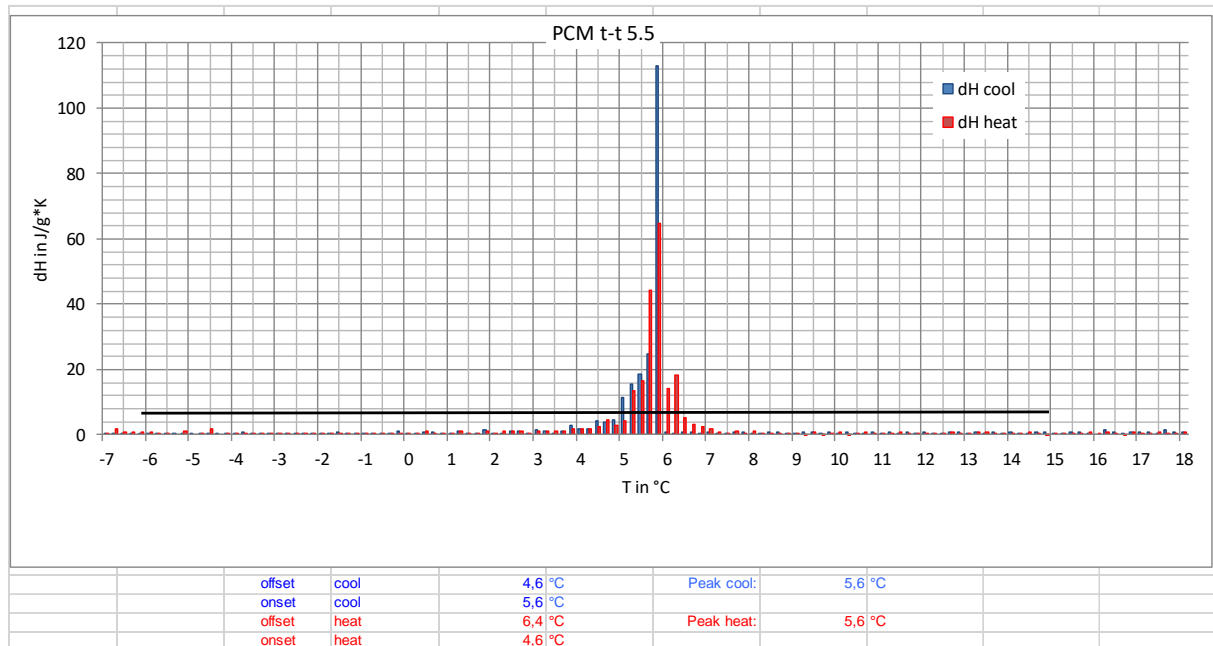


Enthalpy course (25K) samples 1-3 (zero measurement)



RAL diagram using sample 2 as an example (zero measurement)





melting				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	4,6	5,6	6,4	241

crystallization				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	5,6	5,6	4,6	241

4. reproducibility of the phase change

4.1 Cycle method

The samples 1-3 are cycled with the help of the cycle tester ZP204 from w&a. The required heating temperatures are generated by means of heating foils on top and bottom, the cooling temperatures by natural cooling in a freezer at -15°C. The samples remain in the film packaging.

The samples are cycled in a temperature range of -5 - 15°C, at 12 - 13 cycles per day (see diagram 2)

Upper changeover point: 15°C

Lower changeover point: -5°C

The heating temperatures (above and below the samples) are on average 7K above the sample temperature (middle), so a complete "melting" of the samples is guaranteed.

The cooling temperatures (above and below the samples) are on average 10-15K below the sample temperature (middle), so a complete "crystallisation" of the samples is guaranteed. (see diagram 1)

After the respective number of cycles, the samples are taken out of the refrigerator and measured in the 3-layer calorimeter.

