Confidential Technical Report for Aerotrim (Westbury) Ltd

Temperature Trials of a Selection of Polartherm Insulated Covers

28 October 2004

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Introduction

Cambridge Refrigeration Technology is an independent research and test organisation. CRT provides expertise for industry within the area of refrigerated systems, refrigerated transport and cargo care. Our speciality is in refrigerated transport and the storage of perishables, and we also provide technical services relating to commercial and industrial refrigeration.

During Week 40 of 2004, Aerotrim (Westbury) Ltd provided seven (7) different designs of Polartherm insulation products to CRT. Polar Thermal Products are a division of Aerotrim Ltd.

Aerotrim requested temperature trials to be conducted on the thermal covers. The results were to form an independent report that will provide an end user with operational characteristics when the covers are placed in specific environmental conditions.

Packaging and Product Details

Aerotrim's division Polar Thermal Products provided Seven (7) covers for testing, each designed for different purposes.

The references for each cover are numbered below. The approximate internal volumes in litres are also included.

Ref:	Name of Cover	Volume (approx. litres)	Test Product Volume	Proportion of Volume of the Test Product
1)	Tranzcube Pallet Cover	1056	53L	5%
2)	Roll Cage Cover	696	35L	5%
3)	Expandable Pallet Cover	621	31L	5%
4)	20L Carry Bag	21	20 x 0.33L Cans	Approx 100%
5)	60L Carry Bag	60	16L Ice	27%
6)	Vaccine Pouch	2	0.5L Ice	25%
7)	LD3 air container liner	3000	150L	5%

The insulated covers all required a nominal quantity of product inside. The product will offer a 'battery effect' of cool internal air, like in reality when transporting cargo. The variations of test product loaded inside the different covers are detailed under each sub-heading below.

Covers Ref: 1,2,3 and 7.

1) Tranzcube Pallet Cover, 2) Roll Cage Cover, 3) Expandable Pallet Cover, 7) LD3 air container liner

These covers were loaded with water in 25L plastic containers. In each case the volume of water equated to 5% the volume of the loading space.

Covers Ref: 4

4) 20L carry bag – This was fully loaded with twenty (20) 330ml cans = 6.6L.

Covers Ref: 5 and 6

5) 60L carry bag, 6) Vaccine pouch

These covers were specified to be loaded with ice. The 60L carry bag was approximately quarter loaded with 16L of ice at –20°C. The vaccine pouch was loaded with a 500ml block of ice at –20°C.

Figure 1 - Photograph of Polartherm Covers

Methodology

All of the seven (7) thermal covers were tested simultaneously in CRT test chamber 1.

The ambient temperature, covers and liquid product were stabilised overnight at 5°C. When all the temperature measurements were at set-point the covers were loaded with the product and sealed closed.

The data logger was programmed to measure all the temperatures with the time interval set to measure every five minutes.

The test started with the ambient temperature at 5°C, and then immediately after the start the ambient temperature set-point was increased to 30°C. The test continued for 24 hours at 30°C ambient.

Thermocouple (type 'T') probe locations

Each cover had at least two thermocouples installed, one to measure air temperature and the one to measure the product temperature.

Twelve thermocouples were used measured test chamber air temperature.

Results

The average ambient temperature for the test was 30.4°C. The individual results are displayed in the tables below and in the graphs shown in the Appendix.

Table 1 - Summary of Results using Water as Product

		Water Temperatures		
Ref:		**Start (°C)**	**After 24 hours (°C)**	**Rate of rise (°C/hr)**
1	Tranzcube Pallet Cover	4.0	18.3	0.60
2	Roll Cage Cover	4.0	20.7	0.70
3	Expandable Pallet Cover	4.4	16.7	0.51
4	20L Carry Bag	3.4	19.4	0.67
7	LD3 Air Container Liner	3.8	18.3	0.60

The results above show that the 20L carry bag that was virtually full with beverage cans will warm-up at an approximate rate of 0.67°C/hr when the internal/external temperature difference is over 20°C.

The other insulated covers displayed in the table above were filled to 5% of the volume with water. The results show that the water, on average increased at a rate of 0.60°C/hr when the internal/external temperature difference is over 20°C.

Table 2 - Summary of Results using Ice as Product

		During Latent Phase (Ice)		
Ref:		**Average Air Temp (°C)**	**Duration (hours)**	**% ice after 24hrs**
5	60L Carry Bag	10.5	15.0	95%
6	Vaccine Pouch	7.0	18.0	0%

The results in ‘Table 2’ above demonstrate that if the 60L carry bag is filled with only 16L ice at –20°C the results shown that after 24hours the ice will still be 95% latent. Also see the graph in Figure 6 in the Appendix.

