DANISH
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TEST REPORT

for standard version and several prototypes

Test item
Vestfrost POS 72 “Impulse Sales” coolers

Report no.
I08-05

Date
22nd June 2010

VERSION 3

Energy & Climate
Centre for Refrigerating & Heat Pump Technology

DANISH
TECHNOLOGICAL
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TEST REPORT

Enclosure: 1
Contract no. I08-05

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Item	Brand:	Vestfrost
	Model:	POS 72
	Type of appliance:	Impulse sales bottle cooler
	Test/date:	February 2008 – Juni 2010
Remarks	-	

Conditions

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0. TABLE OF CONTENTS

1. TEST PROGRAM

This test report comprises results from the following tests:

Test no.	Description	Item id. no.
Test 1	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Tested with lid assembled and disassembled.	300-KLAB-08-121
Test 2	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. New cooler and altered storage plan. No lid assembled.	300-KLAB-08-151
Test 3	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. New cooler and altered storage plan. No lid assembled.	300-KLAB-08-152
Test 4	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. First generation prototype with new condenser and R134a refrigerant. No lid assembled.	300-KLAB-08-193
Test 5	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. First generation prototype with new condenser and R600a. No lid assembled.	300-KLAB-08-194
Test 6	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Second generation prototype with new condenser and R600a refrigerant. No lid assembled.	300-KLAB-09-127
Test 7	Energy consumption test. Loading: 33 cl aluminium cans,containing fizzy lemonade. Slots installed. No lid assembled.	300-KLAB-09-127
Test 8	Energy consumption test. Loading33 cl aluminium cans, containing fizzy lemonade. Slots and air guides installed. No lid assembled.	300-KLAB-09-127
Test 9	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. No lid assembled.	300-KLAB-09-127

Test no.	Description	Item id. no.
Test 10	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open lid.	300-KLAB-09-127
Test 11	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Closed lid.	300-KLAB-09-127
Test 12	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open/close sequence of lid according to EN 23953.	300-KLAB-09-127
Test 13	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open/close sequence of lid according to EN 23953. Deviation: Lid remains open for 30 sec.	300-KLAB-09-127
Test 14	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open/close sequence of lid according to EN 23953. Deviation: Lid remains open for 30 sec. Power shut off during the first 8 hours of the 12 hour resting period incorporated in the open/close sequence.	300-KLAB-09-127
Test 15	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open lid. Power shut off between 22:00 and 06:00.	300-KLAB-09-127
Test 16	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade.. Open lid.	300-KLAB-10-147
Test 17	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade.. Open lid.	300-KLAB-10-147
Test 18	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade.. Closed lid.	300-KLAB-10-147

2. EQUIPMENT

Equipment	Manufacturer	Type
Power Analyzer	Voltech	PM100
Temperature logger	Anville	TC/16

3. METHOD

The measurements were not carried out according to any specific standard. However the tests were performed in an EN 153 accredited climate chamber and the conditions regarding ambient temperature, ambient humidity and ambient air velocity were consisting with this standard. See item 7. REFERENCES.
The bottle coolers were loaded with 33 cl aluminium cans containing fizzy lemonade according to the storage plan appearing from Enclosure 1. Each bottle cooler contained the total of 96 cans stacked in four layers, each layer containing 24 cans. The temperature was measured in 9 cans distributed throughout the load. Into each can a copper-constantan thermocouple was elevated. These cans were filled with water to prevent interference from the ingredients of the lemonade.

4. PURPOSE & TEST PROGRESS

The purpose of the tests was to decrease the energy consumption of the Vestfrost impulse sales bottle cooler and to implement the use of natural refrigerants in the production of the coolers. Later on, after the series of tests were initiated, maintenance problems were discovered. From this point the development process included this issue as well. The series of tests were performed on six individual bottle coolers in accordance with the test program, see item 1. "TEST PROGRAM". The bottle coolers had the following characteristics and id. no.:

Item characteristics	**Item id.no.**
Original version. Refrigerant: R134a	300-KLAB-08-121
Original version, altered storage plan. Identical with 300-KLAB-08-152 Refrigerant: R134a	300-KLAB-08-151
Original version, altered storage plan. Identical with 300-KLAB-08-151 Refrigerant: R134a	300-KLAB-08-152
First generation prototype, new condenser. Refrigerant: R134a	300-KLAB-08-193
First generation prototype, new condenser (as 300-KLAB-08-193). Refrigerant R600a.	300-KLAB-08-194
Second generation prototype. Refrigerant R600a. The item was gradually changed through the series of tests installing slots, air guides and pulse control of fan. See item 1. TEST PROGRAM.	300-KLAB-09-127
Third generation prototype. Refrigerant R600a. This prototype also contains an improved condenser and better compressor (Danfoss NLE9KTK) The prototype had no LED light.	300-KLAB-10-147

5. RESULTS

The test results solely apply to the tested appliance(s).

Test 1

During test the compressor was running 100 % of the time (except during defrost mode). The temperatures of the cans were too high (should be maximum 7 °C). The energy consumption during test without lid was approximately 7,5 kWh/24h and with lid approximately 5,7 kWh/24h.
The results were discussed at a project meeting at DTI in March 2008, and it was decided to ship two new coolers to the DTI for test. It was also decided to use test cans which were taped into "sixpacks" to better have them organised during the test.
The bottle cooler was shipped back to the Vestfrost Company.

Measuring points	Data sources		
Start		17-03-2008 17:24	24-03-2008 14:28
Stop		18-03-2008 17:29	25-03-2008 14:33
Duration		24:04 [HH.MM]	24:04 [HH.MM]
Ambient temperature			
Average temperature		25,1	25,3
Left	Z:\KFS\ANVILLE\09\01	25,2	25,5
Right	Z:\KFS\ANVILLE\09\02	24,9	25
Appliance			
Average temperature		8,7	7,9
Can 1	Z:\KFS\ANVILLE\15\01	11,1	0,9
Can 2	Z:\KFS\ANVILLE\15\02	10,3	10,2
Can 3	Z:\KFS\ANVILLE\15\03	2	2,1
Can 4	Z:\KFS\ANVILLE\15\04	8,6	9,6
Can 5	Z:\KFS\ANVILLE\15\05	10,4	11,5
Can 6	Z:\KFS\ANVILLE\15\06	11,6	10,8
Can 7	Z:\KFS\ANVILLE\15\07	10,1	10,4
Can 8	Z:\KFS\ANVILLE\15\08	8,7	11,2
Can 9	Z:\KFS\ANVILLE\15\09	5,4	4,6
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	229,1	228,4
Power	Z:\KFS\PM100\12\WATT	235,6	312,6
Running time	Z:\KFS\PM100\12\WATT	100	100
Energy	Z:\KFS\PM100\12\WH	5664,1	7505,7
Energy consumption/24h	Z:\KFS\PM100\12\WH	5644,8	7480,2
		Lid assembled	No lid

Table 1: Test results for Test 1.

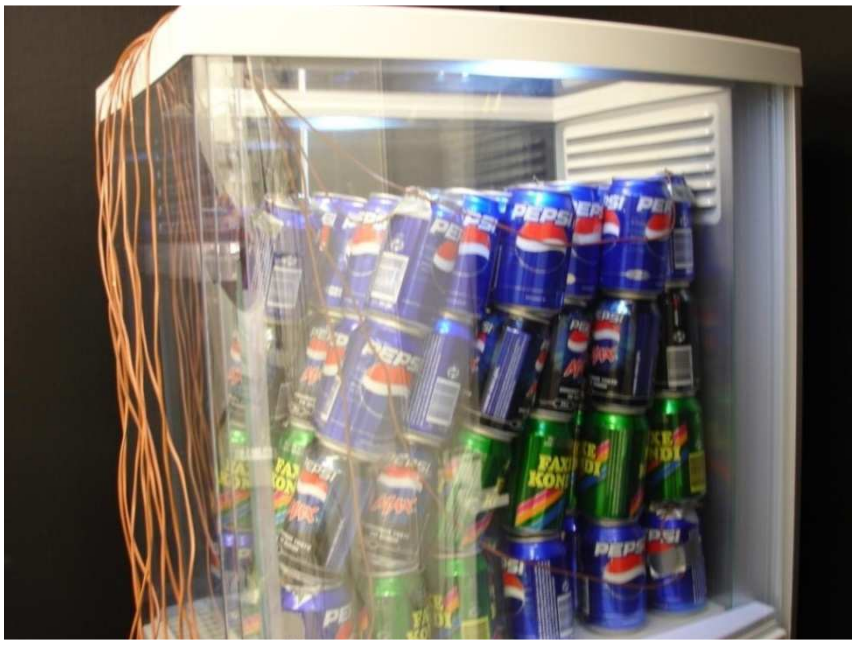


Photo 1: It was difficult to maintain the cans correctly stacked.

Test 2

Photo 2: The cans were wrapped with tape, forming ”six packs”.

Measuring points	Datakilder	
Start		15-06-2008 08:14
Stop		16-06-2008 08:14
Duration		24:00 [HH.MM]
Ambient temperature		
Average temperature		25,3
Left	Z:\KFS\ANVILLE\15\01	24,9
Right	Z:\KFS\ANVILLE\15\02	25,6
Appliance		
Average temperature		5,3
Can 1	Z:\KFS\ANVILLE\15\03	3,7
Can 2	Z:\KFS\ANVILLE\15\04	5,6
Can 3	Z:\KFS\ANVILLE\15\05	4,1
Can 4	Z:\KFS\ANVILLE\15\06	5,6
Can 5	Z:\KFS\ANVILLE\15\07	4,6
Can 6	Z:\KFS\ANVILLE\15\08	5,2
Can 7	Z:\KFS\ANVILLE\15\09	6,2
Can 8	Z:\KFS\ANVILLE\15\10	5,7
Can 9	Z:\KFS\ANVILLE\15\11	6,6
Compressor		
Voltage	Z:\KFS\PM100\12\VRMS	230,9
Power	Z:\KFS\PM100\12\WATT	165,8
Running time	Z:\KFS\PM100\12\WATT	100
Energy	Z:\KFS\PM100\12\WH	3987,1
Energy consumption/24h	Z:\KFS\PM100\12\WH	3986,6

Table 2: Test results for Test 2.

