Unistat 705w and Battery Test Cold Plate

Temperature Control
for Power Cell research
and development

Inspired by **temperature**

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CASE STUDY RESULTS

Authors

Ken Mackenzie

Paddy Delaney

Ryan Nicholls

Ken is the International Sales Man-ager at Huber **SE** respon-sible for Asia and South America. Since joining Huber **SE** in 1999, Ken has extensive application experience specific to temperature control across many industries

Paddy is the Managing Director of Huber UK & Ireland. He has de-grees in Applied Chemistry and a PHD in Organic Sysnthesis along-side an extensive background in medicinal chemistry (mg) and process chemistry (kg).

Ryan is the Senior Applications Specialist at Huber UK. He has a MChem and PhD in Chemistry. Ryan joined Huber UK & Ireland in 2018 and has application experi-ence specific to temperature con-trol across various sectors.

Introduction

This Case Study demonstrates the Process tem-perature control abilities of the Unistat 705w when it is connected to a cold plate fabricated from aluminium (the “application”). To simulate the heat load from battery cells under test, heat-ing mats of varying power outputs were placed on top of the cold plate and insulated with an “Ar-morflex” sheet.

Three tests were made:

1.) The minimum achievable temperature

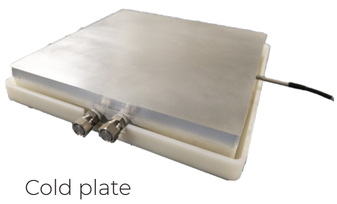
2.) The stability at various set-points

3.) “Recovery” to demonstrate how quickly and accurately a set-point is recovered from a sudden decrease or increase in heat load. The heat pad is disconnected, the system allowed to regain and stabilize at the set point before the heat pad is then reconnected and a heat load applied. This was carried out at various temperature set-points (-60 °C to 120 °C) and wattage inputs

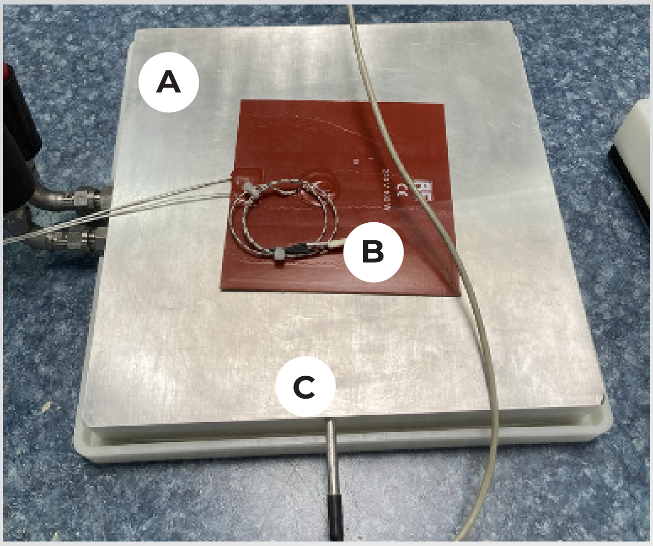
Equipment & Setup

The Cold Plate is connected with the Tempera-ture Control Unit (TCU) using “M16 x 1” insulated metal tubing. A Pt100 is located inside a pocket in the cold plate. The TCU is configured to con-trol the temperature from this point, see figure 1. A heating pad of a known wattage is placed on top of the Cold Plate and then insulation is placed over it.

Unistat 705w

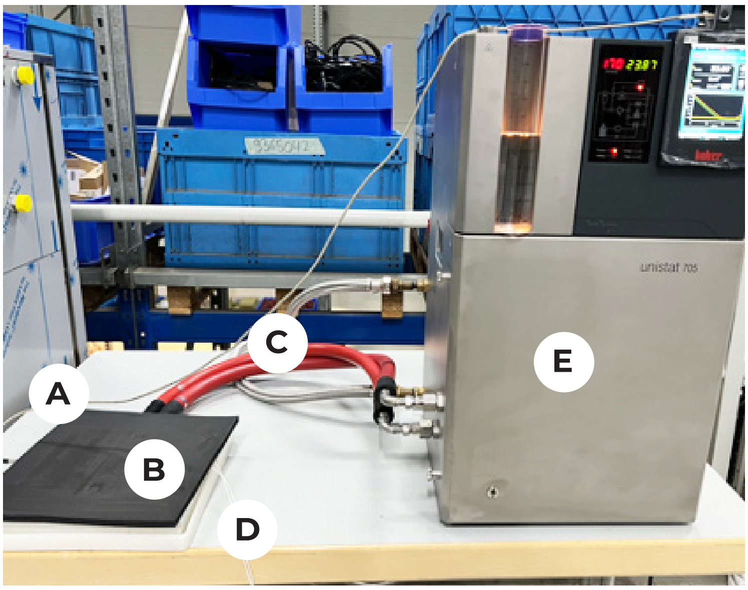


Cold plate



A	Cold plate
B	Heating mat (temperature sensor not used)
C	pt100 temperature sensor connected to TCU

Figure 1: Close-up Image of Cold plate, PT100 Temp Sensor, Heater Mat, Cold plate PTFE Tray, Hosing connections used to carry out this study.



