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Third Quest Regular Trial Shipment

Apples from Chile to the U.K.

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Report 734

Colophon

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Abstract

The "Quest regular" system has been developed to reduce power consumption of reefer containers. The Quest Regular concept and corresponding CCPC software was tested in a real-life shipment of apples from Chile to the Netherlands and the U.K. in July 2006. The goal of the trial shipment was to test the software and compare the power usage, temperature distribution and product quality of two Quest test containers to those of two reference containers, which were shipped simultaneously at original settings.

A 45% power saving was achieved over the whole trip.

During Quest Regular Mode, the minimum supply temperature often did not completely reach supply setting. Carrier has adapted the field trial software to enable supply setting to be reached in following trials.

The supply air fluctuations are only slightly visible in the carton temperature data. The carton temperatures in the Quest containers were satisfactory and quite close to the setpoint and the temperatures in the reference container. The Quest container cartons were 0.1°C further from the setpoint, while the bandwidth was 0.4°C larger. The coolest cartons was 0.1°C closer and the warmest carton 0.4°C further from the setpoint.

The apples from the Quest container were a little less firm than the apples from the Reference container, for the other quality indicators no differences between the Quest and reference container were found. No relation could be found between the average temperature and product quality. This indicates that the Quest regime did not change quality output compared to normal regime.

Acknowledgements

This third real-life Quest trial was largely organized and performed by Maersk Line. Most of the data and information in this report was provided by Maersk employees. We especially would like to thank Mr. Lindhardt and Mr. Nielsen of Maersk's Centre Reefer Management, Mr Hofmann of Maersk's Reefer Management Great Britain, Mr Selsig of Maersk's Claims Rotterdam and Mr. Barfod and Mr. de Castro Alves of Maersk's Reefer Operations - South America.

We also thank Carrier Transicold for providing the necessary CCPC software for the trial and the unit data-files that were made from the unit downloads. We especially would like to thank Mr. Griffin, Mr. Dudly, Mr. McIntosh, Mr. Hofsdal and Mr. Bretherton.

Quality inspections at arrival and power and temperature data logging were supported by MMS. We would like to thank Mr. Bishop and Mr. Pailes for sharing their data files and findings with us, part of which were used for this report.

We are indebted to our A&F colleagues Mr. van den Boogaard, Mr. Boerrigter, Mr. v.d. Geijn and Mr. Verschoor for their help during the organisation of the trial and its preparations as well as the product quality assessments.

Finally, our thanks go to San Clemente, Orchard World, International Produce LTDA and Morrisson, whose fruit was transported and who made quality inspection possible before and after transport.

Contents

1 Introduction

The "Quest regular" system has been developed to reduce power consumption of reefer containers. As a follow-up of the first real-life Quest trial with mangoes, it has been tested for apples and mandarins[1] in July 2006. In order to exactly determine the amount of power reduction, a comparison was made with two standard controlled reefer containers. All four 40 ft. containers were loaded with apples and were transported on the same vessel (Lexa Maersk). The shipment was from Chile (San Antonio) to the U.K. (Felixstowe). The transport time was 25 days.

The test containers (MWCU6827368, Apple test 1 and MWCU6754430 Apple test 2) were equipped with and controlled by the "Quest Regular" software, also referred to as CCPC (Compressor-Cycle Perishable Cooling). The containers MWCU6797617, Apple ref 1 and MWCU6800618, Apple ref 2 served as reference containers. During the shipment power consumption of all containers was measured using externally added KWH-meters. The temperature distribution was measured using 9 sensors per container and logging the actual temperature every 30 minutes. Fruit samples for quality evaluation (18 cartons) were taken from 9 pallets in both containers test 1 and ref 2 (see scheme and location of the temperature sensors). Half of these test cartons contained a temperature sensor (Tiny Tag) to be able to compare the temperature distributions of both containers. With these readings it would be possible to determine correlations between local temperatures and quality development of the fruits. Upon arrival in the Netherlands a first quality inspection of the apples was carried out. The quality evaluation was extended by a shelf life treatment of the test samples using the experimental facilities of A&F in Wageningen, The Netherlands.

A precise quality evaluation was necessary as the Quest Regular mode operation allows the supply air to have a low value during specific interval times. This value is lower than the value that is commonly considered a chilling temperature. The idea behind this is that chilling will be avoided by cycling, as the supplied air is only on this low level for short periods. Product temperature and internal metabolic processes do not follow these quick changes of the temperature settings i.e. chilling will not occur. This hypothesis was tested successfully for several commodities before but not for Braeburn apple. The energy saving method is only of value when product i.e. apple quality is not harmed by it.

[1] *For the results for mandarin see report "Second Quest Regular Trial, mandarins form Chile to the Netherlands and the U.K."*

2 Material and methods

2.1 Product

The apple variety was Braeburn (extra fancy) in various sizes. The apples originated from two growers: 5540 & 575 both from the Talca area in Chile. The initial temperature of the apples was just above 0°C.

Figure 1 Braeburn 5540

Figure 2 Braeburn 575

2.2 Packaging and stowage

The apples are packed in cardboard boxes, with trays and covered with plastic. The box size is 600x400 mm, stacked 13 boxes high (5 on a layer). In total 4 times 1300 cartons are packed, placed on 20 pallets. The pallets used were wooden industrial pallets size 1200x1000 mm. 20 pallets were fitted in the container cross stacked (see also Figure 5).

2.3 Unit settings

The containers used were fitted with Carrier Thinline refrigeration units. The CCPC program (v. 9526) was installed on all units, using a microlink 3 card. The reference containers were running in normal mode with settings as usual for Braeburn. For these, the CCPC software was only used to enable additional data logging. The Quest containers were running in CCPC mode.

The reference container settings were:

◊ Supply setpoint	0.0 °C = 32.0 F
◊ Fan setting	High
◊ Vent setting	20 m³/hr

The CCPC settings were:

◊ Supply setpoint	-2.0 °C = 29.3 F
◊ Return Air Pulldown Low Limit	0.0 °C = 32.0 F
◊ Return Air Low Limit	0.0 °C = 32.0 F
◊ Return Air High Limit	1.0 °C = 22.8 F
◊ Fan setting	Alternating
◊ Vent setting	20 m³/hr

Defrost interval: was set to automatic and Humidity, Dehumidification and Bulb Mode were all set to OFF.

2.4 Voyage schedule

On July 14th the containers were loaded with apples. Subsequently, the containers were taken to the harbour of San Antonio. The setup is shown in Table 1.

Table 1 Container setup

Container nr	Setup mode	Stuffing date	Commodity	Grower
MWCU 679 761 7	Normal (ref 1)	14/7/2006	Apple	5540
MWCU 680 061 8	Normal (ref 2)	14/7/2006	Apple	5540
MWCU 682 736 8	CCPC (test 1)	14/7/2006	Apple	5540
MWCU 675 443 0	CCPC (test 2)	14/7/2006	Apple	575 (4) & 5540 (1)

All containers were loaded to the vessel (Lexa Maersk) during the morning of July 16th (mid ship, bottom side, on deck, see Figure 18 the appendix).

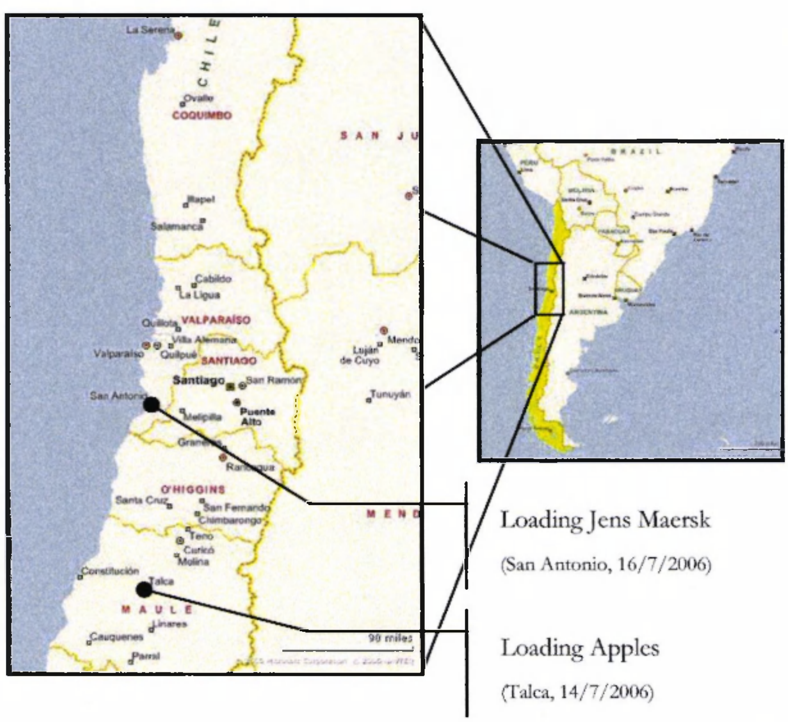


Figure 3 Map of loading and departure locations

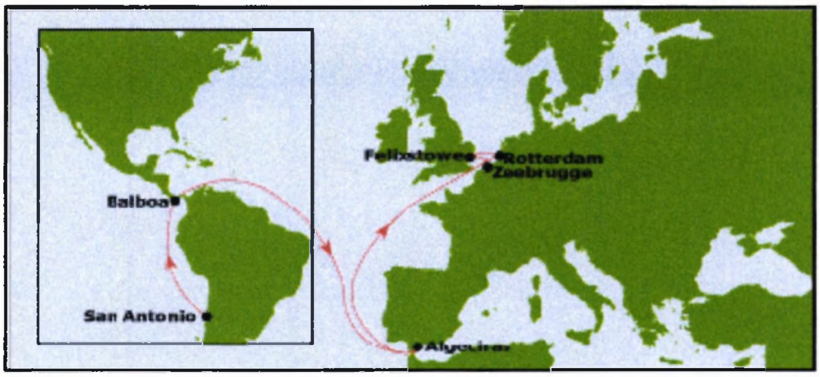


Figure 4 Map of the vessel route

The containers arrived in Felixstowe (U.K.) on August 7th. Figure 16 and Figure 17 in the appendix depict the mean temperature and relative humidity in July for such a trip.

2.5 Unit and climate measurements

External KWh meters were attached to all units. The CCPC software installed on the containers included additional data logging, storing elaborate unit information every hour Temperatures were measured by 4 USDA probes and 9 Tiny tags per inside the containers. In order to measure the temperature reaction of the fruit to the software system the Tiny Tags data loggers were placed next to the fruit to the sidewall of each carton. Data recording had been pre-set for every 30 minutes. Such instruments were placed in 5 pallets bottom and ¾ in height. In each container 3 pallets were also fitted with small bottles in order to retrieve gas decomposition samples of the internal container atmosphere.

Figure 5 shows the stowage of the pallets in the containers. The yellow marked pallets were fitted with temperature, relative humidity and gas decomposition sensors. These are also the pallets from which samples for shelf live testing were taken. The green marked pallets were fitted with USDA-probes (on the 6th layer), measuring product temperature. Probe 1 was installed in pallet 3, Probe 2 was installed in pallet 12 and Probe 3 and 4 were installed in pallet 19 and 20.

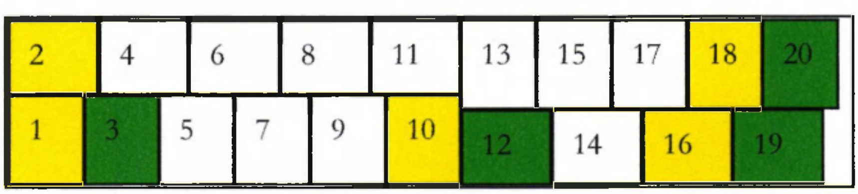


Figure 5 Container layout

2.6 Quality measurements

Apple pallets contained 13 layers of boxes. From pallets 1, 2, 3, 10, 12, 16, 18, 19 and 20 (see Figure 5) a box from layer 1 (bottom box) and a box from layer 10 were taken as sample boxes: 18 boxes per container. The apples were transported from the place of delivery in England to Wageningen in a cooled van (1°C). At arrival in Wageningen from 20 apples of each box colour and firmness were determined and external and internal quality was examined (see Figure 6 and Figure 7).