4.2 Performing a sample cycle

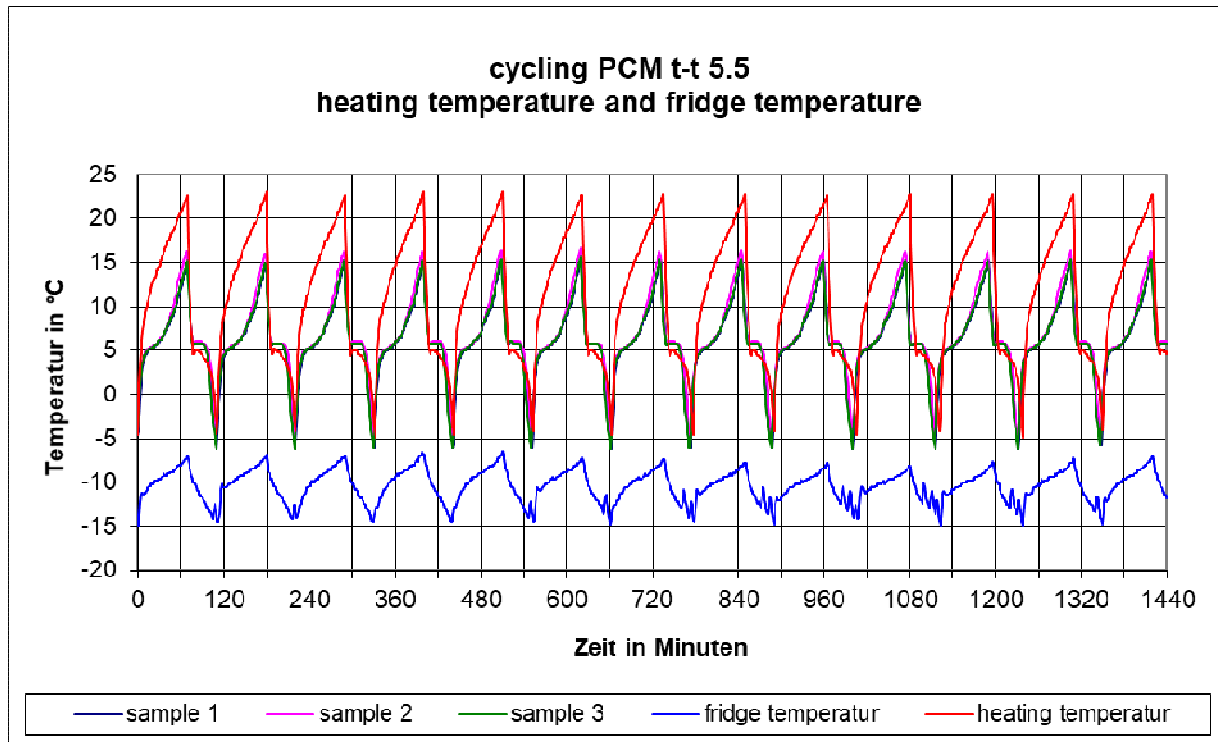


