



INSTITUT INTERNATIONAL DU FROID
INTERNATIONAL INSTITUTE OF REFRIGERATION

Development of energy efficient sales freezers by using state-of-the-art compressors, natural refrigerants, and low emissivity glass cover



**Per Henrik PEDERSEN^(a), Frederik PLOUG
WINTHEREIK^(a),
Hans WALLØE^(a), Mads FRANK^(b)**

^(a) Danish Technological Institute
Taastrup, DK-2630, Denmark, prp@teknologisk.dk

^(b) Elcold Freezers
Hobro, DK-8500, Denmark, m.frank@elcold.com

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Agenda

1. Introduction
2. Aim of project, test of basis cabinet
3. Improving refrigeration system
4. Improving glass lids
5. Conclusion
6. Discussion



Introduction, 1

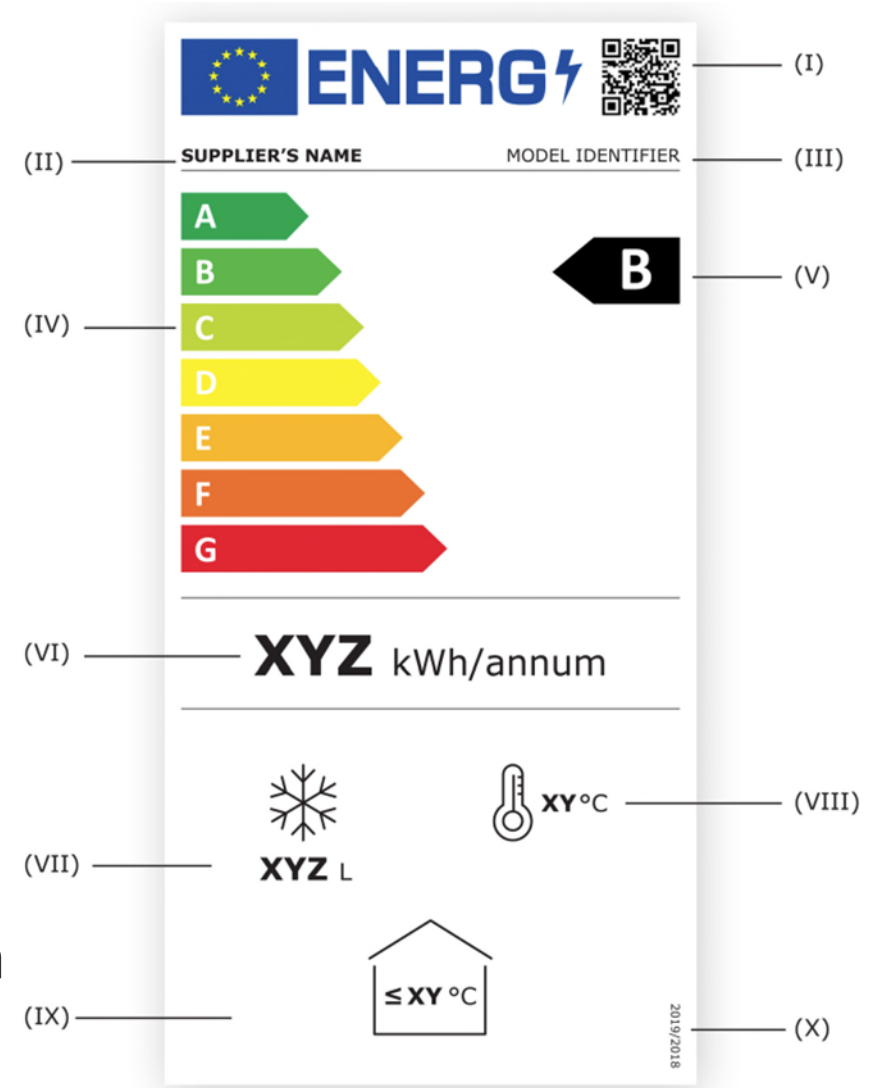
EU regulations 2019/2018 and 2019/2024 specifies energy labelling and ecodesign criteria for refrigerated sales cabinets.

Regulates supermarket cabinets, bottle coolers, refrigerated vending machines and ice cream cabinets.

Vent into force March 2021

Energy efficiency: competition parameter

This presentation shows a method to enhance an ice cream cabinet into a better energy class.



