

Confidential Technical Report for Aerotrim Ltd

Temperature Pull Down Test on a Polar Thermal Portable Field Cold Store

24 August 2006

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Temperature Pull Down Test on a Polar Thermal Portable Field Cold Store

1.0 Introduction

Polar Thermal Products, a division of Aerotrim Ltd, requested Cambridge Refrigeration Technology (CRT) to carry out a pull down test on a Polar Thermal Portable Field Cold Store.

This cold store is specified as a portable fridge/ freezer suitable for the storing of Pharm products and edibles and was delivered to CRT on 15 August 2006.

The cold store has a capacity of 5967 litres and is waterproof, anti fungal, with rot proof stitching and its own-patented polar thermal material for the insulation.

The objective of this test was to find out how long it takes to reduce the temperature of 24 x 1 litre bottles of water from 110°F to 70°F (21.1°C) in an ambient temperature of 110°F (43.3°C), after being soaked for a minimum period of 4 hours.

The work was conducted in CRT environmental test chamber 1.

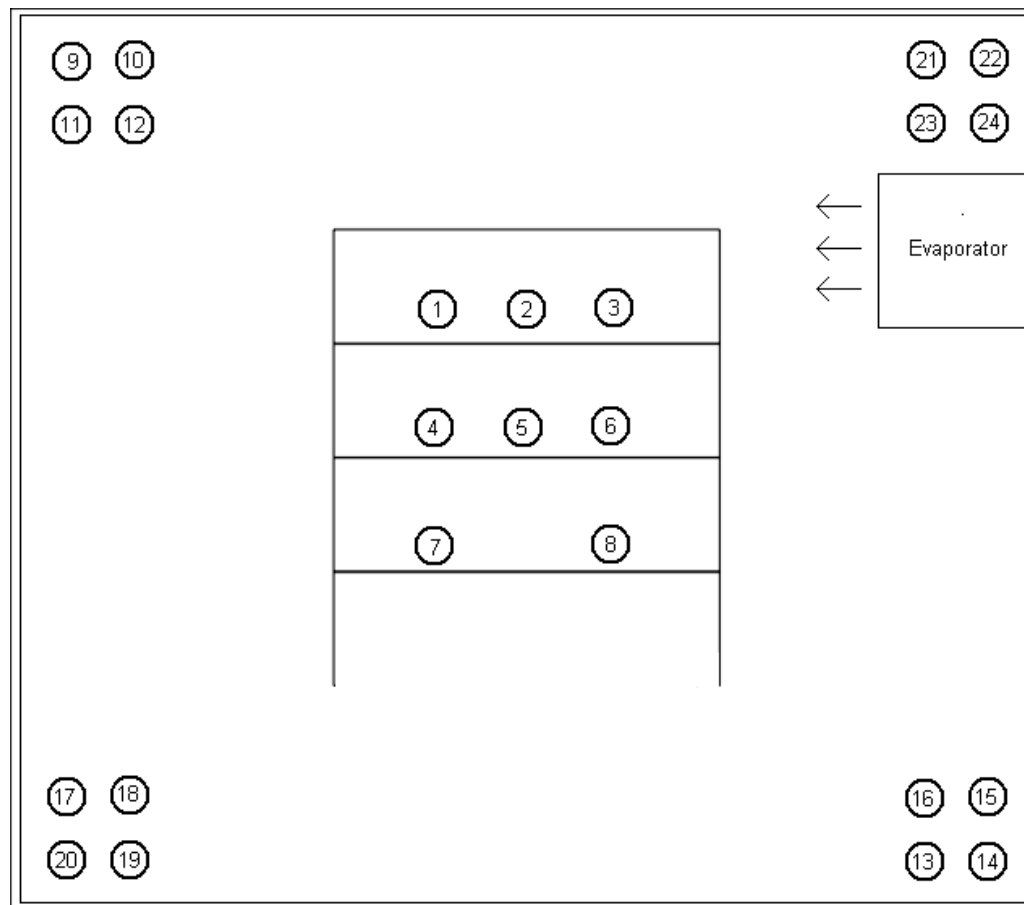
2.0 Equipment Set-up

Aerotrim Ltd set up the portable cold store in the chamber, as shown in figures 3 to 8, in the appendix.

