

Temperature Mapping Study Report

Rev. 1.0 - 04-MAY-2023

SIR.LANCELOT.V-520.MAPPING.07.58T

Approval

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16-MAY-2023

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16-MAY-2023

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30-May-2023



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Introduction

This mapping report has been created based on the mapping protocol SIR.LANCELOT.V-520.MAPPING.07, rev. 1.0 and all tests have been performed in accordance with said mapping protocol.

All tests are described in detail in the attached mapping protocol, and the associated test plans.

This report contains the required documentation based on the mapping protocol, as well as conclusions and recommendations based on the data gathered during the mapping exercise.

Purpose

A mapping study has been performed to provide information on the temperature performance of the unit, and to evaluate the compliance to acceptable levels. This is done to document the mapping activities, and to comply with external governmental regulations.

A summary of the results of the mapping exercise are presented in this report, along with conclusions and recommendations based on these results.

Acronyms and glossary

Acronyms	Definition
EDLM	Electronic Data Logging Monitor
MPE	Maximum Permissible Error
TTSA	Time and Temperature Sensitive Assets
TP	Test Plan
HVAC-system	Heating, ventilation and air conditioning system

References

Document #	Title and revision
SIR.LANCELOT.V-520.MAPPING.07	Temperature Mapping Study Protocol, rev. 1.0
SIR.LANCELOT.V-520.MAPPING.07.TP1	Documentation of Training - Test Plan, rev. 1.0
SIR.LANCELOT.V-520.MAPPING.07.TP2	Datalogger Placement and Identification - Test Plan, rev. 1.0
SIR.LANCELOT.V-520.MAPPING.07.TP3	Stability Study - Test Plan, rev. 1.0
SIR.LANCELOT.V-520.MAPPING.07.TP4	Door opening scheme - Test Plan, rev. 1.0
Appendix 1	Calibration certificates
Appendix 2	Raw data files
Appendix 3	Mapping data report files
Appendix 4	Picture documentation

Description of equipment

Unit data

Owner	SIR LANCELOT DELIVERY & COURIER SERVICE
Address	1019 4th Ave Lester, PA 19029, US
Equipment ID	V-520
Manufacturer	Thermoking
Vehicle ID	Mercedes-Benz Sprinter WD3PE8CC4E5883836
Usage	Transportation of TTSA's
Temperature ranges	Cold: 2-8 °C Ambient: 15-25 °C
Set temperature	Cold : +5 °C Ambient : +20 °C

Unit layout

Table 1 shows the dimensions of the mapped trailer.

Body Length	13.8 feet
Body Width	65 inches
Body Height	71 inches

Table 1. Unit's dimensions

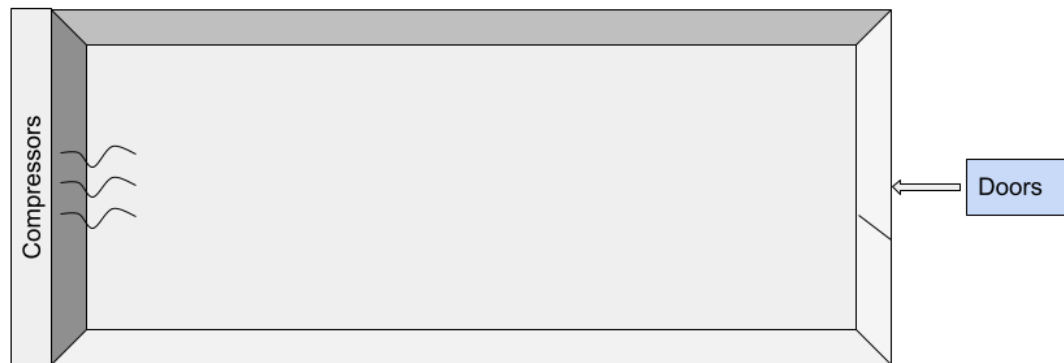


Figure 1. A graphical representation of the mapped unit seen from a bird's-eye view.