A	Pt100
B	Cold plate with insulation
C	Insulated metal hosing
D	Cables for heat mat
E	TCU

Figure 2: Image of all equipment used in this study. Unistat 705w (TCU), Insulated metal hosing, cold plate with “Armourflex insulation and PT 100 temperature sensor.

Technical Specifications of Items used

Unit	Unistat 705w						
Catalogue number	1068.0006.01						
Temperature range	-75°C...250°C						
Heating power kW	3						
Cooling power	200	20	0	-20	-40	-60	°C
	0.6	0.6	0.65	0.6	0.6	0.3	kW
Pump data	Flow	Pressure					
	55 l/min	0.9 Bar					
Test conditions							
Tubing	2 x 1-meter M16 metal insulated tubing #6085						
Control	Process						
Heat Transfer Fluid	M90.055/170.02						
Cold Plate							
Dimensions	30cm x 30cm x 10cm						
Material of construction	Aluminum						
Weight	10Kg						

Results

Minimum Achievable Temperature and Stability.

The table below shows the minimum achievable application temperatures with increasing heat loads and the stability of control of different set points. This work shows that the set-point has minimal effect on temperature stability with all set-points giving better than +/- 0.02. Under no heat load a T-min of -66.6°C is achieved on the cold plate; this indicates an environmental heat gain of ~300 W (Unistat 705w cooling capacity at -60°C). Under an applied heat load the T-min becomes a function of the applied heat load and the environmental heat gain contributing to a greater cooling requirement. For example, 396w heat load has a T-min of -39.9°C, this indicates and additional cooling requirement of ~200w to maintain the T-min is required as the Unistat 705w cooling capacity at -40 °C is 0.6kW.

This data suggests that a greater cooling capacity is required to counter cool a given heat load and the relationship between the applied heat load and cooling capacity is non-linear.

Therefore, when specifying a Huber system for temperature control of a cold plate additional capacity at the lowest working set-point should be considered. The authors of this work hope that Table 1 will serve as a guide, but is by no means extensive and further work to understand your cell heat transfer properties should be carried out.

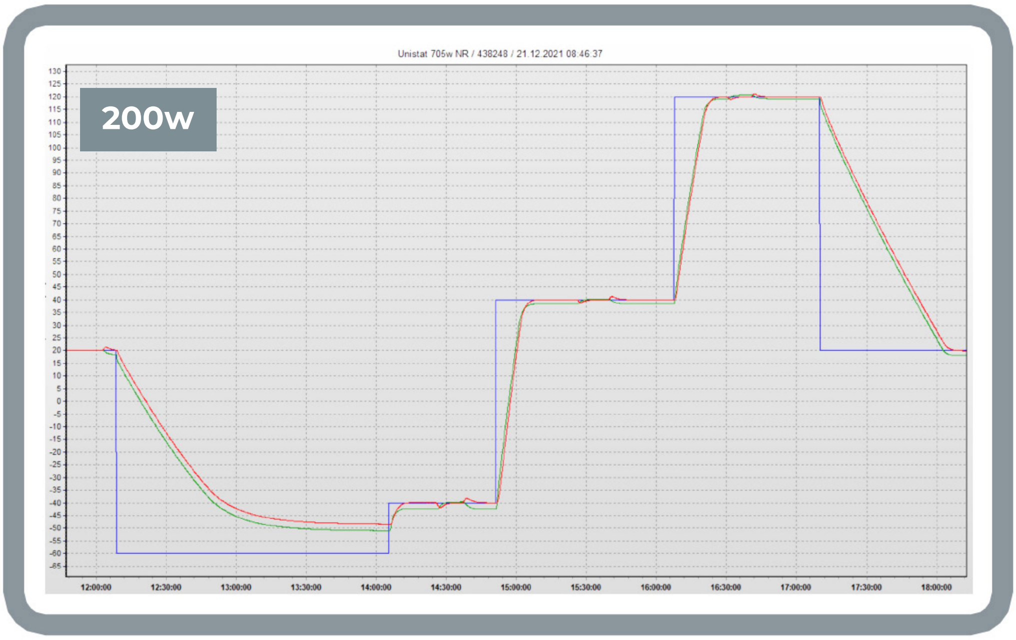
Recovery

The "recovery" is a demonstration of the ability of the Unistat to recover the set-point of the application after a sudden change in heat load achieved by turning the heat source "Off" and after the set-point has been reached and stabilized and then "On" again. The table below shows both the decrease and in the increase from the set-point in the application's temperature and the approximate time taken for the set-point to be regained. The 'screen shots' of temperature control curves on the following page (and in appendix) show the overall curve for the tests listed above and a close-up of the recovery tests described above. In each screen shots below, the following colour codes apply: Blue is the Set-point / Green is the HTF temperature / Red is the application temp.

