



# TEMPERATURE STABILIZATION OF SENSITIVE PRODUCTS BY PHASE CHANGE MATERIALS DURING TRANSPORTATION

Herkkien tuotteiden kuljetuslämpötilan  
stabilointi lämpö- ja kylmävaraajien avulla



Business from technology

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VTT, Espoo, Otaniemi



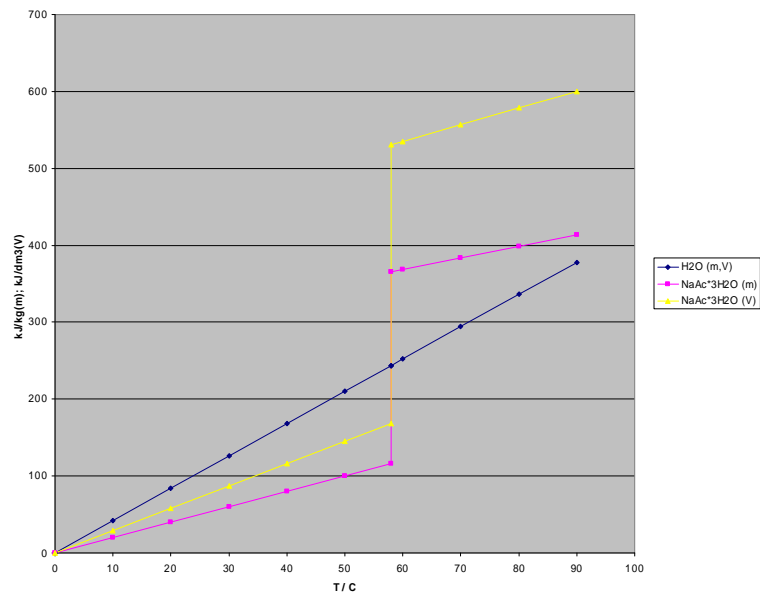
## Presentation outline

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1. Heat storage in phase change materials
2. Transportation of sensitive goods, e.g. foodstuff and medicine
3. Case studies:
  - a) Exhaust gas and noise emission reduction of mobile refrigeration units
  - b) Cold box transport of blood prepreparates
4. Other PCM applications
5. Acknowledgements

# 1. Heat storage in phase change materials (PCM)

- § Relative large amounts of heat can be stored in a narrow temperature interval as latent heat of fusion in the melting and crystallization processes.
- § The melting point of the PCM must always be fitted to the application temperature.
- § There are a number of commercial PCM salts and paraffins available but they cover only a discrete number of temperatures.
- § The capacity and stability of the commercial PCM products vary greatly.
- § PCMs can be applied as heat or cool storage in buildings, industrial processes, electronics cooling, protective clothing and transportation.



## 2. Transportation of sensitive goods, e.g. foodstuff and medicine

- § Temperature sensitive products are typically transported using mobile diesel engine driven refrigeration units in vans, lorries and trucks or electric refrigerators in containers.
- § More recently, solar PV driven refrigerators have been applied in developing countries.
- § PCM stabilized cold boxes offer a small scale alternative for mobile refrigerators.
- § Electric or PCM stabilized cold boxes are commonly used for home and leisure.



[www.napssystems.com](http://www.napssystems.com)



[www.va-q-tec.com](http://www.va-q-tec.com)

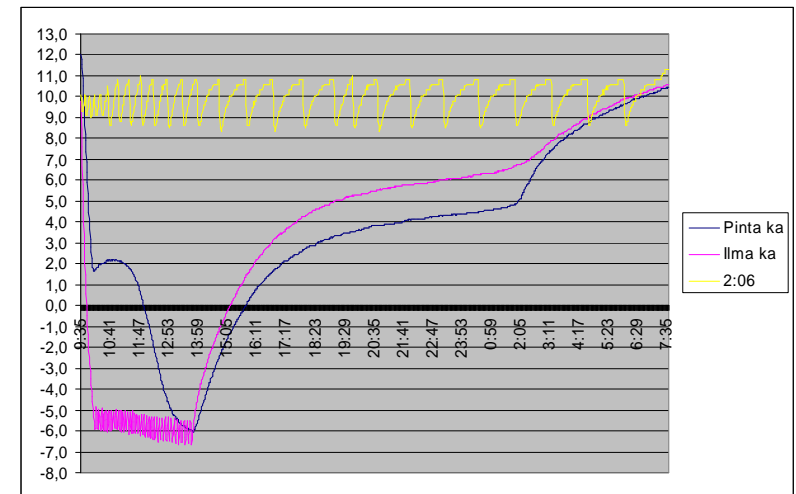
## 3a. Case mobile refrigeration units

- § Background: In many cases, distribution of grocery products take place in silent early morning hours.
- § Objective: The exhaust gas and noise emissions of mobile diesel engine driven refrigeration units should be reduced, especially in densely populated areas.
- § Solution: PCM cold storage could facilitate temporary switch off of the diesel driven refrigerator.