External influences

The external influences consists of:

1. Non-conformant temperatures entering from the doors facing the external environment.
2. Non-conformant temperatures acquired from the compressor.

Internal influences

The internal influences consist of:

1. Non-homogeneous distribution of temperatures inside the unit.
2. Unreasonable measurements by the control temperature sensor.

Normal use

The equipment is planned to be used for transport of TTSA's.

Loading

When the unit will be in operation, it is expected that the loading will vary from a few pallets to maximal loading of goods.

Door openings

A door is placed in the back end of the trailer and a sliding side door is placed close to the vehicle, which is used for loading and unloading goods.

Temperature control

The temperature is controlled by a HVAC-system from Thermo King.

Scope

The scope of the described mapping exercises is to map the mentioned unit to get a temperature distribution overview. The purpose of this is to document whether or not the unit is compliant with the internal and regulatory requirements.

History

The unit has no prior history of temperature mapping.

Roles and responsibilities

Original author

The mapping report has been authored by Sena Salih, Eupry ApS.

Review

Arsalan Bassir from Eupry ApS will review this mapping report and associated test plans.

Approval

Jeff Weingard is appointed as responsible for approving the mapping report and associated test plans.

Qualified third party

Sir Lancelot Courier & Delivery Service has commissioned Eupry ApS as a qualified third party to write the final report.

Tester

Tester is responsible for performing the mapping exercises and filling in test plans during mapping exercises. Arsalan Bassir from Eupry ApS has been chosen as the responsible tester according to the training test plan SIR.LANCELOT.V-520.MAPPING.07.TP1.

Objectives

The mapping exercise will aim to gain information on the following subjects:

- Measure temperature variations at each location within the specified area to determine temperature stability.
- Document high and low temperatures in the described unit, to determine hot and cold zones.
- Gain data on suitable placement of temperature monitoring for subsequent use, and make recommendations based on the gathered data.

Acceptance criteria

For the unit to be in compliance with internal requirements, the measured temperature characteristics must be within the following:

	Low Limit	High Limit
Temperature measurements (all measurement points)	2 °C	8 °C
Temperature when accounting for MPE ($\pm 0.50^{\circ}\text{C}$)	2.50 °C	7.50 °C

Table 2a. Temperature measurements and criteria - Cold

	Low Limit	High Limit
Temperature measurements (all measurement points)	15 °C	25 °C
Temperature when accounting for MPE ($\pm 0.50^{\circ}\text{C}$)	15.50 °C	24.50 °C

Table 2b. Temperature measurements and criteria - Ambient

Risk assessment

The following risks have been identified:

- Based on the identified external influences, loggers were placed to mitigate the possibility of non-conformant temperatures near these locations.
- The loggers were placed in a grid in accordance with *WHO Technical Report Series, No. 961, 2011 Annex 9* taking into account risk areas such as corners, locations adjacent to the ventilation system and the door.
- Based on the identified internal influences, loggers were placed to mitigate the possibility of non-conformant temperatures near the cooling system and door.
- The mapping was done without loading of goods in order to validate that it operates as required.

Methodology

Test equipment

EDLMs used for measuring the temperature in the designated positions are of the type DW1ST with external sensor type P1T from Eupry Aps.

Datasheet for the temperature sensor must be attached to the mapping study documentation.

EDLM requirements for P1T (Temperature sensors):

MPE	$\pm 0.50\text{ }^{\circ}\text{C}$
Calibration points	-20°C, 0°C, and +50 °C (Traceable Calibration)
Calibration date limit	≤ 360 days prior to use
Datalogging interval	3 minutes
Operating range	-50 °C to +50°C

Table 3. EDLM requirements for P1T temperature sensors

Identification of test equipment

Test equipment is identified using the unique Eupry serial number placed on the side of each datalogger together with the serial number of each external sensor. In the mapping software, the identification of the datalogger is used as the identifier.