Test 3

Measuring points	Data sources	
Start		20-06-2008 23:39
Stop		21-06-2008 23:39
Duration		24:00 [HH.MM]
Ambient temperature		
Average temperature		25,2
Left	Z:\KFS\ANVILLE\15\01	24,7
Right	Z:\KFS\ANVILLE\15\02	25,6
Appliance		
Average temperature		4,6
Can 1	Z:\KFS\ANVILLE\15\03	3,1 / min. 2,25
Can 2	Z:\KFS\ANVILLE\15\04	4,4
Can 3	Z:\KFS\ANVILLE\15\05	3,3
Can 4	Z:\KFS\ANVILLE\15\06	5
Can 5	Z:\KFS\ANVILLE\15\07	3,9
Can 6	Z:\KFS\ANVILLE\15\08	4,8
Can 7	Z:\KFS\ANVILLE\15\09	5,8
Can 8	Z:\KFS\ANVILLE\15\10	4,8
Can 9	Z:\KFS\ANVILLE\15\11	6,2 / max. 6,44
Compressor		
Voltage	Z:\KFS\PM100\12\VRMS	230,9
Power	Z:\KFS\PM100\12\WATT	180
Running time	Z:\KFS\PM100\12\WATT	100
Energy	Z:\KFS\PM100\12\WH	4311,8
Energy consumption/24h	Z:\KFS\PM100\12\WH	4311,3

Table 3: Test results for Test 3.

On the basis of the test results from Test 2 and Test 3, it was decided to initiate the development of a bottle cooler using natural refrigerants. It was also decided to continue trying to decrease the energy consumption. At this point, the maintenance problems were discovered, why it was decided to take this issue into account as well.

Test 4 and test 5

The first generation prototypes (one with R134a and one with R600a refrigerant) were equipped with a new condenser type, made from smooth steel pipe which was easy to clean.
Both prototypes were working badly because the heat transmission area of the condenser was too little and the condenser temperature was too high. Especially the R134a cooler was hot on the condenser side.
Both coolers were running 100 % of time.
After the first tests it was decided to terminate and ship the coolers back to the Vestfrost Company.

Test 6

Vestfrost improved the condenser and build a new R600a cooler. The Vestfrost Company made a strategic decision to drop the R134a cooler and concentrate the future work on R600a natural refrigerant.

The new cooler had a higher heat transmission area of the condenser and improved cooling of the compressor. The airflow inlet and outlet at the condenser side was also separated to prevent short-circuit of the airstream.

The cooler was installed at DTI in February 2009 and tested in February and March.

Measuring points	Data sources		
Start		28-02-2009 13:19	01-03-2009 18:06
Stop		01-03-2009 13:19	02-03-2009 18:06
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature			
Average temperature		24,9	24,8
Left	Z:\KFS\ANVILLE\03\01	25	24,9
Right	Z:\KFS\ANVILLE\03\02	24,7	24,7
Appliance			
Average temperature		2,1	2,1
Can 1	Z:\KFS\ANVILLE\03\03	0,5	0,5
Can 2	Z:\KFS\ANVILLE\03\04	2,9	2,8
Can 3	Z:\KFS\ANVILLE\03\05	0,8	0,8
Can 4	Z:\KFS\ANVILLE\03\06	2,9	2,9
Can 5	Z:\KFS\ANVILLE\03\07	1,2	1,2
Can 6	Z:\KFS\ANVILLE\03\08	1,8	1,8
Can 7	Z:\KFS\ANVILLE\03\09	3,6	3,6
Can 8	Z:\KFS\ANVILLE\03\10	2,2	2,2
Can 9	Z:\KFS\ANVILLE\03\11	3,2	3,2
Kompressor			
Voltage	Z:\KFS\PM100\12\VRMS	230,8	230
Power	Z:\KFS\PM100\12\WATT	170,7	169,3
Running time	Z:\KFS\PM100\12\WATT	100	100
Energy	Z:\KFS\PM100\12\WH	4072,7	4067,3
Energy consumption/24h	Z:\KFS\PM100\12\WH	4072,2	4066,9

Table 4: Test results for Test 6.

The bottle cooler was working fine, and “did the job”. It kept the 96 cans between freezing point and 7 °C. The energy consumption was approximately 4,07 kWh/24h.

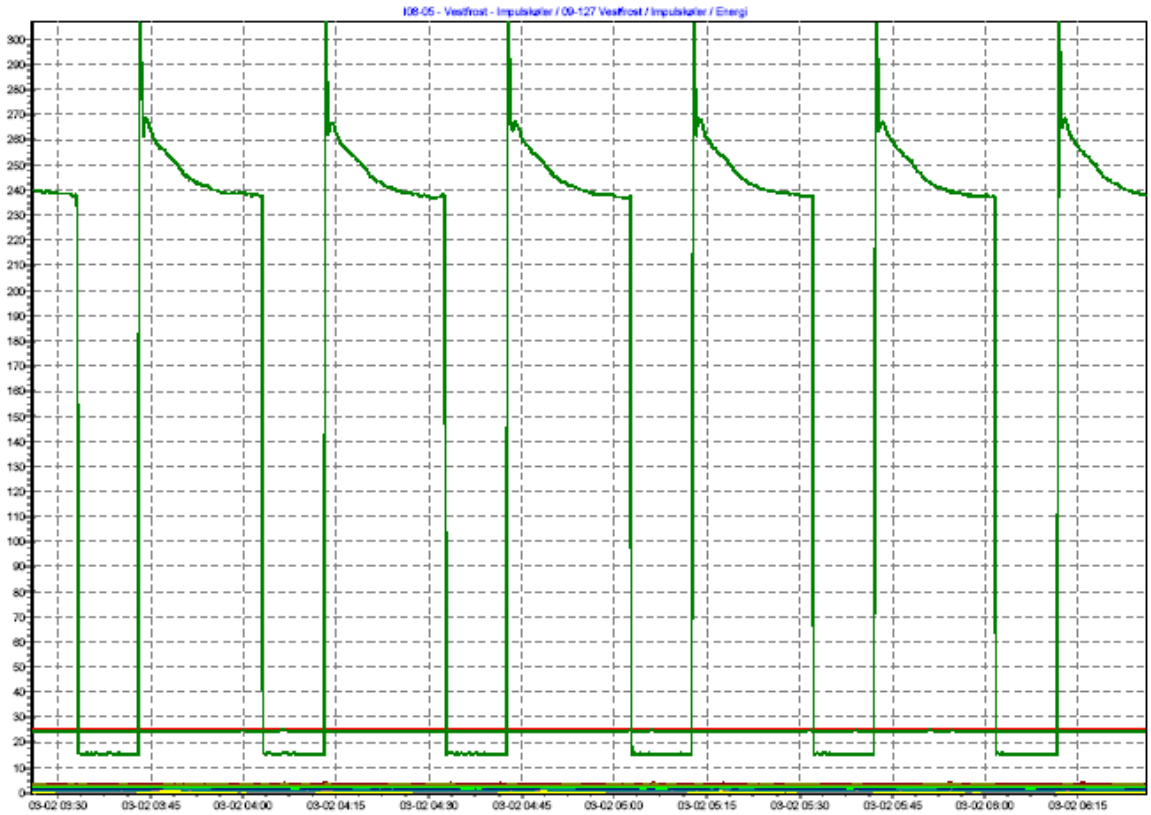


Chart 1: Typical power course for the bottle cooler.

Test 7

CFD calculation has shown a better performance by small geometric changes at the inlet and outlet air channels inside the cooler (at the cold side). The changes should reduce the air infiltration of warm ambient air into the cooler and reduce the energy consumption.
Therefore small changes were made in connection to test 7 and 8.

In test 7 additional small narrow slots were made at the inlet and outlet of the airflow. The slots were installed under the existing slots, which were placed in the upper region in the rear and the front of the cooler.

Measuring points	Data sources	
Start		19-04-2009 04:07
Stop		20-04-2009 04:12
Duration		24:04 [HH.MM]
Ambient temperature		
Average temperature		24,9
Left	Z:\KFS\ANVILLE\03\01	24,9
Right	Z:\KFS\ANVILLE\03\02	24,8
Appliance		
Average temperature		2,3
Can 1	Z:\KFS\ANVILLE\03\03	0,6
Can 2	Z:\KFS\ANVILLE\03\04	2,9
Can 3	Z:\KFS\ANVILLE\03\05	1
Can 4	Z:\KFS\ANVILLE\03\06	3,3
Can 5	Z:\KFS\ANVILLE\03\07	1,4
Can 6	Z:\KFS\ANVILLE\03\08	1,9
Can 7	Z:\KFS\ANVILLE\03\09	4
Can 8	Z:\KFS\ANVILLE\03\10	2,1
Can 9	Z:\KFS\ANVILLE\03\11	3,7
Compressor		
Voltage	Z:\KFS\PM100\10\VRMS	232,1
Power	Z:\KFS\PM100\10\WATT	167,6
Running time	Z:\KFS\PM100\10\WATT	100
Energy	Z:\KFS\PM100\10\WH	4016,7
Energy consumption/24h	Z:\KFS\PM100\10\WH	4002,9

Table 5: Test results for Test 7.

Test in climate chamber showed only minor improvement, since the energy consumption was measured to approximately 4,0 kWh/24h.

Test 8

Test 8 was performed as Test 7, but with air guides at the “new” narrow air slots. The guides ensured that inlet air was pressed downwards in the cooler. This prevented the air from moving up over the columns of cans and to be mixed with the ambient air.

Measuring points	Data sources	
Start		11-05-2009 20:25
Stop		12-05-2009 20:30
Duration		24:04 [HH.MM]
Ambient temperature		
Average temperature		25,1
Left	Z:\KFS\ANVILLE\03\01	25,1
Right	Z:\KFS\ANVILLE\03\02	25
Appliance		
Average temperature		2,5
Can 1	Z:\KFS\ANVILLE\03\03	0,8
Can 2	Z:\KFS\ANVILLE\03\04	3
Can 3	Z:\KFS\ANVILLE\03\05	1,3
Can 4	Z:\KFS\ANVILLE\03\06	3,4
Can 5	Z:\KFS\ANVILLE\03\07	1,7
Can 6	Z:\KFS\ANVILLE\03\08	2
Can 7	Z:\KFS\ANVILLE\03\09	4,5
Can 8	Z:\KFS\ANVILLE\03\10	2,3
Can 9	Z:\KFS\ANVILLE\03\11	3,9
Compressor		
Voltage	Z:\KFS\PM100\12\VRMS	229,7
Power	Z:\KFS\PM100\12\WATT	166,1
Running time	Z:\KFS\PM100\12\WATT	100
Energy	Z:\KFS\PM100\12\WH	3956,2
Energy consumption/24h	Z:\KFS\PM100\12\WH	3942,5

Table 6: Test results for Test 8.

The test in climate chamber showed no improvements with the air slots and the air guides installed. The explanation might be that the columns of cans were not in perfect order and the area of air pass was smaller than expected from an ideal calculation.