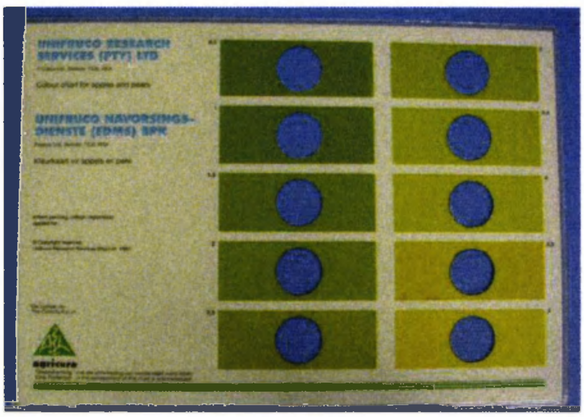


Figure 6 Colour chart

Figure 7 Penetrometer for firmness

The remaining apples were stored at 18°C/75% relative humidity (RH) as a simulation of shelf life. After a 14 days' shelf life simulation the same quality indicators were determined again.

3 Temperatures

Figure 8 and Figure 9 show the Tiny Tag data for the coolest and warmest cartons, as well as the mean temperature of all cartons. This gives an overview of all carton temperature readings, which are shown in Figure 19 through Figure 21 in the appendix. Time instance July 13th 00:00 is defined as t=0. To get a good impression of the spatial distributions of the carton temperatures and how these change in time, see the movies on the accompanying cd.

3.1 Temperature readings at the start of the trip

The initial temperature readings of the cartons in the test and reference containers are comparable (with somewhat higher values for Quest test 2) mostly between 0 and 1°C (see Figure 19 through Figure 21 in the appendix). Pulp temperature readings lie between 0 and 1.3°C (see Figure 22 through Figure 25 in the appendix).

3.2 Temperature readings during pull down

As the apples were pre-cooled, initial temperatures lay fairly close to setpoint already. The cartons are only cooled down by and additional 0.5 - 1°C, which takes approximately 2 days. A few relatively warm boxes in test 2 and ref 2 need up to 10 days to pull down or keep their somewhat high value (e.g. one box of 1.2 °C in test 2) for the whole trip.

3.3 Supply air temperatures during Quest Regular Mode

During Quest Regular Mode, the minimum supply temperature often does not reach supply setting, but stops at about 0.5 deg C higher value (see Figure 22 to Figure 25 in the appendix).In some cases, e.g. after defrost and when ambient temperature is high, the supply air does reach its setpoint. Unit data show that SMV does not open fast enough. The PI-controllers P-action is not large enough to open the smv quickly when heat load is small. The I-action is reset when compressor is turned off and needs some time to build up, which does not happen fast enough with these fast cycles. Carriers proposed solution is to use same logic as is used for scroll-compressors already, namely to remember the smv position when compressor is turned off and using this old setting when starting up again. Carrier has adapted the field trial software accordingly for the following trials.

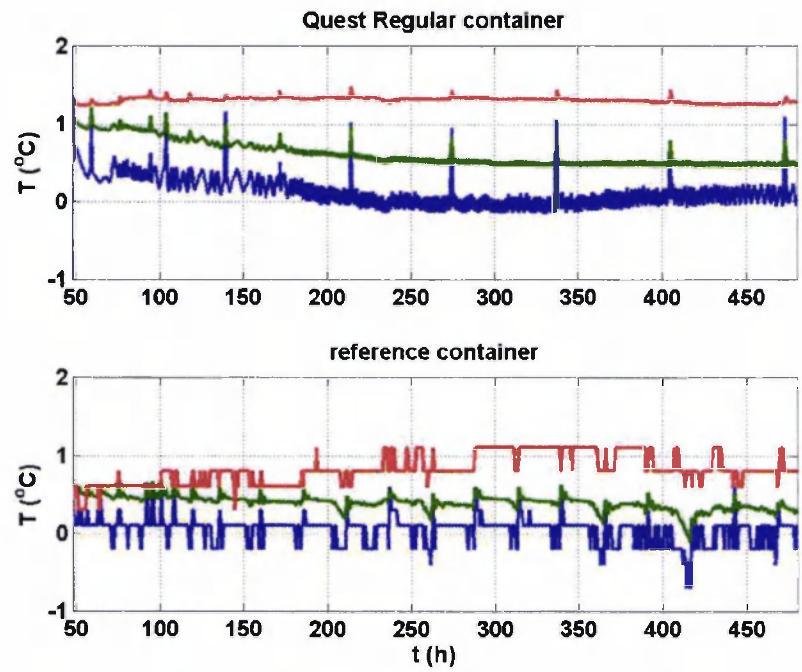


Figure 8 Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-) , for Apple test 2 and ref 1

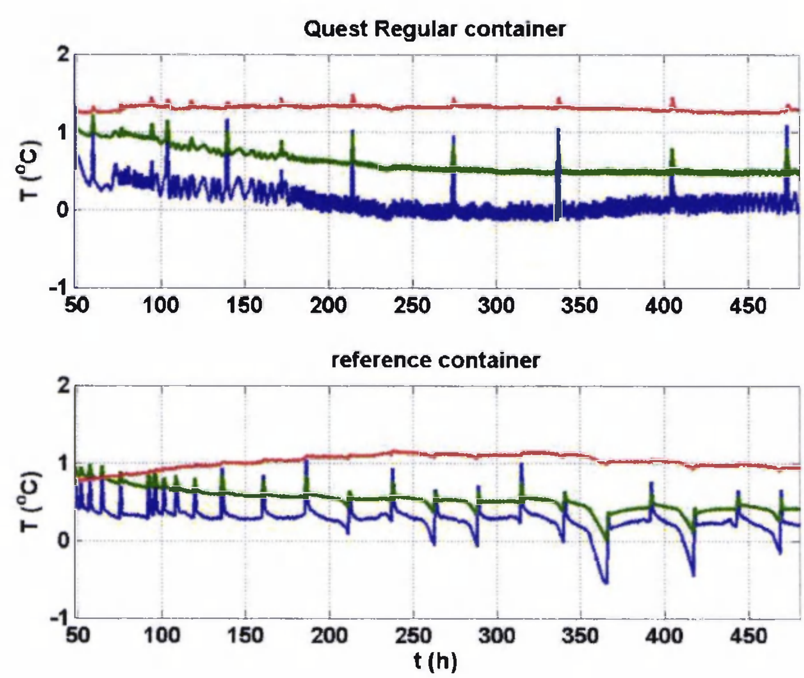


Figure 9 Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-) , for both Apple 2 containers

3.4 Temperature readings during Quest Regular Mode

The supply air of the Quest containers fluctuates in time, but with such a high frequency, that the fluctuations are only slightly visible in the carton temperature data (measured with a 30 min period).

The temperature data for the Quest Regular period (July 15th until August 2nd, t=48 – 480 h) have been summarized in Table 2 through Table 6. The tables contain information on the temperatures of the coolest and warmest cartons as well as the mean temperature of all cartons combined.

First of all, the deviation from the given setpoint is important (see column 3 of Table 3 and Table 6). The mean carton temperature of the Quest container is 0.6°C. The mean carton temperature of the reference containers is 0.5°C. Thus, the Quest container is 0.1°C further from the setpoint of 0.0°C than the reference containers.

Secondly, the maximum bandwidth of the carton temperatures is considered (see column 2 and 4 of Table 2). Looking at the lowest and highest temperatures measured in the cartons, the maximum temperature difference between the coolest and warmest cartons was 1.7°C in the Quest container and 1.8°C in the reference containers. Thus, in the most extreme situation, the Quest container had a 0.1°C smaller maximum temperature bandwidth than the reference containers.

Thirdly, the mean bandwidth of the carton temperatures is considered (see column 2 and 4 of Table 3). Looking at the mean of the carton temperatures in time, the temperature difference between the coolest and warmest cartons was 1.2°C in the Quest container and 0.8°C in the reference containers. Thus, on average, the Quest container had a 0.4°C larger temperature bandwidth than the reference container.

Fourthly, the deviation of the coolest carton from the given setpoint is important (see column 2 of Table 5 and Table 6). The coolest carton of the Quest container was 0.1°C above setpoint. The coolest cartons of the reference containers are 0.2°C above setpoint. Thus, the coolest cartons of the Quest containers are 0.1°C closer to the setpoint than the reference containers.

Finally, the deviation of the warmest cartons from the given setpoint is important (see column 4 of Table 5 and Table 6). The warmest carton of the Quest container is 1.3°C above setpoint. The warmest cartons of the reference containers are 0.9°C above setpoint. Thus, the warmest carton of the Quest container is 0.4°C further from the setpoint than the reference containers.

Overall, carton temperatures in the Quest container were satisfactory and quite close to the setpoint and the temperatures in the reference container. The Quest container cartons were

Table 2 The ranges of the minimum, maximum and mean carton temperature readings (from July 15th 00:00 to August 2nd 00:00 for apple)

	min carton T (°C)	mean carton T (°C)	max carton T (°C)
Quest container 2	-0.2 to 1.4	0.4 to 1.3	1.2 to 1.5
reference cont. 2	-0.6 to 1.0	0.0 to 1.0	0.8 to 1.1
reference cont. 1	-0.7 to 0.6	-0.1 to 0.7	0.3 to 1.1

Table 3 The mean of the minimum, maximum and mean carton temperature readings

	mean min carton T (°C)	mean mean carton T (°C)	mean max carton T (°C)
Quest container 2	0.1	0.6	1.3
reference cont. 2	0.3	0.5	1.0
reference cont. 1	0.0	0.4	0.8

Table 4 The deviations from setpoint for the minimum, maximum and mean carton temperature readings

	dev min carton T (°C)	dev mean carton T (°C)	dev max carton T (°C)
Quest container 2	-0.2 to 1.4	0.4 to 1.3	1.2 to 1.5
reference cont. 2	-0.6 to 1.0	0.0 to 1.0	0.8 to 1.1
reference cont. 1	-0.7 to 0.6	-0.1 to 0.7	0.3 to 1.1

Table 5 The deviations from setpoint for the mean of the minimum, maximum and mean carton temperature readings

	dev mean min carton T (°C)	dev mean mean carton T (°C)	dev mean max carton T (°C)
Quest container 2	0.1	0.6	1.3
reference cont. 2	0.3	0.5	1.0
reference cont. 1	0.0	0.4	0.8

Table 6 The difference in deviation from setpoint for the Quest container compared to the reference container, for the coolest, mean and warmest carton

	ΔT coolest carton (°C)	ΔT mean carton (°C)	ΔT warmest carton (°C)
Quest 2 & ref 1, 2	+0.1	-0.1	-0.4

0.1°C further from the setpoint, while the bandwidth was 0.4°C larger. The coolest cartons was 0.1°C closer and the warmest carton 0.4°C further from the setpoint.

USDA readings during the trip are shown in Figure 22 to Figure 25 in the appendix. Temperatures in Quest container test 1 lie in the same range as those of the reference containers. Some of the temperatures in Quest container test 2 are lower than those of the reference containers, but lie on equal distance form the setpoint than the USDA readings of the reference containers.

3.5 Temperatures at the end of the trip

Figure 10 and Figure 11 show a snapshot of the carton temperatures near the end of the trip. They show that carton temperatures of the Quest container lie a little bit further from the setpoint than in the reference containers. Also, they give an indication of the temperature distributions over the various locations inside the containers.