Inside the cold store racking was arranged and 24 x 1 litre bottles of water were then distributed across the shelves and floor.

Type “T” thermocouples were attached to the side of each bottle and connected to a fluke data logger, with a logging interval of 1 minute. These thermocouples are calibrated and have an error of better than $\pm 0.5^{\circ}\text{C}$. Figure 1 below shows the thermocouple layout:

Figure 1 – Thermocouple Layout



Power consumption and current draw were measured using a Northern Design multicube meter and also logged at 1 minute intervals using a computer.

The refrigeration unit is a Technblock s.p.A, model VK201E, serial number 130784 and charged with refrigerant HFC R404a, which powered from a single phase main supply of 230V, 50Hz and is quoted by the manufacturer to have a maximum power draw of 1.51kW.

3.0 Methodology

After setting up the equipment, the cold store, being off power and with its door open, the bottles inside were soaked at 110°F overnight for a period of at least 4 hours, inside the test chamber.

With the chamber remaining at 110°F the door was then closed and the refrigeration unit switched on. The time taken for each bottle to reach 70°F was then recorded.

Temperature, power consumption and current draw were recorded throughout the test.

4.0 Results

Throughout this test the refrigeration unit operated satisfactory.

The results are shown in figures 2 below, figures 9 and 10, details of test chamber and table 2 (containing the raw data) are in the appendix.

Figure 2 shows the temperature of all the bottles during the test and Table 1 shows the time taken for first, last and the mean of the bottles bottle to reach a temperature of 70°F:

Figure 2 – Temperature of each bottle

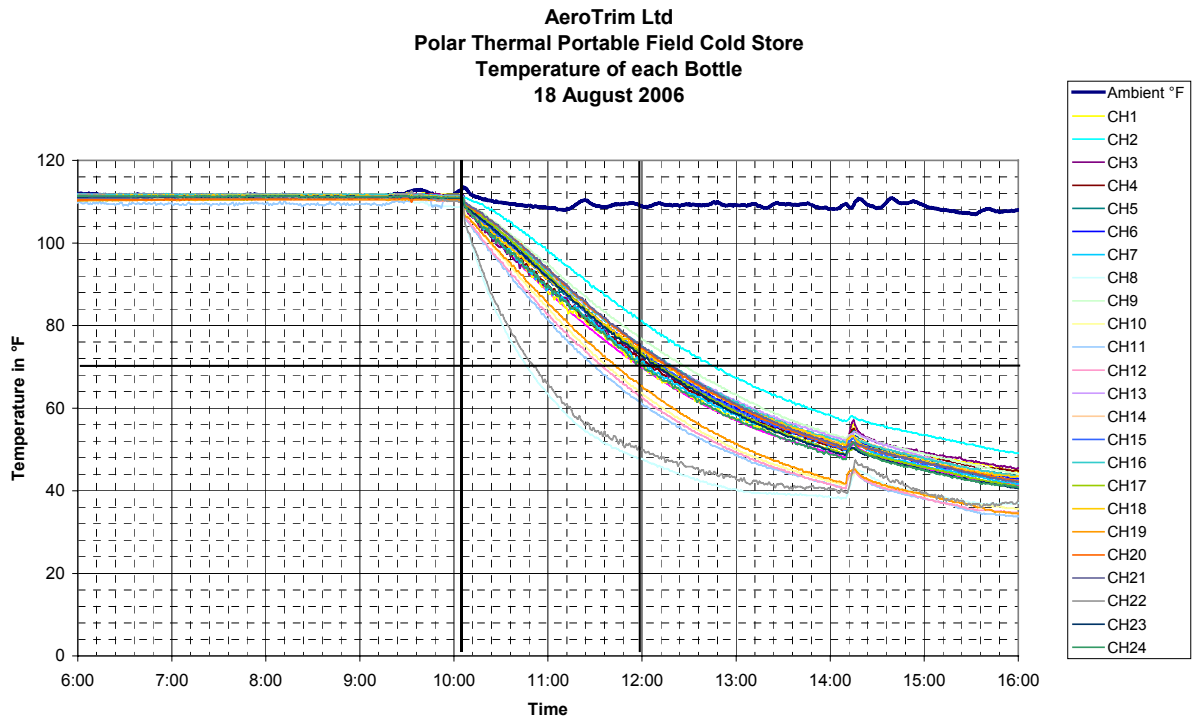


Table 1 – Summary of Final Results

	Initial Temperature °F	Actual Time bottle reached 70°F	Duration (minutes)	Channel Number
First	108.5	10:47	42	Ch8
Last	111.6	12:47	162	Ch2
Average	110.8	11:59	114	(all)

Unit was switched on at 10:05

Ch8 was located on the first shelf up, a few inches away from the outlet of the evaporator. Ch2 was located at the centre of the highest shelf.

During the test this refrigeration unit was consuming **1.84 kWh** with an average current of 9.47 amps, which peaked at 12.78 amps during the initial start up. Figures 9 and 10 in the appendix contain the results.

5.0 Conclusion

The Polar Thermal Portable Field Cold store took less than 2 hours to reduce the average of 24 x 1 litre bottles of water from 110°F to 70°F.

The last bottle to reach 70°F was located in the top centre position on the racking and took less than 2³/₄ hours.

APPENDIX

Figure 3 – Side Photograph of the Cold Store set up in Test Chamber 1



Figure 4 – Front Photograph of the Cold Store set up in Test Chamber 1



Figure 5 – Photograph of the Central Inside Area of the Cold Store



Figure 6 – Photograph of the Inside Corner Area of the Cold Store



Figure 7 – Photograph of the Central Back Area of the Cold Store



Figure 8 – Photograph of the Evaporator Inside the Cold Store



Figure 9 – Power Consumption

AeroTrim Ltd
Polar Thermal Portable Field Cold Store
Power Consumption
18 August 2006

