Bijlage A

Innovative PCM's
and
Thermal Technology

Product
Information

RUBITHERM® RT

Phase Change Material based on n-Paraffins and Waxes

A new generation of ecological heat storage materials utilising the processes of phase change between solid and liquid (melting and congealing) to store and release large quantities of thermal energy at nearly constant temperature.

The *RUBITHERM®* phase change materials (PCM's) provide a very effective means for storing heat and cold, even when limited volumes and low operating temperature differences are applicable.

We look forward to discussing your particular questions, needs and interests with you.

Properties:

- High thermal energy storage capacity
- Heat storage and release take place at relatively constant temperatures
- No supercooling effect
- Long life product, with stable performance through the phase change cycles
- Ecologically harmless and non-toxic
- chemically inert
- Melting temperature range between approx. –4 °C and 100 °C
- viscosity- and density increasing through additives, this impeded deliquesce at melting

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Data Sheet

RUBITHERM® **RT 21**

(before: RT 20)

		Typical Values
Melting area	°C	18 - 23 typical being: 21°C
Congealing area	°C	22 - 19 typical being: 22°C
Heat storage capacity temperature range 15°C to 30°C	kJ/kg	134
Density solid at 15°C	kg/l	0.88
Density liquid at 25°C	kg/l	0.77
Volume expansion In phase change range	%	14
Heat conductivity	W/(m*K)	0.2
Kin. Viscosity at 50°C	mm^2/s	25.71
Flash point (PCM)	°C	154
corrosion		chemically inert with respect to most materials
water hazard		Water hazard class (WGK) 1

Version: 20.08.2009

PHASE CHANGE MATERIAL

Version: 1 Date: 15.01.2007 Revision: 18/03/2009

1. **Chemical product and company identification**

RUBITHERM® RT 21 (before: RT 20)

Manufacturer/supplier:
Rubitherm Technologies GmbH
Sperenberger Str. 5a, 12277 Berlin
Tel.: +49 30/720004-62, Fax: +49 30/720004-99
Emergency telephone:
Tel.: +49 30/720004-62

2. **Potential hazards**

EEC-labelling: Xn, harmful
Potential dangers for health and environment:
In case of swallowing product lung damage can be caused.
Danger of fire and explosion:
Low risk. Product creates only ignitable mixtures or burns, if temperature exceeds flash point.

3. **Composition/information of ingredients**

Chemical characterisation:
Liquid saturated hydrocarbons,
molecular formula C_nH_{2n+2}

CAS-No: 64771-72-8
EINECS-No: 265-233-4

4. **First-aid measures**

Inhalation:
Take concerned person to fresh air. In case of lasting aches and pains take medical advices.
Eye contact:
In case of eyes contact rinse out eyes. In case of irritation take medical advices.
Skin contact:
In case of skin contact wash concerned area with water and soap. In case of irritation take medical advices.
In case of swallowing:
Drink water and rinse out mouth. Don't induce vomiting, risk of aspiration. Take medical advices immediately.

5. **Fire-fighting measures**

Suitable means for extinguishing:
Carbon dioxide, foam, powder, sand, water mist
Unsuitable means for extinguishing:
water jet
Special hazards caused by the substance, its combustion products or arising gases:
Product fumes and air can cause explosive conglomerates heavier than air. Inflammation by hot surfaces, unshielded flames and sparks.
Don't inhale combustion gases. Carbon monoxide, carbon dioxide and soot can also develop.
Special protective equipment in closed rooms:
Use breathing apparatus independent from ambient air.
Additional information:
Cool endangered containers externally with water
Fire class according to DIN-EN 2: B

6. **Measures in case of unintended release**

Personal precautions:
Caution of wet floor by leaking product. Slip hazard.
Avoid inhalation of product fumes. Keep product away from ignition sources, don't smoke.
Environmental precautions:
It's not allowed to drain into environment, into bodies of water or savage system.
Avoid soil contamination.
Methods for cleaning up:
Solid: remove product mechanically
Liquid: use binder to bind liquid product and than remove it mechanically.

7. **Handling and storage**

Handling
Advices for safe handling:
No special measures necessary while using correctly.
Avoid skin- and eyescontact.
Advices for protection against fire and explosion:
Product mist and air can cause explosive conglomerate.
Storage
Requirements for storerooms and containers:
Store the product cool, dry and in closed barrels devoid of light.
Avoid storage nearby ignition or heat sources.
Take measure against electrostatic charging. Earth appliances.
Information for storage together with other products:
Avoid storage together with strong oxidising agents.