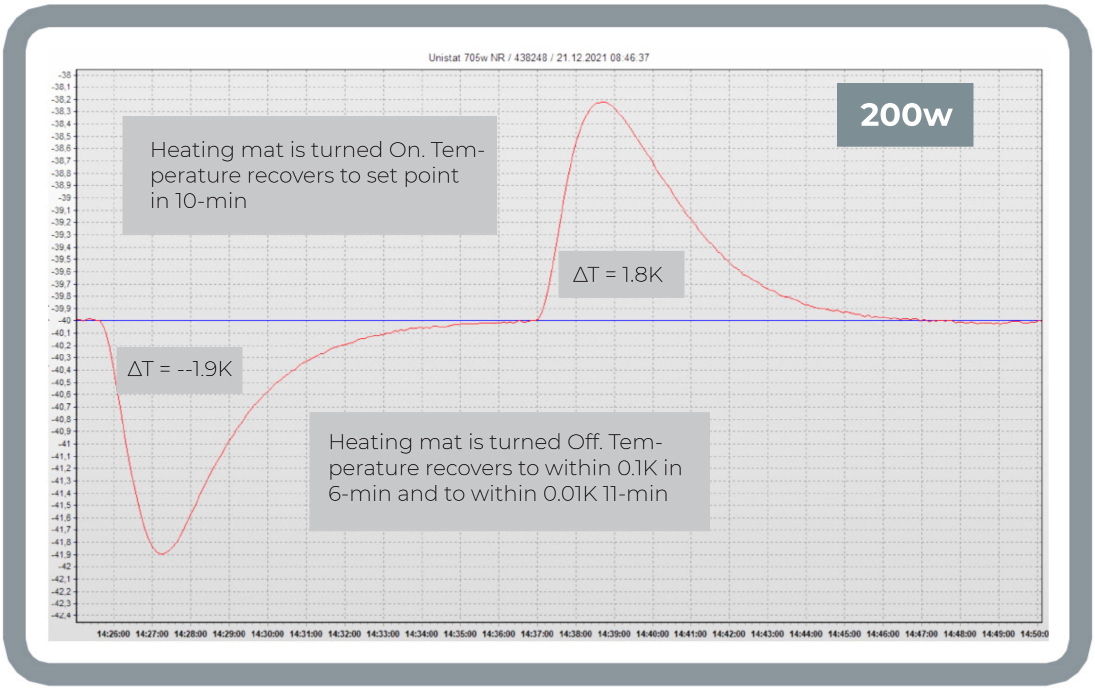
	Heater mat			Stability @ (°C)		
				-40	40	120
	Dimensions	w/cm²	T-min			
Heat Load	cm		°C	+/- K	+/- K	+/- K
200w	20 x 30	0.33	-48.7	0.02	0.01	0.01
275w	25 x 25	0.44	-45.5	0.01	0.01	0.01
396w	30 x 30	0.44	-39.9	***	0.01	0.01

Table 1: Summary table of heat load applied to cold plate (heater pad), associated pad dimensions, w/cm² value per heat pad, lowest achievable working temperature under applied heat load (T-min) and Temperature stability at listed set-points (-40 °C, 40 °C, 120 °C).

200w Overall view



Recovery Set point:-40°C



Recovery Results Summary

Minimum Achievable Temperature and Stability

The table below (Table 2) shows both the decrease and the increase from the set-point in the application's temperature after a change in heatload and the corresponding time taken for the set-point to be regained.

Conclusions

Specifying the best Unistat for any application with theoretical calculations can yield disappointing results. This case study shows empirical data with detailed technical specifications such as the cooling and heating power of the Unistat, the surface area (cm²) of the "component" under test (the heat pad) and the heat (w) that it generates.

Given the technical specifications, the data shows the efficiencies in temperature control when the w/cm² ratio is low. This could result in (perhaps) a less powerful machine being required or a factor to be taken into consideration during the design of the component under test to increase the efficiencies of thermal transfer.