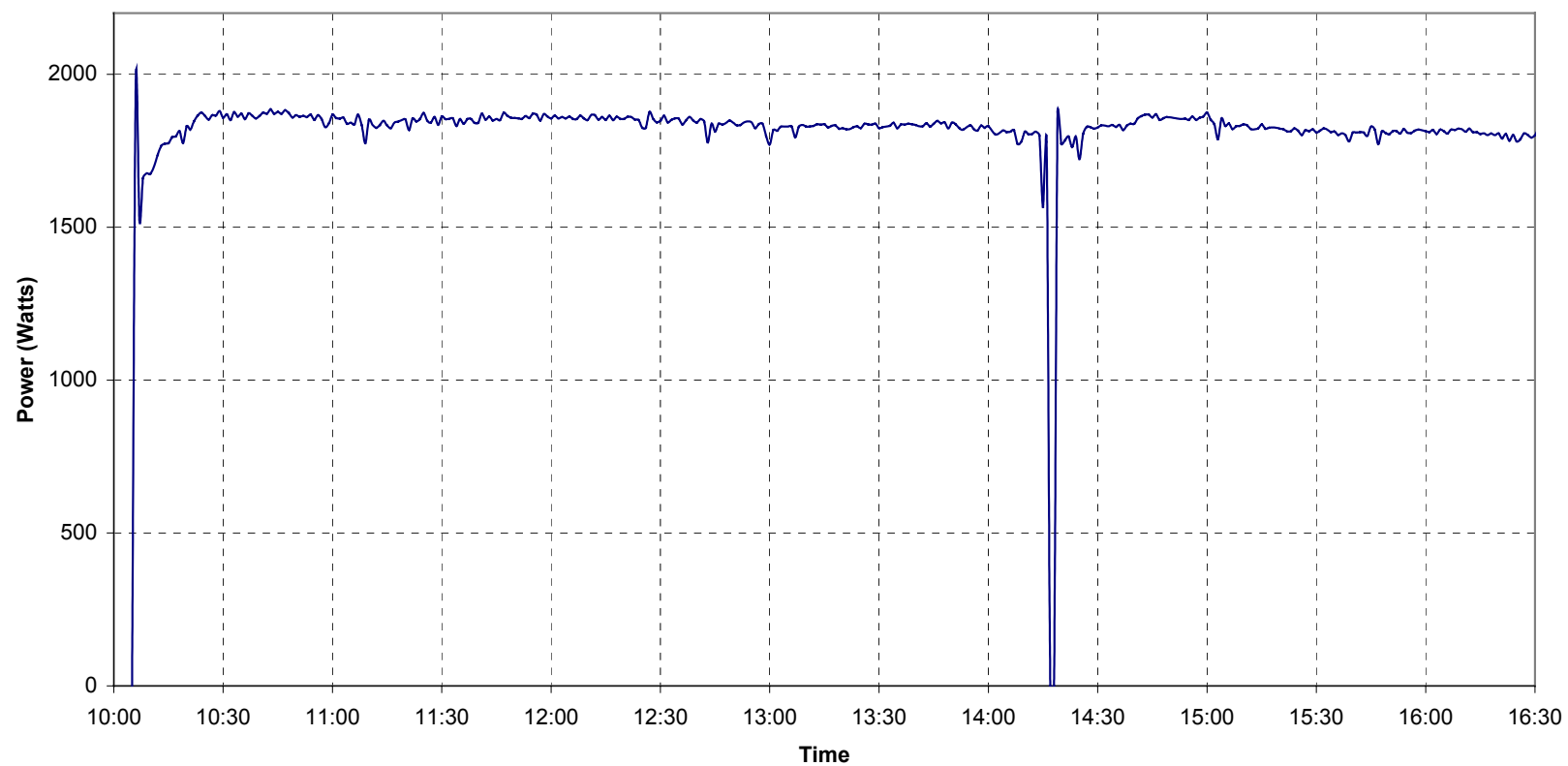


Figure 10 – Current Draw

**AeroTrim Ltd
Polar Thermal Portable Field Cold Store
Current Draw (230V, 50Hz)
18 August 2006**

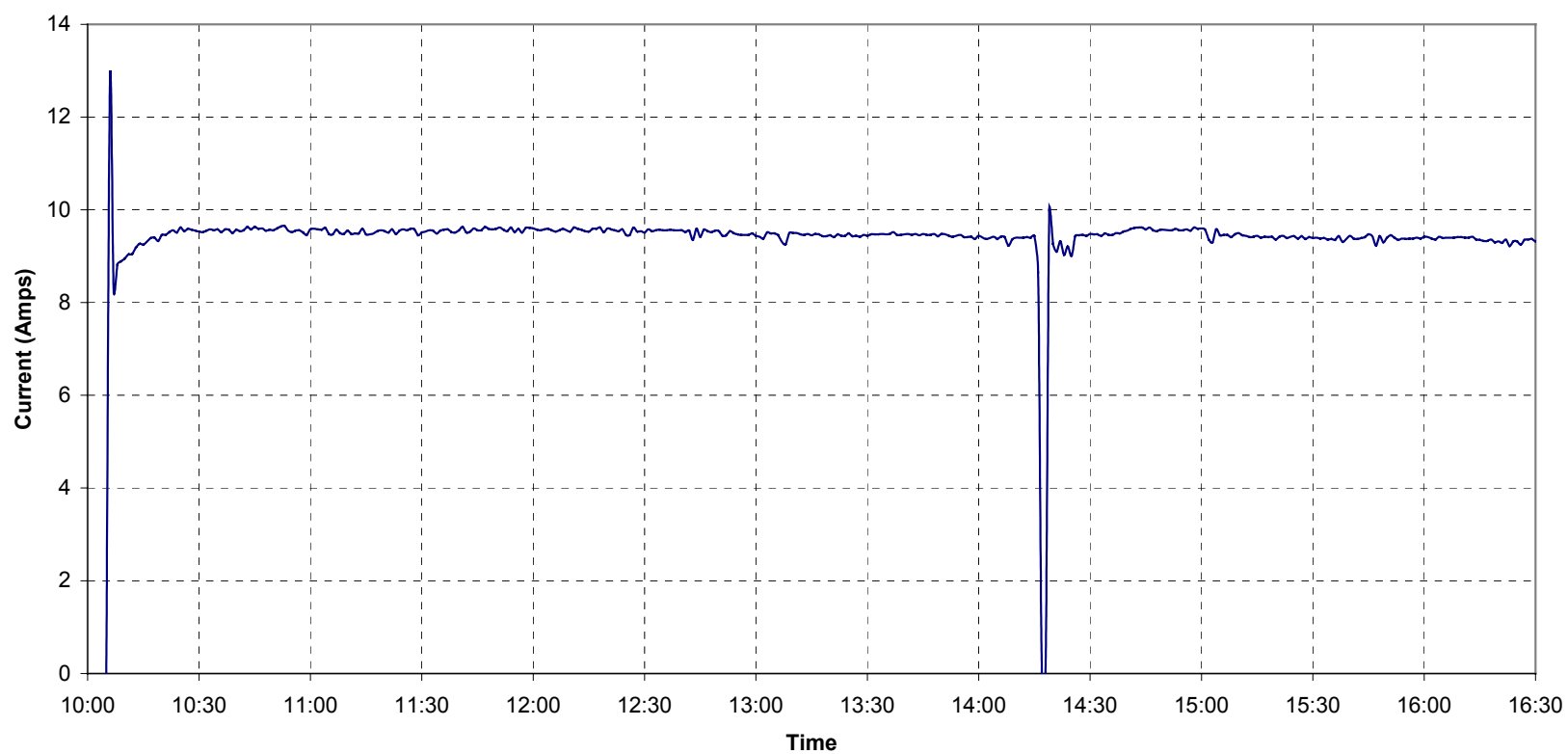


Table 2 – Raw Data of all Thermocouples

Time	Ambient	Average	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10	CH11	CH12	CH13	CH14	CH15	CH16	CH17	CH18	CH19	CH20	CH21	CH22	CH23	CH24
10:05	113.0	110.8	111.7	111.6	111.6	111.4	111.4	111.4	111.0	108.5	111.0	110.3	110.3	110.1	111.4	111.0	110.8	111.4	110.5	111.2	110.3	110.7	110.8	109.9	110.8	111.0
10:10	112.1	107.2	108.0	110.5	106.5	107.4	108.0	108.5	107.4	101.1	109.0	106.0	104.5	104.9	109.0	108.9	107.6	108.5	108.5	107.4	105.8	108.7	109.0	102.2	108.0	107.6
10:15	111.1	105.2	105.8	109.8	104.9	105.8	106.3	107.1	105.8	95.2	108.0	103.8	102.0	102.6	107.4	107.2	106.2	107.2	107.1	105.6	103.6	107.2	107.8	97.0	106.5	105.1
10:20	110.6	103.2	103.8	108.7	102.6	103.3	104.4	105.4	103.8	90.0	106.9	101.3	99.9	100.0	106.0	105.8	104.4	105.8	105.8	104.0	101.7	106.3	106.3	91.4	105.1	103.6
10:25	110.0	101.1	101.3	107.8	100.4	101.7	102.9	103.8	101.1	85.1	105.3	99.1	97.3	97.3	104.4	104.7	102.7	104.5	104.4	102.2	99.3	105.1	105.1	86.9	103.3	101.5
10:30	109.8	99.2	99.9	106.5	99.0	99.5	101.1	102.4	99.9	81.0	104.0	96.8	95.0	95.4	102.6	103.3	101.3	102.6	102.6	100.6	97.3	103.5	103.5	82.6	101.7	99.7