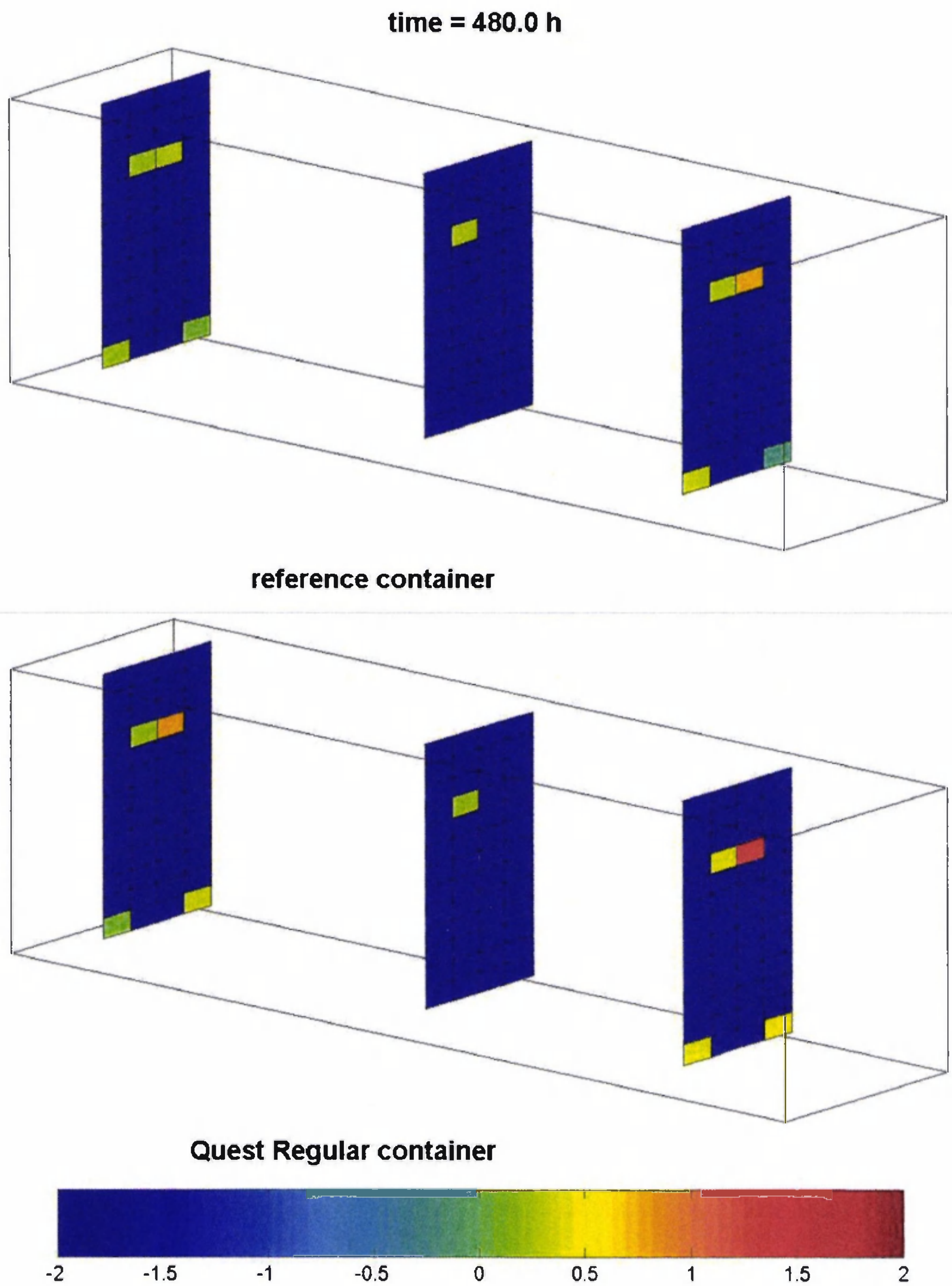


Figure 10 Tiny Tag readings of the carton temperatures near the end of the trip, on August 2nd 00:00, Apple ref 1 and test 2

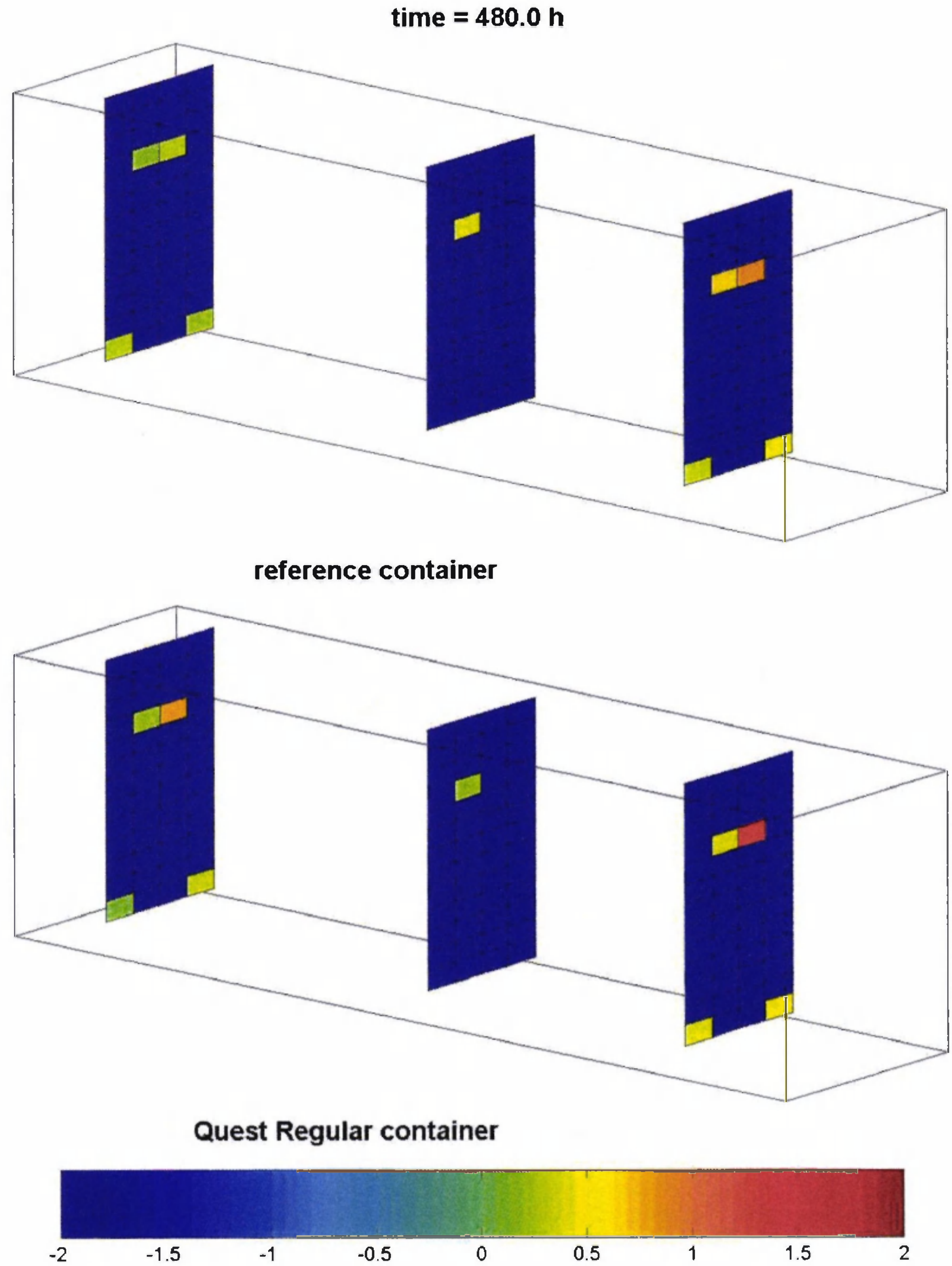


Figure 11 Tiny Tag readings of the carton temperatures near the end of the trip, on August 2nd 00:00, Apple ref 2 and test 2

4 Power Consumption

Power consumption data were read from the kWh meters by Maersk employees twice a day during the sea voyage. Time and energy data were taken from the kWh meters and ambient temperature readings were read from the unit's user interface, see Figure 12. Time axis is such that t = 0 starts at July 13th 2006 00:00.

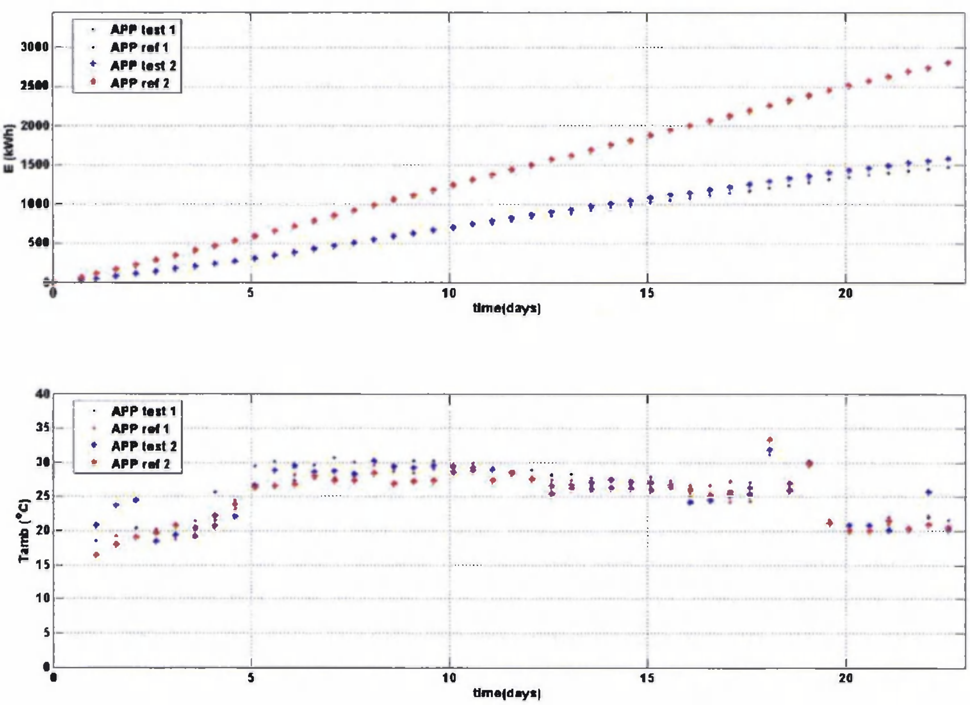


Figure 12 Energy and temperature readings as a function of time for both container sets

The reference containers used 2798 and 2798 kWh in 542 hour, a mean power usage of 5.2 and 5.2 kW. The Quest container used 1478 and 1577 kWh in 542 h, a mean power usage of 2.7 and 2.9 kW, which is 47 and 44% less compared to the reference containers. The power and savings per day are shown in Figure 13. Mean savings are 45%.

The power savings are largely due to the periods that the compressor is turned off during cycling, the length of which can be seen in Figure 30 in the appendix. (For comparison, also the active hours and defrost time of the units are shown.) Compressor off time intervals last approximately 20 minutes for Apple test 1 and 15 minutes for Apple test 2, almost twice as long as the compressor-on time intervals. The compressor off periods become somewhat shorter when ambient temperature is higher. Compressor on times do not change much during the trip. Other factors of influence are defrost intervals, the reduced fan speed during compressor-off time intervals and the somewhat reduced amount of ventilation during low fan speed/compressor off periods.

Defrost setting is AUTO, leaving the unit to learn from its measurement data how often a defrost action is necessary. Both reference units defrost about once a day, whereas the test containers defrost period increases to about once every 3 days. The defrost actions of the reference containers take approximately 25 minutes. Those of the Quest containers take somewhat shorter, approximately 20 minutes. These small values indicate that little ice was present on the coil. The reduced amount of defrost actions for the Quest containers is mainly due to the reduction in compressor run hours (approximately 1/3rd).