Introduktion, 2

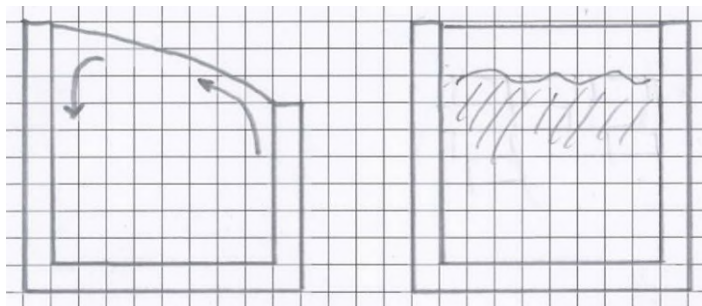
During the last 20 years for ice cream cabinets:

From horizontal flat glass lids to **curved lids**.

Expects better sale.

But creates **challenges with dew** caused by convection.

Curved glass lid must be heated to prevent dew on the glass.



Horizontal flat lids with low emissivity surface on lower side will create a still layer of air under the glass.

Potentially more energy efficient.



Aim of project, test of basis model

Develop new model of ice cream cabinet with reduced energy consumption and better energy class compared to existing unit.

Method: Better components and better glass lids.

Basis Model: Elcold Nova 45 (with R600a)

Net Volume: 343 liter

Energy Class D

14.65 cm³ compressor

80 g R600a

Fan

Skin condenser

Integrated evaporator



Test of basis model

Accredited tests, EN22043:2020

Climate class 4 (30 C, 55% RH)

$E = 2.483 \text{ kWh/d}$

$EEI = 48.8\%$

Energy Class D (close to E)

Additional tests:

Night cover: $E = 2.023 \text{ kWh/d}$, saves 18.5%

Without fan: $E = 2.164 \text{ kWh/d}$, saves 12.8%

Energy class	EEI (%)
A	$EEI < 10$
B	$10 \leq EEI < 20$
C	$20 \leq EEI < 35$
D	$35 \leq EEI < 50$
E	$50 \leq EEI < 65$
F	$65 \leq EEI < 80$
G	$EEI \geq 80$



Improved refrigeration system

New prototype

New more efficient compressor

Allmost same size

14.77 cm³

80 g R600a

E = 1.874 kWh/d, saving 24.5%

EEl = 36.8%

No fan (not necessary).



Improved glass lids 1

Lids in basis model: low-emissivity coating on lower surface.
 $\epsilon_{\text{glass}} = 0.11$. (declared by manufacturer)

Standard in high-end products.

In late 2021 new glass samples were archived
"super low emissivity"

$\epsilon_{\text{glass}} = 0.03$ (declared by manufacturer)

This makes a big difference!