8. **Exposure controls / personal protection**

Ingredients with occupational exposure limits which should be monitored:
1. **Germany/Switzerland/Austria**
   There is no AGW-value for paraffin wax.
2. **Germany:**
   For aerosols and fine dust AGW-value of 3 mg/m³ has to be kept to.
3. **USA**
   TLV-value for paraffin vapour: 2 mg/m³

Technical measures of control and air ventilation
Ensure good ventilation at workplace in case of handling the product in closed rooms with higher temperature. Product concentration is to be kept under exposition threshold values.
Personal protective equipment:
Hand protection: protective gloves made of rubber
Eye protection: safety goggles
Body protection: protective clothes
Breathing protection: In case of arising gases and inadequately ventilation at workplace use breath apparatus.

9. Physical and chemical properties

Physical state:	at room temperature liquid
Colour:	clear (liquid), whitish (solid)
Odour:	odourless
pH-value at 20°C:	n.e.
Melting point (OECD 103):	18 - 23°C
Typical:	21 °C
Boiling range (OECD 103):	> 280°C
Flash point:	approx. 154°C
Auto flammability:	> 220°C
Explosive limit in air:	0.6 - 7Vol.-%
Vapour pressure at 50°C (OECD104):	0.01 hPa
Vapour density:	> 1
Density at 20°C (DIN 51 757):	0.761 g/ml
Solubility at 20°C - in water:	< 0.1 mg/l
Viscosity at 25°C (Brookfield):	24 $mm^2$7s

n.a. = not applicable; n.e. = not established

10. Stability / reactivity

Conditions to avoid:
No hazard reactions under normal conditions.
Avoid high thermal load.
Material to avoid:
Strong oxidising agents.
Decomposition products:
None.

11. Toxicological information

Acute toxicity :

Orale LD50:	> 5000 mg/kg (Rat)
Dermale LD50:	>2000 mg/kg (Rat)
Chronically toxicity:	LOEL = 9600 mg/kg (skin, mouse, 140 days) (C14)
Skin irritation:	slightly irritant
Eye irritation:	slightly irritant
Sensitisation:	not available
Mutagenic:	not mutagenic
Carcinogenic:	not carcinogen

12. Environmental details

Avoid drain into environment.
Elimination/persistence and degradability:
Easy biological degradable (OECD 301 F).
Aquatic toxicity:

LC50 / fish:	no reaction
EC50 / daphnia (2 days):	no reaction
EC50 / algae (3 days):	no reaction

13. Disposal considerations

After reprocessing, the product can get used again or utilised thermally otherwise it can be disposed off after consultation with authorities according the following waste disposal codes (European Waste Catalogue):

EWC-Code	Description
07 01 04	other organic solvent washing liquids and mother liquors
07 01 99	wastes not otherwise specified

Packaging:
Drums: can be returned to supplier or producer

14. Transport information

Product is not a hazardous good according to ADR/RID; GGVs/GGVE, ADNR/ADN; IMDG/GGVSee; ICAO-TI and IATA-DGR).
No dangerous good.

15. Statutory provisions

Labelling in accordance with the EEC directives:
Xn harmful

Risk-phrase, R-phrase:

R 65	Harmful. In case of swallowing product lung damage can be caused.

Safety advice, S-phrase:

S 2	keep away from children
S 23	Do not inhale gas/smoke/fumes/aerosol
S 24	Avoid skin contact
S 62	In case of swallowing do not induce vomiting! Take medical advice and show packaging and label.

Classification according to VbF: Not applicable

TA-Luft:	Substance class 3.1.7.III
Waterhazard class (WGK):	1
StörfallVo:	Not applicable
Swiss:	BAG-T-Nr.610200; Poison class: 0

16. Other information

Literature:
Ullmanns Encyclopädie der technischen Chemie
4. Auflage, Band 24, Kapitel "Wachse aus Erdöl",
Verlag Chemie GmbH, 1983.

This safety data sheet contains only safety related information.
For specific data see product data sheet.

The information on this data sheet is gathered to the best of RUBITHERMS knowledge and belief and fits as the experience stand at the moment. RUBITHERM doesn't guarantee the adherence of certain features in sense of legally binding.

In case of questions please call number given in point 1.

