

Test report

ThermoCare box for 15.0 °C ... 25.0 °C shipments

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ThermoCare box for 15.0 °C ... 25.0 °C shipments

Approved by: Philipp Amendt

Version: 1.2

Abstract

The ThermoCare box container is tested within the ambient temperature scenarios V05.05 provided by Post Logistics CH for 15.0 °C ... 25.0 °C shipments. va-Q-tec's 44253 +22G va-Q-accus are used as a phase change material to stabilize the temperature inside the ThermoCare box.

According to the defined delivery process the ThermoCare box is tested to:

Table 1: Test results

Temperature scenario	Tested $t_{15.0\text{ °C} \dots 25.0\text{ °C}}$ [hrs]	Tested (temp x time) [K*hrs] ¹	Average ambient temperature [°C]
V05.05 summer	49	323	26.6
V05.05 winter	32	-262	11.8

In this test report, the equipment and the test procedures are described step by step.

¹ The calculated (temp x time)-values refer to an internal average container temperature of 20 °C

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1 Test target

The ThermoCare box container, in combination with several va-Q-accus, filled with a +22G phase change material (PCM), allows the transportation of goods that must be kept between 15.0 °C and 25.0 °C. The target of this test is the evaluation of the duration $t_{15.0\text{ °C} \dots 25.0\text{ °C}}$ of temperature stability of the inner temperature between these limits. The time span $t_{15.0\text{ °C} \dots 25.0\text{ °C}}$ defines when the average value of the four sensors undercuts the 15.0 °C limit or exceeds the 25.0 °C limit.

$$t_{15.0\text{ °C} \dots 25.0\text{ °C}} \geq 25 \text{ hrs}$$

The simulated ambient temperature scenario V05.05 represents the logistic process of the ThermoCare box and is explained more detailed in chapter 3.2. The targeted temperature stability of the ThermoCare box between 15.0 °C and 25.0 °C is given in Table 2.

For simulating a worst-case scenario, the ThermoCare box is tested without product load. All tests are carried out with the pack out and the pre-conditioning as described in chapter 3.4 and 3.5.

Table 2: Targeted $t_{15.0\text{ °C} \dots 25.0\text{ °C}}$ value for the test scenario

Test scenario	Average ambient temperature [°C]	Targeted timespan ($t_{15.0\text{ °C} \dots 25.0\text{ °C}}$) [hrs]	Targeted (temp x time) ($\Delta T \times t_{15.0\text{ °C} \dots 25.0\text{ °C}}$) [K*hrs]
V05.05 summer	26.8	≥ 25	≥ 45
V05.05 winter	14.3	≥ 25	≤ -18

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2 Equipment used

2.1 Shipment containers

To simulate the transport the ThermoCare box is used. Table 3 lists the dimensions and the weight of the ThermoCare box.

The thermal insulation performance of the ThermoCare box is given by its Q-value. From statistical measurements the Q-value of the ThermoCare box can be determined to (0.24 ± 0.02) W/K.

Table 3: Detailed information about the ThermoCare box

ThermoCare box	
Outer dimensions [mm ³] (length x width x height)	597 x 397 x 335
Outer dimensions [inch ³] (length x width x height)	23.6 x 15.7 x 13.2
Inner dimensions [mm ³] (length x width x height)	440 x 250 x 160
Inner dimensions [inch ³] (length x width x height)	17.3 x 9.8 x 6.2
Tolerance [mm]	± 5
Tolerance [inch]	± 0.2
Weight (empty container) [kg]	6.1
Weight (empty container) [lbs]	13.4
Weight (with va-Q-accus) [kg]	10.7
Weight (with va-Q-accus) [lbs]	23.6
Tolerance [kg]	± 1.0
Tolerance [lbs]	± 2.2
Q-value [W/K]	0.24
Tolerance [W/K]	± 0.02

2.2 Phase-change-material (PCM)

va-Q-tec's PCM flasks, named va-Q-accu, are the cooling or heating material stabilizing the temperature inside the ThermoCare box. In this test 2 pcs of va-Q-accu +22G 44253 with a phase transition temperature of 15.0 °C ... 25.0 °C are used (see also Table 4).