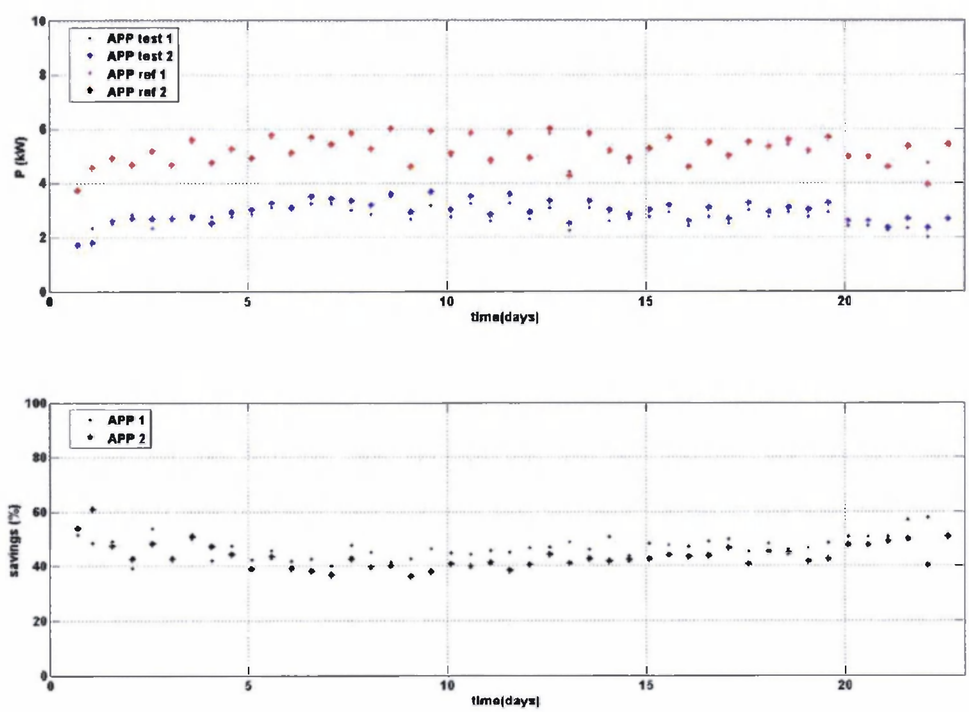


Figure 13 Power and savings as a function of time for both container sets

5 Evaluation of fruit quality

5.1 General remarks

The apples in all containers were from the same grower, but not from the same size. Average diameter per box varied from 65 – 76 mm. The smallest apples (65 mm) were packed in pallets 12, 19 and 20 in both containers.

Upon arrival the apples were slightly less firm than usual. No differences between the containers were determined. At arrival at AFSG in Wageningen quality differences between boxes appeared to be considerable. It is likely that the apples were harvested months ago and stored in suboptimal conditions and therefore ageing symptoms occurred. Firmness was suboptimal and many apples showed loss of structure.

Because apples in both containers were from the same grower, the produce is considered to be homogenous enough to compare the containers.

The atmosphere samples showed a (significant) lower ethylene level in the Quest container (test 1, 2.8 ppm) than in the Reference container (ref 2, 5.0 ppm). This indicates sufficient ventilation in the Quest container.

5.2 External quality

At the start of shelf life one apple with core flush was found (from the Reference container) and one apple that showed brown discolouration (from the Quest container).

5.2.1 Colour

At the beginning of shelf life the apples from the reference container were in colour stage 3.2, the ones from the Quest container in stage 3.1. After 14 days of shelf life the average stage of background colour was 3.8 for apples of both containers. No differences in background colour were found between the containers.

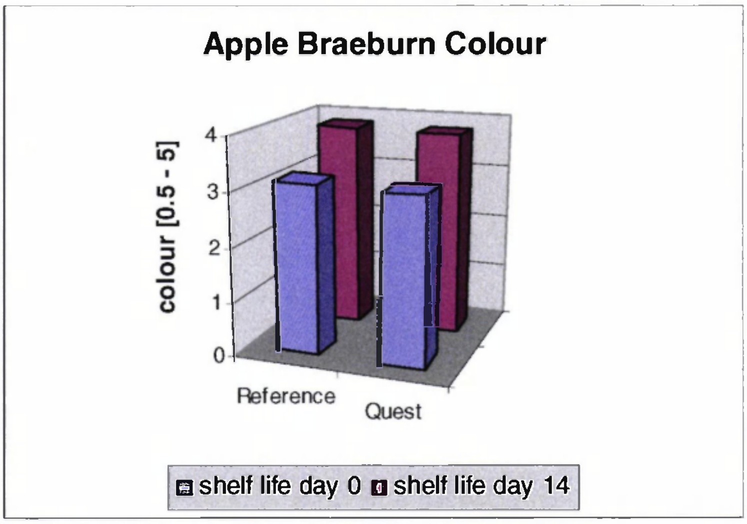


Figure 14 Background colour of Braeburn apples from the Reference container and the Quest container

5.2.2 Firmness

At day 0 of shelf life the apples from the reference container showed firmness value 6.4, the ones from the Quest container 6.2. After 14 days of shelf life firmness values were respectively 5.0 and 4.9. Although the differences were very small, statistical analysis showed a significant effect.

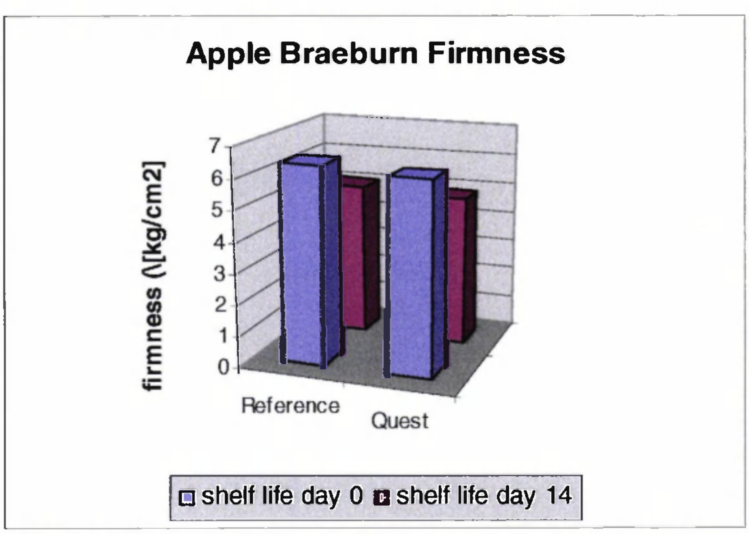


Figure 15 Firmness of Braeburn apples from the Reference container and the Quest container

5.3 Internal quality

One box with apples with a very poor internal quality was found in the reference container. Furthermore core flush was found in a few apples from both containers and internal brown discolouration was found in a few apples from the Reference container. One single symptom of chilling injury was found (brown discolouration), but more likely is that this symptom is due to ageing.

5.4 Average temperature and quality

No temperature data are available from container Apple test 1. Therefore, the temperature data from container Apple test 2 were related to the quality indicators of the apples from container Apple test 1. Furthermore, the relation between the average temperature and product quality in container Apple ref 2 was determined.

The average temperature was calculated from July 15th 00:00:00 to August 2nd 00:00:00. Temperatures were logged in the pallets 1, 2, 16 and 18 at two levels (layer 1 and 10) and in pallet 10 at layer 1.

The lowest average temperature in Quest container 2 (0.1°C) was measured in pallet 1 at layer 1, the highest average temperatures were measured in pallet 2, layer 10 (1.2°C) and pallet 18, layer 10 (1.3°C).

The lowest average temperature in Reference container 2 (0.25 °C) was measured in the pallets 1 and 2 at layer 1 and in pallet 1 at layer 10. The highest temperature (1.0°C) was measured in pallet 18, layer 10.

No relation was found between the time-averaged temperatures in container test 2 and product quality in container test 1. Also, no relation was found between the time-averaged temperature and product quality in the container ref 2.

5.5 Quality conclusions

- The main differences in quality were found between boxes
- The apples from the Quest container were a little less firm than the apples from the Reference container
- For the other quality indicators no differences were found due to one of the containers
- One single symptom of chilling injury was found (brown discolouration), this symptom is likely due to ageing
- No relation was found between the average temperature and product quality

6 Conclusions

6.1 Power savings

The reference containers had a mean power usage of 5.2 kW, this was 2.8 kW for Quest, a 45% saving.

6.2 Temperatures

The supply air of the Quest containers fluctuates in time, but with such a high frequency, that the fluctuations are only slightly visible in the carton temperature data (measured with a 30 min period).

During Quest Regular Mode, the minimum supply temperature often did not reach supply setting, but stops at about 0.5 deg C higher value. Carrier has adapted the field trial software to remember the smv position when compressor is turned off and using this old setting when starting up again. This should enable supply setting to be reached in following trials.

The carton temperatures in the Quest container were satisfactory and quite close to the setpoint and the temperatures in the reference container. The Quest container cartons were 0.1°C further from the setpoint, while the bandwidth was 0.4°C larger. The coolest cartons was 0.1°C closer and the warmest carton 0.4°C further from the setpoint.

6.3 Product quality

The apples from the Quest container were a little less firm than the apples from the Reference container, for the other quality indicators no differences between the Quest and reference container were found. No relation could be found between the average temperature and product quality. This indicates that the Quest regime did not change quality output compared to normal regime.

References

[1] http://www.cdc.noaa.gov/cgi-bin/Composites/comp.pl

Appendix I: Ambient conditions from San Antonio to Felixstowe

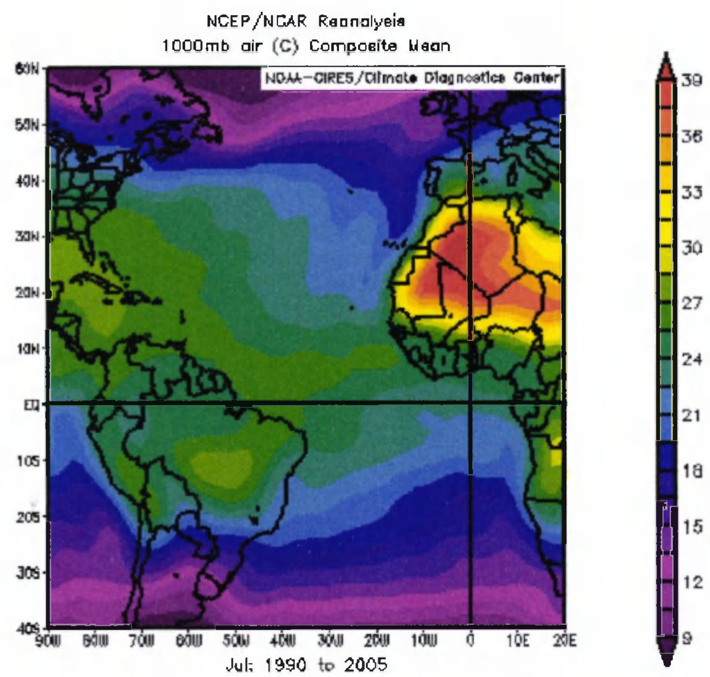


Figure 16 Mean July temperature between San Antonio (Chile) and Felixstowe (U.K.)