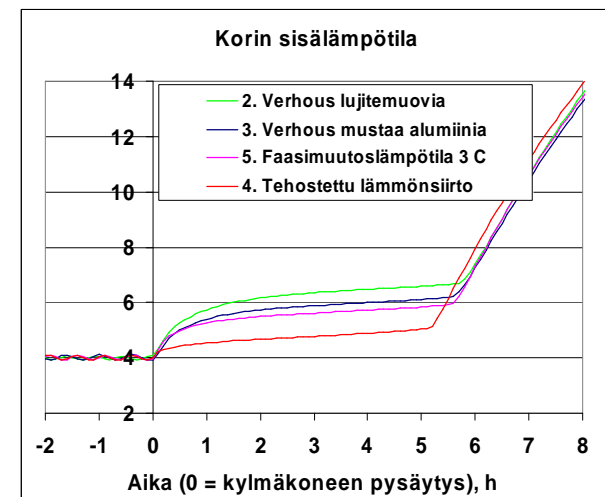
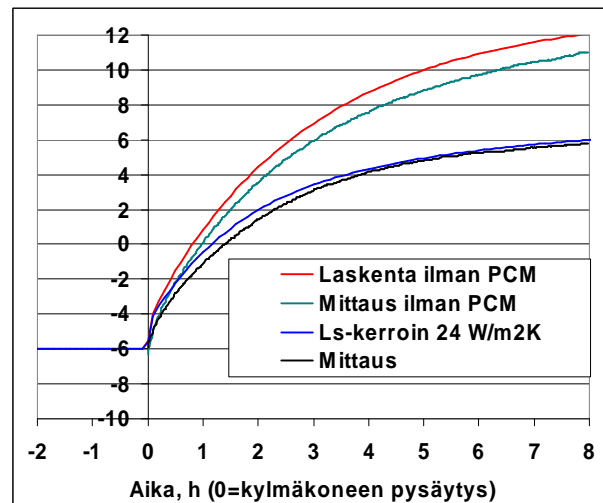
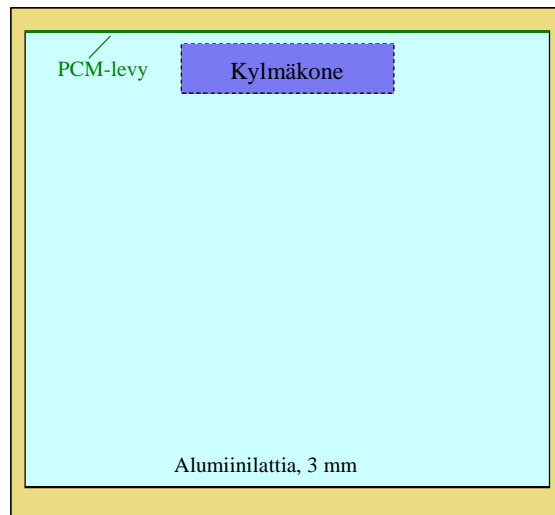
### 3a. Case mobile refrigeration units - Experimental

- § A 10 mm thick, 2.0 m<sup>2</sup> aluminium honeycomb plate was designed, manufactured and filled with a commercial PCM paraffin.
- § The plate was tested by Lumikko Ltd. in a 5 m<sup>3</sup> laboratory cold box with a refrigeration unit.
- § Temperature raise of the test box was measured after refrigerator switch off both with and without the PCM plate.



## 3a. Case mobile refrigeration units - Analysis of the results

- § The tests by Lumikko Ltd. were used to verify the VTT Talo numerical simulation model which was then used to analyse the performance of a full scale lorry.
- § A 10 mm PCM plate could keep the cargo space under  $+6^{\circ}\text{C}$  for 4 to 6 h after refrigerator shut off when the outdoor temperature is  $+30^{\circ}\text{C}$ .