Table 4: Used PCM configuration for the test criterion

Test criterion	Size of va-Q-accu	PCM type	Weight per va-Q-accu [kg]	Amount of va-Q-accu per container
15.0 °C ... 25.0 °C	44253	+22G	2.3	2 pcs

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2.3 Climate chambers

A climate chamber is used in order to simulate different ambient temperature scenarios as well as to pre-condition the PCM flasks.

The climate chamber and the corresponding specifications are summarized in Table 5 and Table 6.

Table 5: internal labeling and corresponding serial number of climate chambers

Internal Climate chamber number	Climate Chamber number	Serial no.	Site
W2	CTS T-40/600	064012	Wuerzburg
W5	CTS T-40/600	174019	Wuerzburg
W6	CTS T-40/1500	174020	Wuerzburg

Table 6: Physical data of climate chambers

Internal Climate Chamber Number	Internal dimensions	Temperature range	Spatial accuracy	Temperature dependent accuracy
W2	(850 x 850 x 830) mm ³	-40 °C to +180 °C	± 0.6 K	± 0.3 K
W5	(850 x 850 x 830) mm ³	-40 °C to +180 °C	± 0.6 K	± 0.3 K
W6	(900 x 1000 x 1600) mm ³	-40 °C to +180 °C	± 0.6 K	± 0.3 K

2.4 Temperature measuring equipment

To monitor the temperatures during the test process, calibrated temperature data loggers and the corresponding sensor sets are used.

Table 7: Temperature range of measurement equipment

Description	Number of probes	Accuracy for a temperature range of	
Data logger ELPRO Ecolog TN4 with NTC temperature sensor set	4	-50 °C ... -25 °C	± 0.4 °C
		-25 °C ... 0 °C	± 0.3 °C
		0 °C ... 30 °C	± 0.2 °C
		30 °C ... 70 °C	± 0.3 °C
		70 °C ... 100 °C	± 0.4 °C
		100 °C ... 140 °C	± 0.7 °C

The temperature data loggers are programmed to save one temperature value for each sensor every minute. They are factory calibrated and checked annually according to recommended standards of the supplier. The corresponding temperature sensor sets are also checked annually.

Calibration certificates and raw data can be found in the appendix of this report. The ISO documentation is available on request.

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2.5 Simulated goods

During the tests, no transport good is placed inside ThermoCare box to simulate a worst-case scenario.²

² A rationale explaining why empty testing represents a worst-case scenario can be provided on request.

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3 Test procedure

3.1 Sensor positions

The packed ThermoCare box is placed in the relevant climate chamber for the simulation of the shipment. To control the temperature inside the inner compartment of the ThermoCare box the temperature sensors of an ELPRO Ecolog TN4 are placed diagonally inside the box (see Figure 1).

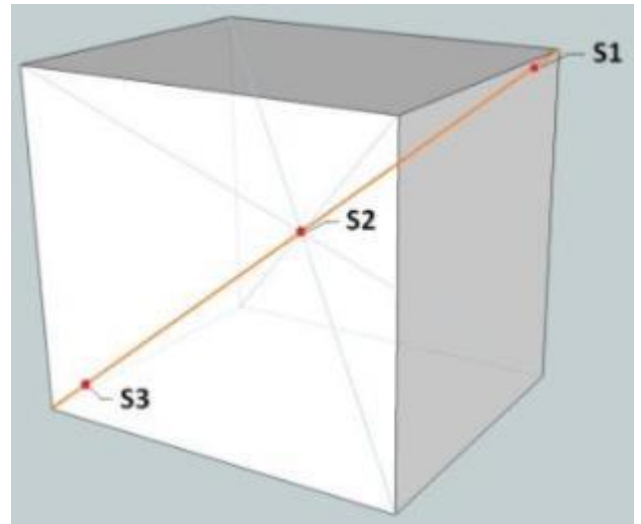


Figure 1: Empty test box with sensor positions in the body diagonal.