10:35	109.5	97.5	97.9	105.4	98.4	98.2	99.9	100.8	98.6	77.0	102.4	94.6	92.3	93.2	100.9	101.7	99.3	101.3	100.9	99.1	95.5	102.0	102.0	79.7	100.0	98.2
10:40	109.2	95.6	96.6	103.8	95.4	96.4	98.6	99.0	95.9	73.9	100.9	92.8	90.1	91.0	99.3	99.9	98.2	99.9	99.3	97.5	93.2	100.2	100.4	76.3	98.6	96.3
10:45	109.0	93.6	94.1	102.6	94.3	94.5	96.3	97.2	94.3	71.1	99.3	90.5	88.0	88.7	97.7	98.4	96.6	98.1	97.5	95.9	91.4	98.4	98.8	73.0	96.8	93.9
10:50	108.8	91.9	91.8	101.1	93.0	93.6	95.0	95.7	92.5	68.4	97.9	88.2	85.6	86.9	96.1	96.6	94.8	96.4	95.7	94.5	89.4	97.2	97.2	70.7	95.0	93.2
10:55	108.7	90.0	90.1	99.7	91.4	91.4	93.0	93.4	90.9	65.7	96.3	86.0	83.7	84.6	94.5	94.8	93.2	95.2	94.1	92.8	87.3	95.4	95.7	68.0	93.4	90.7
11:00	108.5	88.3	88.2	98.2	88.9	89.8	91.4	92.1	89.1	63.5	94.8	84.2	81.5	82.6	92.5	93.2	91.8	93.2	92.3	91.2	85.5	93.6	93.7	66.0	91.6	89.8
11:05	108.3	86.5	86.9	96.4	87.4	88.2	89.6	90.3	87.8	61.3	93.0	81.9	79.2	80.8	91.0	91.2	90.0	91.6	90.5	90.0	83.5	91.8	91.9	63.3	90.0	88.0
11:10	108.1	84.8	84.9	95.0	86.7	86.4	87.6	88.5	86.4	59.2	91.4	80.1	77.4	78.6	89.2	89.6	88.5	89.6	88.9	88.7	81.5	90.0	90.5	61.2	88.3	86.0
11:15	108.6	83.0	83.3	93.6	84.4	84.6	86.2	86.7	84.0	57.4	89.8	78.3	75.4	76.8	87.6	88.3	86.7	88.0	87.1	86.5	79.9	88.5	88.5	59.5	86.4	84.2
11:20	109.9	81.4	81.9	92.3	82.4	82.8	84.7	85.3	83.5	55.6	88.2	76.5	73.6	75.2	86.2	86.7	84.6	86.5	85.5	84.9	77.9	86.9	86.7	58.1	84.7	83.3
11:25	110.2	79.8	80.4	90.7	82.4	81.1	82.9	83.1	81.7	54.3	86.7	74.5	71.6	73.4	84.7	84.7	83.5	85.1	83.8	83.3	76.1	85.1	85.5	56.5	83.3	81.7