Test 9

From CFD calculations it was seen, that the main heat transfer to the refrigeration systems came from air infiltration at the open top.
In the standard cooler and in the previous prototypes the air fan (for cold air into the cooler) was running 100 % of the time.
Theoretical it was not necessary to run the fans at the compressor OFF-time. By stopping the fans simultaneous with the compressor, the air infiltration would be reduced.

On the other hand it was necessary for the controller to receive a correct temperature signal, which corresponded with the actual can temperature.

The solution was to develop a “pulse control” for the (cold air) fan, to reduce the warm air infiltration and to ensure a correct temperature signal for the electronic controller.
It was possible to order an electronic control which could be programmed for that purpose, and this control was installed in the prototype in June 2009.
The controller was programmed to stop the fan for 3 minutes and then to run the fan for one minute, followed by a 3 minutes stand still period etc. until the compressor turned on.

Measuring points	Datakilder		
Start		27-06-2009 00:51	28-06-2009 01:28
Stop		28-06-2009 00:51	29-06-2009 01:28
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature			
Average temperature		24,9	24,9
Left	Z:\KFS\ANVILLE\03\01	24,9	24,9
Right	Z:\KFS\ANVILLE\03\02	24,8	24,8
Appliance			
Average temperature		3,5	3,5
Can 1	Z:\KFS\ANVILLE\03\03	0,8	0,8
Can 2	Z:\KFS\ANVILLE\03\04	3,7	3,7
Can 3	Z:\KFS\ANVILLE\03\05	1	1
Can 4	Z:\KFS\ANVILLE\03\06	4	4
Can 5	Z:\KFS\ANVILLE\03\07	2,2	2,2
Can 6	Z:\KFS\ANVILLE\03\08	4	4
Can 7	Z:\KFS\ANVILLE\03\09	6,5	6,5
Can 8	Z:\KFS\ANVILLE\03\10	3,2	3,2
Can 9	Z:\KFS\ANVILLE\03\11	6,1	6,1
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	6,6	6,7
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	231	231,3
Power	Z:\KFS\PM100\12\WATT	151,2	152,2
Running time	Z:\KFS\PM100\12\WATT	72,6	72,5
Energy	Z:\KFS\PM100\12\WH	3624,5	3650,2
Energy consumption/24h	Z:\KFS\PM100\12\WH	3624,1	3649,4

Table 7: Test results for Test 9.

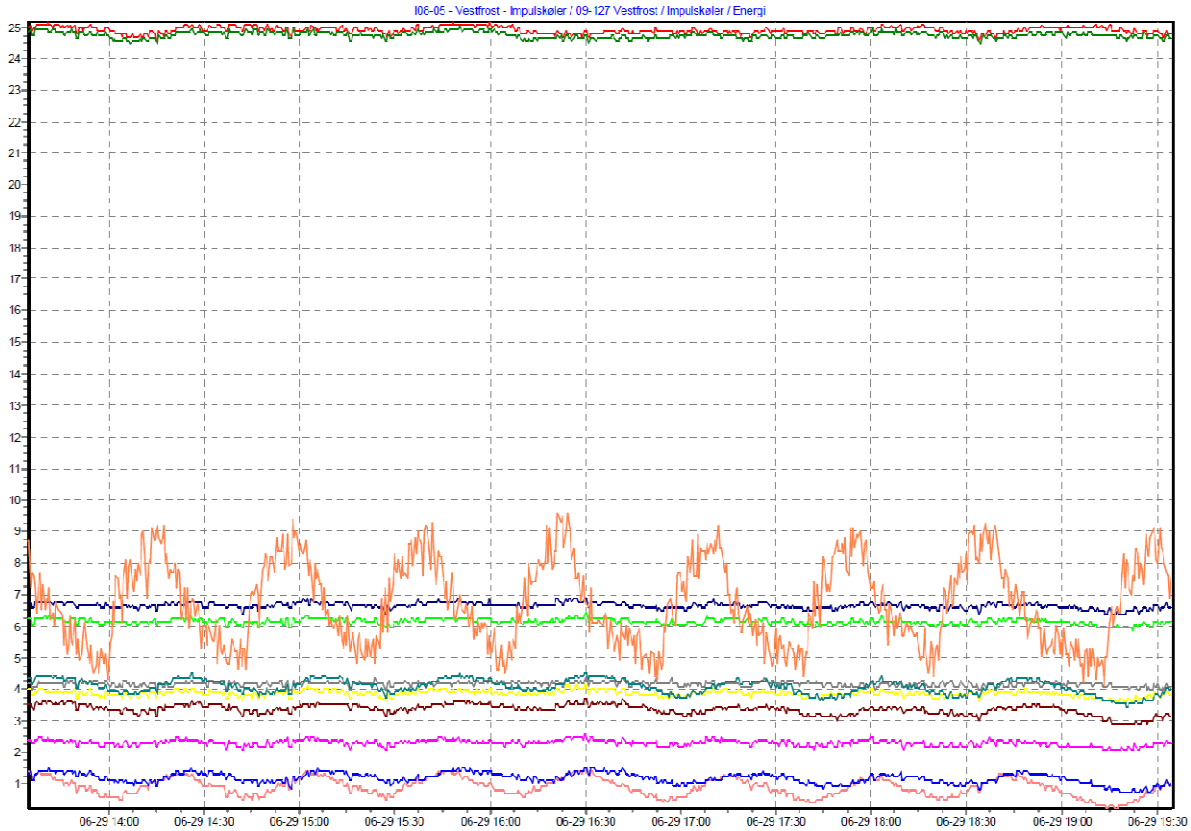


Chart 2: Temperatures measured during Test 9. The orange, fluctuating curve illustrates the temperature of the return air.

Chart 3: Power measured during Test 9.

Test 10

Measure points	Data sources		
Start		27-10-2009 23:43	28-10-2009 23:53
Stop		28-10-2009 23:43	29-10-2009 23:53
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	24,7	24,7
Appliance			
Average temperature		6,1	6,0
Can 1	Z:\KFS\ANVILLE\03\03	5,1	5
Can 2	Z:\KFS\ANVILLE\03\04	6,4	6,3
Can 3	Z:\KFS\ANVILLE\03\05	4,7	4,5
Can 4	Z:\KFS\ANVILLE\03\06	6,7	6,6
Can 5	Z:\KFS\ANVILLE\03\07	5,1	5
Can 6	Z:\KFS\ANVILLE\03\08	6,3	6,2
Can 7	Z:\KFS\ANVILLE\03\09	7,7	7,6
Can 8	Z:\KFS\ANVILLE\03\10	5,8	5,7
Can 9	Z:\KFS\ANVILLE\03\11	7,3	7,2
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	8,4	8,2
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	228,1	228,6
Power	Z:\KFS\PM100\12\WATT	161,6	160,6
Running time	Z:\KFS\PM100\12\WATT	100	100
Energy consumption	Z:\KFS\PM100\12\WH	3871,9	3856,7
Energy consumption/24h	Z:\KFS\PM100\12\WH	3871	3856,3

Table 8: Test results for Test 10.

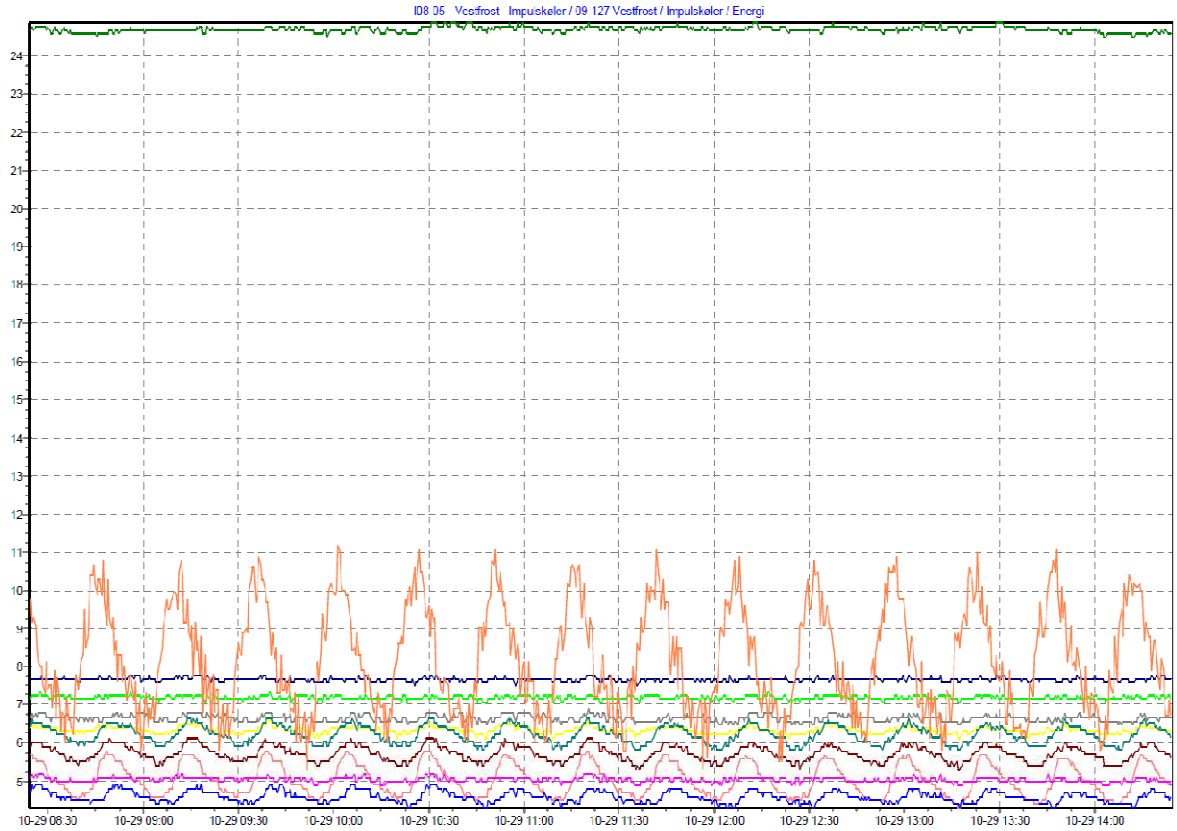


Chart 4: Temperatures measured during Test 10.