Placement of dataloggers

Following the risk assessment above, the number of temperature loggers are decided to be 9 dataloggers. The distribution of the loggers inside the unit is shown in **Figure 2**.

Placements are named as B = bottom, M= middle and T = top. The actual heights in meters were documented in test plan SIR.LANCELOT.V-520.MAPPING.07.TP2.

- B = Lowest height of goods to be stored on pallets
- M= Middle of goods placed on pallets
- T = Maximum height of goods stored on pallets

All loggers were placed according to the following rationales in order to mitigate risks identified in the risk assessment section.

Rationales

List of rationales:

- D Doors and gates
- G Grid logger
- C Compressor

Overview of placements

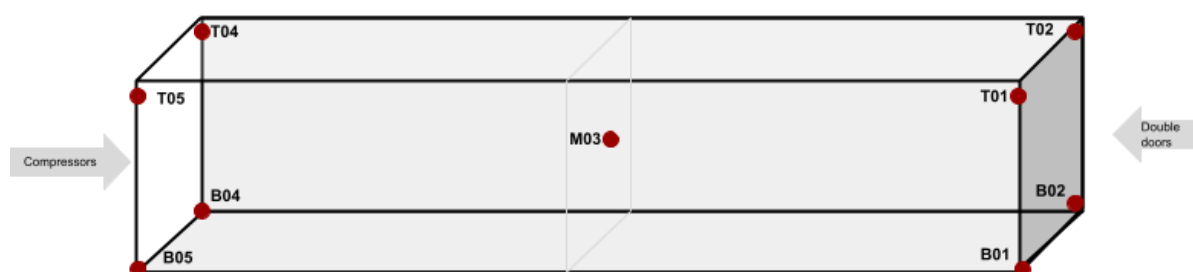


Figure 2. Placement of temperature loggers during mapping exercises.

Placement	EDLM identifier	Probe ID	Rationale	Height	Comments
B01	13434	12706	G,D	0.2 m	N/A
T01	13426	2080	G,D	1.72 m	N/A
B02	13502	6502	G,D	0.2 m	N/A
T02	13397	14451	G,D	1.7 m	N/A
M03	13615	6421	G	0.9 m	N/A
B04	13453	8622	G, C	0.2 m	N/A
T04	13464	11197	G	1.75 m	N/A
B05	13493	12687	G, C	0.2 m	N/A
T05	13690	7621	G	1.75 m	N/A

Table 4. Placement of temperature loggers during mapping exercises.

Performed tests

During the mapping exercise the following tests were performed in timezone GMT-4 and in the following order:

	Stability study - Cold		Stability study - Ambient	
Duration:	3 hours	12 hours	3 hours	12 hours
Start Time & Date:	21-APR-2023 20:00	21-APR-2023 23:00	22-APR-2023 22:00	23-APR-2023 01:00
End Time & Date:	21-APR-2023 23:00	22-APR-2023 11:00	23-APR-2023 01:00	23-APR-2023 13:00
Timezone:	GMT-4	GMT-4	GMT-4	GMT-4
Objective:	Stabilization	Stability study	Stabilization	Stability study
Test Plan	TP3	TP3	TP3	TP3

Table 5. Mapping procedure for empty unit.

Test procedures

Conditions during test

Any activity during the mapping tests was logged in SIR.LANCELOT.V-520.MAPPING.07.TP4, rev. 1.0 throughout all the mapping exercises performed in said unit.

Empty

The unit was empty during the testing. Picture documentation was taken.