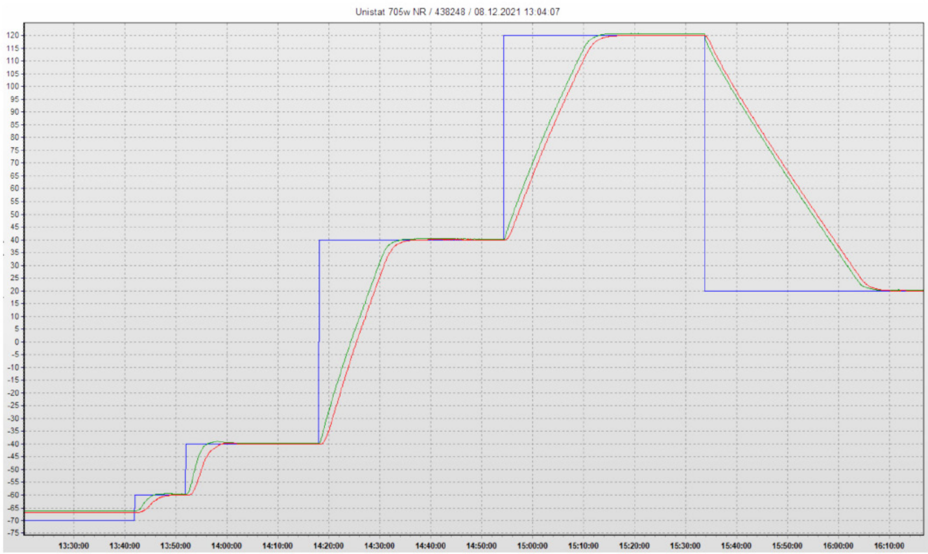
The data also demonstrates the lowest working temperatures under varying heat loads as well as the performance (response times and stability) at different set-points.

Heat Load	Set Point	Decrease	Recovery time	Increase	Recovery time
200w	-40°C	-1.9k	11-Min	1.8k	10-Min
	40°C	-1.3k	8-Min	1.2k	10-Min
	120°C	-1.2k	9-Min	1.2k	8-Min
275w	-40°C	-2.2k	10-Min	2.1k	11-Min
	40°C	-1.5k	10-Min	1.4k	10-Min
	120°C	-1.4k	10-Min	1.4k	9-Min
396w	-30°C	-2.2k	12-Min	2.1k	11-Min
	40°C	1.6k	12-Min	1.5k	12-Min
	120°C	1.6k	9 Min	1.5k	10-Min

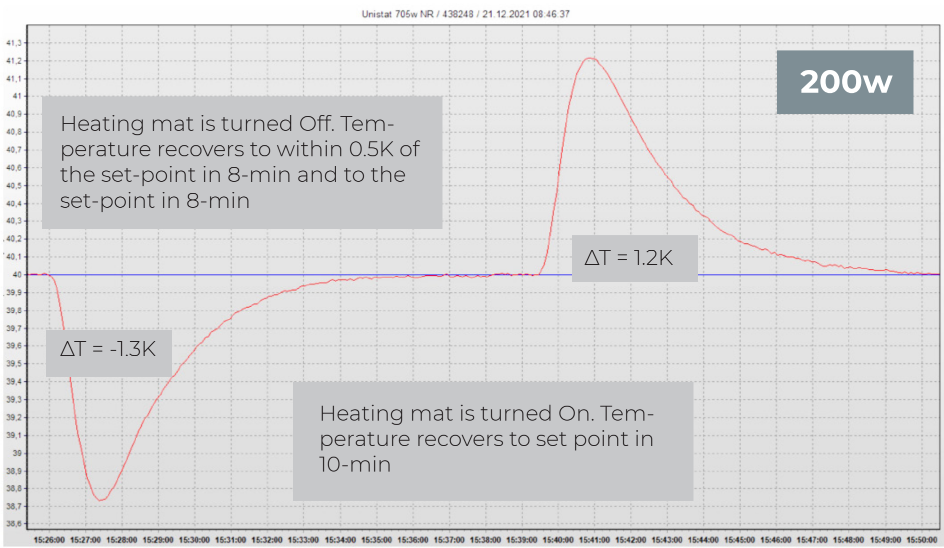
Table 2: Summary table of applied heat load, temperature set-point, decrease in temperature from loss of heat load (Decrease), recovery time (Off) to set-point after heat load loss, increase in temperature from applied heat load (Increase) and recovery time (On) to set-point under applied heat load.