The graph for the vaccine pouch results is shown in Figure 7. It shows that 500ml of ice enclosed in the pouch will remain at 0°C for 18 hours in a 30°C ambient.

Analysis and Conclusions

In simple terms the results are summarised below.

- For Ref's: 1) Tranzcube Pallet Cover, 2) Roll Cage Cover, 3) Expandable Pallet Cover, and 7) LD3 air container liner

  Using a container of water/product, equivalent to 5% of the internal volume of the insulated cover. Then subjecting it to an ambient temperature 20-25°C warmer than the product, the results show that the rate of temperature increase was on average less than 0.7°C per hour.

- For Ref: 4) 20L carry bag.

  The bag was almost full with 20 x 330ml beverage cans. The can temperature increased on average at 0.67°C per hour when place in a 30°C ambient.

The rate of product temperature increase for all the insulated covers detailed above will be further reduced if more product is loaded or if ice blocks are included to refrigerate the internal air.

For Ref: 5) 60L carry bag, and 6) Vaccine pouch

- 16L of ice stored in the 60L bag and subjected to 30°C ambient resulted in 95% ice and 5% water after 24 hours.
- A 500ml block of ice will maintain the vaccine pouch with an average air temperature of 7°C for 18 hours in a 30°C ambient.

NOTE:
The report does not account for the effect of solar radiation or high air movement and cannot be precisely applied for products with significantly different specific heat capacities.

The temperature trends are for the environmental conditions and product detailed in this report. It is intended to offer a benchmark for temperature change, and be used as a 'Rule of Thumb' guide to indicate how quickly a product will warm-up in a 30°C environment.