These three sensors are connected with temperature data loggers and sensor probes, which are stored inside the test box. Sensor S4 is neglected in the evaluation but records data due to the construction of the logger.

The ambient temperature is measured with another logger. The measurement points are illustrated in Figure 2.

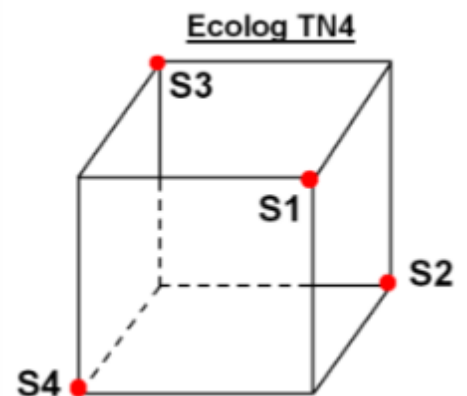


Figure 2: Sensor positions inside the relevant climate chamber for ambient temperature measurement.

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3.2 Ambient temperature scenarios

The shipment is simulated in two different temperature scenarios according to the ambient temperature profiles provided by the Post Logistics CH. The profiles simulate the shipment conditions starting from the commissioned box in the fulfillment center until the delivery of the box to the customer.

During the summer scenario the testing time is made up of transport of the ThermoCare box for five hours at 30 °C, storing the box for one day at 22 °C and 49 hours of the provided summer profile V05.05. Detailed information on the profile is given in Table 8 and Figure 3.

Table 8: Ambient temperature scenario V05.05 summer

Transport from fulfillment center		
Temperature [°C]	Cycle Period [hrs]	Total Time [hrs]
30	5	5
Box storage		
Temperature [°C]	Cycle Period [hrs]	Total Time [hrs]
22	24	29
Summer profile V05.05		
Temperature [°C]	Cycle Period [hrs]	Total Time [hrs]
30	1	30
25	1	31
30	2	33
25	1	34
30	3	37
25	9	46
30	2	48
35	6	54
25	2	56
30	1	57
25	1	58
30	3	61
25	9	70
30	2	72
35	6	78
Average temperature: 26.8 °C ± 2.0 °C		

targeted performance →

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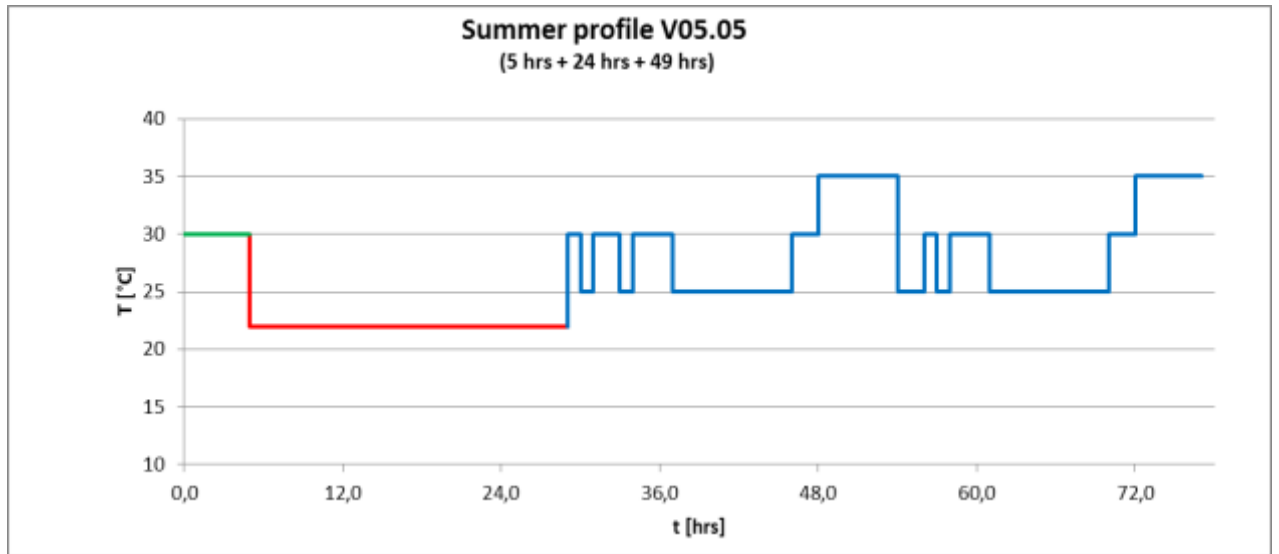


Figure 3: Testing profile including transport (green), storage (red) and summer profile V05.05 (blue).