Appendix

No Load

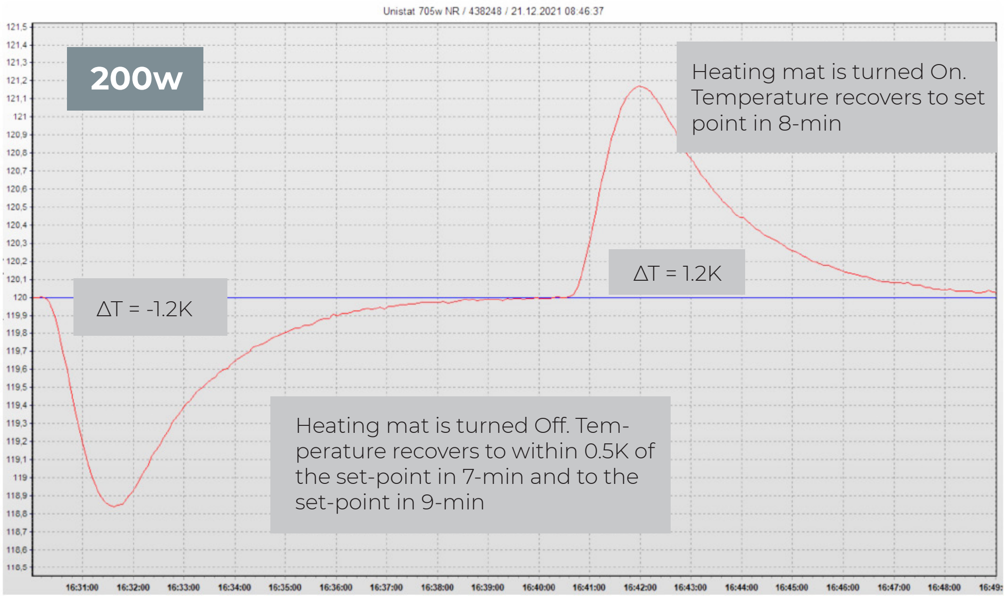


Set point: 40°C

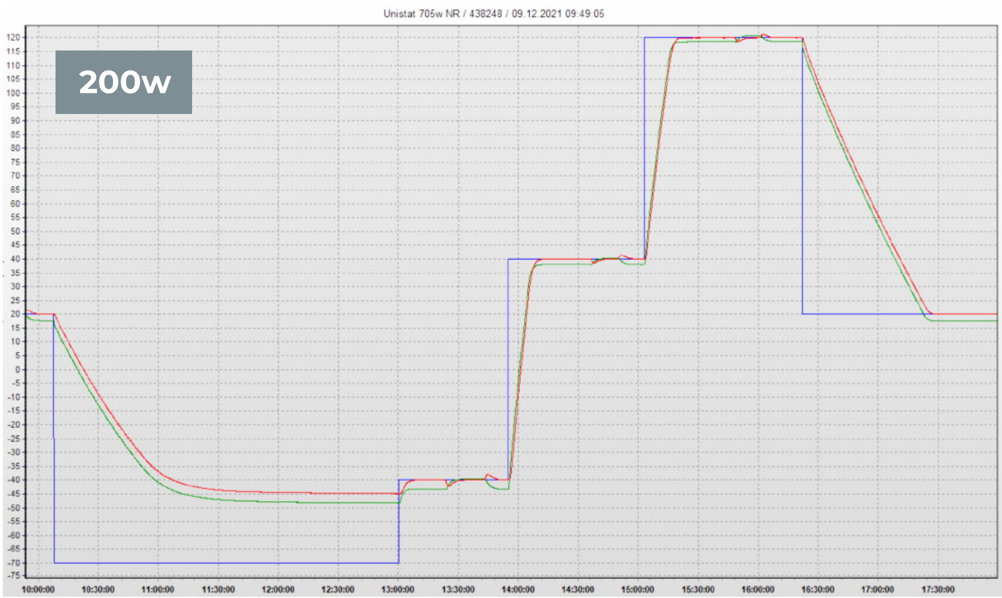


Appendix

Set point: 120°C

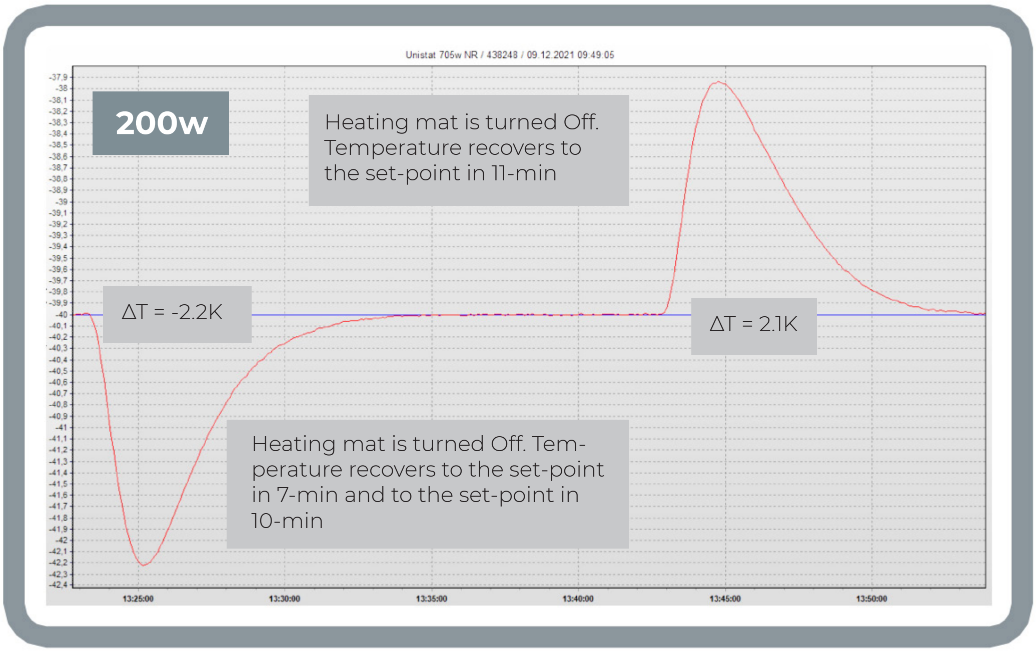


Set point: 120°C