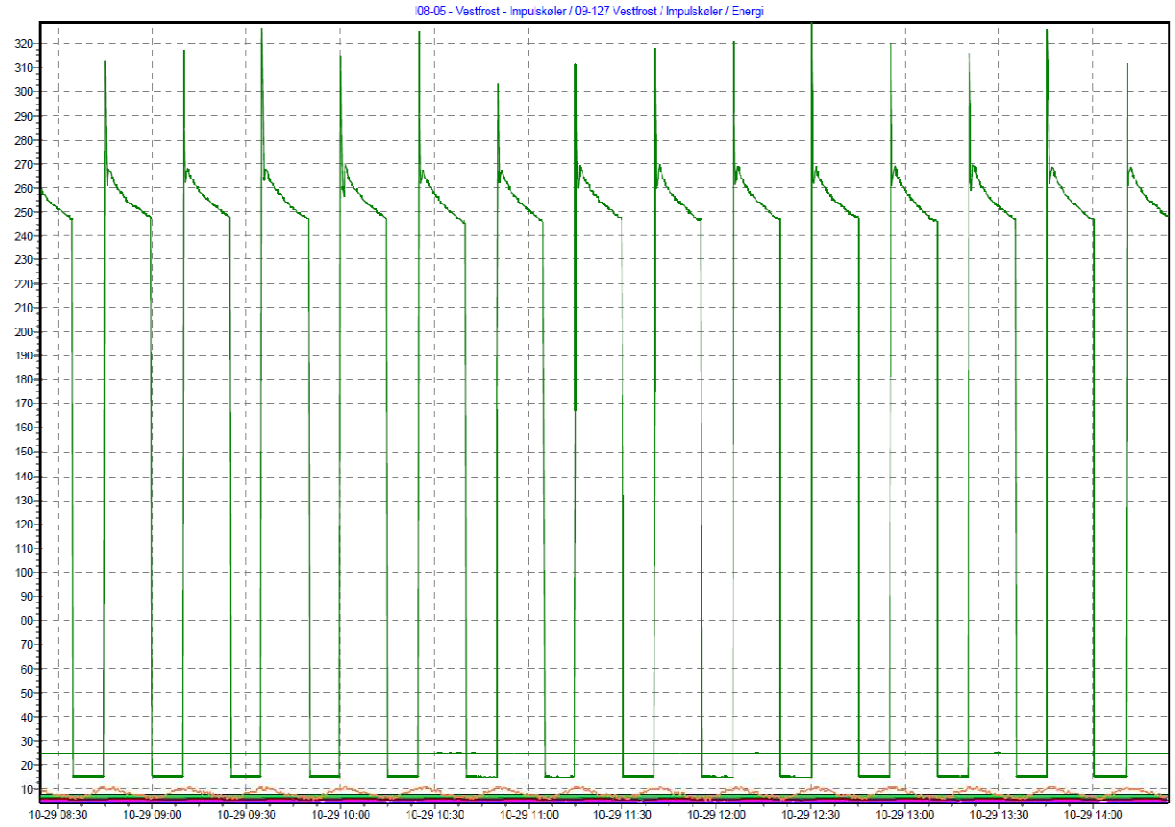


Chart 5: Power measured during Test 10. For an unknown reason, the pulse controller did not follow the programmed sequence and did not at any point run during Test 10.

Test 11

Measure points	Data sources		
Start		31-10-2009 09:28	01-11-2009 09:24
Stop		01-11-2009 09:28	02-11-2009 09:25
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	24,8	24,8
Appliance			
Average temperature		5,9	6,1
Can 1	Z:\KFS\ANVILLE\03\03	4,4	4,4
Can 2	Z:\KFS\ANVILLE\03\04	6,3	6,4
Can 3	Z:\KFS\ANVILLE\03\05	4,3	4,4
Can 4	Z:\KFS\ANVILLE\03\06	6,4	6,5
Can 5	Z:\KFS\ANVILLE\03\07	5	5,2
Can 6	Z:\KFS\ANVILLE\03\08	6,1	6,3
Can 7	Z:\KFS\ANVILLE\03\09	7,7	7,9
Can 8	Z:\KFS\ANVILLE\03\10	5,6	5,8
Can 9	Z:\KFS\ANVILLE\03\11	7,3	7,6
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	7,8	7,9
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	229	228,9
Power	Z:\KFS\PM100\12\WATT	100,2	99,5
Running time	Z:\KFS\PM100\12\WATT	74	73,7
Energy consumption	Z:\KFS\PM100\12\WH	2394,1	2394,2
Energy consumption/24h	Z:\KFS\PM100\12\WH	2393,6	2393,6

Table 9: Test results for Test 11.

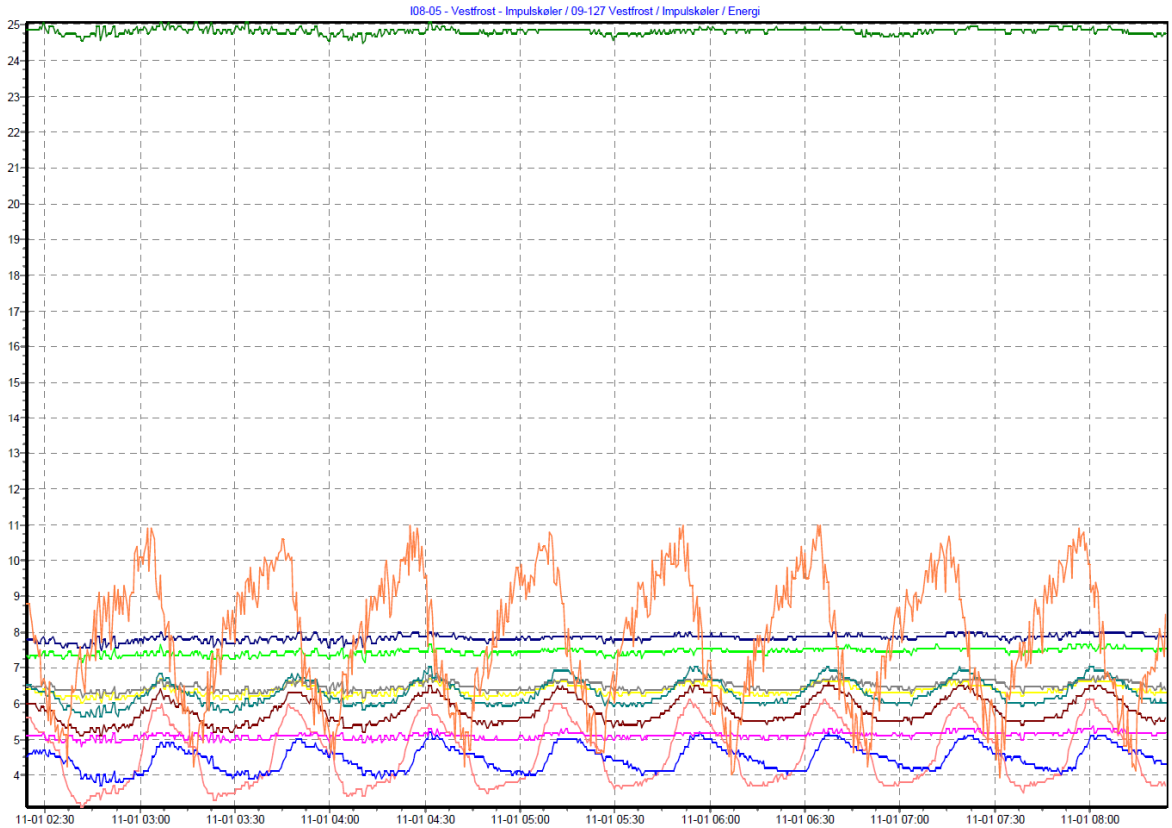


Chart 6: Temperatures measured during Test 11.

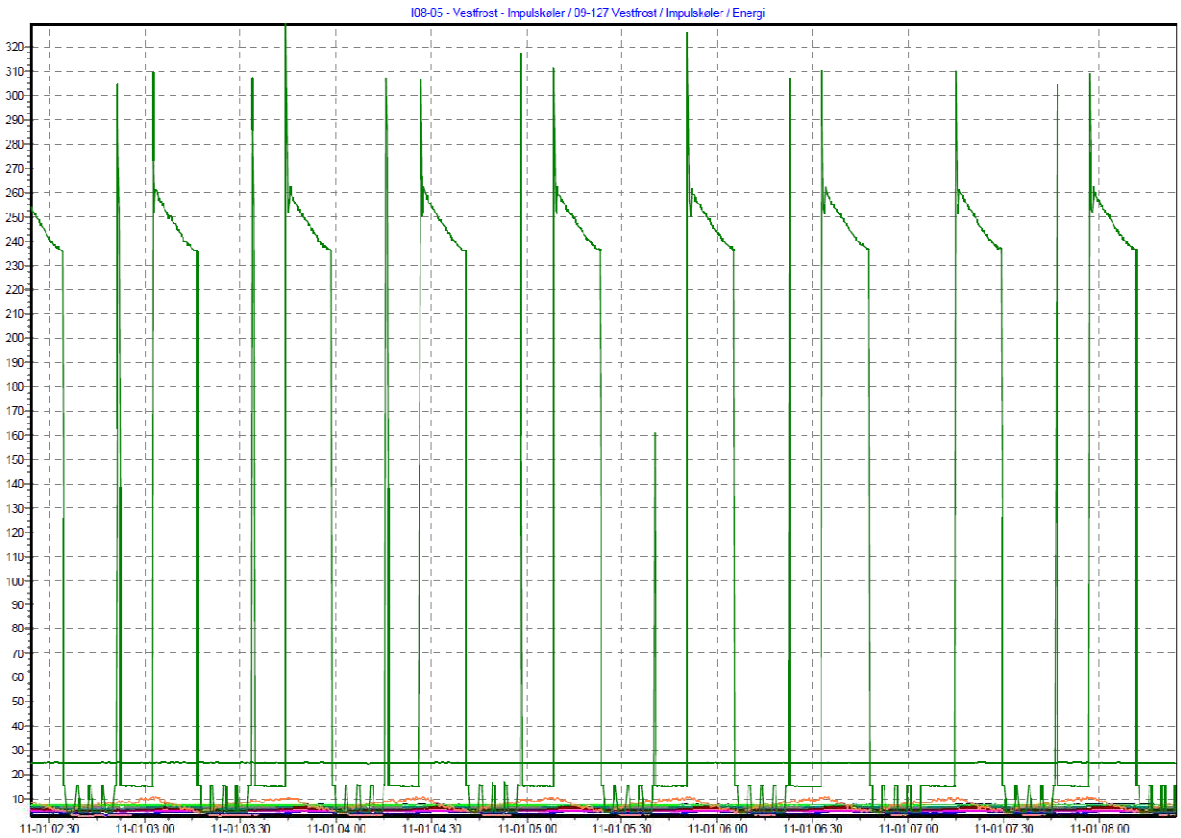


Chart 7: Power measured during Test 11.