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During the winter scenario the testing time is made up of transport of the ThermoCare box for five hours at 8 °C, storing the box for one day at 21 °C and 49 hours of the provided winter profile V05.05. Detailed information on the profile is given in Table 9 and Figure 4.

Table 9: Ambient temperature scenario V05.05 winter

Transport from fulfillment center		
Temperature [°C]	Cycle Period [hrs]	Total Time [hrs]
8	5	5
Box storage		
Temperature [°C]	Cycle Period [hrs]	Total Time [hrs]
21	24	29
Winter profile V05.05		
Temperature [°C]	Cycle Period [hrs]	Total Time [hrs]
8	1	30
18	1	31
5	2	33
18	1	34
5	5	39
0	3	42
18	2	44
-5	3	47
0	7	54
18	2	56
5	1	57
18	1	58
5	5	63
0	3	66
18	2	68
-5	3	71
0	7	78
Average temperature: 14.3 °C ± 2.0 °C		

targeted performance →

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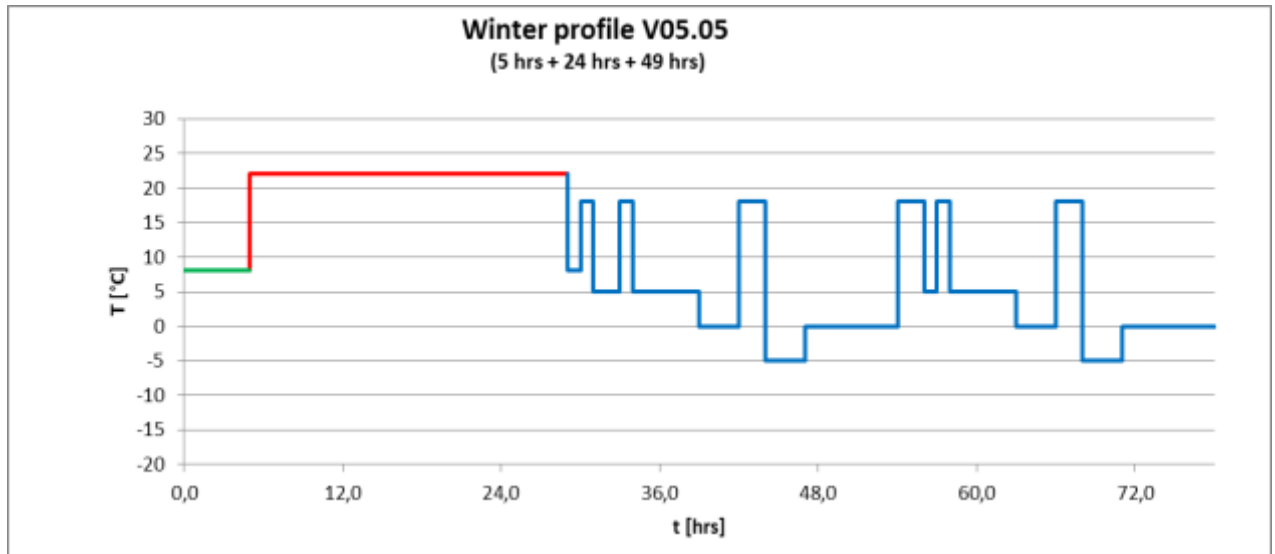


Figure 4: Testing profile including transport (green), storage (red) and summer profile V05.05 (blue).