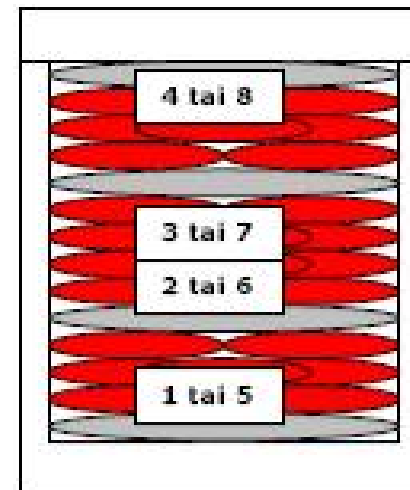


## 3a. Case mobile refrigeration units - Conclusions

- § The performance of the PCM plate was excellent during discharge, **but**  $-5^{\circ}\text{C}$  was needed to recharge (i.e. freeze) the PCM plate.
- § The PCM accumulator cannot be recharged on the road, it must be precharged before loading the goods.
- § The bottleneck is heat transfer between the plate surface and air. Forced convection is needed.
- § Different goods need different transportation temperatures and the same transportation units are used for all the goods. PCM accumulators can be tailored for one temperature only. Dedicated units are needed for different products.
- § The technology could be more promising for frozen goods.

## 3b. Blood prepares

- § Blood prepares are transported in PCM stabilized cold boxes by Red Cross Finland Blood Service.
- § Whole blood and trombocytes are transported at  $+22 \pm 2^\circ\text{C}$  (RT), red cells at  $+4 \pm 2^\circ\text{C}$  (cool) and plasma below  $-20^\circ\text{C}$  (frozen).
- § A commercial PCM is used for RT, an ice gel for cool and  $\text{CO}_2$  ice for frozen transportation.



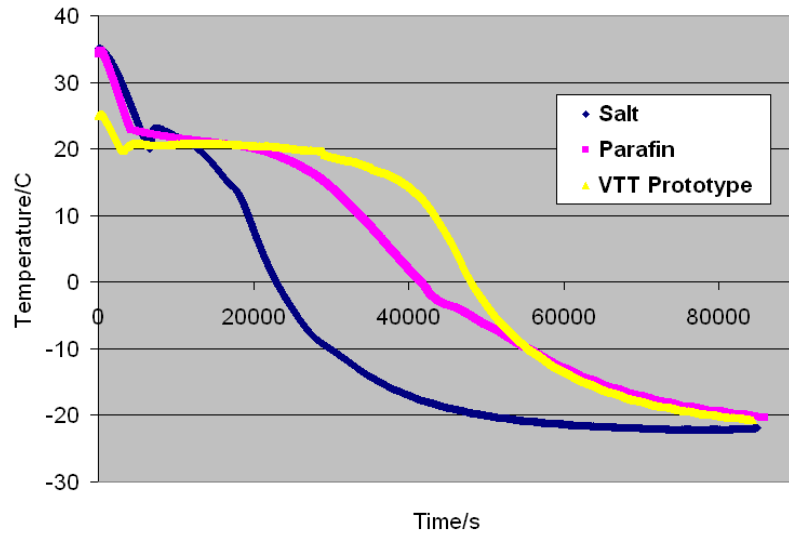
## 3b. Blood preparates - Experimental

- § A commercial PCM paraffin recommended by VTT has been shown to outperform the state-of-the-art ice gel in red cell transportation in independent testing by Red Cross Finland.
- § Replacement of CO<sub>2</sub> ice by an eutectic salt solution could mitigate the problems associated with CO<sub>2</sub> attack on plastics used for red cell packaging.
- § The performance of commercial RT PCMs is not satisfactory.

### 3b. Blood preparates - Experimental

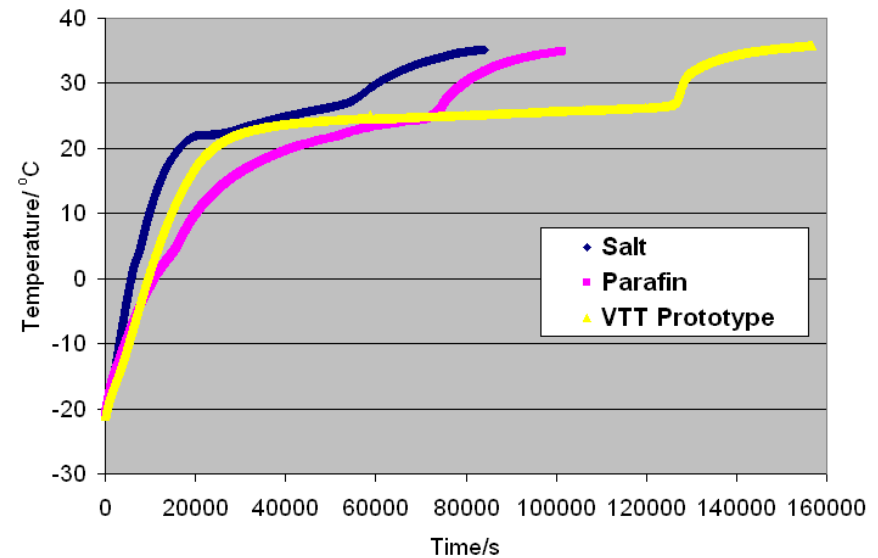
Comparison of VTT Prototype cold packs to the commercial counterparts for RT stabilization (+22°C).