Test 12

Measure points	Data sources		
Start		03-11-2009 10:25	04-11-2009 10:25
Stop		04-11-2009 10:26	05-11-2009 10:25
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	24,8	24,7
Appliance			
Average temperature		6,1	6,1
Can 1	Z:\KFS\ANVILLE\03\03	4,6	4,5
Can 2	Z:\KFS\ANVILLE\03\04	6,5	6,5
Can 3	Z:\KFS\ANVILLE\03\05	4,5	4,4
Can 4	Z:\KFS\ANVILLE\03\06	6,6	6,6
Can 5	Z:\KFS\ANVILLE\03\07	5,2	5,2
Can 6	Z:\KFS\ANVILLE\03\08	6,4	6,3
Can 7	Z:\KFS\ANVILLE\03\09	7,9	8
Can 8	Z:\KFS\ANVILLE\03\10	5,9	5,8
Can 9	Z:\KFS\ANVILLE\03\11	7,6	7,7
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	8	7,9
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	228,9	229,3
Power	Z:\KFS\PM100\12\WATT	97,9	96,9
Running time	Z:\KFS\PM100\12\WATT	73,3	72,8
Energy consumption	Z:\KFS\PM100\12\WH	2352	2333,4
Energy consumption/24h	Z:\KFS\PM100\12\WH	2351,5	2333,2

Table 10: Test results for Test 12.

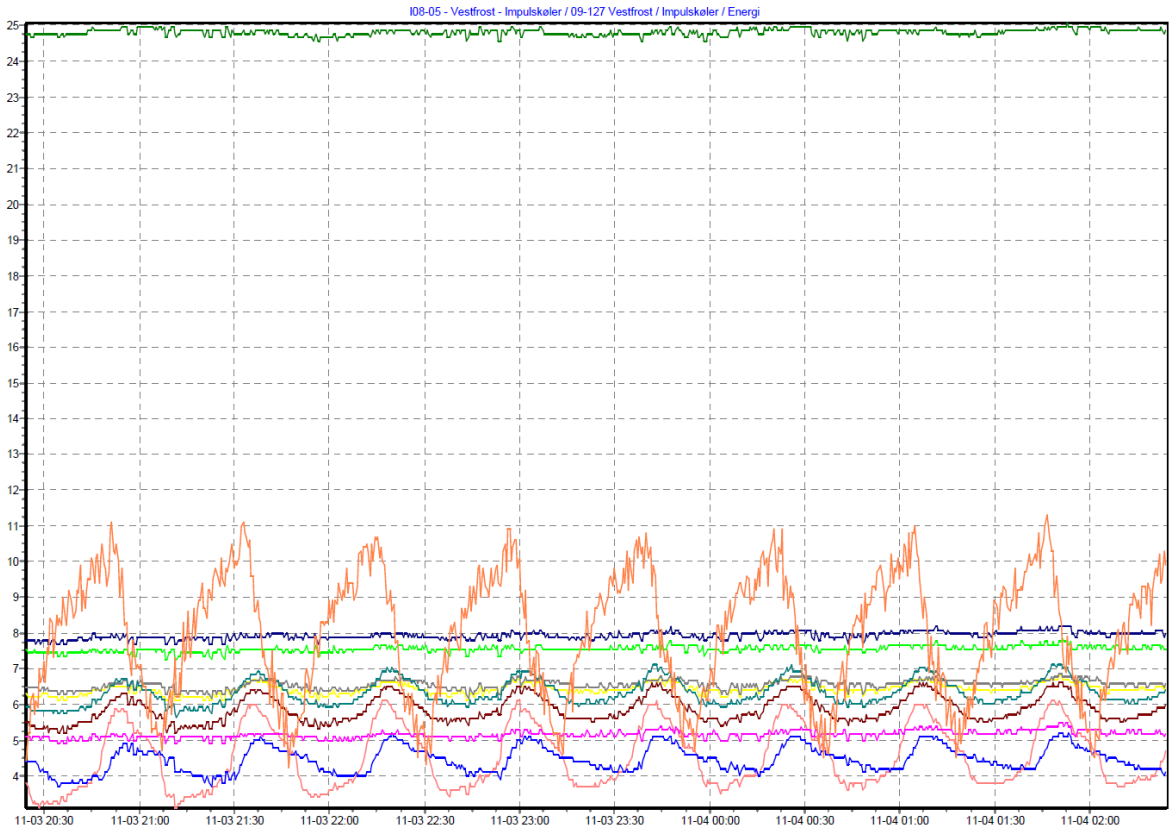


Chart 8: Temperatures measured during Test 12.

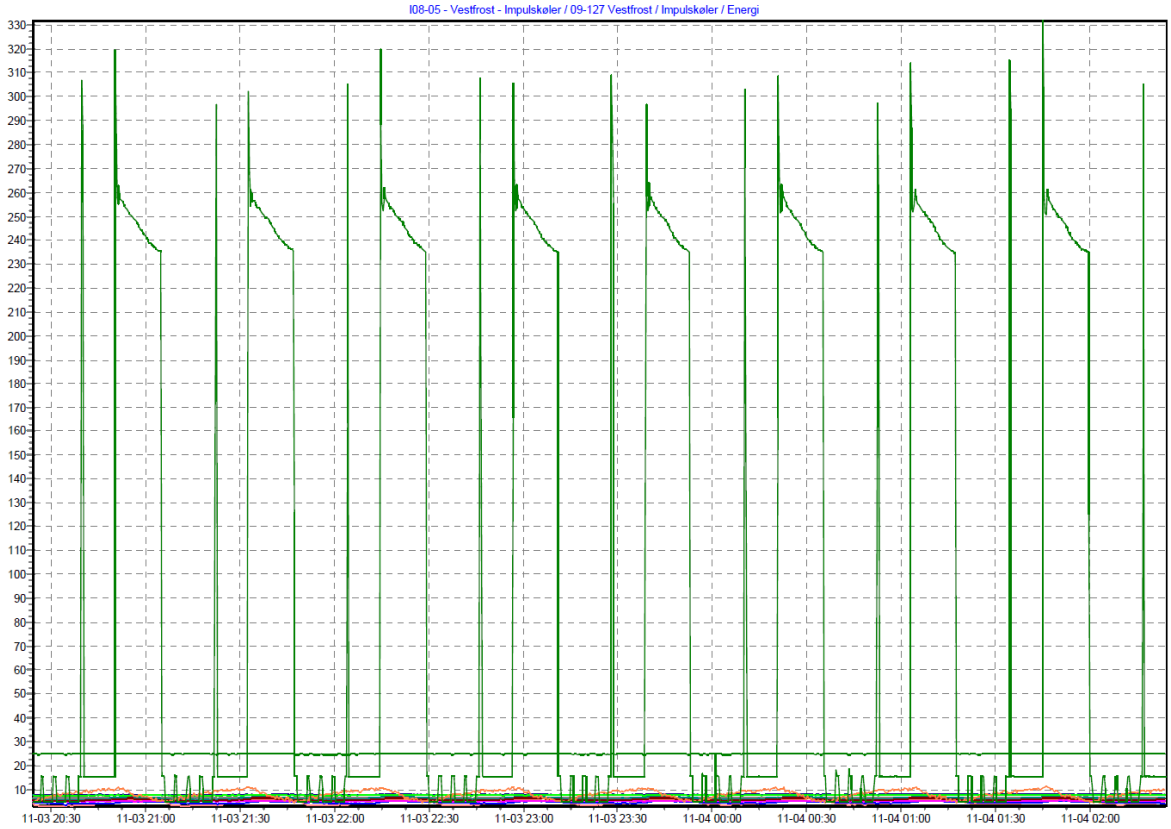


Chart 9: Power measured during Test 12.

Test 13

Measure points	Data sources		
Start		14-11-2009 09:43	15-11-2009 09:46
Stop		15-11-2009 09:43	16-11-2009 09:46
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	25,1	25,1
Appliance			
Average temperature		5,4	5,4
Can 1	Z:\KFS\ANVILLE\03\03	3,7	3,8
Can 2	Z:\KFS\ANVILLE\03\04	5,8	5,8
Can 3	Z:\KFS\ANVILLE\03\05	3,8	3,9
Can 4	Z:\KFS\ANVILLE\03\06	6	6
Can 5	Z:\KFS\ANVILLE\03\07	4,6	4,6
Can 6	Z:\KFS\ANVILLE\03\08	5,6	5,6
Can 7	Z:\KFS\ANVILLE\03\09	7,2	7,2
Can 8	Z:\KFS\ANVILLE\03\10	5	5,1
Can 9	Z:\KFS\ANVILLE\03\11	6,8	6,8
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	7,3	7,3
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	231	230,2
Power	Z:\KFS\PM100\12\WATT	115,4	115,5
Running time	Z:\KFS\PM100\12\WATT	80,4	80,6
Energy consumption	Z:\KFS\PM100\12\WH	2772	2768,7
Energy consumption/24h	Z:\KFS\PM100\12\WH	2771,4	2768,4

Table 11: Test results for Test 13.

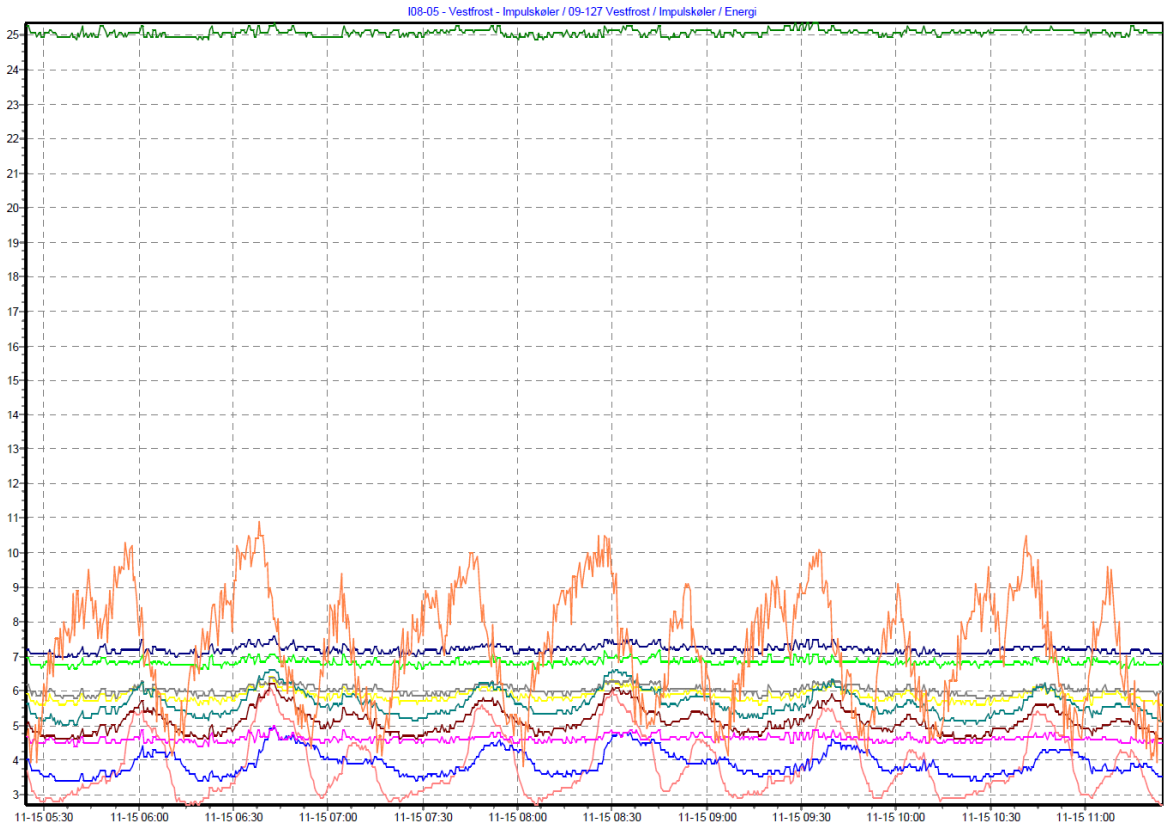


Chart 10: Temperatures measured during Test 13.