11:30	109.1	78.3	79.0	89.1	80.6	79.7	81.3	82.0	80.2	52.9	85.1	72.9	70.2	71.6	83.3	83.5	82.4	83.1	82.2	82.0	74.5	83.3	83.7	54.5	81.5	79.9
11:35	108.7	76.7	78.3	88.0	79.2	78.6	80.1	80.2	79.0	51.6	83.7	71.1	68.2	70.0	81.7	81.9	80.4	81.5	80.4	80.4	72.7	81.9	82.0	53.2	79.5	78.4
11:40	108.9	75.3	76.6	86.4	77.0	77.0	78.4	79.2	77.0	50.9	82.0	69.3	66.9	68.4	80.4	80.2	79.3	80.2	79.0	79.2	71.2	80.4	80.4	52.5	78.4	76.6
11:45	109.4	73.8	74.8	84.7	75.6	75.4	77.0	77.2	75.2	50.0	80.8	67.8	65.3	66.9	78.6	79.0	77.9	79.2	77.4	77.9	69.6	78.8	79.3	51.4	77.0	74.7
11:50	109.5	72.5	72.3	83.7	74.8	74.7	75.7	75.9	74.3	49.1	79.5	66.4	63.7	65.5	77.5	77.4	76.1	77.4	75.9	76.8	68.2	77.5	77.9	51.3	75.6	73.4
11:55	109.6	71.1	71.6	82.6	73.8	73.2	74.3	74.3	71.8	48.2	78.1	64.9	62.4	63.9	76.1	76.1	74.5	76.5	74.5	75.0	66.6	75.9	76.1	50.5	73.9	71.8
12:00	108.9	69.8	70.3	81.1	71.6	71.8	72.9	73.2	71.2	47.7	76.6	63.7	61.0	62.6	75.0	74.3	73.4	75.0	73.0	73.8	65.3	74.5	74.8	49.8	72.7	70.9
12:05	108.9	68.5	69.1	79.7	70.0	70.3	72.1	72.0	69.8	46.8	75.6	62.1	59.7	61.0	73.6	73.0	72.0	73.6	71.6	72.3	63.9	73.2	73.6	48.9	71.1	68.9
12:10	109.6	67.3	67.1	78.1	70.0	69.6	70.7	70.7	68.5	45.9	74.3	60.8	58.5	59.7	72.1	72.0	70.3	72.5	70.3	71.4	62.4	71.8	72.1	48.4	70.0	67.8
12:15	109.2	66.1	66.2	77.2	68.7	67.8	69.3	69.3	67.3	45.3	72.9	59.5	57.4	58.6	70.9	70.7	69.8	71.2	69.1	70.3	61.2	70.5	70.9	46.9	68.7	66.6