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3.3 Table of actions

Table 10: Table of actions for the test process

Step	Action	Duration
1	Pre-conditioning of all va-Q-accu 44253 +22G at 20.0 °C ± 1.0 °C for the summer scenario and at 25 °C ± 1.0 °C for the winter scenario	≥ 44 hrs
2	Preparation of the climate chamber and the data logger for the ambient temperature	≤ 10 minutes
3	Loading one va-Q-accu 44253 +22G onto the bottom of the ThermoCare box	≤ 15 min
4	Starting the internal data logger	
5	Placing the top va-Q-accu 44253 +22G on top of the accu holder	
6	Closing of the ThermoCare box	
7	Placing the ThermoCare box inside the climate chamber	
8	Starting the external data logger	≥ 78 hours
9	Start the climate chamber with the desired temperature scenario and simulate the shipment	
10	Collecting and saving pre-conditioning data	NA
11	Remove the ThermoCare box from the climate chamber and collect the data.	NA

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3.4 PCM and container pre-conditioning

Table 11: Pre-conditioning data

PCM pre-conditioning	va-Q-accu	Temperature	Duration
	+22G	(20.0 ± 1.0) °C	≥ 44 hrs
		(25.0 ± 1.0) °C	≥ 44 hrs
Container pre-conditioning	ThermoCare box summer	No specific pre-conditioning	
	ThermoCare box winter	(25.0 ± 1.0) °C	≥ 44 hrs

3.5 va-Q-accu loading

After pre-conditioning, the PCM flasks are packed into the ThermoCare box as shown in Figure 5. The container is packed in the following order: bottom, top. Before positioning the top va-Q-accu, the temperature data logger is placed inside the ThermoCare box.