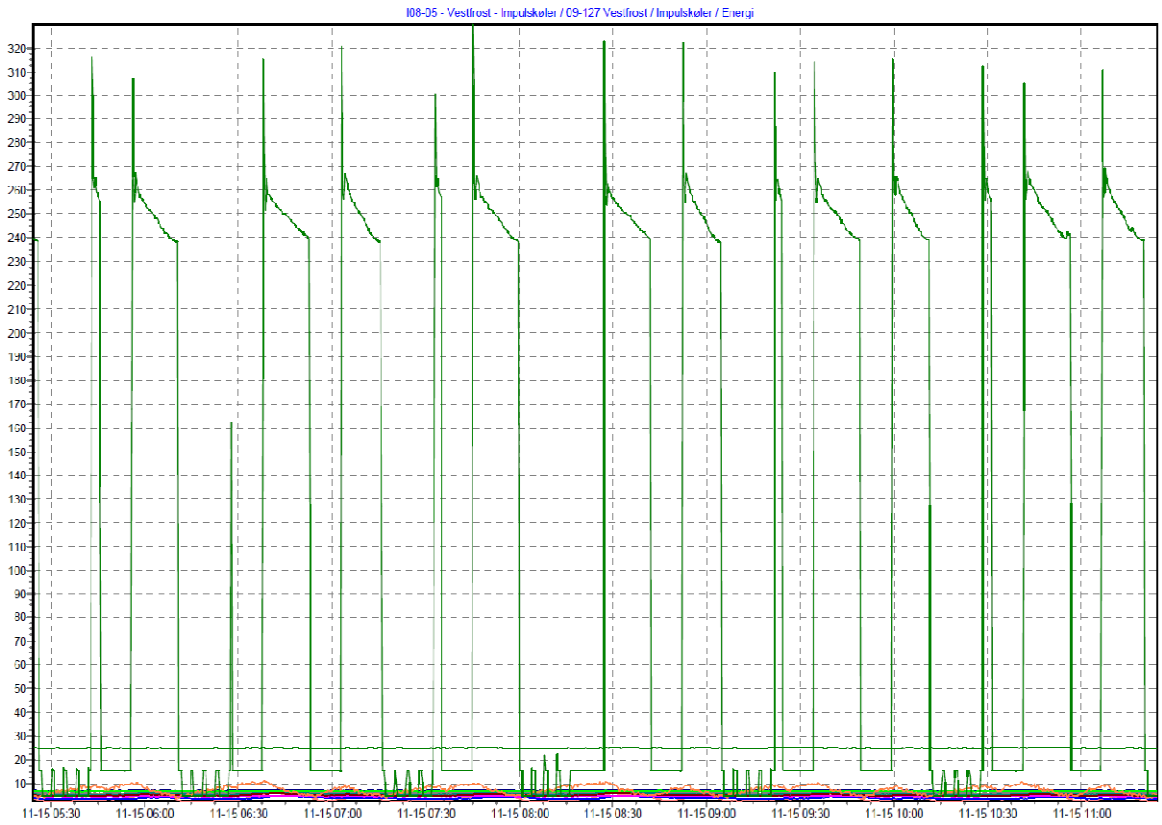


Chart 11: Power measured during Test 13.

Test 14

Measure points	Data sources		
Start		16-11-2009 22:01	17-11-2009 22:04
Stop		17-11-2009 22:01	18-11-2009 22:04
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	25,2	25,3
Appliance			
Average temperature		8,0	8,1
Can 1	Z:\KFS\ANVILLE\03\03	5,5	5,6
Can 2	Z:\KFS\ANVILLE\03\04	7,4	7,5
Can 3	Z:\KFS\ANVILLE\03\05	5,6	5,7
Can 4	Z:\KFS\ANVILLE\03\06	7,6	7,6
Can 5	Z:\KFS\ANVILLE\03\07	7	7,1
Can 6	Z:\KFS\ANVILLE\03\08	8,9	9
Can 7	Z:\KFS\ANVILLE\03\09	11,2	11,3
Can 8	Z:\KFS\ANVILLE\03\10	8,4	8,4
Can 9	Z:\KFS\ANVILLE\03\11	10,7	10,8
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	9,3	9,4
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	230,2	230,7
Power	Z:\KFS\PM100\12\WATT	90,3	88,6
Running time	Z:\KFS\PM100\12\WATT	67	67
Energy consumption	Z:\KFS\PM100\12\WH	2166,8	2122,2
Energy consumption/24h	Z:\KFS\PM100\12\WH	2166,6	2121,8

Table 12: Test results for Test 14.

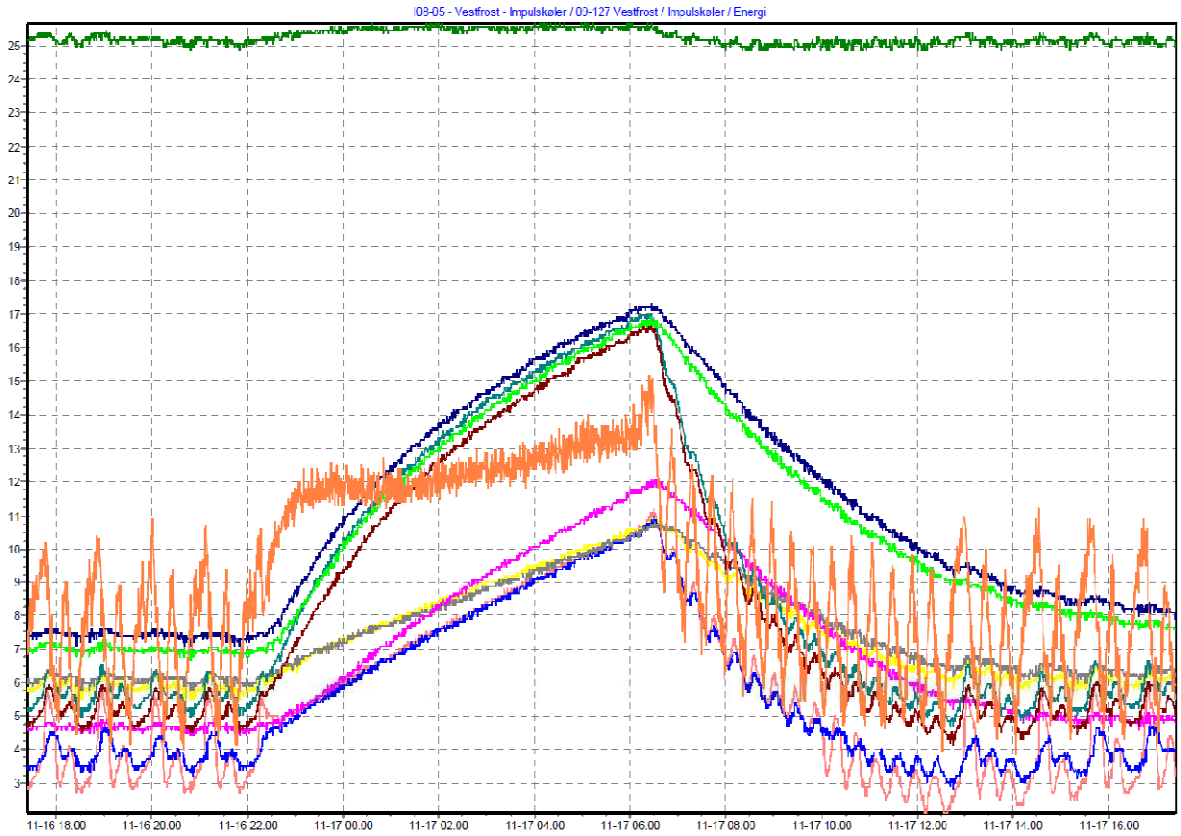


Chart 12: Temperatures measured during Test 14.