Temperature data during the mapping period (Outside air)

All mapping activities took place from the 21-APR-2023 until the 23-APR-2023, and the outside temperature during that period has been collected from timeanddate.com weather archive:

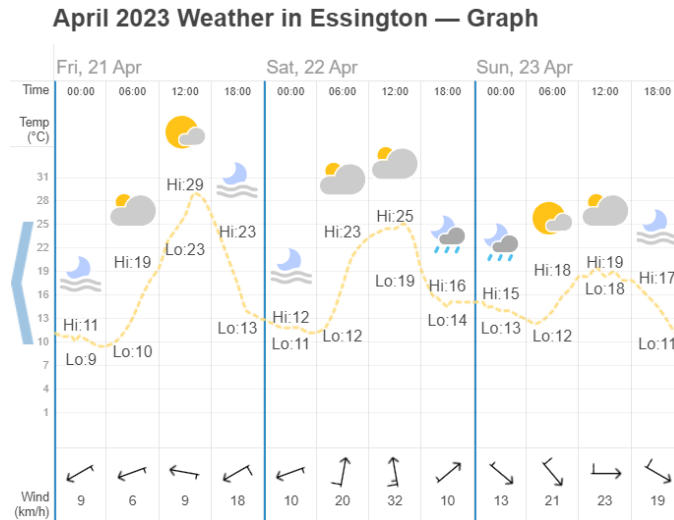


Figure 3. Outside temperature during the mapping period.

Stabilization

Prior to the tests all the temperature loggers were within the acceptable temperature range unless otherwise stated in the non-conformity section.

The unit was allowed to stabilize before the mapping exercises. During stabilization, no door openings were performed, and no loading of the unit was done. A stabilization of 3 hours took place prior to the start of testing.

Test documentation

The performance of each test has been documented on the associated test plan.

- TP1 - Documentation of Training
- TP2 - Datalogger Placement and Identification
- TP3 - Empty Stability Study Test
- TP4 - Door Opening Scheme

All filled-in test plans will be appended to this report in digital format.

All documentation has been reviewed and approved and has been deemed acceptable.

Furthermore, all measurements from the mapping exercise are appended to this report

Non-conformities

All observed non-conformities have been described in the non-conformities section and have been assessed and handled.

Data review

All data has been reviewed prior to the making of this report and deemed fulfilled completely. All non-conformities have been processed with associated comments as shown in the non-conformities section.

Mapping data and conclusions

First each scenario will be discussed and concluded, and thereafter an overall conclusion will be included.

Graphical representation of temperatures for every scenario will be attached to this report.

The following sections analyze data gathered during the mapping. Every test scenario have its own sections with subsections as follows:

- Table with temperature data from within measurement area containing minimum, mean, and maximum values for all dataloggers
- Cold spots and hot spots (both peaks and mean values) are indicated in the data tables as blue and red boxes respectively with bold typography
- Excursions below the accepted range marked with blue boxes
- Excursions above the accepted range marked with red boxes
- Sub-conclusions on every test-scenario
- List of non-conformities if any non-conformities have occurred
- The raw data collected during the study is found in association folder for each testing

OQ TP3 - Stability test - Empty (Cold)

Raw data

The raw data collected during the study is found in the associated folder.

Minimum, maximum and average

The following thermal characteristics were observed during the study.

Temperature data from within measurement area

Placement (Datalogger)	Min	Mean	Max
B01 (13434)	4.06 °C	4.94 °C	5.91 °C
B02 (13502)	4.24 °C	5.09 °C	6.21 °C
B04 (13453)	5.55 °C	6.15 °C	6.75 °C
B05 (13493)	6.09 °C	6.50 °C	7.17 °C
M03 (13615)	4.17 °C	4.84 °C	5.55 °C
T01 (13426)	3.86 °C	4.77 °C	5.81 °C
T02 (13397)	4.05 °C	4.93 °C	6.00 °C
T04 (13464)	4.34 °C	5.10 °C	5.92 °C
T05 (13690)	5.23 °C	5.66 °C	6.30 °C
Overall	3.86 °C	5.33 °C	7.17 °C

Table 6. Temperature data from within the measurement area, where the bold indication is the coldest and hottest area, respectively.