APPENDIX

Results

Figure 2 - Ref1: Graph of Tranzcube Temperatures

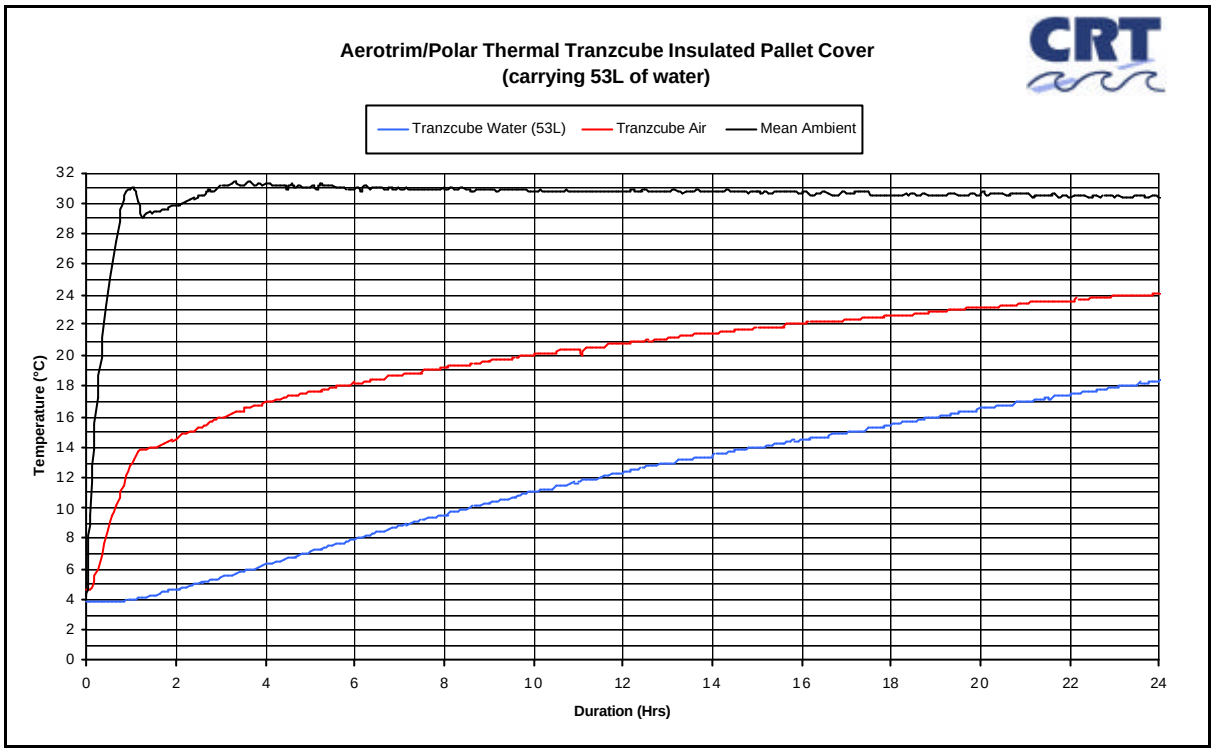


Figure 3 - Ref2: Graph of Roll Cage Temperatures