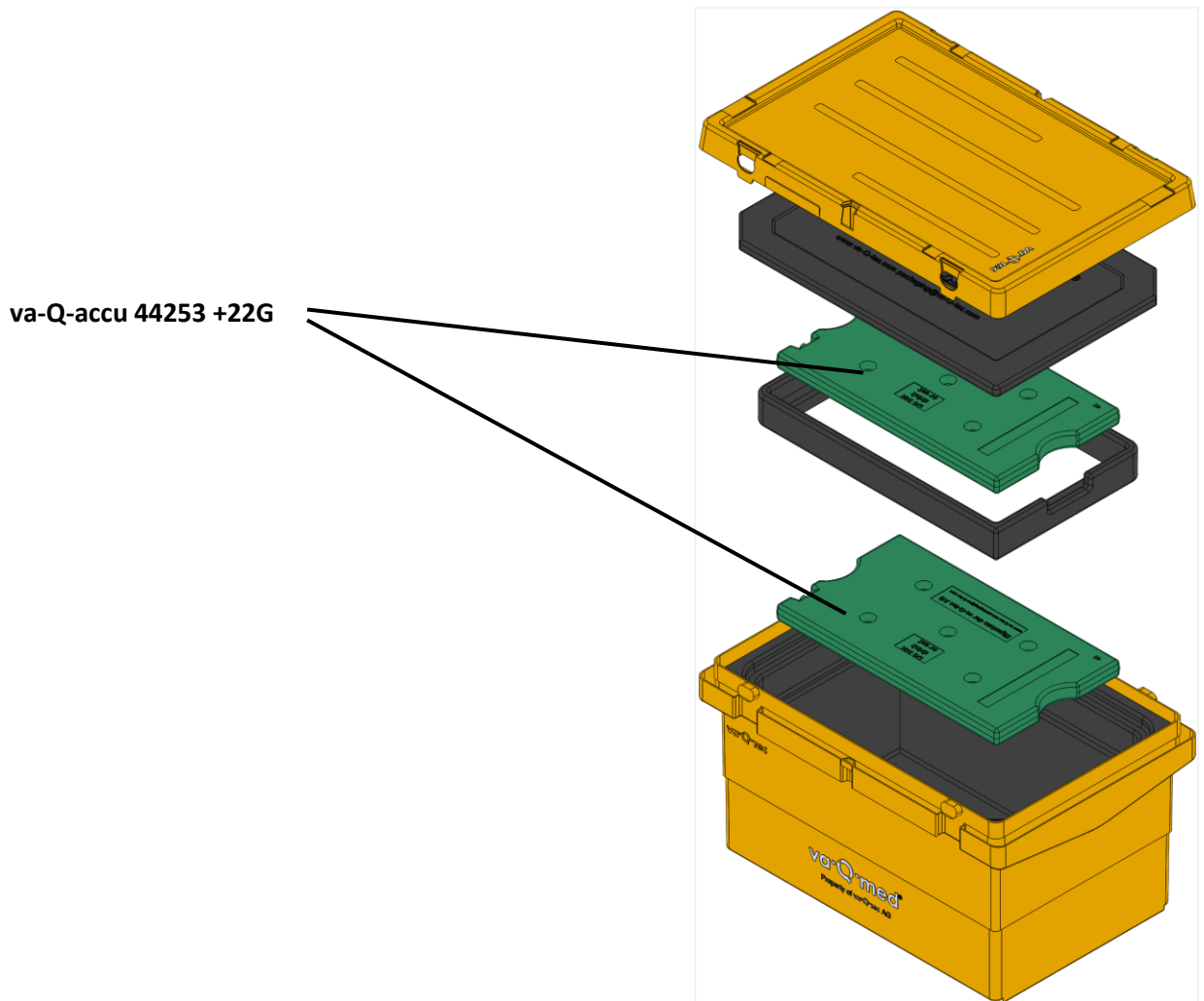


Figure 5: Arrangement of the PCM flasks in the ThermoCare box.

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3.6 Evaluation of data

The targeted time $t_{15.0\text{ °C} \dots 25.0\text{ °C}}$ is measured from the start of the profile V05.05 until the time when the average value of the inner temperature sensors exceeds the 25.0 °C limit or undercuts the 15.0 °C limit. The exact start date and time is defined by the start of the data logger recordings.

Data logger recordings also document the average pre-conditioning temperature of the va-Q-accu during the 44 hours pre-conditioning process.

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4 Test results

4.1 Summer scenario

The detailed device characteristics during the summer scenario can be found in Table 12, Table 13, Table 14 and Table 15 as well as in Figure 6. Hence, the ThermoCare box in combination with the specified load of pre-conditioned PCMs (2 pcs of va-Q-accu +22G 44253) is able to fulfill the requested quality criterion of

$$t_{15.0\text{ }^{\circ}\text{C} \dots 25.0\text{ }^{\circ}\text{C}} \geq 25 \text{ hrs.}$$

Table 12: Detailed information on the summer test results

$t_{15.0\text{ }^{\circ}\text{C} \dots 25.0\text{ }^{\circ}\text{C}}$ [hrs]	(temp x time) [K*hrs]	Average ambient temperature [°C]	Test passed
49	323	26.6	✓

Table 13: Detailed information on the used temperature measurement equipment

ThermoCare box	Used data logger	Calibration valid until	Used sensor set	Calibration valid until
Inner temperature	75956	Oct. 18	S4N020	Jun. 18
Ambient temperature	403812	Aug. 18	S4N033	Sep. 18

Table 14: Used climate chambers for va-Q-accu pre-conditioning (summer scenario)

Used climate Chamber (Internal Number)	Calibration valid until	temperature	Purpose
W6	March 18	19.7 °C	Pre-conditioning of va-Q-accus

Table 15: Used climate chambers for summer scenario

Used Climate chamber (Internal Number)	Calibration valid until	temperature	Purpose
W5	Feb 18	25.2 °C	Average ambient temperature during the complete test time