Graphical representation of temperature data All temperatures

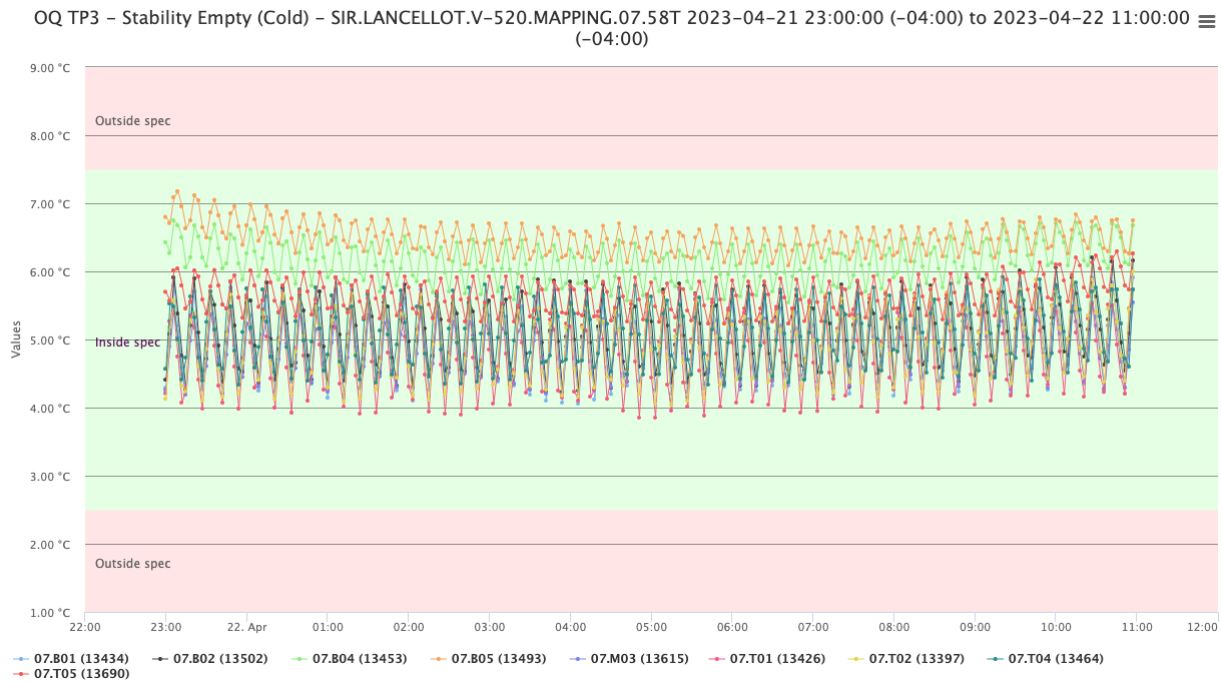


Figure 4. Graphical representation of the temperature measurements for all positions.

Hot and cold spots

Hot/Cold Spot	Placement (Datalogger)	Min	Mean	Max
Hot Spot (Peak)	B05 (13493)	6.09 °C	6.50 °C	7.17 °C
Hot Spot (Mean)	B05 (13493)	6.09 °C	6.50 °C	7.17 °C
Cold Spot (Peak)	T01 (13426)	3.86 °C	4.77 °C	5.81 °C
Cold Spot (Mean)	T01 (13426)	3.86 °C	4.77 °C	5.81 °C

Table 7. Hot and cold spots, where the bold indication is the coldest and hottest area respectively.

Tendencies of interest

The highest temperature peak and mean were both at position B05 at 7.17°C and at 6.50°C, respectively.

The lowest temperature peak and mean were both at position T01 at 3.86°C and at 4.77°C, respectively.

The measured temperatures for all positions showed fluctuations from time to time as seen in **Figure 4**, since the room's temperature is controlled with a HVAC-system that has cooling cycles. Positions B04, B05 and T05 measured higher temperatures compared to the other positions.