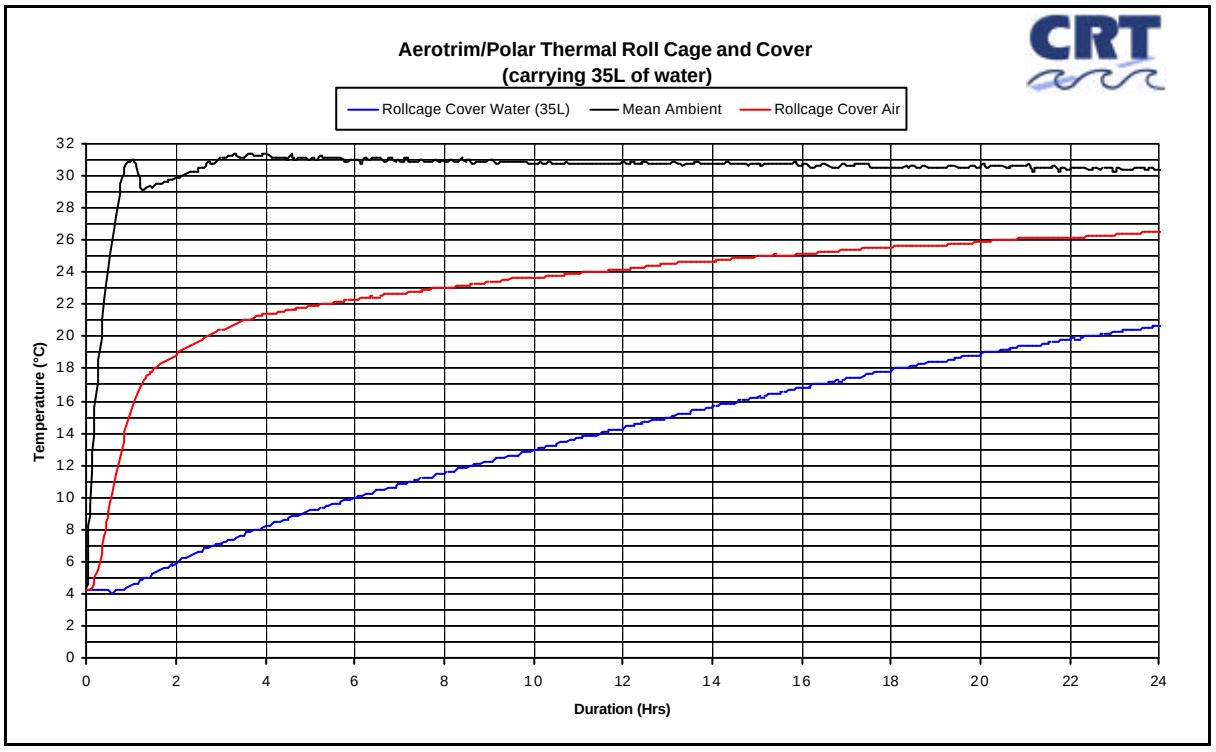


Figure 4 - Ref3: Graph of Expandable Pallet Cover Temperatures

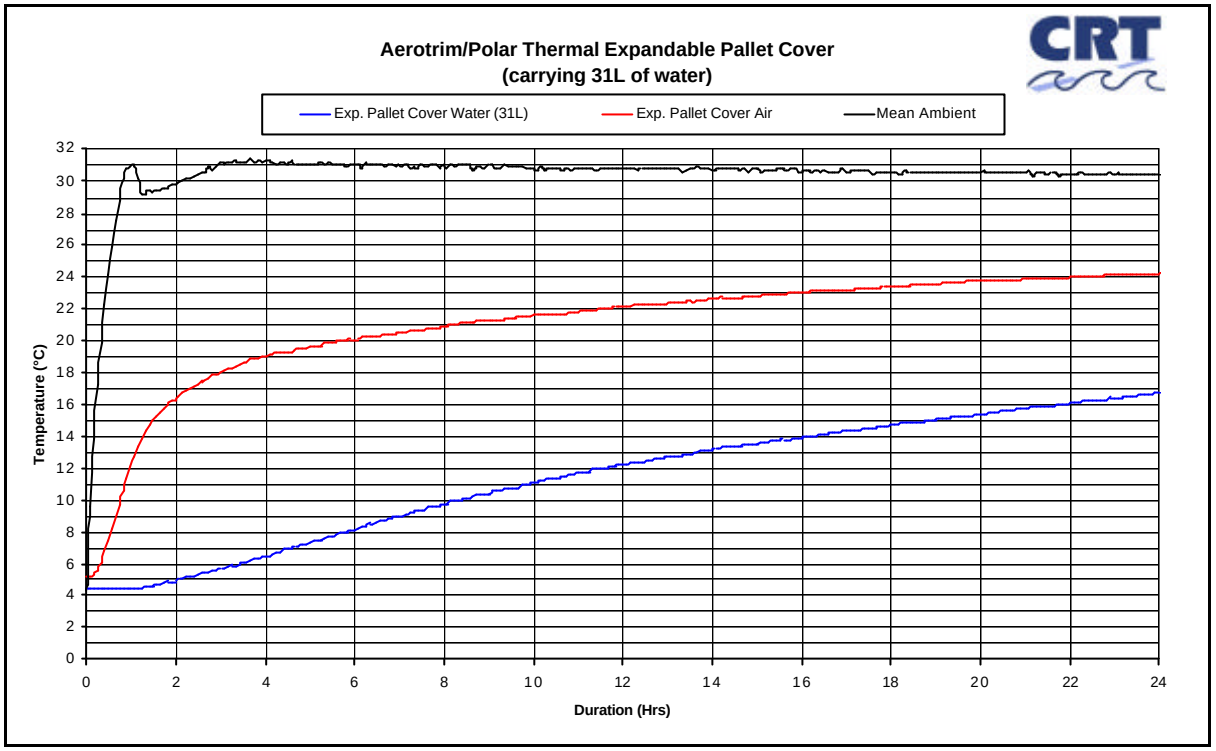