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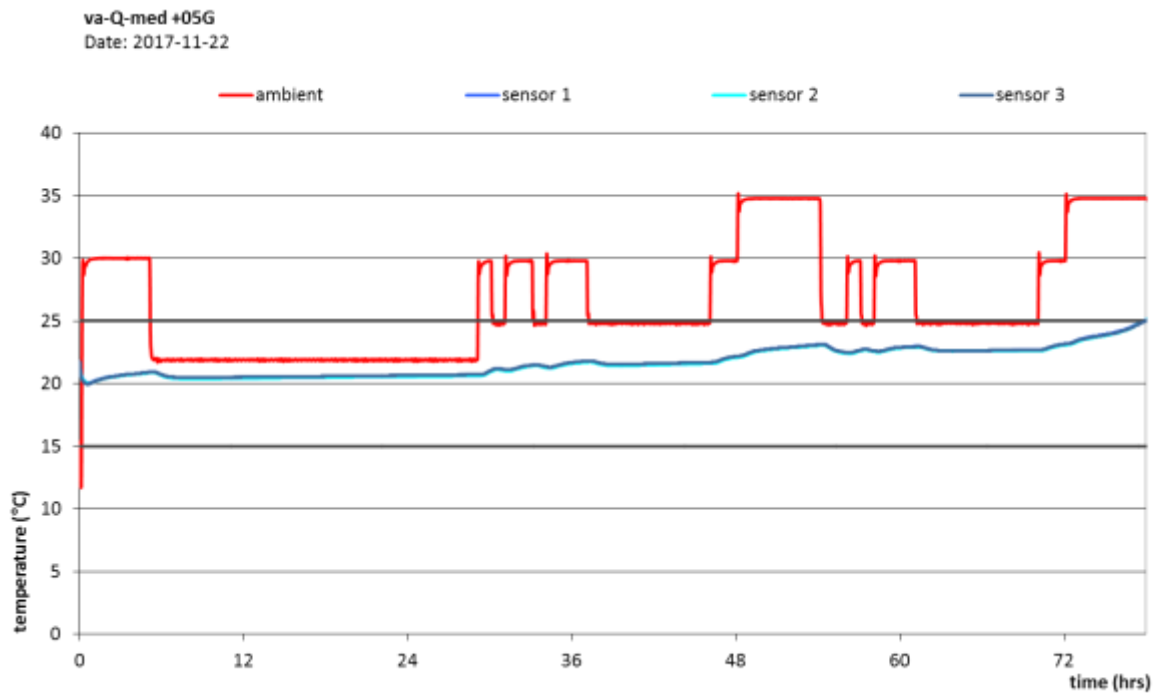


Figure 6: Test result ThermoCare box (summer scenario).

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4.2 Winter scenario

The detailed device characteristics during the winter scenario can be found in Table 16, Table 17, Table 18 and Table 19 as well as in Figure 7. Hence, the ThermoCare box in combination with the specified load of pre-conditioned PCMs (2 pcs of va-Q-accu +22G 44253) is able to fulfill the requested quality criterion of

$$t_{15.0\text{ °C} \dots 25.0\text{ °C}} \geq 25 \text{ hrs.}$$

Table 16: Detailed information on the summer test results

$t_{15.0\text{ °C} \dots 25.0\text{ °C}}$ [hrs]	(temp x time) [K*hrs]	Average ambient temperature [°C]	Test passed
32	-262	11.8	✓

Table 17: Detailed information on the used temperature measurement equipment

ThermoCare box	Used data logger	Calibration valid until	Used sensor set	Calibration valid until
Inner temperature	403817	Jul. 18	S4N074	Jun. 18
Ambient temperature	93790	Oct. 18	S4N022	Sep. 18

Table 18: Used climate chambers for va-Q-accu pre-conditioning (summer scenario)

Used climate Chamber (Internal Number)	Calibration valid until	temperature	Purpose
W2	Nov. 17	25.2 °C	Pre-conditioning of va-Q-accus and Thermo Care box

Table 19: Used climate chambers for summer scenario

Used Climate chamber (Internal Number)	Calibration valid until	temperature	Purpose
W2	Nov. 17	14.0 °C	Average ambient temperature during the complete test time