Conclusion

The data gathered during the empty stability test showed that the temperatures are well within the requirements for acceptance criteria listed in **Table 1** for all positions. Therefore it can be concluded that the unit was able to maintain temperatures within the acceptable range.

When MPE is taken into consideration the positions that are considered peak and mean hot spots are B04 and B05.

When MPE is taken into consideration the positions that are considered peak and mean cold spots are B01, B02, M03, T01, T02 and T04.

Non-conformities

No non-conformities were observed during the study.

OQ TP3 - Stability test - Empty (Ambient)

Raw data

The raw data collected during the study is found in the associated folder.

Minimum, maximum and average

The following thermal characteristics were observed during the study.

Temperature data from within measurement area

Placement (Datalogger)	Min	Mean	Max
B01 (13434)	17.84 °C	19.44 °C	20.52 °C
B02 (13502)	17.77 °C	19.42 °C	20.45 °C
B04 (13453)	17.81 °C	19.38 °C	20.32 °C
B05 (13493)	17.74 °C	19.51 °C	20.33 °C
M03 (13615)	17.76 °C	19.43 °C	20.45 °C
T01 (13426)	17.86 °C	19.52 °C	20.81 °C
T02 (13397)	17.84 °C	19.49 °C	20.63 °C
T04 (13464)	17.87 °C	19.50 °C	20.59 °C
T05 (13690)	17.63 °C	19.47 °C	20.62 °C
Overall	17.63 °C	19.46 °C	20.81 °C

Table 8. Temperature data from within the measurement area, where the bold indication is the coldest and hottest area, respectively.