Improved glass lids, 2 - Test

Placed on the prototype

Significant influence on temperatures

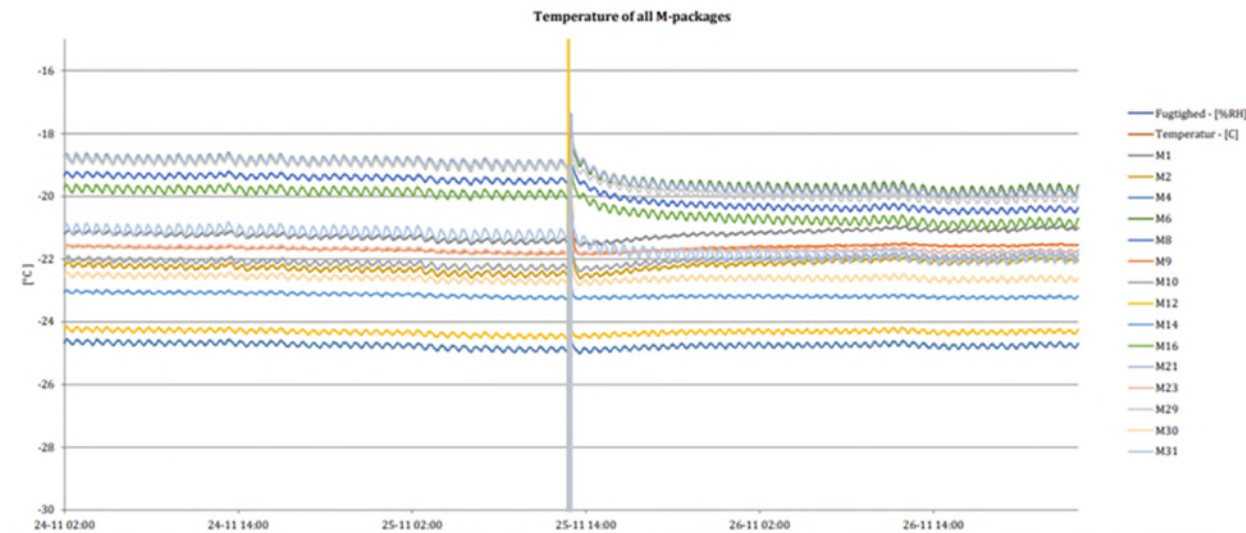
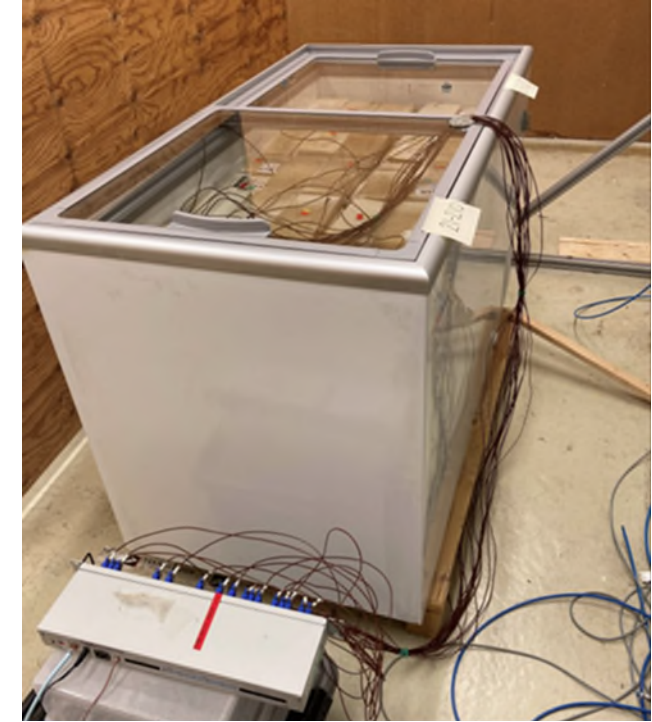
$E = 1.579 \text{ kWh/d}$

Saving from prototype: 15.8%

Saving from basis: 36.4%

Now EEI = 31.0%

Energy Class C



Improved glass lids, 3 - Calculation

$$q = q_{\text{conduction}} + q_{\text{radiation}}$$

No convection.

$$q_{\text{conduction}} = \lambda_{\text{air}} / \delta * (T_{\text{glass}} - T_{\text{packages}})$$

$$= 0.0244 \text{ W/mK} / 0.09\text{m} * 38\text{K} = 10.30\text{W/m}^2$$

$$q_{\text{radiation}} = \sigma * (T_{\text{glass}}^4 - T_{\text{packages}}^4) / (1/\epsilon_{\text{glass}} + 1/\epsilon_{\text{packages}} - 1)$$

In case 1, with $\epsilon_{\text{glass}} = 0.11$:

$$q_{\text{radiation}} = 19.48 \text{ W/m}^2$$

In case 2, with $\epsilon_{\text{glass}} = 0.03$:

$$q_{\text{radiation}} = 5.34 \text{ W/m}^2$$

$$\text{Case 1: } q = 29.78 \text{ W/m}^2$$

$$\text{Case 2: } q = 15.64 \text{ W/m}^2$$

The heat flux through the lids is almost halved

Conclusion

By increasing the efficiency of the refrigeration system, the energy consumption has been reduced by 24.5 %.

By using a new compressor for R600a.

No fan is necessary to cool the compressor.

Horizontal lids create a still layer of air. "Extra insulation"

By using new super-low emissivity glass with $\varepsilon_{\text{glass}} = 0.03$, the energy consumption of the prototype has been reduced with 15.8%

The total energy consumption has been reduced from 2.483 kWh/d to 1.579 kWh/d. This is a reduction of 36.4% and the energy class has been improved from D to C.

Discussion

Horizontal glass lids with super low emissivity of the lower surface can reduce energy consumption and is like a solid lid or a night cover.

Can stop the tendency for using curved lids and hence "go back to" horizontal lids.

Can also be used for other types of cabinets. Forced ventilation will reduce the relative improvement.

Ice manufacturer: it is good to avoid the fan, because it is the most frequent source for failure and repair.

The cost of new compressor +20%, and the cost of and installation of a fan can be saved. This is all most cost neutral.

There is an additional cost for the new glass lids.

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