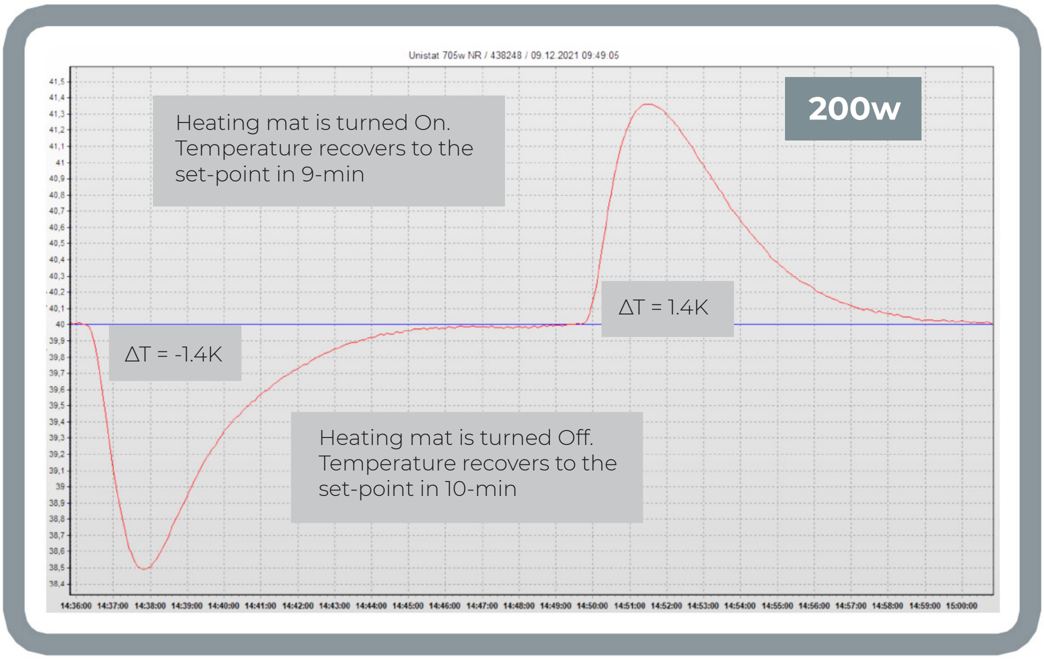


Appendix

Recovery Set point: -40°C

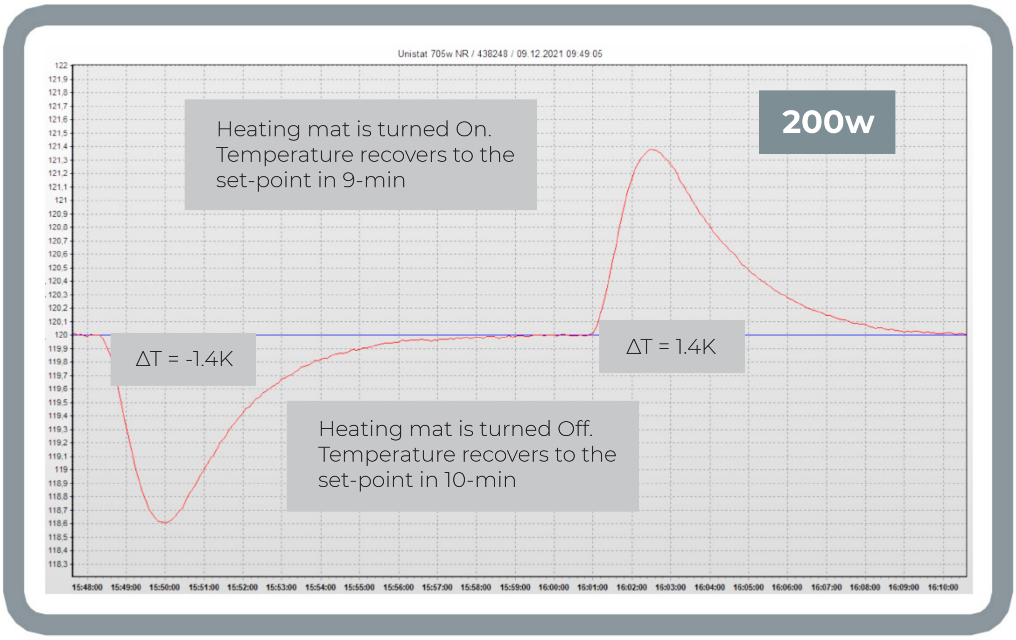


Set point: 120°C

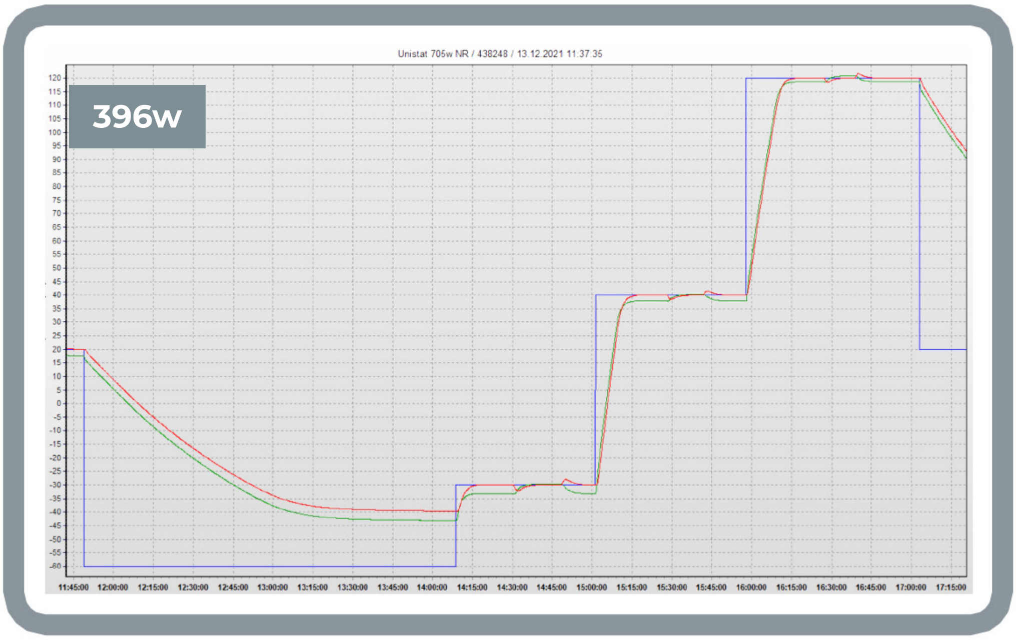


Appendix

Set point: 120°C

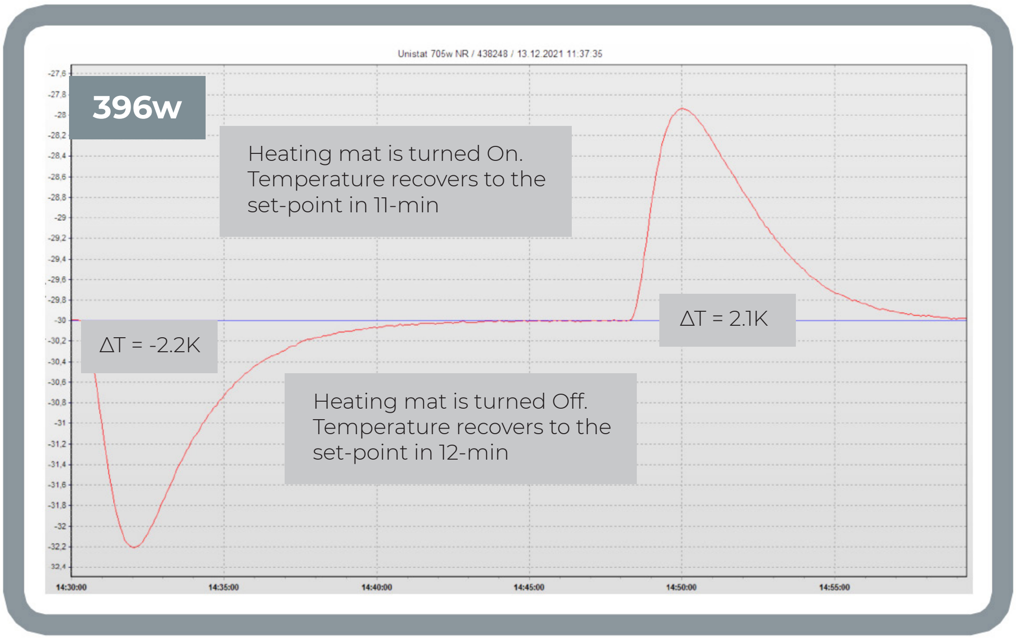