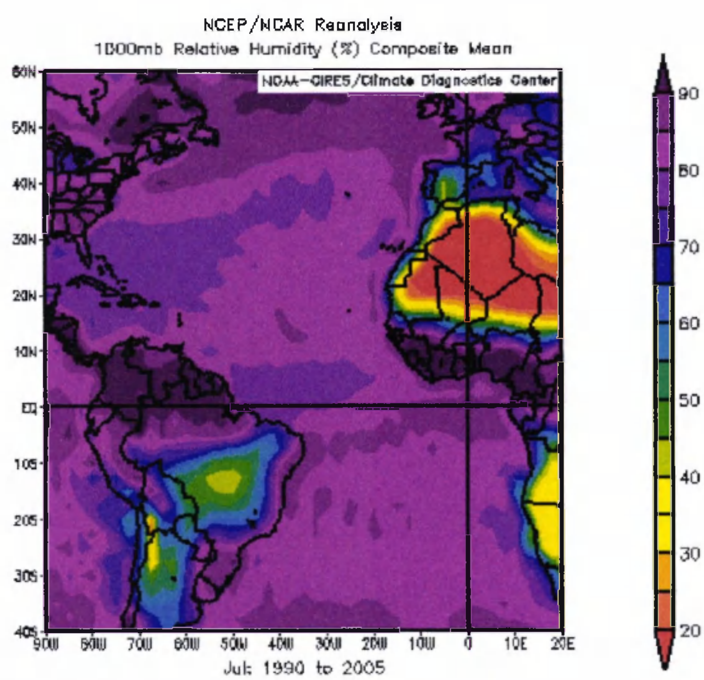


Figure 17 Mean July relative humidity between San Antonio and Felixstowe

Appendix II: Photos of mandarin and apple containers on vessel

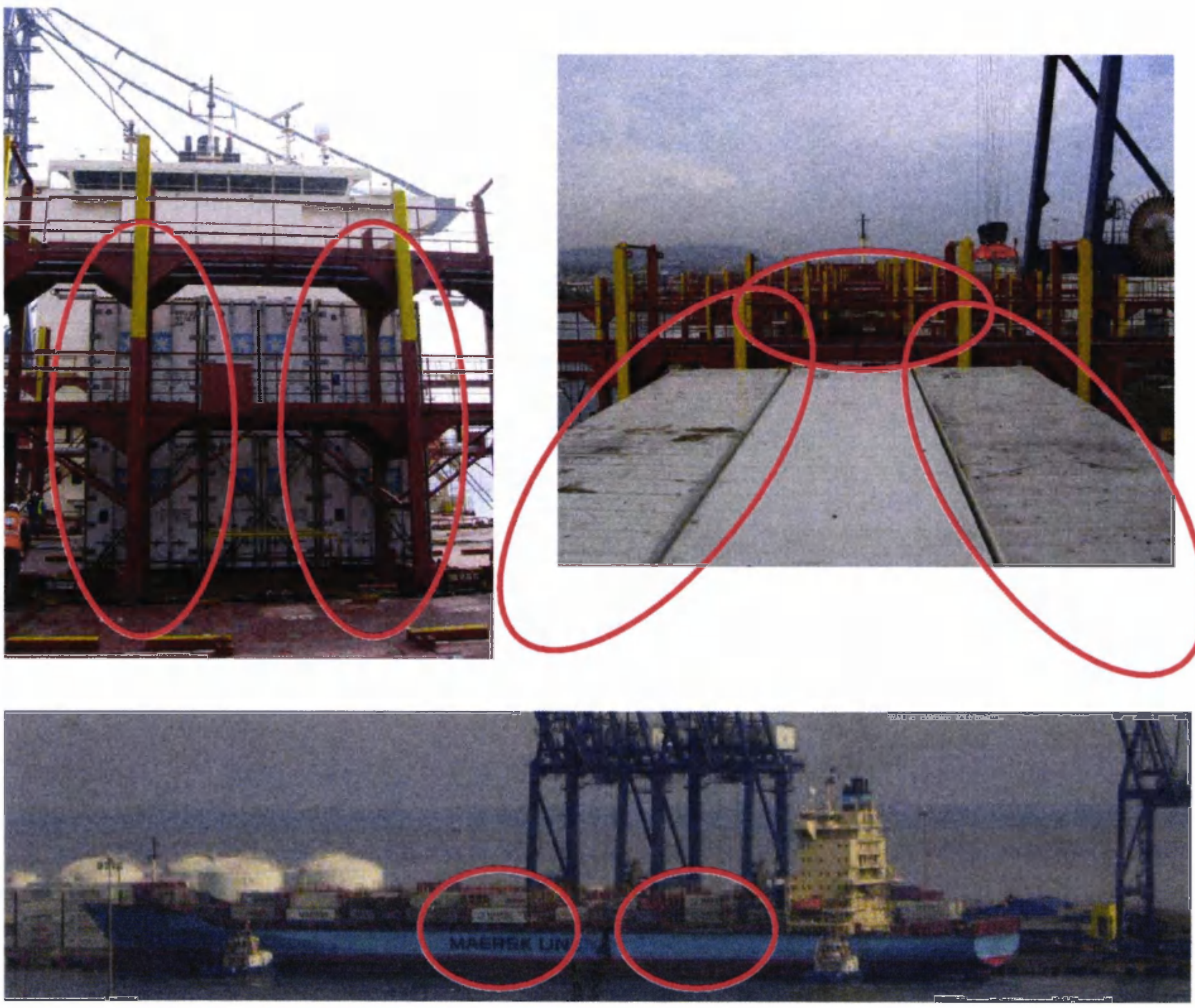


Figure 18 Photos of containers upon Lexa Maersk

Appendix III: Carton temperatures

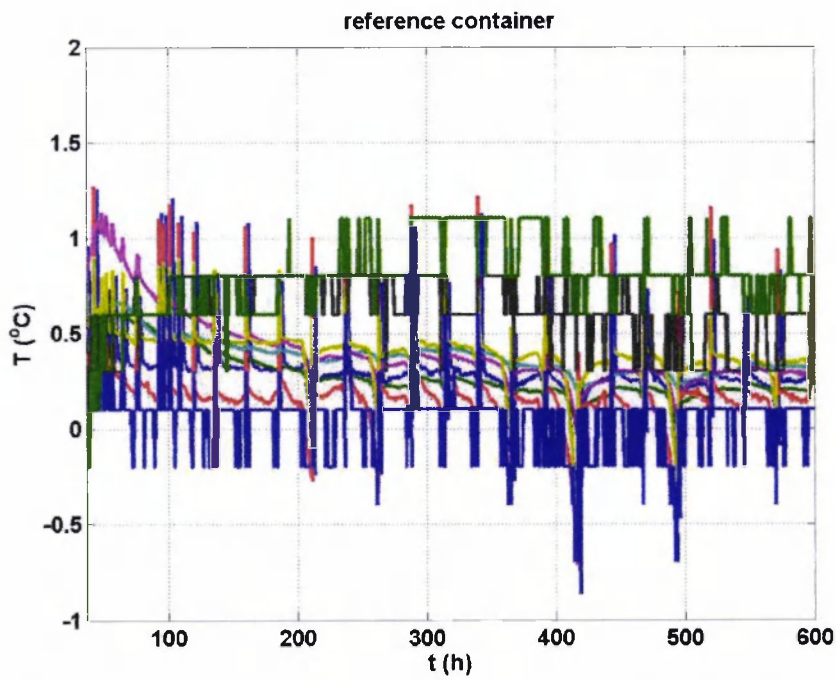


Figure 19 Temperature readings of Tiny Tags in cartons, all data, for Apple ref 1

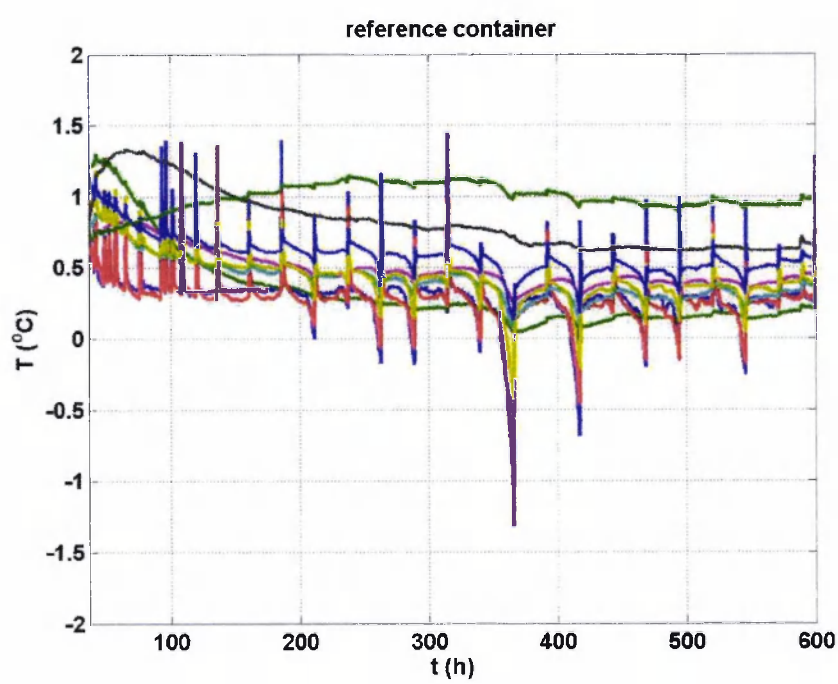


Figure 20 Temperature readings of Tiny Tags in cartons, all data, for Apple ref 2

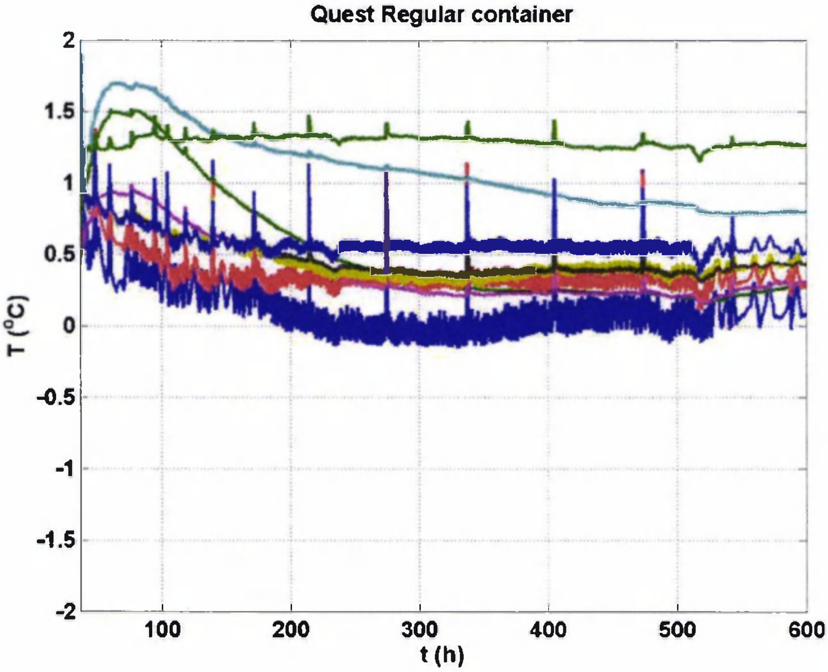


Figure 21 Temperature readings of Tiny Tags in cartons, all data, for Apple test 2

Appendix IV: Unit temperature readings as a function of time

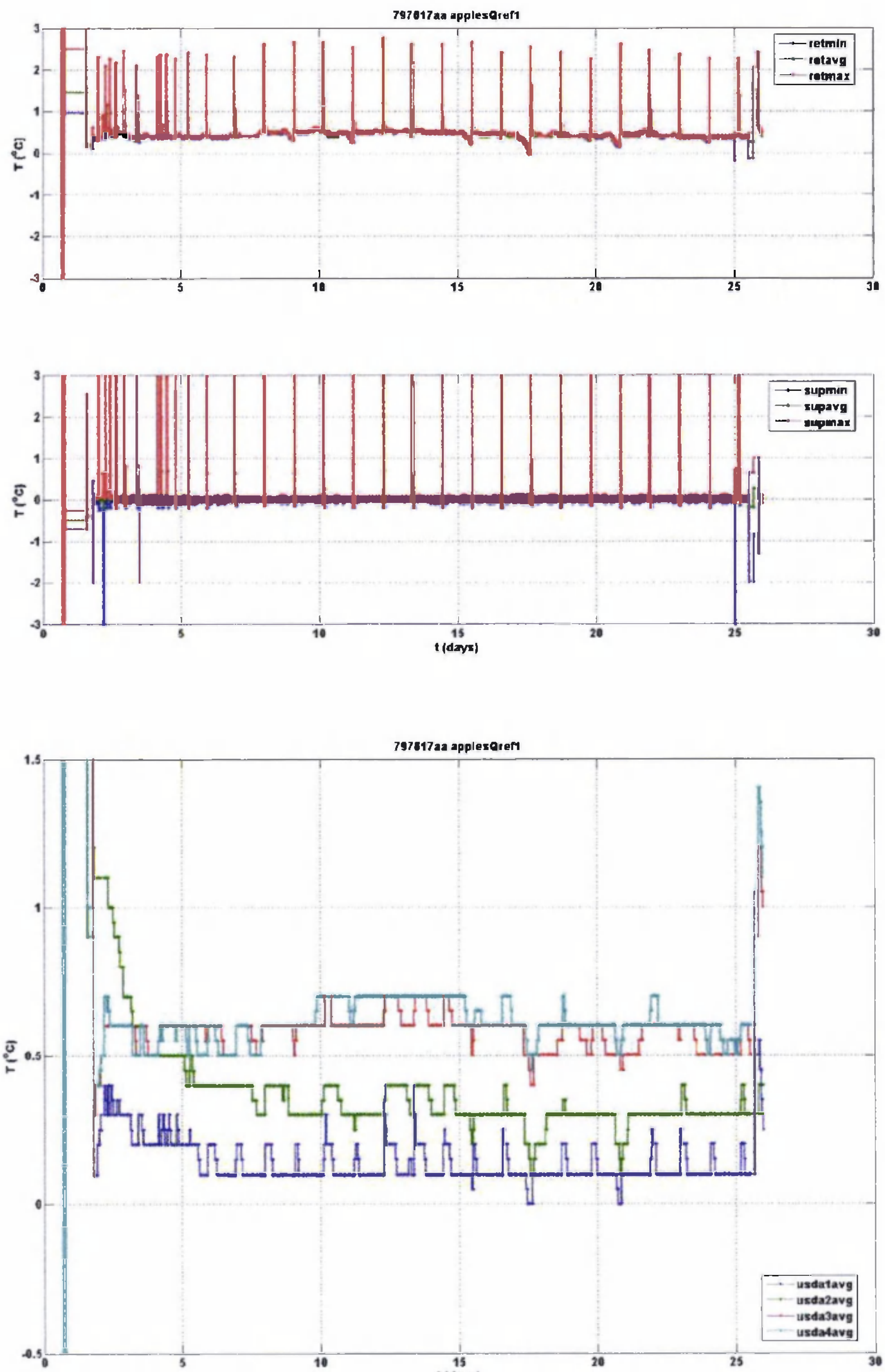


Figure 22 Temperature readings from the unit for the Apple ref 1 container.

