ENVIRONMENTAL TECHNOLOGY VERIFICATION

DANETV

DANISH TECHNOLOGICAL INSTITUTE

ETV Verification Statement

TECHNOLOGY TYPE:	**Controller for appliance control**
APPLICATION:	**Cooling and freezing cabinets in retail stores**
PRODUCT NAME:	**AK-CC Controller Series**
COMPANY:	**Danfoss A/S**
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Reduced energy consumption by adaptive control

J.no.1001
Test no.1 – Reduced energy consumption

DANETV was established by four independent Danish research and technology organizations and supported by the Danish Agency for Science, Technology and Innovation under the Danish Ministry of Science, Technology and Innovation to provide environmental technology verification for vendors of innovative environment technologies. Information and DANETV documents are available at www.etv-denmark.com.

VERIFICATION AND TEST DESCRIPTION

Verification and tests were performed by Danish Technological Institute (DTI) under DANETV and by contract with Danfoss A/S.

The verification was planned and conducted to satisfy the requirements of the ETV scheme currently being established by the European Union (EU- ETV).

The test organization is shown in figure 1.

The day-to-day operations of the verification and tests were coordinated and supervised by DTI personnel, with the participation of the vendor, Danfoss A/S.

Experts from DTI Test Centre (test sub-body) performed all testing for energy consumption and temperature levels.

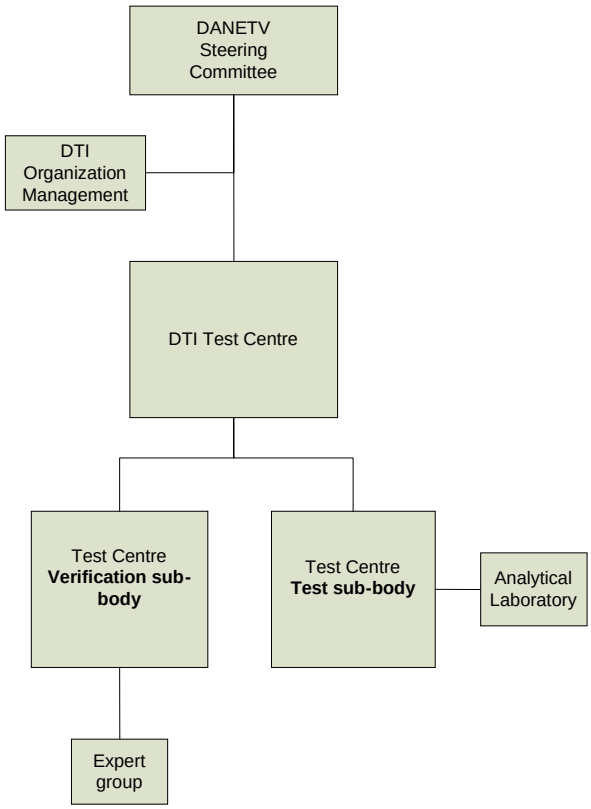

Figure 1:- Verification organization.

Table 1: Responsible personnel in the test organization.

Test and Verification Center	**Danish Technological Institute (DTI)** **Verification Centre** **Refrigeration and Heat Pump Technology**
Verification responsible	**Bjarke Paaske**
Test responsible	**Klaus Frederiksen**
Address:	**Kongsvang Allé 29** **8000 Aarhus C**
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Test plan

The product test consists of two similar test series at different ambient conditions representing small retail stores located in Denmark. Energy consumption and temperature levels are analyzed during the tests. One test series will be carried out by using predefined default settings on rail heat and defrost and another series will be carried out by using adaptive rail heat and defrost. The effect of the adaptive functions in AK-CC controllers are verified by comparing the results.

The performance test is based on the existing European Standard ISO 23953. ISO 23953 is the standard performance test for freezing cabinets, measuring both power consumption and cooling ability. It is important to notice that ISO 23953 is a performance test of the cabinet – not the controller. By comparing several performance tests of the cabinet, using default and adaptive settings, the effect of adaptive control will be proven through the performance of the cabinet.

Quality assurance

The quality assurance includes control of the data quality and integrity. The test plan, test report, verification protocol and verification report have been reviewed by experts at DTI and by external members of the expert group as described in a quality manual and DAN-ETV standard procedures.

Technology and product description

AK-CC controllers are complete refrigeration appliance controllers for a great number of different refrigeration appliances and cold store rooms.