12:20	109.1	64.9	65.1	76.1	66.9	66.7	68.0	68.4	65.8	44.6	71.8	58.3	56.3	57.4	69.8	69.6	68.4	69.8	67.8	69.3	59.9	69.4	70.0	46.9	67.5	64.8
12:25	109.1	63.9	64.2	74.5	66.4	65.8	66.7	66.9	64.8	43.9	70.7	57.2	55.0	56.3	68.7	68.5	67.6	68.9	66.7	68.4	58.6	68.2	68.5	46.9	66.4	64.2
12:30	109.4	62.7	63.3	73.8	64.9	64.2	65.8	66.2	63.7	43.3	69.4	55.9	53.8	55.0	67.6	67.1	65.7	67.8	65.5	66.9	57.6	66.9	67.3	45.9	65.1	63.0
12:35	109.2	61.7	62.2	72.3	63.7	63.3	64.6	64.9	62.8	42.8	68.4	54.9	52.9	54.0	66.7	66.2	64.6	66.6	64.2	65.7	56.3	65.8	66.2	45.5	63.9	61.5
12:40	109.1	60.6	61.0	71.4	63.7	62.2	63.5	63.7	61.9	42.1	67.3	53.8	52.0	53.1	65.5	65.1	63.1	65.3	63.3	64.6	55.2	64.8	65.3	43.9	62.8	61.0
12:45	109.8	59.7	59.9	70.2	62.2	61.7	62.6	62.8	60.8	41.4	66.2	52.9	50.9	52.0	64.6	64.2	62.2	64.2	62.1	63.5	54.3	63.5	64.2	44.1	61.7	59.9
12:50	109.5	58.8	59.2	69.4	61.3	60.6	61.7	61.9	60.1	41.2	65.3	52.0	50.2	51.3	63.7	63.0	61.3	63.5	61.2	62.6	53.2	62.6	63.0	43.9	60.6	59.0
12:55	109.1	57.9	58.5	68.2	60.1	59.9	61.0	61.2	59.2	40.5	64.2	50.9	49.5	50.2	62.6	62.2	60.8	62.4	60.1	61.5	52.2	61.7	62.1	43.7	59.5	58.3
13:00	109.1	57.0	57.4	67.3	59.9	58.8	60.1	60.1	58.3	40.3	63.3	50.0	48.6	49.3	61.7	61.5	59.4	61.5	59.0	60.6	51.4	60.6	61.0	42.8	58.6	57.2

- All temperatures in °F

Appendix

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 Lucas 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