Rubitherm-Technologies GmbH

TECHNO-COMMERCIAL STATEMENT OF PCM PRODUCT T-SERIES LATEST™

PCM Energy P. Ltd.	PCM Latest™	PCM Latest™	PCM Latest™	PCM Latest™
Product	Latest™29T	Latest™25T	Latest™20T	Latest™18T
Series	T-series Latest™			
Description	Viscous Semi-Solid near Phase Change Temp.			
Appearance	Translucent.			
Base Material	Inorganic Salts			
Phase Change Temp.	28-30°C	24-26°C	19-20°C	17-19°C
Sub Cooling	2°C max.	2°C max.	2°C max.	2°C max.
Specific Gravity	1.48-1.50	1.48-1.50	1.48-1.50	1.48-1.50
Latent Heat Practically	175 Joules/g	175 Joules/g	175 Joules/g	175 Joules/g
Latent Heat Theoretical	188 Joules/g	188 Joules/g	188 Joules/g	188 Joules/g
Spec. Heat	2 Joules/g °C	2 Joules/g °C	2 Joules/g °C	2 Joules/g °C
Thermal Cond.	1Watt/m °C	1Watt/m °C	1Watt/m °C	1Watt/m °C
Congruent Melting	Yes	Yes	Yes	Yes
Flammability	No	No	No	No
Hazardous	No	No	No	No
Thermal Stability	> 10000 cycles	> 10000 cycles	> 10000 cycles	> 10000 cycles
Max. Operating Temp.	100°C	100°C	100°C	100°C
Rates	Available on request.			

Bijlage C

Quality and Testing Regulations for
Phase Change Materials – PCM

1 Scope
These quality and testing regulations define the general principles for PCM including PCM composites, particularly concerning definitive properties and requirements, and the content and extent of control measures.

1.1 Definition of terms

Phase Change Material (PCM)
In the following, phase change material will be abbreviated as PCM. The term "latent heat storage (material)" is also commonly used for the same type of materials.
PCM's in the context of these quality-control regulations are materials which change their state between solid and liquid or between two different solid crystallisation states over a defined temperature range (phase transition). This process is reversible (reproducible phase transition). This change can be used for thermotechnical purposes.
The advantages of PCM's compared to other storage materials are that they can absorb large amounts of energy per storage volume / mass for a small temperature difference between the storage medium and its surroundings, they can store the energy over a period of time with minimal losses and finally, they can release the energy again when needed.

Phase Change Material Composites (PCM composites)
are composite materials which always include PCM constituents. By combining the PCM with at least one further material, the PCM gains a new or modified property, e.g.

- graphite -> high thermal conductivity
- wood fibreboard -> mechanical stability
- granulate -> free-flowing form of bulk goods

Examples: PCM graphite matrix, granulates, plaster, wood fibres, PCM foam matrix, PCM film, PC textiles (as fabric, not as complete clothing articles), all free-flowing granulate materials. Further examples will be identified by the quality-control committee and publicised under **www.pcm-ral.de**.
The properties of the PCM and PCM composites listed above can also be determined from samples (small quantities). Powders and in particular granulates are usually PCM composites.

Phase Change Material Objects (PCM objects)
PCM objects have specific properties, i.e. properties which cannot be determined from samples (parts of an object) but only with the complete object. The thermal conductivity e.g. is not a property of an object.
Examples: Macro-capsules (panels, packs, spheres), clothing articles made of PCM textiles.

Phase Change Material Systems (PCM systems)
PCM systems are products which are positively changed in an essential function by inclusion of PCM, e.g. ski boots, gloves, quilts.

Material Properties and Object Properties
Properties of materials and material composites are those properties which depend only on the internal composition. An example is the thermal conductivity of a material. It is independent of the form and amount of the material.
Properties of objects are those properties which do not depend solely on the internal composition but are also determined by the outer form and ambient conditions.
An example is the amount of heat released by a panel. This depends both on the form and dimensions of the panel, and on the ambient conditions.

2 Quality Regulations

2.1 Requirements for PCM and PCM composites
Manufacturers' specifications for the definitive properties named in paragraphs 2.1.1 to 2.1.3 are permissible only according to the following definitions:

2.1.1 Quality Criterion 1: Phase transition temperature and stored heat
The stored quantity of heat must be specified in the pre-defined temperature intervals for the cases of melting and solidification. Specifications of enthalpy are to be with respect both to mass and to volume. Similarly, a measure for sub-cooling is to be specified. When specifications are made with respect to volume, the larger volume is to be used, i.e. usually the volume in the liquid state.

2.1.2. Quality Criterion 2: Reproducibility of the phase transition
PCM must survive a defined number of cycles (see 3.6.2.2.2) without damage. One cycle is defined as complete melting and recrystallisation of the PCM.

Damage criteria
The product is defective if one of the following changes with respect to the initial state has occurred:

- change in total enthalpy ≥ 10%,
- change in enthalpy-temperature profile: 1 K max. deviation
- mass change > 3%; testing is imperative if the manufacturer specifies "encapsulated"; not required for "not encapsulated".

Cycling category
The reproducibility is to be specified by cycling categories as follows:

Cycling category	Number of cycles
A	10000 cycles
B	5000 cycles
C	1000 cycles
D	500 cycles
E	100 cycles
F	50 cycles

Table 2.1.2: Cycling categories and required number of cycles

2.1.3 Quality Criterion 3: Thermal conductivity
The thermal conductivity in both the solid and the liquid state is to be specified in predefined temperature intervals.