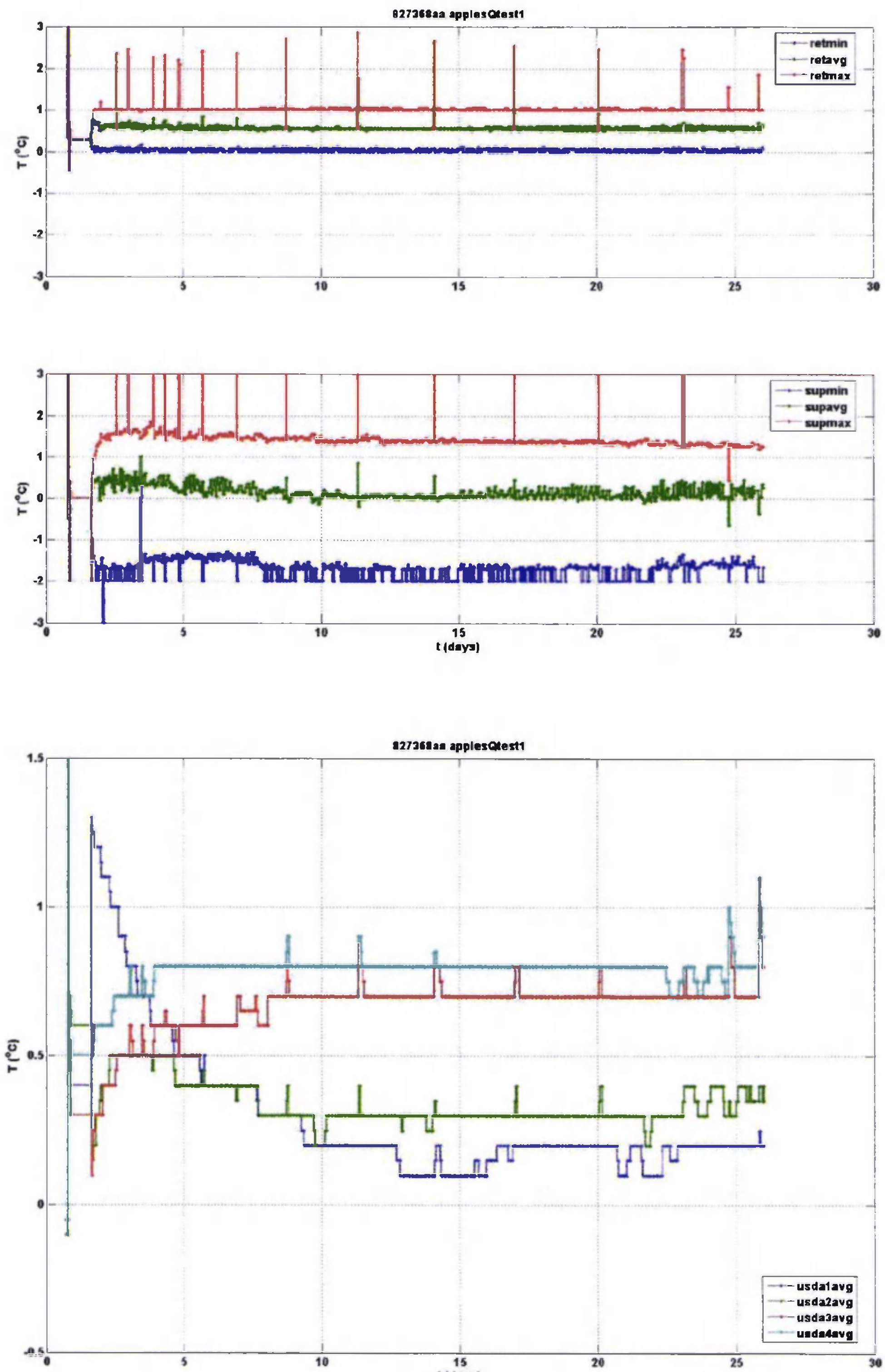


Figure 23 Temperature readings from the unit for the Apple test 1 container.

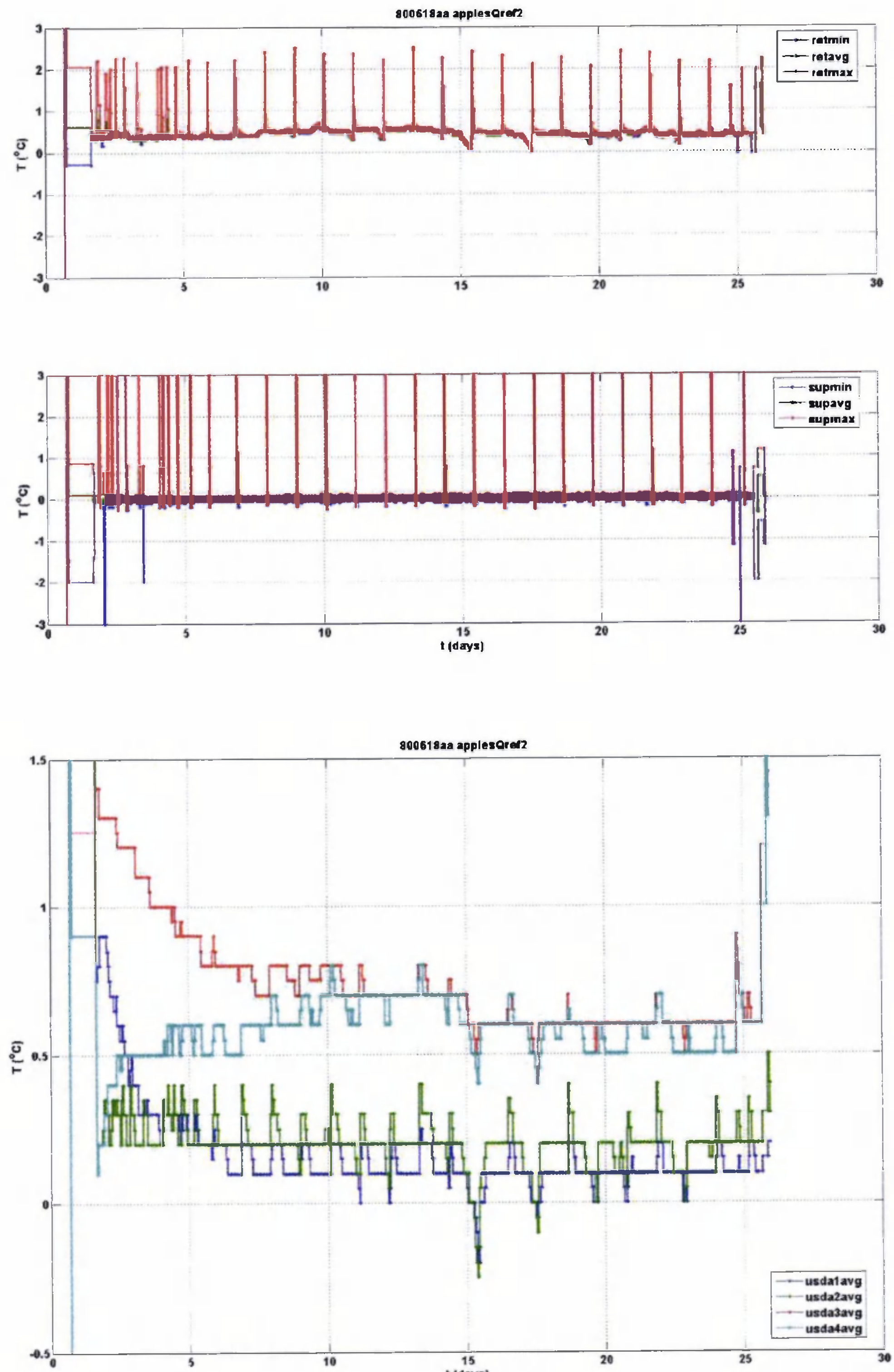


Figure 24 Temperature readings from the unit for the Apple ref 2 container.

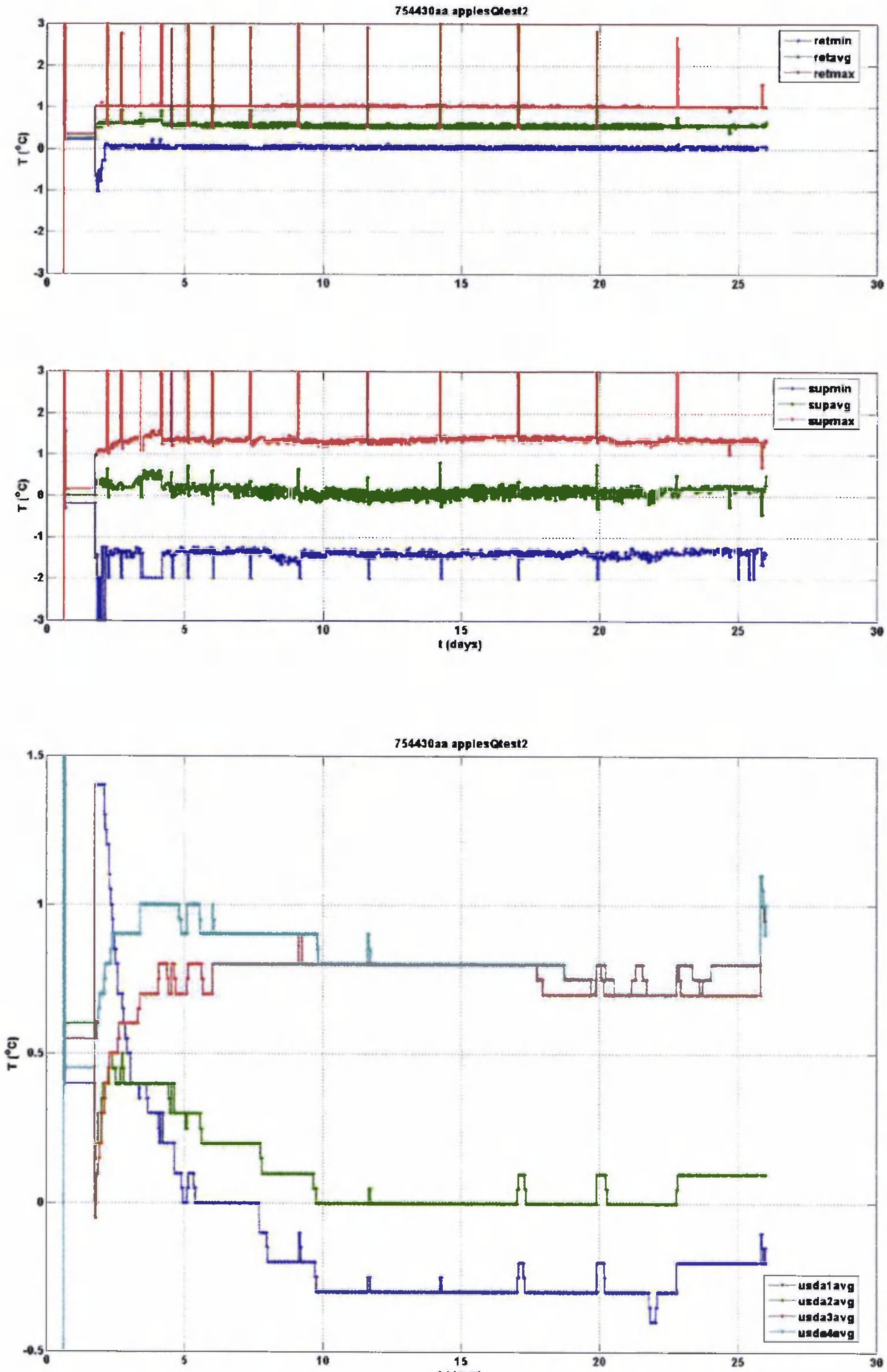


Figure 25 Temperature readings from the unit for the Apple test 2 container.