Diagramm 1

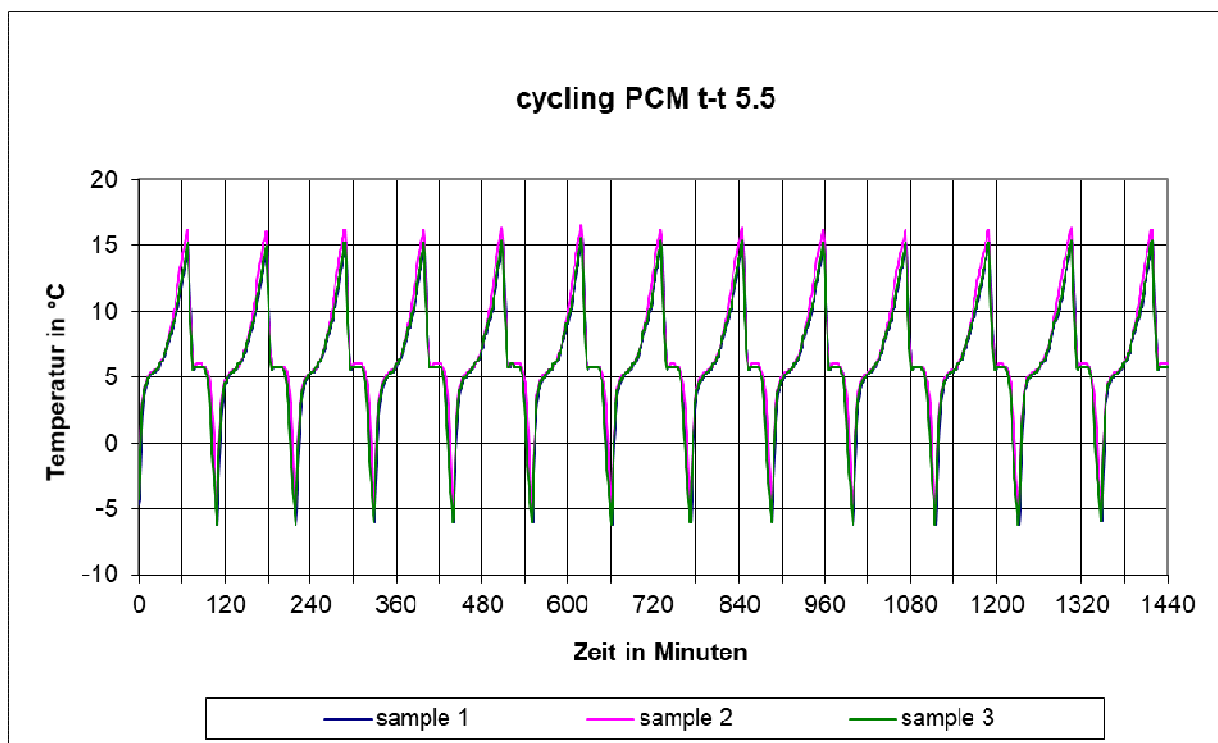