Graphical representation of temperature data All temperatures

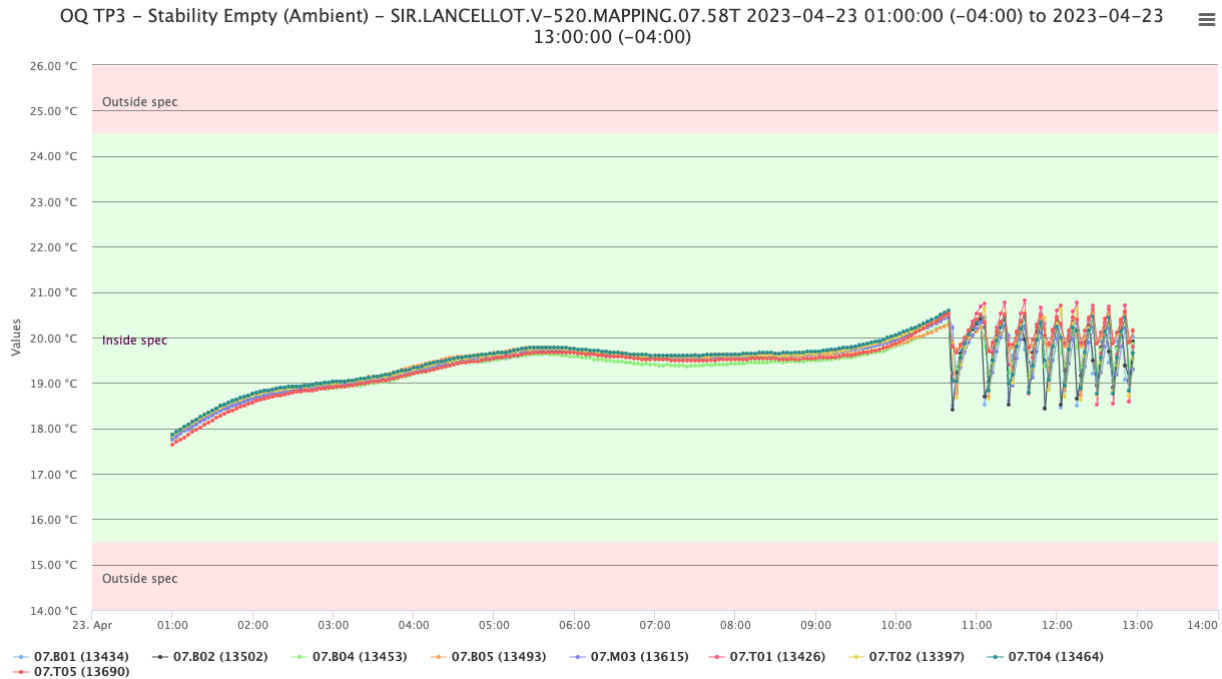


Figure 5. Graphical representation of the temperature measurements for all positions.

Hot and cold spots

Hot/Cold Spot	Placement (Datalogger)	Min	Mean	Max
Hot Spot (Peak)	T01 (13426)	17.86 °C	19.52 °C	20.81 °C
Hot Spot (Mean)	T01 (13426)	17.86 °C	19.52 °C	20.81 °C
Cold Spot (Peak)	T05 (13690)	17.63 °C	19.47 °C	20.62 °C
Cold Spot (Mean)	B04 (13453)	17.81 °C	19.38 °C	20.32 °C

Table 9. Hot and cold spots, where the bold indication is the coldest and hottest area respectively.

Tendencies of interest

The highest temperature peak and mean were both at position T01 at 20.81°C and at 19.52°C, respectively.

The lowest temperature peak and mean were at position T05 at 17.63°C and B04 at 19.38°C, respectively.

The temperatures were very stable between 01:00 to 10:39 on 23-APR-2023. The measured temperatures for all positions showed fluctuations approximately every 20 minutes as seen in **Figure 5**, this can be due to the HVAC-systems cooling cycles.

Conclusion

The data gathered during the empty stability test showed that the temperatures are well within the requirements for acceptance criteria listed in **Table 1** for all positions. Therefore, it can be concluded that the unit is capable of maintaining temperatures well within the acceptance criteria at all positions as for the ambient temperature.

When MPE is taken into consideration the positions that are considered peak and mean hot spots are all positions.

When MPE is taken into consideration the positions that are considered peak and mean cold spots are all positions.

Non-conformities

No non-conformities were observed during the study.

Overall Non-conformities

No non-conformities were observed overall during the mapping study.

Overall conclusion and recommendations

The temperatures were well within the acceptable range for all positions during the OQ study of both cold and ambient temperatures.

Overview of the mapping results

Test ID:	Hot spots:		Cold spot:	
	Peak	Mean	Peak	Mean
Empty Stability Study (Cold)	B04, B05	B04, B05	B01, B02, M03, T01, T02, T04	B01, B02, M03, T01, T02, T04
Empty Stability Study (Ambient)	B01, B02, B04, B05, M03, T01, T02, T04, T05	B01, B02, B04, B05, M03, T01, T02, T04, T05	B01, B02, B04, B05, M03, T01, T02, T04, T05	B01, B02, B04, B05, M03, T01, T02, T04, T05

Table 10. Overview of hot and cold spots during the mapping study.

The recommendation for placement of temperature monitoring dataloggers is based on the analysis of hot and cold spots and the risks enlisted previously in the risk assessment section. As seen in **Table 10** summarizing all the hot and cold spots found during the mapping period, it can be concluded that many positions are statistically candidates for the cold/hot positions.

Recommendations for the placement of constant temperature monitoring are as follows, with placement of fixed monitoring in some/all of the listed positions:

Cold spots:

- B01, B02, M03, T01, T02, T04

Hot spots:

- B04, B05

Lastly, the fixed monitoring should take consideration into areas at risk of measuring temperatures outside of the accepted range as, close to the door connected to non-controlled areas, the ventilation system and so forth.

Change history

Revision #	Initials	Date	Comment
1.0	SSA	04-MAY-2023	First revision.