Appendix V: Snapshot pictures of carton temperature readings

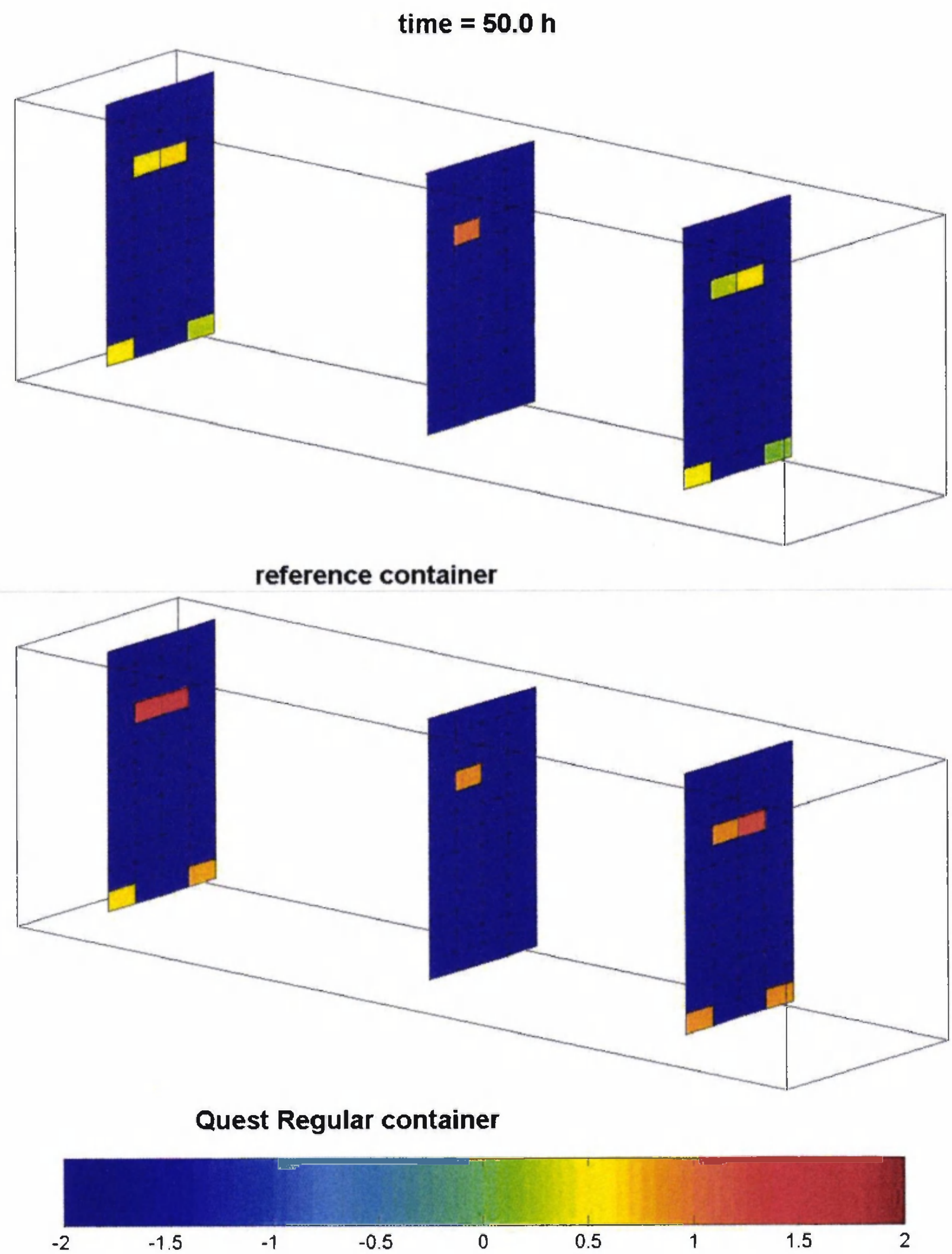


Figure 26 Tiny Tag readings of the carton temperatures at the start of the trip, on July 15th 02:00, Apple ref 1 and test 2

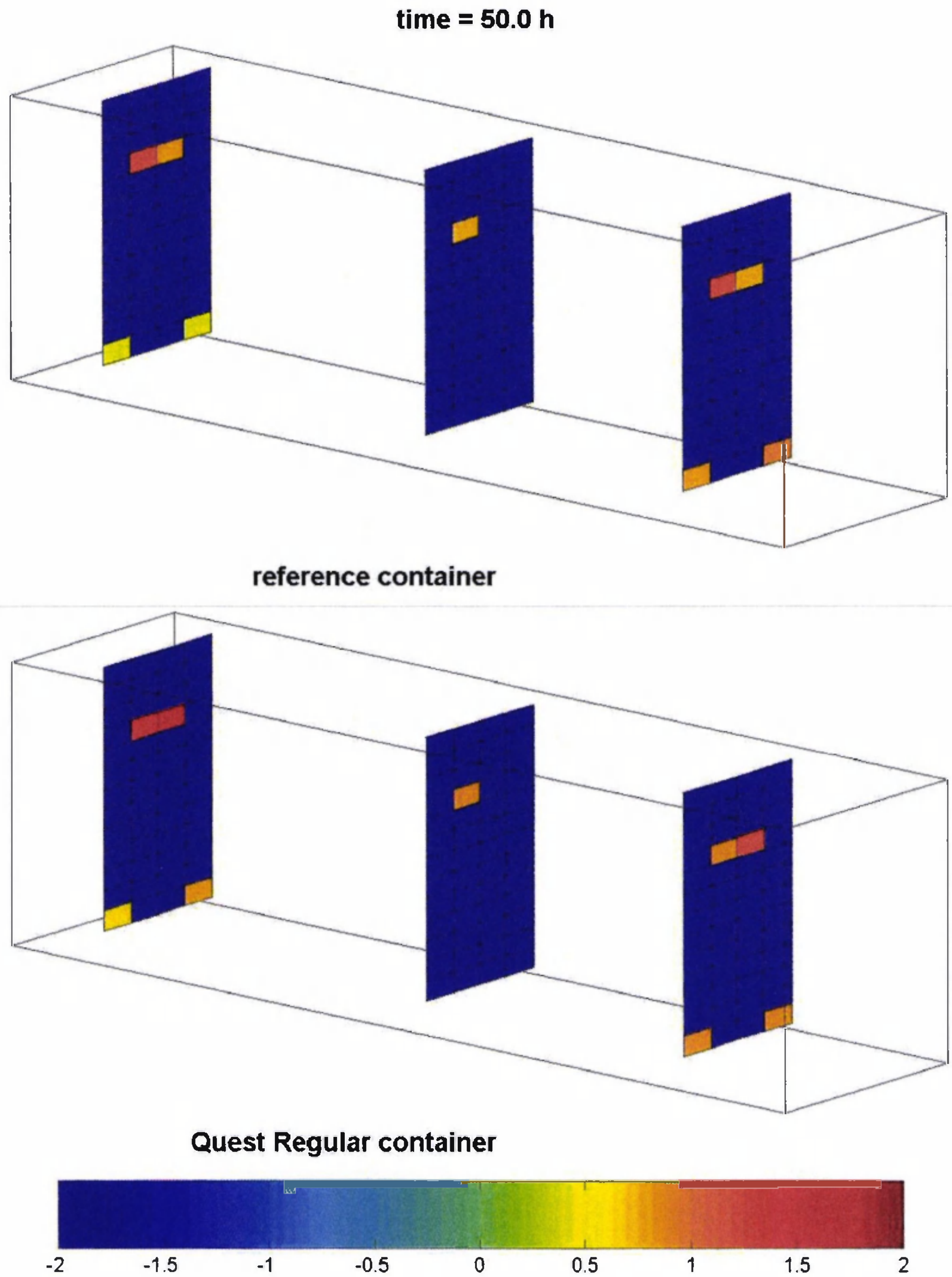


Figure 27 Tiny Tag readings of the carton temperatures at the start of the trip, on July 15th 02:00, Apple ref 2 and test 2

Appendix VI: Ambient temperatures

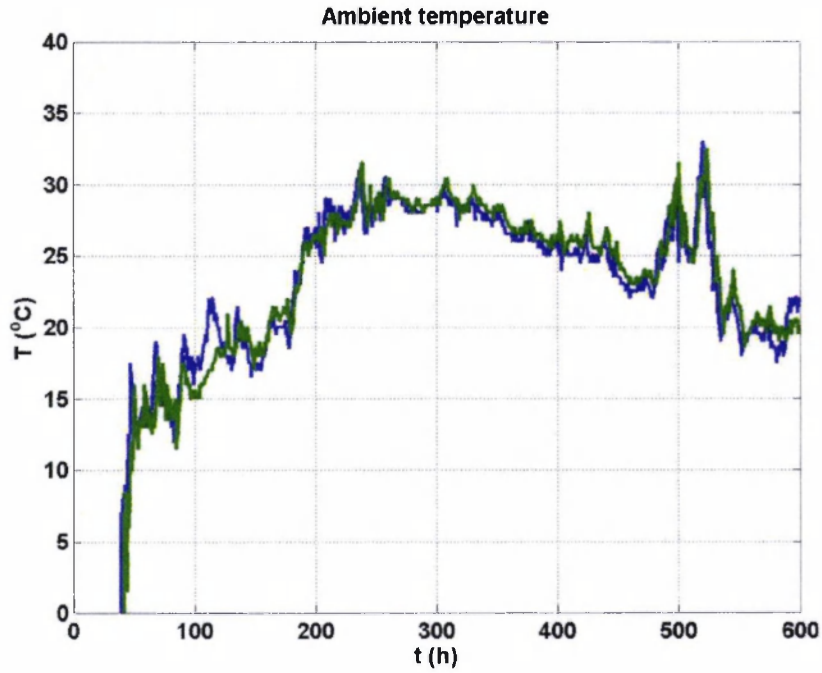


Figure 28 Ambient temperature readings from the Ibutton on the outside of the container, Apple test 1 and ref 1

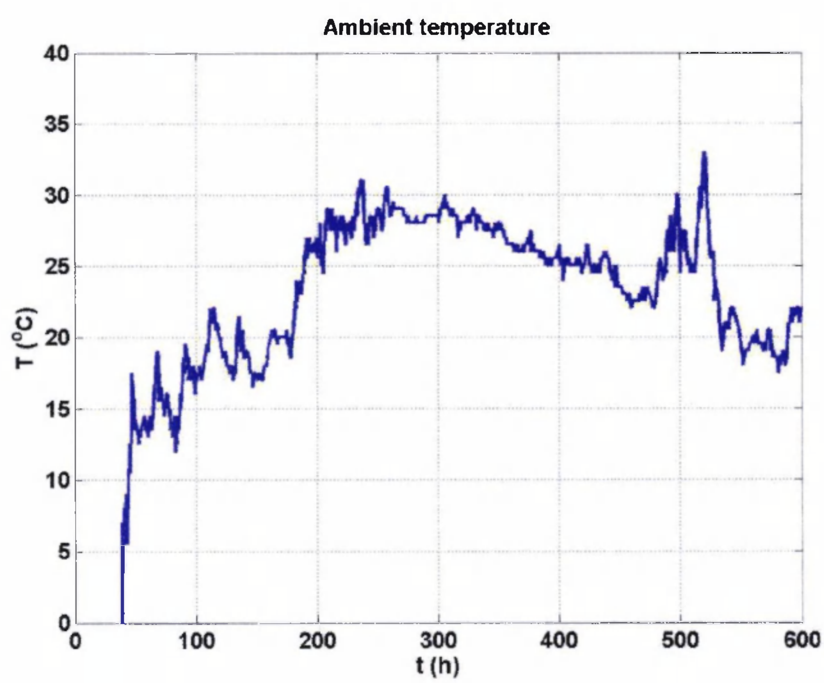
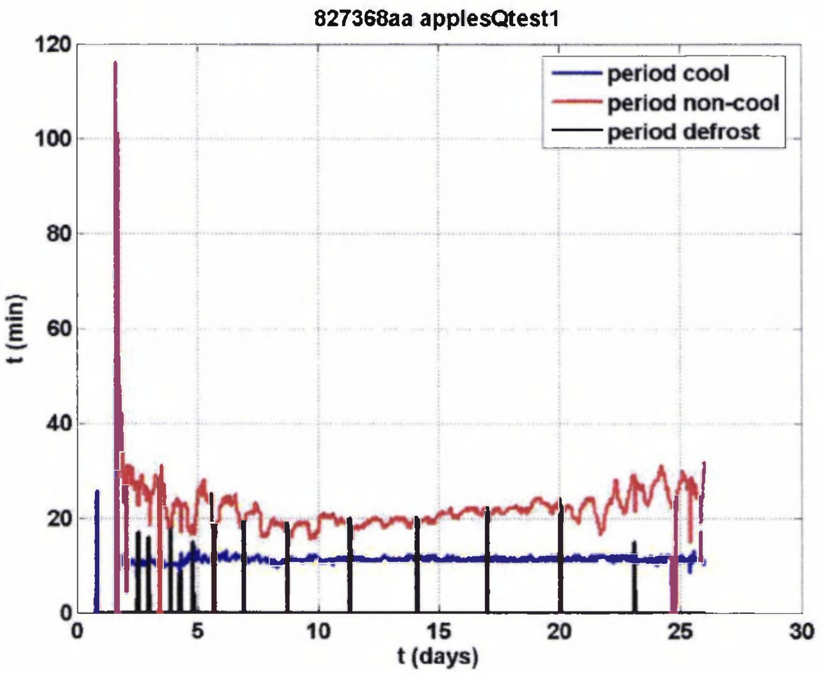