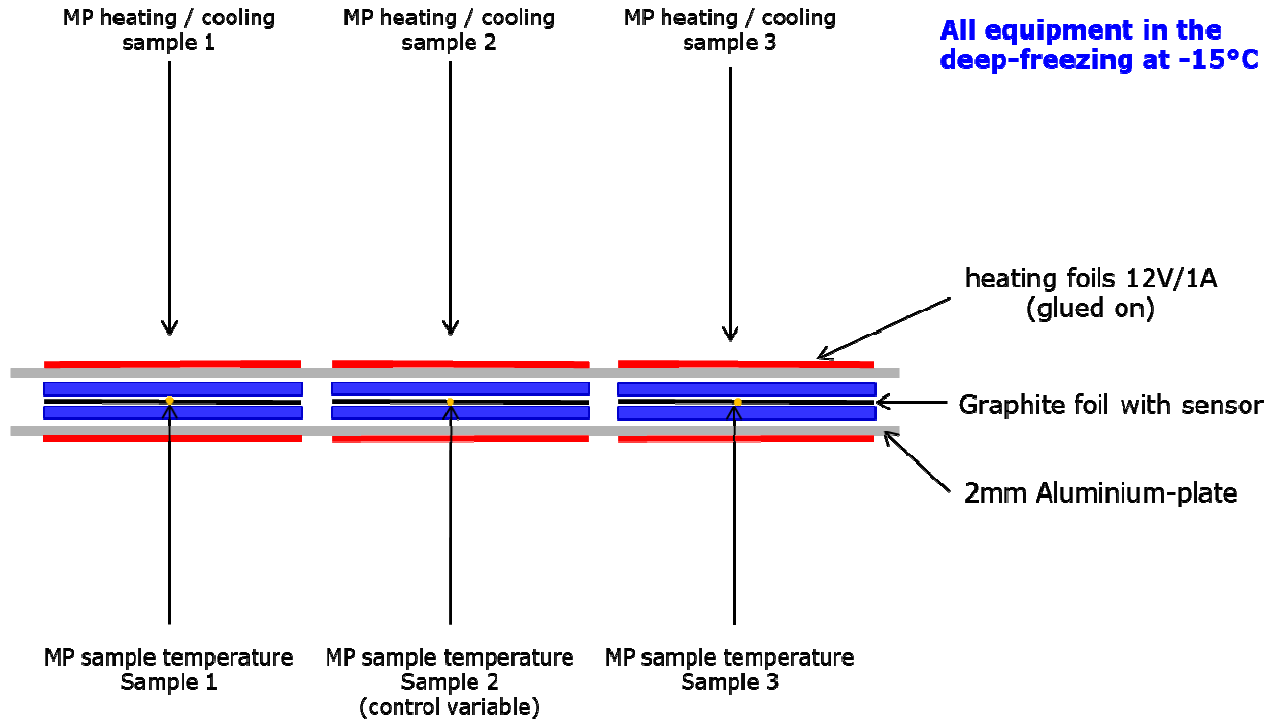
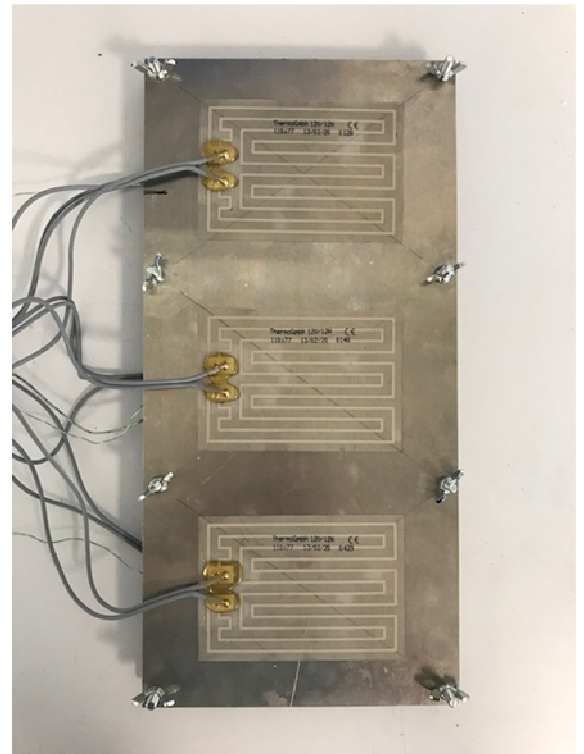