The controller is an electronic unit that controls the different functions of a cooling application. In applications with cooling and freezing cabinets the main functions of the controller are: liquid injection of refrigerant in the evaporators, monitoring of superheat, defrosting of evaporators, rail heat, control of compressors, control of night blinds and control of lights.

The verification process concerns two energy reducing features in Danfoss AK-CC controllers. One feature is automatic adaptation of rail heat. The other is adaptation of defrost sessions. The necessity of both rail heat and defrost depends on the current humidity level in the surrounding air.

The controller monitors the current dew point of the ambient air all the time. The controller then calculates the amount of heat necessary to avoid water vapor condensation at the cabinet and provides the amount of heat accordingly. In that way, excessive rail heat is eliminated.

Defrost is necessary when a certain amount of frost is formed at the evaporator. The adaptive function is able to monitor the amount of ice at the evaporator and initiate defrost sessions only when necessary. In that way, excessive defrost sessions are eliminated.

The verification process regards the total electrical energy reduction of both technologies. The temperature of the cooled products must not reach higher levels when applying the technology - not even briefly.

VERIFICATION RESULTS

Table 2: Target and measured values of tested parameters.

Parameters	Target	Measured value	Method
Overall performance			
Total electrical energy reduction	15 %	15.1 %	TI-DOP
Reduction of average temperature levels	> 0 K	0.35 K	TI-DOP
Reduction of peak temperature levels	> 0 K	> 0.4 K	TI-DOP
Water vapor condensation (running water)	None	None	Visual inspection

It is important to note that the results were reached when testing one single freezing cabinet under certain conditions. The test matrix is designed to reflect conditions in small retail stores in Denmark without air conditioning and with long opening hours.

The effect of the product will vary in different applications, settings, environments, locations etc. The target verified during this process will not be achievable in all installations.

The performance test was carried out by completing five test samples with different ambient conditions to represent the annual variations of humidity in Denmark. The 1st sample had low humidity levels representing winter time and the 5th sample represented summer time using high humidity levels. Each sample consists of two test runs – one using the standard control method and one using the adaptive functions of the controller.

However, the freezing cabinet used for this verification was not able to cope with the highest humidity levels and it was not possible to obtain a valid result of sample no. 5. Therefore, the 5th sample was neglected and the effect during that period was regarded as 0, when determining the annual result.

The overall test results are summarized in table 2 below. Results from sample five are neglected because of improper functioning of the freezing cabinet.

Table 3: Average and maximum temperature of the measuring packages, total electrical energy consumption (24h period) and the effect of the product in the specific samples. To the right, the average annual temperature and energy reduction (effect) are shown.

		Temperature [° C]		Energy	Results			Average	
Sample	Run no.	Package average	Package max.	Total [kWh]	Temp. diff. [K]	Energy red.	Factor	Temp. red. [K]	Energy red.
1	1	-17.15	-11.44	29.1	-0.45	29 %	0.09	**-0.35**	**15.1 %**
	2	-17.60	-12.32	20.7					
2	3	-17.21	-11.25	29.2	-0.39	26 %	0.17		
	4	-17.61	-12.45	21.6					
3	5	-17.10	-10.90	30.1	-0.32	16 %	0.39		
	6	-17.42	-11.32	25.2					
4	7	-16.81	-9.64	31.6	-0.52	7 %	0.23		
	8	-17.33	-10.73	29.3					
5	9	-	-	-	0.00	0 %	0.12		
	10	-	-	-					

It is concluded for Danfoss AK-CC Controllers:

- For this type of application, the adaptive control method gives an annual reduction in electrical energy consumption of the cabinet of 15.1 %.
- Using the adaptive control method gives an annual average temperature reduction of 0.35 K of the cooled products for this type of cabinet.
- Using the adaptive control method gives reduced water vapor condensation for this type of cabinet (running water was only present in run 7).
- The result of this verification process is very dependent on the type of cabinet used as well as geographical location, settings, opening hours etc. It is likely that the adaptive control method will have a different influence on other types of cabinets in different applications.

Responsible for this verification are:

Original signed 06/05/10 by:
Bjarke Paaske, Consultant
DTI – Refrigeration and Heat Pump Technology

Original signed 06/05/10 by:
Klaus Frederiksen, Consultant
DTI – Refrigeration and Heat Pump Technology