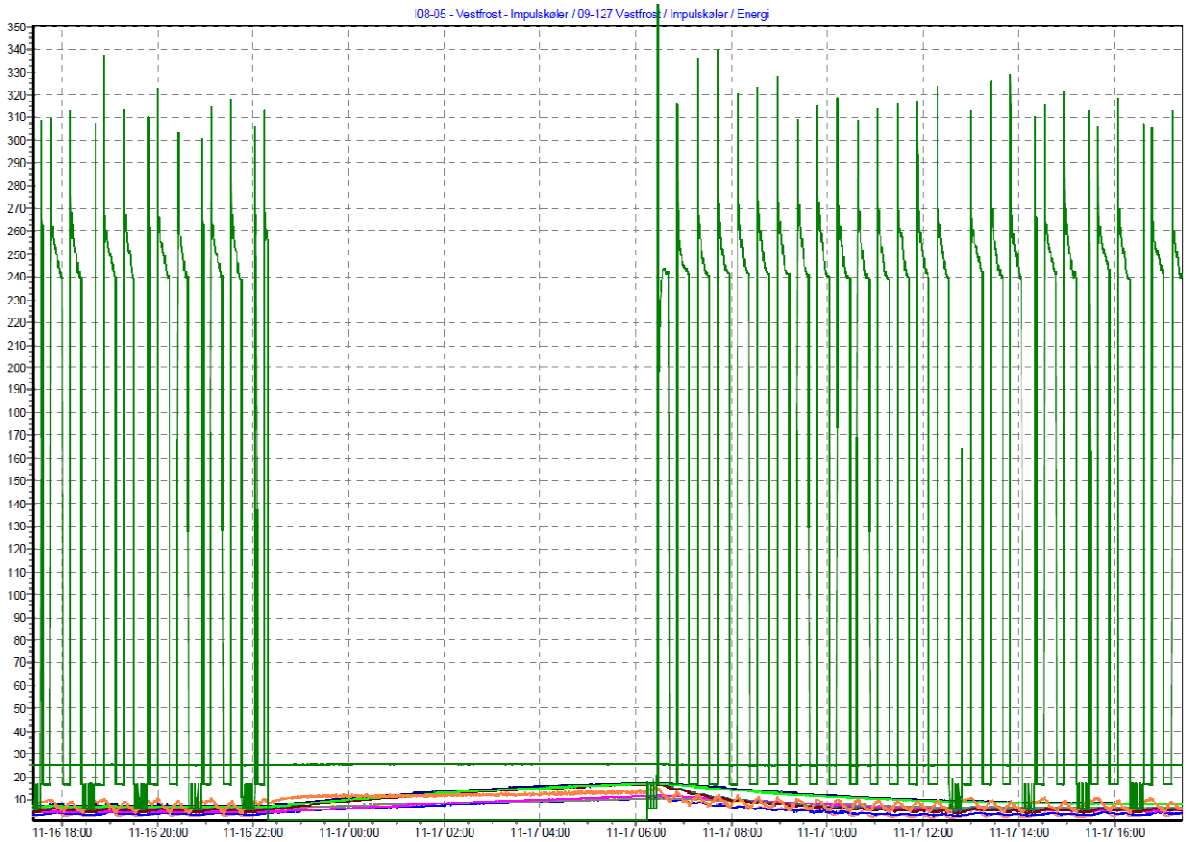


Chart 13: Power measured during Test 14. The pulse controller was active.

Measure points	Data sources		
Start		18-11-2009 09:54	18-11-2009 21:57
Stop		18-11-2009 10:04	18-11-2009 22:07
Duration		00:10 [HH.MM]	00:10 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	25,02	25,07
Appliance			
Average temperature		7,7	5,5
Can 1	Z:\KFS\ANVILLE\03\03	4,64	3,9
Can 2	Z:\KFS\ANVILLE\03\04	7,53	5,91
Can 3	Z:\KFS\ANVILLE\03\05	4,65	3,72
Can 4	Z:\KFS\ANVILLE\03\06	7,96	6,04
Can 5	Z:\KFS\ANVILLE\03\07	7,68	4,62
Can 6	Z:\KFS\ANVILLE\03\08	6,92	5,63
Can 7	Z:\KFS\ANVILLE\03\09	12,13	7,43
Can 8	Z:\KFS\ANVILLE\03\10	6,4	5,13
Can 9	Z:\KFS\ANVILLE\03\11	11,57	7,05
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	6,25	7,04

Table 13: Temperatures measured during Test 14. The first column shows the temperature in the cans at 10:00 (the supermarket opens). The second column shows the temperature at 22:00 as the power was shut off.

Test 15

Measure points	Data sources		
Start		23-11-2009 06:15	24-11-2009 06:12
Stop		24-11-2009 06:15	25-11-2009 06:12
Duration		24:00 [HH.MM]	24:00 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	25,2	25,2
Appliance			
Average temperature		9,6	9,6
Can 1	Z:\KFS\ANVILLE\03\03	7,4	7,4
Can 2	Z:\KFS\ANVILLE\03\04	8,9	8,9
Can 3	Z:\KFS\ANVILLE\03\05	7	7
Can 4	Z:\KFS\ANVILLE\03\06	9	9
Can 5	Z:\KFS\ANVILLE\03\07	8,5	8,5
Can 6	Z:\KFS\ANVILLE\03\08	10,7	10,7
Can 7	Z:\KFS\ANVILLE\03\09	12,8	12,8
Can 8	Z:\KFS\ANVILLE\03\10	10,1	10,2
Can 9	Z:\KFS\ANVILLE\03\11	12,2	12,2
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	10,7	10,7
Compressor			
Voltage	Z:\KFS\PM100\12\VRMS	230,7	231,1
Power	Z:\KFS\PM100\12\WATT	109,7	109,4
Running time	Z:\KFS\PM100\12\WATT	67	67
Energy consumption	Z:\KFS\PM100\12\WH	2620,2	2623
Energy consumption/24h	Z:\KFS\PM100\12\WH	2619,6	2622,7

Table 14: Temperatures measured during Test 15.

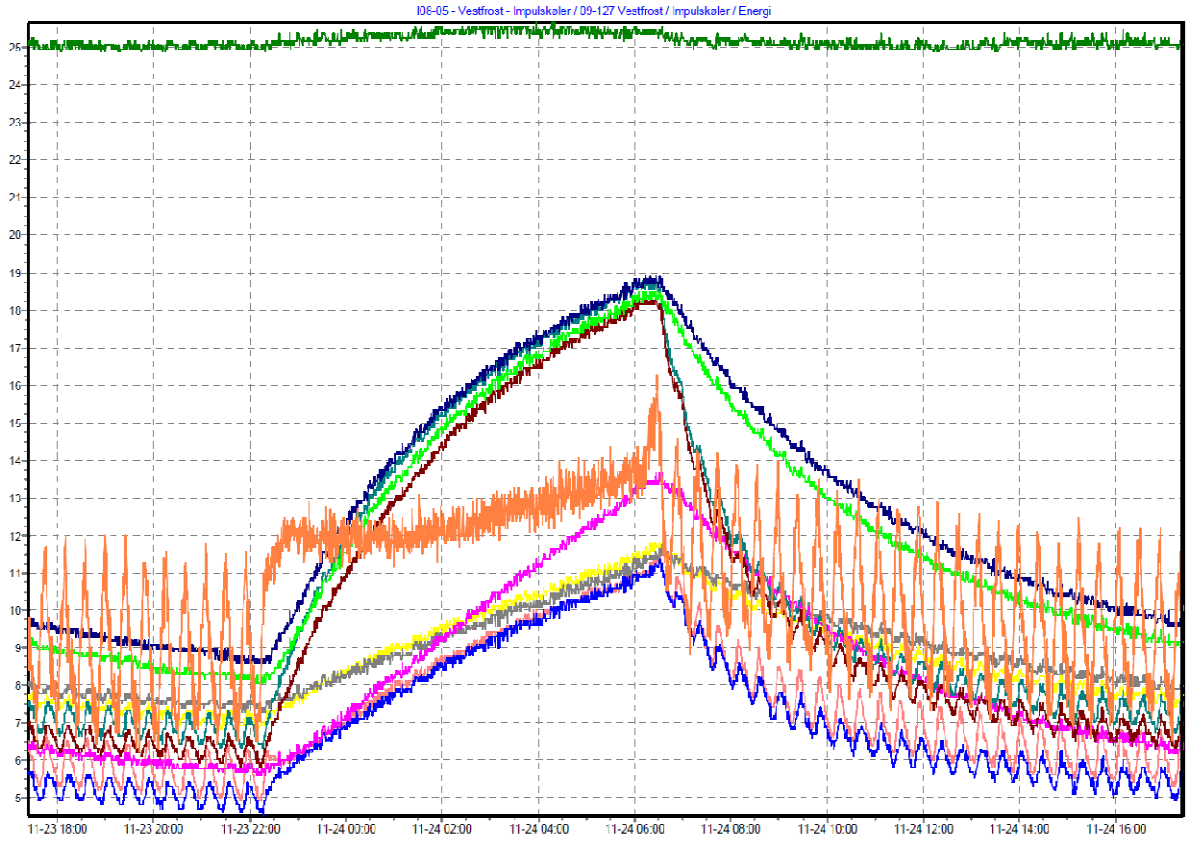


Chart 14: Temperatures measured during Test 15.

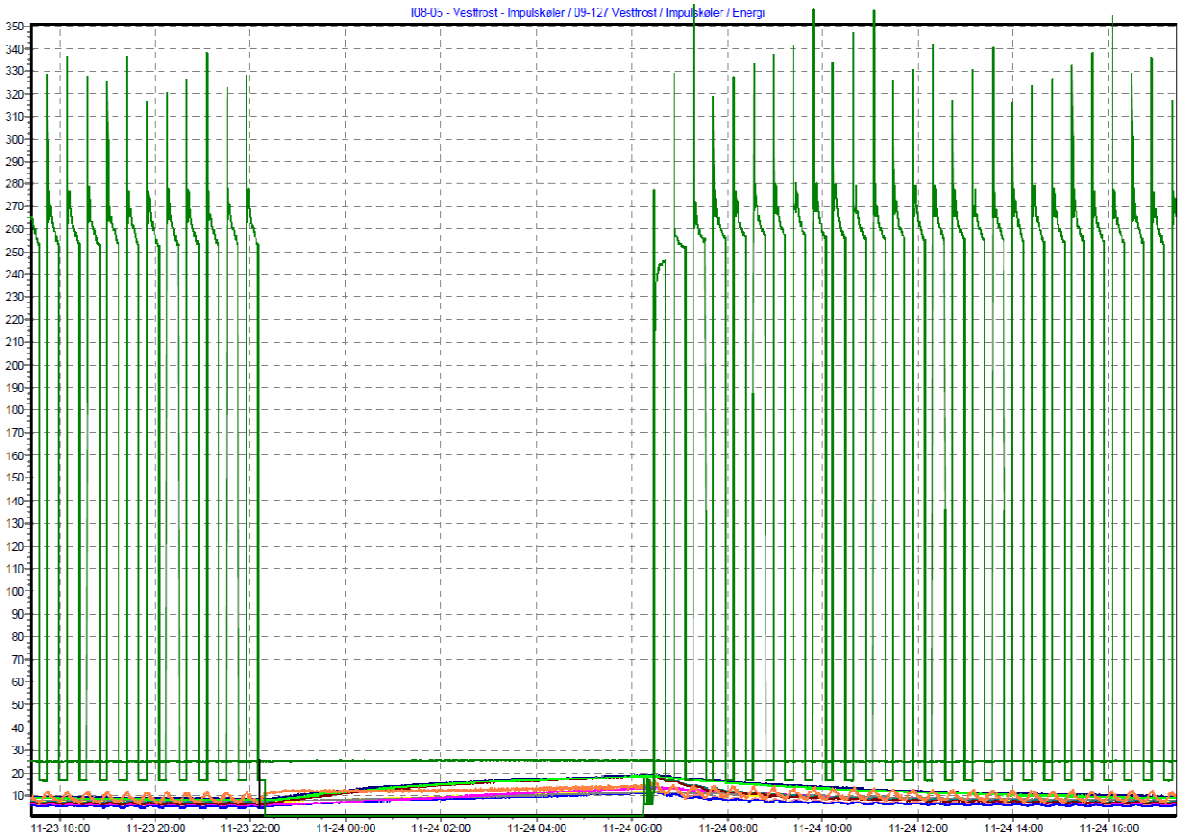


Chart 15: Power measured during Test 15. For an unknown reason the pulse controller did not act the same way as for Test 14. Most of the time, it did not seem to work at all.