396w Overall view

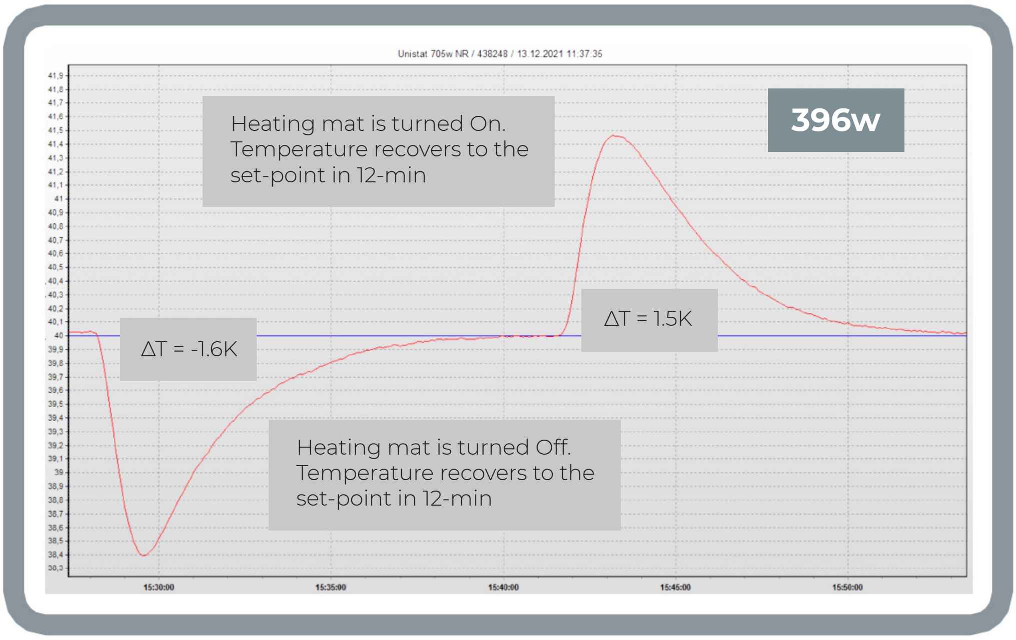


Appendix

Recovery Set point: -30°C

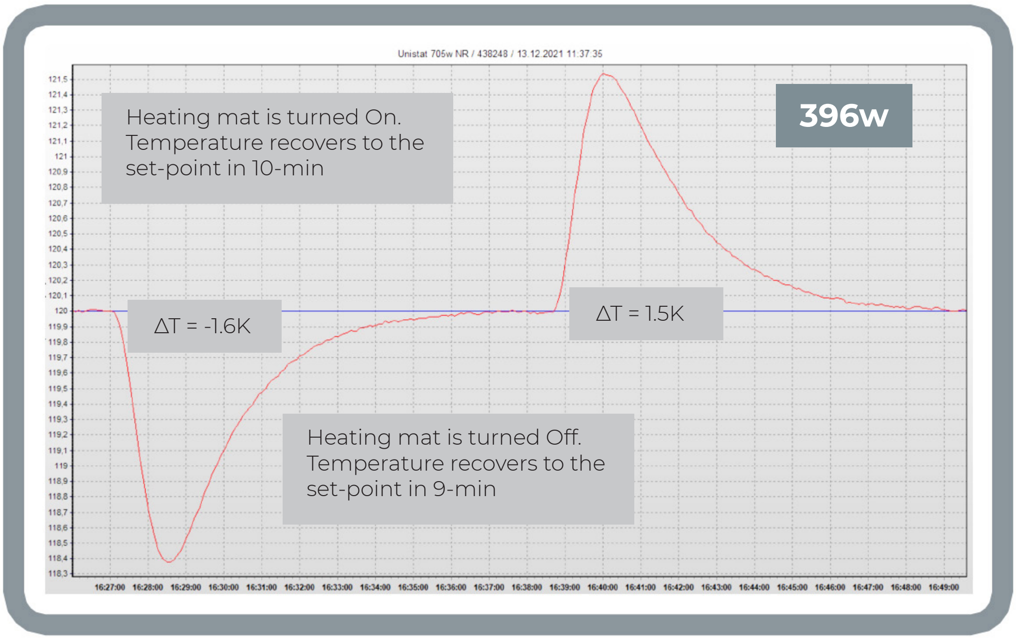


Set point: 40°C



Appendix

Set point: 120°C



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Peter Huber Kältemaschinenbau SE

Werner-von-Siemens-Str. 1 · 77656 Offenburg / Germany Telephone +49 (0)781 9603-0 · Fax +49 (0)781 57211 info@huber-online.com · www.huber-online.com