Figure 5 - Ref4: Graph of 20L Carrybag Temperatures

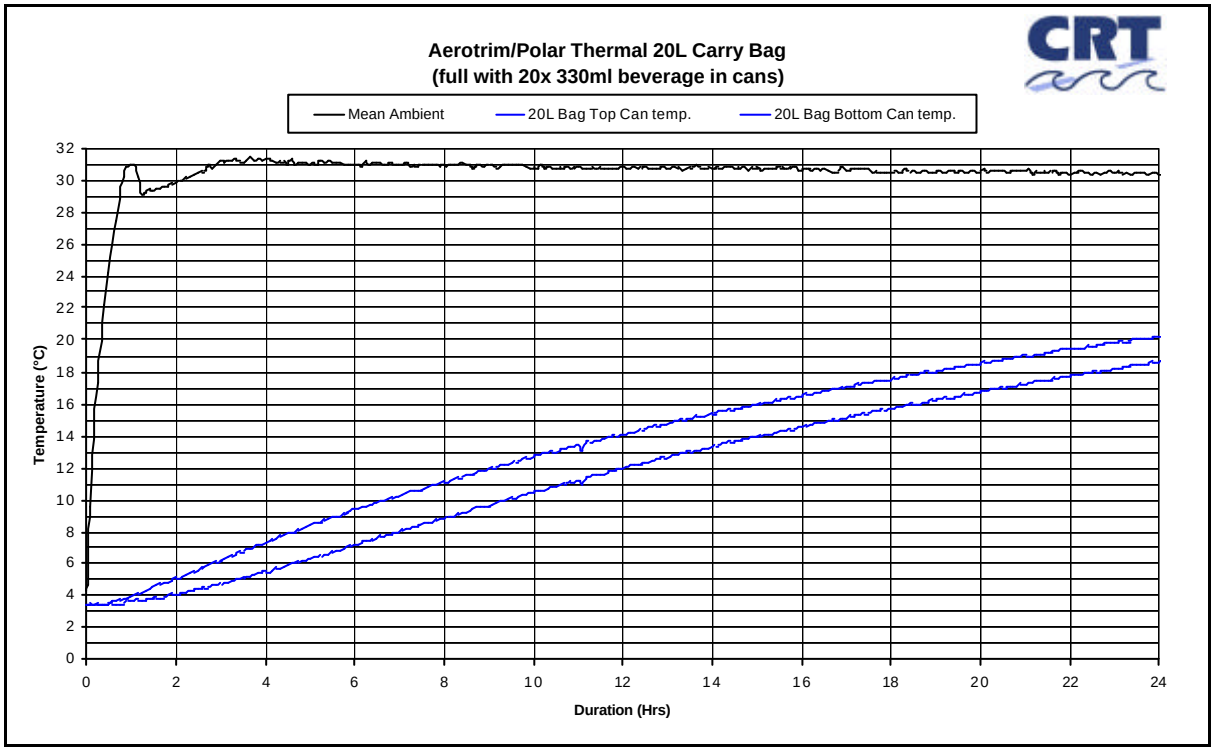


Figure 6 - Ref5: Graph of 60L Carry Bag Temperatures