Measure points	Data sources		
Start		24-11-2009 09:56	24-11-2009 22:10
Stop		24-11-2009 10:06	24-11-2009 22:20
Duration		00:10 [HH.MM]	00:10 [HH.MM]
Ambient temperature	Z:\KFS\ANVILLE\03\02	25,08	25,01
Appliance			
Average temperature		9,7	6,6
Can 1	Z:\KFS\ANVILLE\03\03	7,04	5,31
Can 2	Z:\KFS\ANVILLE\03\04	9,41	6,94
Can 3	Z:\KFS\ANVILLE\03\05	6,74	4,77
Can 4	Z:\KFS\ANVILLE\03\06	9,8	7,35
Can 5	Z:\KFS\ANVILLE\03\07	9,5	5,68
Can 6	Z:\KFS\ANVILLE\03\08	9,34	6,52
Can 7	Z:\KFS\ANVILLE\03\09	13,68	8,62
Can 8	Z:\KFS\ANVILLE\03\10	8,87	6,08
Can 9	Z:\KFS\ANVILLE\03\11	13,02	8,1
Channel 16 - return air	Z:\KFS\ANVILLE\03\16	9,13	9,35

Table 15: Temperatures measured during Test 15. The first column shows the temperature in the cans at 10:00 (the supermarket opens). The second column shows the temperature at 22:00 as the power was shut off.

Test 16 - 18

Start	Data Sources	07-06-2010 07:32	13-06-2010 02:37	16-06-2010 12:47
Stop		08-06-2010 07:47	14-06-2010 02:57	17-06-2010 12:47
Duration		24:14 [HH.MM]	24:19 [HH.MM]	24:00 [HH.MM]
Ambient		25,2	25,4	24,8
Left	Z:\KFS\ANVILLE\23\01	25,1	25,3	24,6
Right	Z:\KFS\ANVILLE\23\02	25,3	25,5	24,9
Average		5,5	4,2	4,4
Can 6	Z:\KFS\ANVILLE\23\03	5,6	4,4	4,4
Can 7	Z:\KFS\ANVILLE\23\04	5,8	4,4	4,5
Can 8	Z:\KFS\ANVILLE\23\05	7,5	6,3	6
Can 9	Z:\KFS\ANVILLE\23\06	7,6	6,4	6,1
Can 5	Z:\KFS\ANVILLE\23\07	5	3,6	4
Can 1	Z:\KFS\ANVILLE\23\08	3,5	2,1	2,7
Can 2	Z:\KFS\ANVILLE\23\09	3,3	1,9	2,6
Can 3	Z:\KFS\ANVILLE\23\10	5,8	4,4	4,8
Can 4	Z:\KFS\ANVILLE\23\11	5,5	4,1	4,6
Compressor				
Voltage	Z:\KFS\PM100\12\VRMS	230,4	231,7	231,8
Energy consumption/24h	Z:\KFS\PM100\12\WH	1907,3	2022,6	1805,1
Thermostat position		Position 12:00	Position 01:30	Position 01:30
		Without lid	Without lid	With lid

Table 16. Temperatures and energy consumption after modification of cooling system.

This cooler was working fine with a reduced energy consumption, which was about 2,0 kWh/day. This prototype had no LED light. To compare with the other prototypes and the standard cooler, about 0,25 kWh/day must be added to the consumption. This results in an energy consumption of 2,25 kWh/day – or a reduction of about 43 %. If the lid was placed on the cooler, the consumption was reduced by 0,218 kWh/day to an energy consumption of 1,805 kWh/day (+ 0,25 kWh/day for LED light)

6. SUMMARY

The following is a short review of the results of the energy consumption tests:

Test no.	Description	Energy consumption kWh/24 h + remarks
Test 1	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Tested with lid assembled and disassembled.	7,480 Array of cans in disorder
Test 2	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. New cooler and altered storage plan. No lid assembled.	3,987
Test 3	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. New cooler and altered storage plan. No lid assembled.	4,311
Test 4	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. First generation prototype with new condenser and R134a refrigerant. No lid assembled.	-
Test 5	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. First generation prototype with new condenser and R600a. No lid assembled.	-
Test 6	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Second generation prototype with new condenser and R600a refrigerant. No lid assembled.	4,070
Test 7	Energy consumption test. Loading: 33 cl aluminium cans,containing fizzy lemonade. Slots installed. No lid assembled.	4,003
Test 8	Energy consumption test. Loading33 cl aluminium cans, containing fizzy lemonade. Slots and air guides installed. No lid assembled.	3,943
Test 9	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. No lid assembled.	3,636

Test no.	Description	
Test 10	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open lid.	3,863 Pulse control did not work
Test 11	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Closed lid.	2,394
Test 12	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open/close sequence of lid according to EN 23953.	2,342
Test 13	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open/close sequence of lid according to EN 23953. Deviation: Lid remains open for 30 sec.	2,770
Test 14	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open/close sequence of lid according to EN 23953. Deviation: Lid remains open for 30 sec. Power shut off during the first 8 hours of the 12 hour resting period incorporated in the open/close sequence.	2,143 Warmest can = 12 °C at 10:00 h
Test 15	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Slots, air guides and pulse control of fan installed. Open lid. Power shut off between 22:00 and 06:00.	2,621 Warmest can = 13.5 °C at 10:00 h
Test 16	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Open lid. Without LED light.	1,907 (1)
Test 17	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Open lid. Without LED light	2,023 (1)
Test 18	Energy consumption test. Loading: 33 cl aluminium cans, containing fizzy lemonade. Lid closed. Without LED light	1,805 (1)

(1) Estimated energy consumption for LED light is not included.

Test 10-15
The second generation prototype installed with (automatic) lid and tested after EN23953 (European standard for refrigerated sales display coolers) + hydrocarbon refrigeration system + pulse control of fans reduced the energy consumption from approximately 4,0 kWh/day to 2,342 kWh/day. This was a reduction of 41.5 %

If, in addition to that, the cooler was turned off the first 8 hours of a 12 hour resting period, the energy consumption was 2,143 kWh/day, which was a reduction of 46,4 %

Test 16 - 18

This cooler, the third generation prototype, was working fine with a reduced energy consumption, which was about 2,0 kWh/day. This prototype had no LED light. To compare with the other prototypes and the standard cooler, about 0,25 kWh/day must be added to the consumption. This results in an energy consumption of 2,25 kWh/day – or a

reduction of about 43 %. When the lid was placed on the cooler, the consumption was reduced by 0,218 kWh/day to an energy consumption of 1,805 kWh/day (+ 0,25 kWh/day for LED light)

The results from the eighteen tests have to be discussed with Elforsk and with the project group. A project meeting is expected to take place medio 2010.

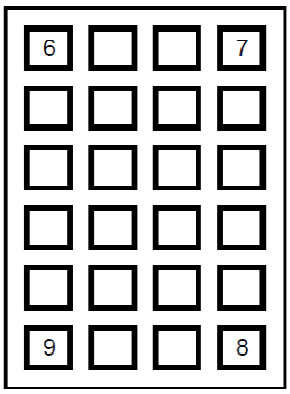
7. REFERENCES

1. EUROPEAN STANDARD EN 153, February 2006
”Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage cabinets, food freezers and their combinations together with associated characteristics”.

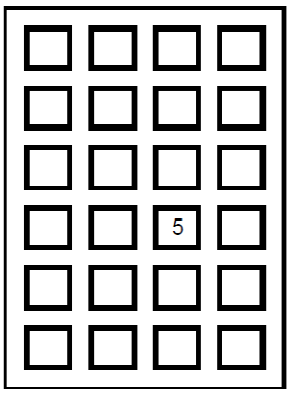
ENCLOSURE 1

No.:	**D5.05**		DANISH TECHNOLOGICAL INSTITUTE
Edition:	5		
Made by:	LBK		
Area:	13		
Date:	21-11-2007		
Vestfrost impulse sales bottle cooler		**Storage plan - energy consumption**	300-KLAB-08-121
Loading: 33 cl aluminium cans containing fizzy lemonade			
Total load: 96 cans		The storage plan is in accordance with the manufactures plan	

Rear liner, air inlet

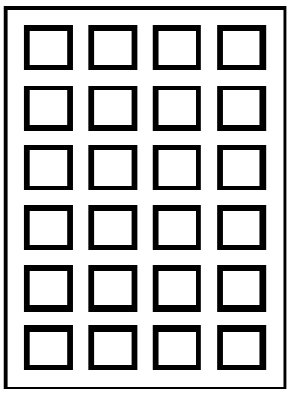


Layer 1 - top

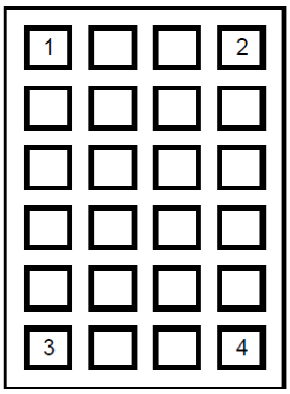


Top view

Layer 2



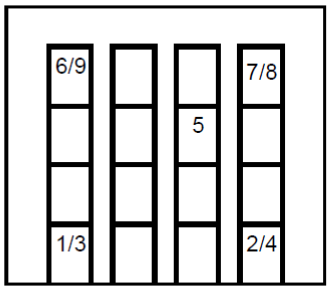
Layer 3



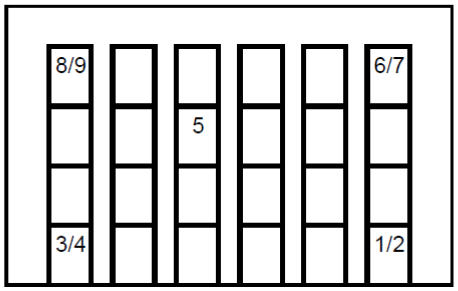
Layer 4 - bottom

ENCLOSURE 1

No.:	**D5.05**		DANISH TECHNOLOGICAL INSTITUTE
Edition:	5		
Made by:	LBK		
Area:	13		
Date:	21-11-2007		
Vestfrost impulse sales bottle cooler		**Storage plan - energy consumption**	300-KLAB-08-121
Loading: 33 cl aluminium cans containing fizzy lemonade			



Front view



Side view

Figure:Storage plan including the temperature measurement points.