Diagramm 2

Cycle test structure



All equipment in the deep-freezing at -15°C



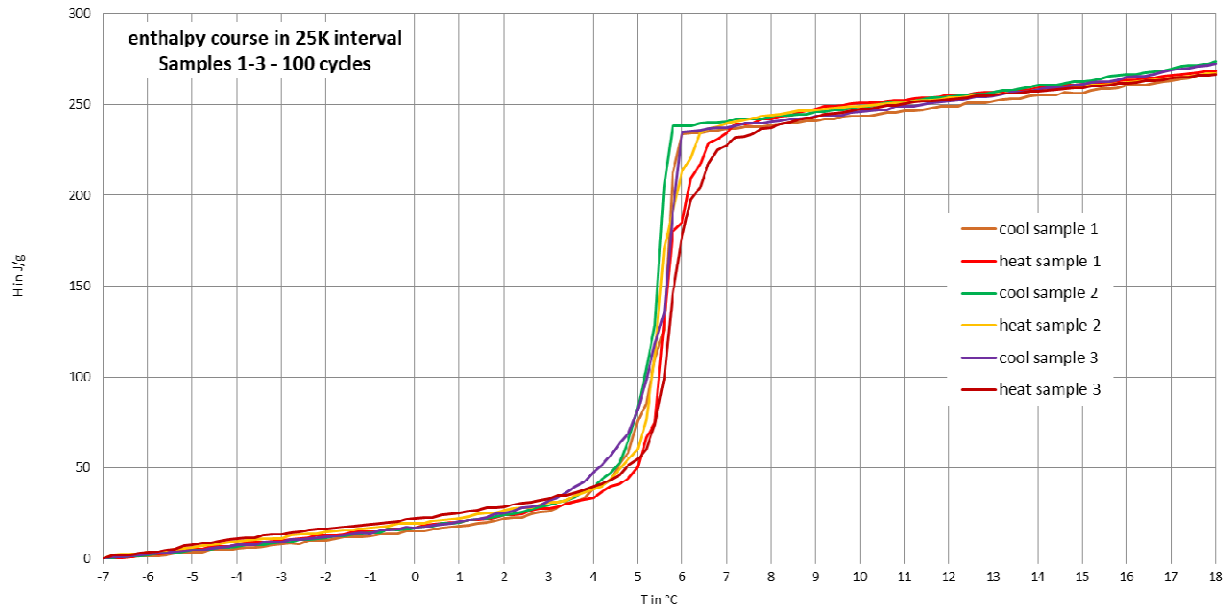
5. results after 100 cycles

melting sample 1					crystallization sample 1				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	5	5,6	6,6	243	0 cycles	5,6	5,6	4,6	244
100 cycles	5	5,6	6,6	247	100 cycles	6	5,8	4,2	245
differenz	0	0	0	1,65%	differenz	0,4	0,2	-0,4	0,41%

melting sample 2					crystallization sample 2				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	4,6	5,6	6,4	241	0 cycles	5,6	5,6	4,6	241
100 cycles	4,6	5,6	6,4	243	100 cycles	5,8	5,6	4,4	247
differenz	0	0	0	0,83%	differenz	0,2	0	-0,2	2,49%

melting sample 3					crystallization sample 3				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	4,6	5,8	6,8	239	0 cycles	6	5,8	4,2	243
100 cycles	4,6	5,8	7	241	100 cycles	6	5,8	4,2	245
differenz	0	0	0,2	0,84%	differenz	0	0	0	0,82%

Melting Average value					crystallization Average value				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
Average value 0 cycles	4,7	5,7	6,6	241	Average value 0 cycles	5,7	5,7	4,5	243
Average value 100 cycles	4,7	5,7	6,7	244	Average value 100 cycles	5,9	5,7	4,3	246
differenz	0	0	0,1	1,11%	differenz	0,2	0,1	-0,2	1,24%



6. results after 500 cycles

melting sample 1					crystallization sample 1				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	5	5,6	6,6	243	0 cycles	5,6	5,6	4,6	244
500 cycles	4,8	5,6	6,6	251	500 cycles	6	5,6	4,4	249
differenz	0,2	0	0	3,29%	differenz	0,4	0	-0,2	2,05%
melting sample 2					crystallization sample 2				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	4,6	5,6	6,4	241	0 cycles	5,6	5,6	4,6	241
500 cycles	4,8	5,8	6,6	244	500 cycles	5,8	5,8	4,6	245
differenz	-0,2	-0,2	0,2	1,24%	differenz	0,2	0,2	0	1,66%
melting sample 3					crystallization sample 3				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
0 cycles	4,6	5,8	6,8	239	0 cycles	6	5,8	4,2	243
500 cycles	4,6	5,8	6,8	245	500 cycles	6	5,8	4,2	245
differenz	0	0	0	2,51%	differenz	0	0	0	0,82%
Melting Average value					crystallization Average value				
	Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)		Onset (°C)	Peak (°C)	Offset (°C)	Enthalpie (J/g)
Average value 0 cycles	4,7	5,7	6,6	241	Average value 0 cycles	5,7	5,7	4,5	243
Average value 500 cycles	4,7	5,7	6,7	247	Average value 500 cycles	5,9	5,7	4,4	246
differenz	0,0	-0,1	0,1	2,35%	differenz	0,2	0,1	-0,1	1,51%