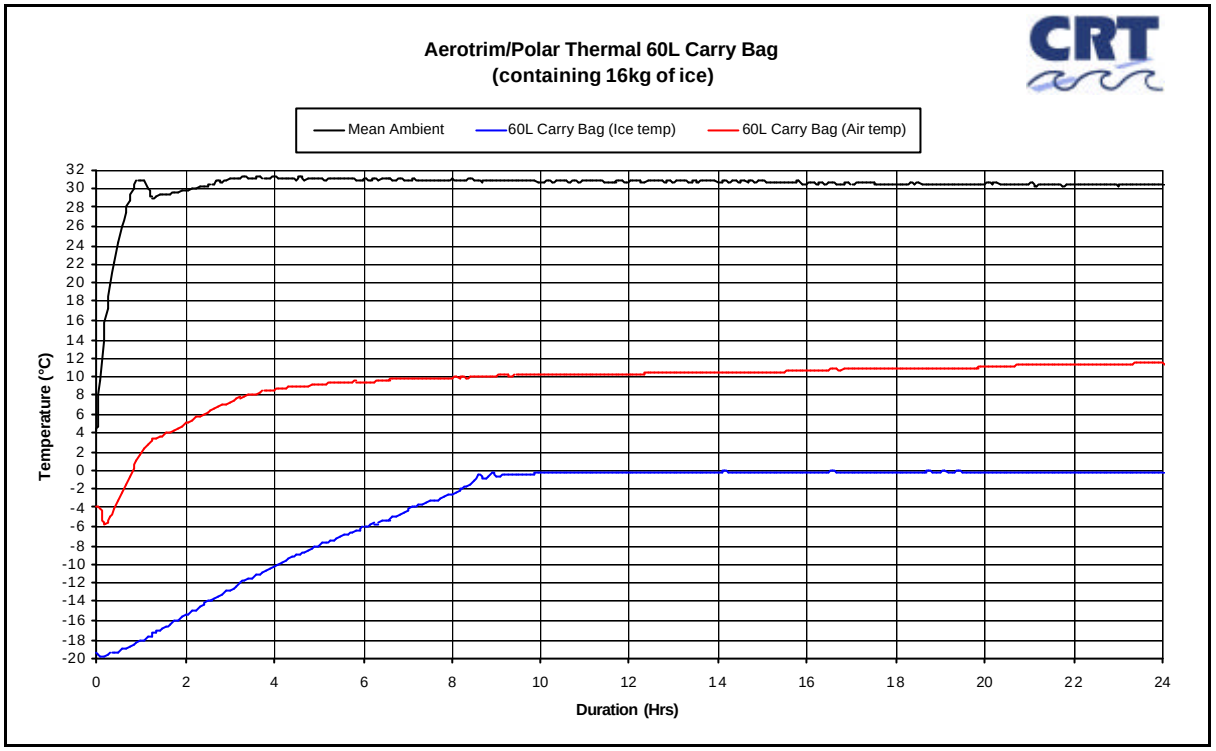


Figure 7 - Ref6: Graph of Vaccine Pouch Temperatures

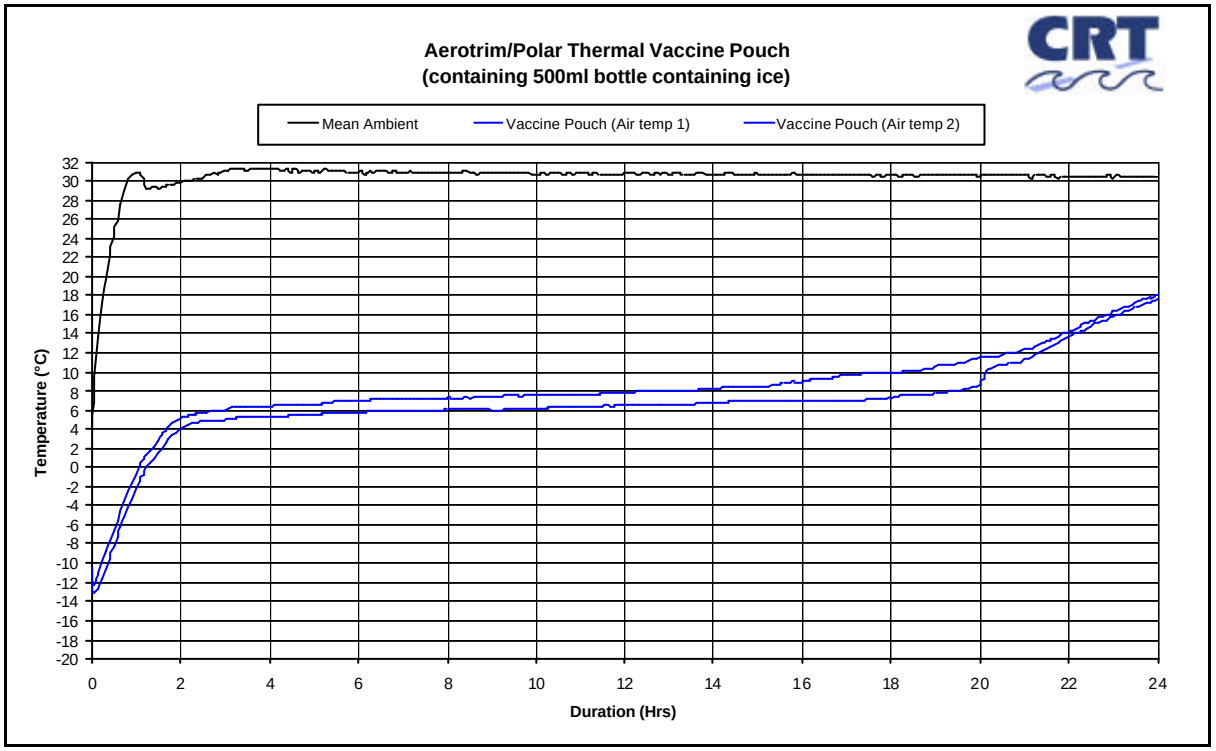
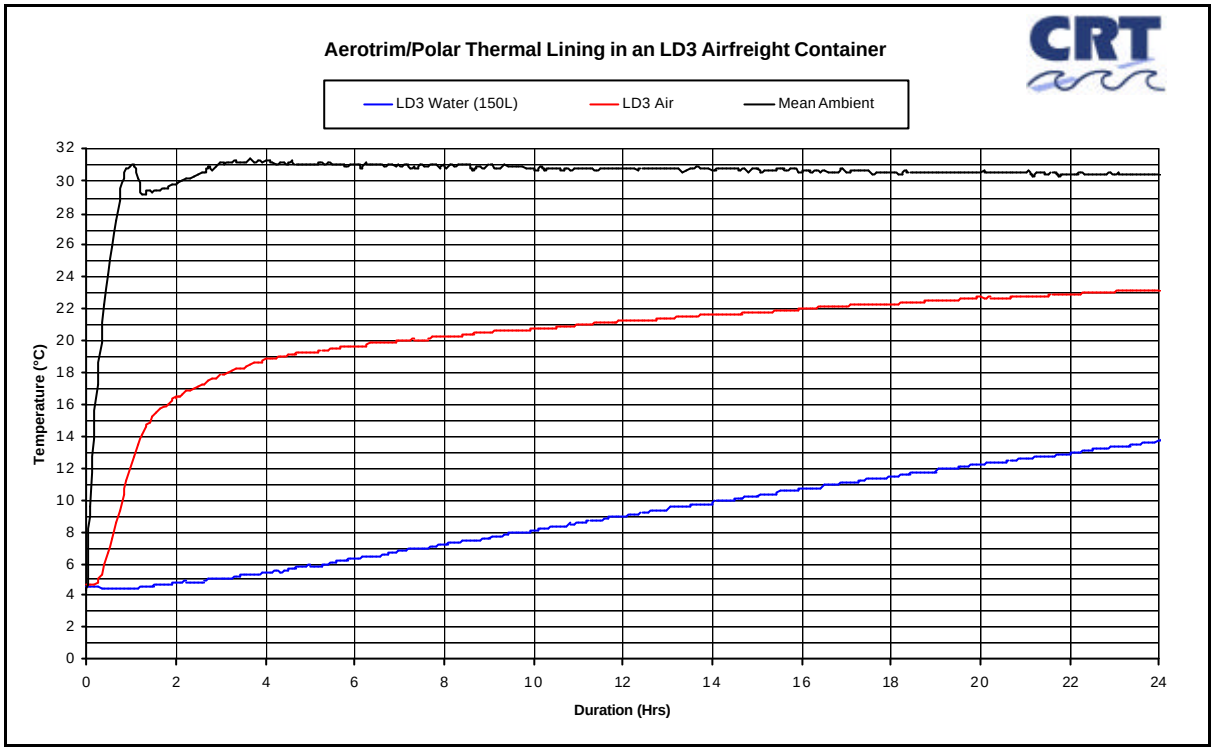