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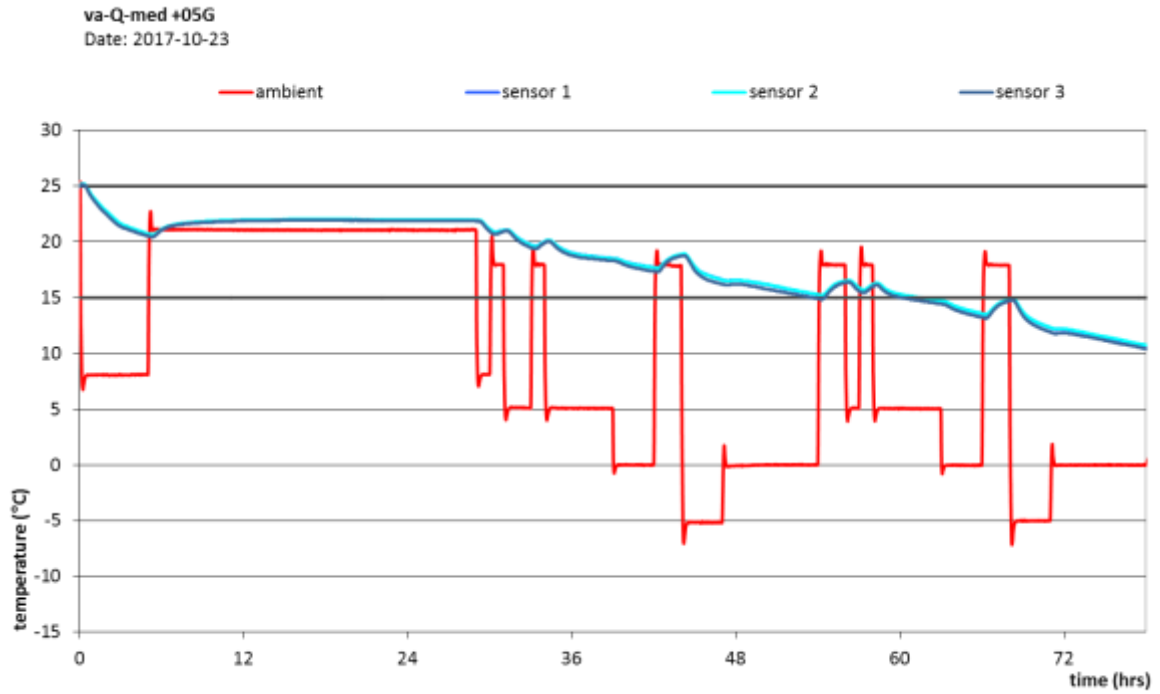


Figure 7: Test result ThermoCare box (winter scenario)

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5 Conclusion

The ThermoCare box container is tested within the ambient temperature scenarios V05.05 provided by Post Logistics CH for 15.0 °C ... 25.0 °C shipments. va-Q-tec's 44253 +22G va-Q-accus are used as a phase change material to stabilize the temperature inside the ThermoCare box.

According to the defined delivery process the ThermoCare box is tested to:

Table 20: Test results

Temperature scenario	Tested $t_{15.0\text{ °C} \dots 25.0\text{ °C}}$ [hrs]	tested (temp x time) [K*hrs]	Average ambient temperature [°C]
V05.05 summer	49	323	26.6
V05.05 winter	32	-262	11.8

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6 Personnel Involved

Table 21: Personnel Involved

	Name	Function
Head of TCS	Philipp Amendt	<input type="radio"/> Consulting <input type="radio"/> Provision of resources
Product Engineer	Kristina Kletzel	<input type="radio"/> Coordination <input type="radio"/> Revision
Operator	Kristina Kletzel Philipp Amendt Sascha Bader Konstantin Hoff	<input type="radio"/> Preparation <input type="radio"/> Performance of Measurement <input type="radio"/> Evaluation of Data <input type="radio"/> Compilation of test report

Table 22: Approval

Date and Signature	
Approved by Philipp Amendt (Team leader laboratory, va-Q-tec AG):	Revised by Kristina Kletzel (Team leader product development, va-Q-tec AG):

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7 Change History

Table 23: Change history

Version	Date	Approval by	Comments about changelog
1.0	2017-11-22	Martin Heinemann	New Document
1.1	2018-10-10	Philipp Amendt	Minor corrections
1.2	2018-10-31	Philipp Amendt	Minor corrections

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8 Appendix

- Calibration check certificates of used data loggers
- Calibration check certificates of used temperature sensor sets
- Calibration check certificates of used climate chamber
- Raw data of used data loggers

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