Figure 29 Ambient temperature readings from the Ibutton on the outside of the container, Apple test 2

Appendix VII: Unit activity graphs



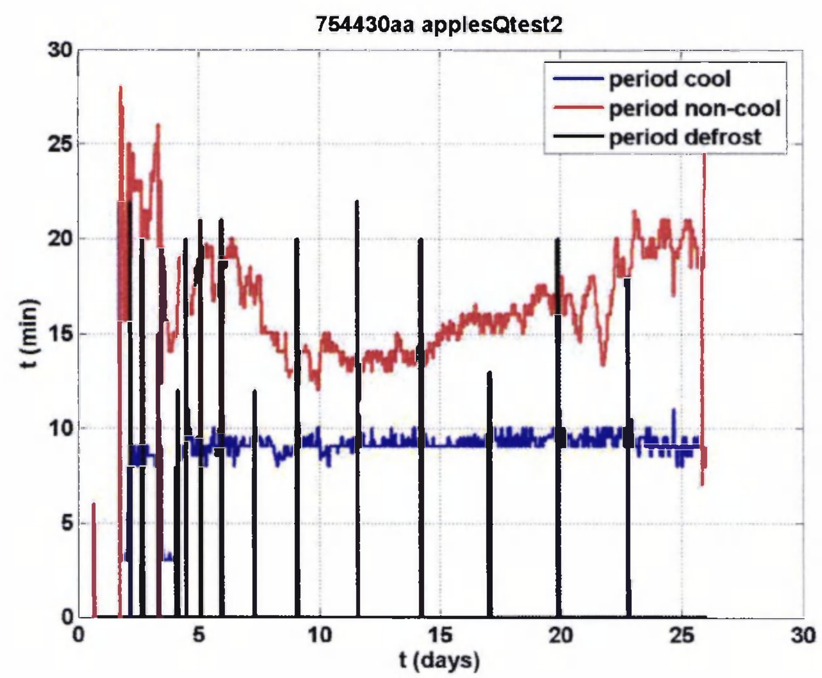


Figure 30 The number of minutes per cooling, non-cooling and defrost period as a function of time for the Quest Apple containers. At each time instant during the voyage when a period is finished a bar is drawn with the number of minutes that that period has lasted. If the period is smaller than an hour, the bars turn into a line.

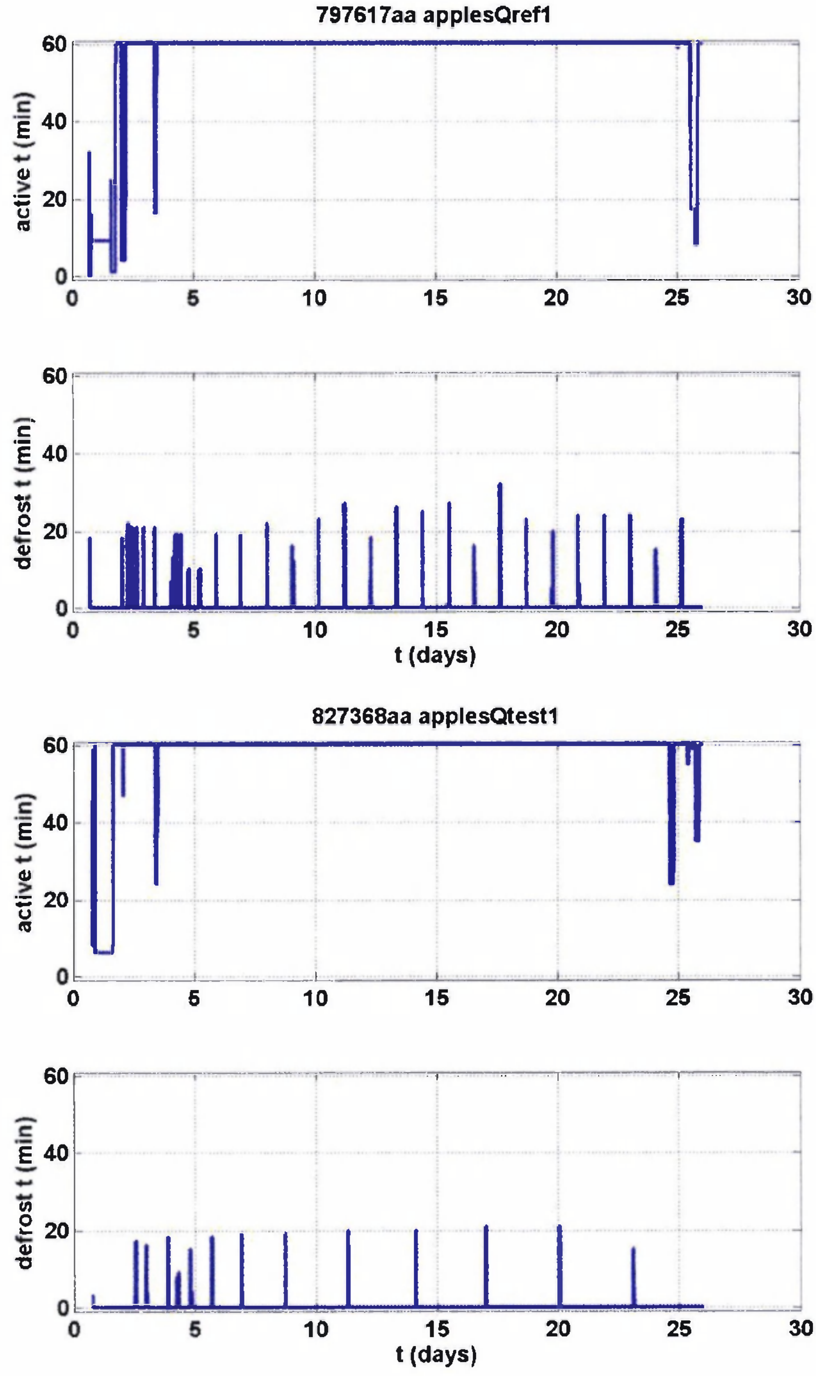


Figure 31 The number of minutes active, non-active and defrost period as a function of time for the Apple 1 containers. Every hour of the trip the number of minutes that was used for defrost was recorded. The number of minutes the unit was active was recorded as well, which is mostly 60 min/hour but sometimes less.

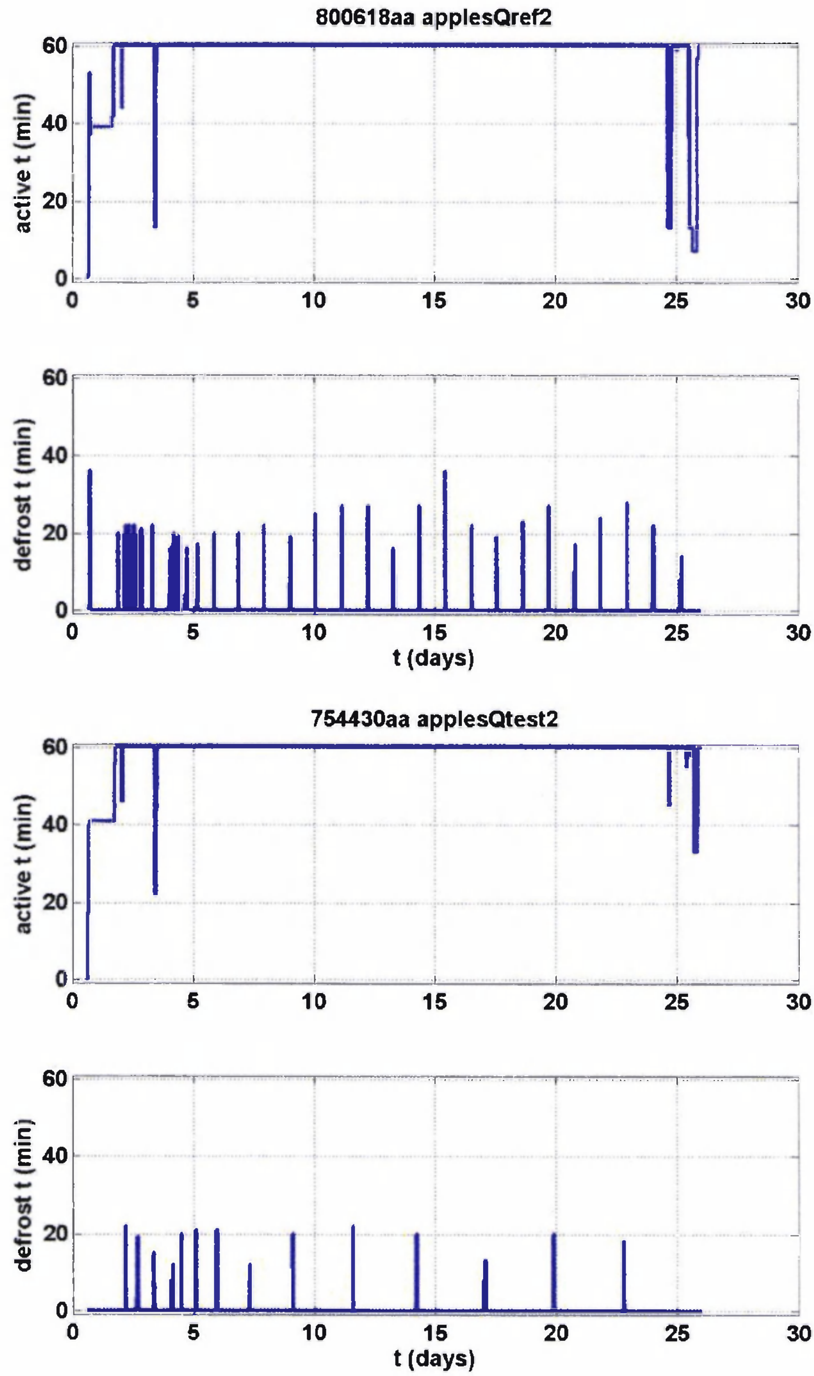


Figure 32 The number of minutes active, non-active and defrost period as a function of time for the Apple 2 containers. Every hour of the trip the number of minutes that was used for defrost was recorded. The number of minutes the unit was active was recorded as well, which is mostly 60 min/hour but sometimes less.

Appendix VIII: Power measurements before departure

Container nr	Setup mode	Commodity	14/7/2006	15/7/2006 18:00	16/7/2006 11:00
MWCU 679 761 7	Normal	Apple	12	105	167
MWCU 680 061 8	Normal	Apple	252	366	429
MWCU 682 736 8	CCPC	Apple	151	202	232
MWCU 675 443 0	CCPC	Apple	187	234	263