Figure 8 - Ref7: Graph of LD3 Liner Temperatures



CRT Chamber No 1 - Specification

Name	Environmental Chamber 1	
Size	4.85H x 4.45W x 11.90L metres	
Door size	4.60H x 3.85W metres	
Floor	150mm reinforced concrete	
Drainage	100mm central drain	
Refrigeration	Main system	2x 5hp
	Auxiliary booster	1x 7hp
	Auxiliary booster	1x 3hp
	Auxiliary booster	1x 15hp
Insulation	100mm polystyrene slab	
Temperature range	-30.0 to +50°C	
Max extraction	20 kW at -15°C	
Temperature control	Hot gas modulation ± 0.25°C	
Chamber temp. spread	Vehicle in room typically 1°C 6kW heat load chamber at 0°C	
Air circulation	7 x 250 mm evaporator fans 2 x 600 mm side wall fans 4 x 380 mm portable with speed control Airspeed 1-2 m/s	
Air freshening	600 mm roof extractor for fan with controller	
Fume extraction	125 mm exhaust extractor	
Relative humidity	50-100% rh Lucus Daw Ultrasonic	
Power supply	240V/415V 50Hz main 440V 60Hz converter	
Water supply	15mm rising main	
Compressed air supply	$20m^3$/hr 100psi	
Solar Arrays	8 @ 4 kW plus 1 @ 8.5 kW	

Fixed instrumentation

Temperature Measurement

Fluke Data logger 2240B
100 type "T" thermocouples

BBC Servogor SE460
6 pen chart recorder
4 x type "T" thermocouples
2 x millivolt inputs

Power Measurement

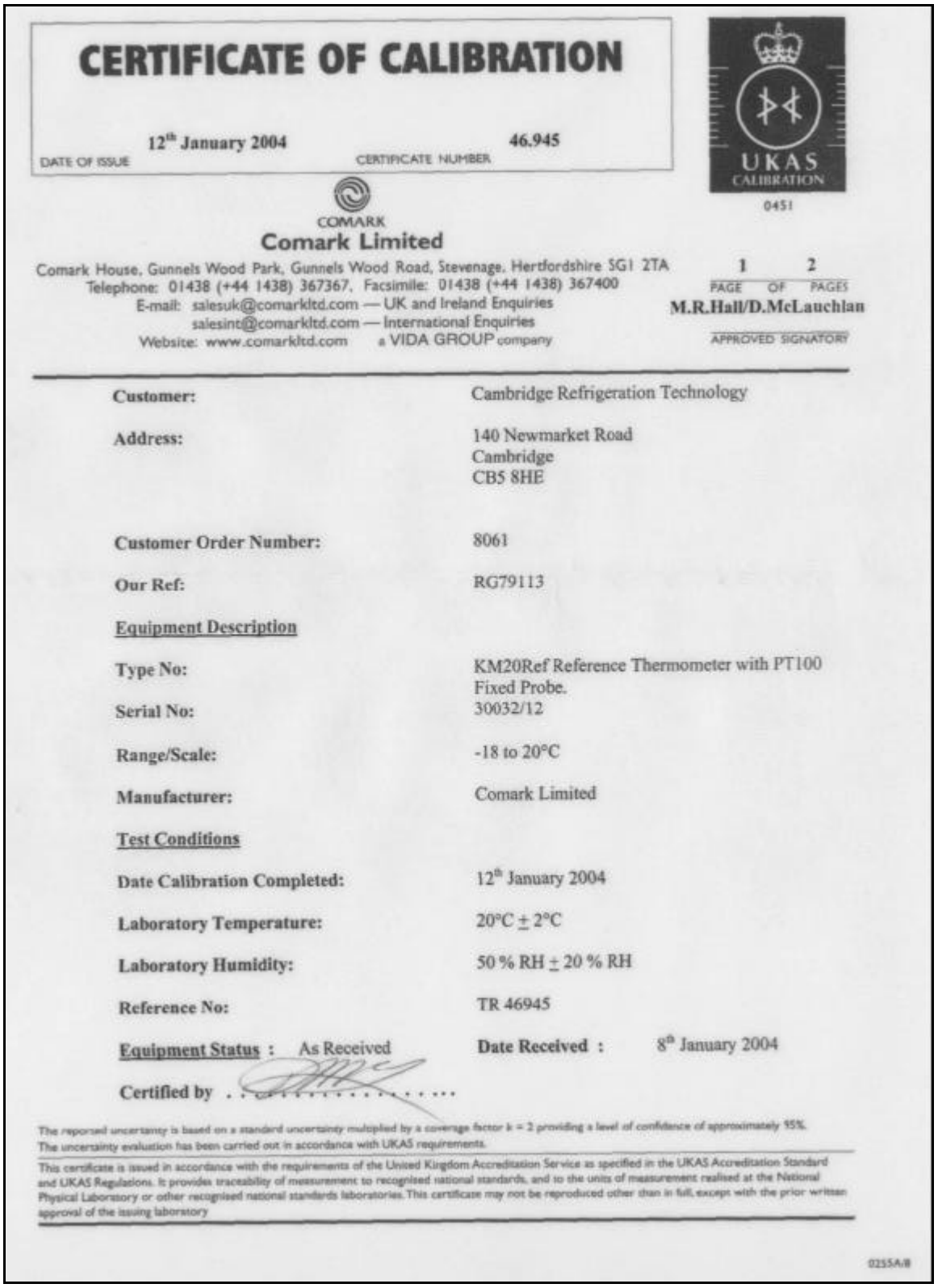
3 Phase Class 1
Northern Design Powerminder
Volts each phase
Amps each phase
Power factor
Instant power
Cumulative power RS232 interface
Printer