Crystallization in cold box at -26 °C



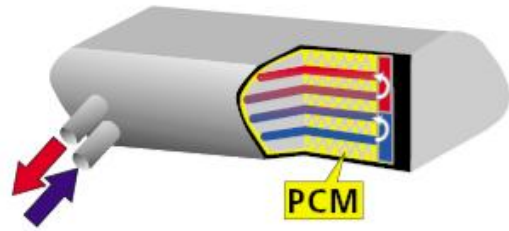
Crystallization in the cold box at -26°C

Melting in cold box at +35 °C

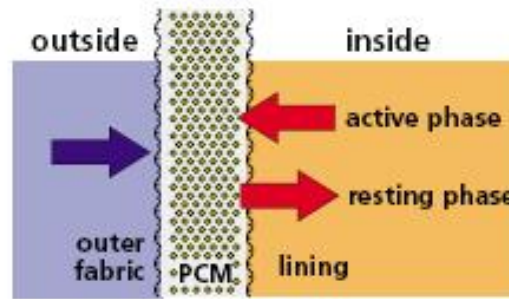


Melting in the cold box at +35°C

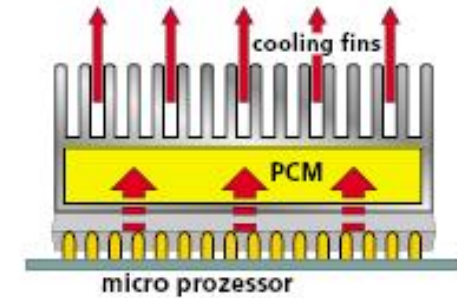
## 4. Other PCM applications



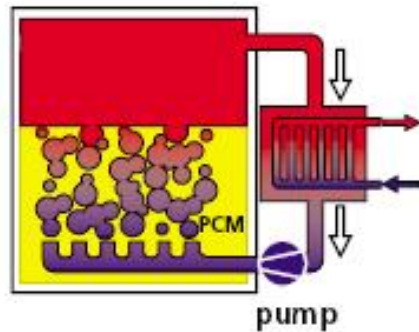
Automobile



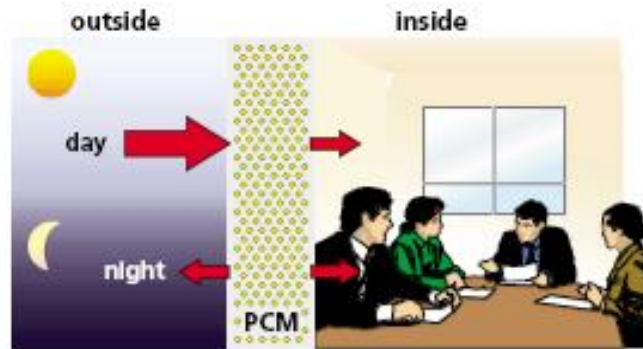
Textiles



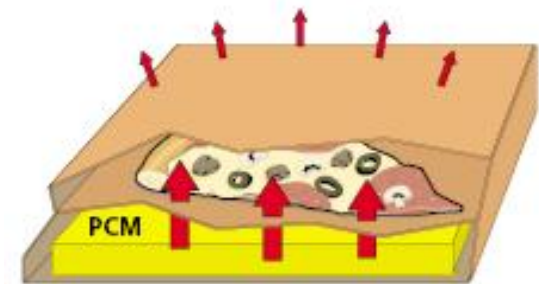
Electronics cooling



Heat or cool storage in buildings, industry and district heating and cooling networks



PCM wallboards



Catering

Source: EM Industries Inc. (Merck KGaA)

## 5. Acknowledgements



**Motiva**



First you add knowledge...



## Further information

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<http://www.motiva.fi/fi/yjay/kuljetusala/lampojakylmaenergianvarastointikuljetusvalineissa/>