Single phase Class 1
Northern Design WM 302 pulsing
Cumulative power
Printer

Thermal test equipment	Pulsing P.I.D. controller and heater adjustable air circulation

Certificate of Calibration

All CRT 'type T' thermocouples are calibrated twice each year. The calibration is checked against our reference probe. Below is the UKAS verification Certificate of calibration for the reference check probe.



CERTIFICATE OF CALIBRATION

DATE OF ISSUE: 12th January 2004

CERTIFICATE NUMBER: 46.945

UKAS CALIBRATION 0451

COMARK
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M.R.Hall/D.McLauchlan
APPROVED SIGNATORY

Customer:	Cambridge Refrigeration Technology
Address:	140 Newmarket Road Cambridge CB5 8HE
Customer Order Number:	8061
Our Ref:	RG79113
Equipment Description	
Type No:	KM20Ref Reference Thermometer with PT100 Fixed Probe.
Serial No:	30032/12
Range/Scale:	-18 to 20°C
Manufacturer:	Comark Limited
Test Conditions	
Date Calibration Completed:	12th January 2004
Laboratory Temperature:	20°C ± 2°C
Laboratory Humidity:	50 % RH ± 20 % RH
Reference No:	TR 46945
Equipment Status : As Received	**Date Received :** 8th January 2004

Certified by . . . . . .

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2 providing a level of confidence of approximately 95%.
The uncertainty evaluation has been carried out in accordance with UKAS requirements.

This certificate is issued in accordance with the requirements of the United Kingdom Accreditation Service as specified in the UKAS Accreditation Standard and UKAS Regulations. It provides traceability of measurement to recognised national standards, and to the units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory

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CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No. 0451

46.945
CERTIFICATE NUMBER

2 2
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Indicator S/N: 30032/12 **Probe Type:** PT100 **Serial No:** N/A
Length: 100 mm **Diameter:** 3 mm

The instrument was Calibrated by immersing the probe to a depth of 100mm, in a closely controlled temperature reference environment together with two standard reference instruments having known and traceable values of uncertainty.

The following temperature readings are derived from the mean values of a number of observations.

TEST TEMPERATURE (°C)	INSTRUMENT READING (°C)
-18.018	-18.1
0.012	00.0
4.996	05.0
7.991	08.0
20.008	20.0

The uncertainty associated with the above measurement(s) does not exceed ±0.1°C + instrument resolution.

The above uncertainty refers to the measurement and is not intended to indicate the specification, or repeatability of the instrument. The temperature scale in use is the International Temperature Scale of 1990. ITS-90.

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2 providing a level of confidence of approximately 95%.
The uncertainty evaluation has been carried out in accordance with UKAS requirements.

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