2.1.4. Product data sheet
Manufacturers must prepare a product data sheet for every product, which includes at least specifications for the following properties:

- Product name with specification of:
    - encapsulated PCM or not encapsulated PCM,
    - operating range (this is the temperature range in which the main properties specified by the manufacturer are valid),
    - maximum permissible temperature (If the maximum permissible temperature is exceeded, the definitive properties specified according to Sections 2.1.1.1 – 2.1.1.3 are lost irreversibly, either partly or completely),
    - specific weight.
- Definitive properties
    - phase transition temperature and stored heat,
    - reproducibility of the phase transition,
    - thermal conductivity.

An informative, non-obligatory example of a product data sheet can be found in Appendix I.

2.1.5 Safety data sheet
The safety data sheet must comply with the legal requirements of the intended country of sale and include all relevant warnings.

2.2. Requirements for PCM objects

2.2.1PCM constituent materials
PCM objects may contain only approved PCM or PCM composites.

2.2.2 2. Phase transition temperature and stored heat
Analogous to PCM / PCM composites

2.2.3 Reproducibility of the phase transition
Analogous to PCM / PCM composites**2.3. Requirements for PCM systems**

2.3.1 PCM constituent materials
PCM systems may contain only approved PCM, PCM composites or PCM objects.
They must be encapsulated. The cycling category according to 2.1.2 must be appropriate for the intended application.

2.3.2. Product specifications
Manufacturers of PCM systems must specify the PCM-specific utility for each product group of PCM systems.
This specification must be accessible to the customer at the time of purchase, e.g. on the packaging, operating instructions, in certain cases by specification of an Internet link.

3 Testing regulations
The basic testing principles and additions or modifications to these basic testing principles of the quality-control association, "Gütegemeinschaft PCM e.V", based on recommendations of the external inspection institutions, as publicised under www.pcm-ral.de , are to be observed in all measurements made by the external inspection institutions. The following regulations about the tests apply exclusively to external tests.

3.1 Scope of the tests
For the definitive properties, phase transition temperature, stored heat, reproducibility of the phase transition and thermal conductivity, the conducted tests apply within the following limits:

- PCM: Only for one single product with a unique manufacturer's product name.
- PCM composites: For composite materials with identical components (including identical particle size), but variable mixing ratios. Interpolation between measured mixing ratios is permissible. The calculation method must agree with test results.
- PCM objects: For objects with an identical construction but variable volumes and comparable geometrical configuration.
- N.B. The dimensions may be so large that the object does not fit inside the testing equipment, e.g. panels with the same width and thickness but variable height. Then the maximum dimension cannot be tested.
- PCM systems: Within the same product category according to the specifications of the quality-control committee.

3.2 Transferability of the test results
After consultation with an external inspection institution, the quality-control committee can transfer test results on request to untested product variants if the manufacturer's specifications are based on the widely accepted state of the art or plausible tests or calculations.

3.3Adaptation of tests to the state of the art
With regard to the dynamic development of measurement methods, the quality-control committee can continually authorise new measurements corresponding to the state of the art in measurement technology after consultation with the external inspection institution. The authorisation is valid from the date of Internet publication under www.pcm-ral.de .

3.4 Accuracy of the measured values
As a general principle, the functionality and accuracy of the applied measurement system is to be assured to guarantee the accuracy of the measured values.

3.5 Sample requirements
Test sample
The test sample (PCM, PCM composite, PCM object) must be typical of the product to be investigated and must be carefully prepared and handled (based on the specifications in the corresponding product data sheet). The preparation procedure for test items must be documented.

Sample density
The minimum density of the PCM in the operating temperature range must be used as the sample density (tolerance ± 1%).

3.6 Special testing regulations for PCM and PCM composites

3.6.1 Phase transition temperature and stored heat for PCM / PCM composites

3.6.1.1 Determination of the stored heat as a function of temperature
The stored heat is determined according to one of the following measurement methods:

- hf-DSC dynamic measurement with constant rates of heating and cooling,
- hf-DSC quasi-stationary measurement with a step profile for heating,
- m-DSC,

- T-history method,
- CALVET calorimeter,
- multi-layer calorimeter procedure.

3.6.1.2 Making the measurement

When the measurements are made, the requirements of the quality-control association, Gütegemeinschaft PCM e.V., must be observed particularly with regard to

- number of samples and measurements and
- procedures to ensure thermal equilibrium within the sample with sufficient accuracy.

3.6.1.3Contents of the test result and the test report

The stored heat as a function of temperature must be specified separately for the cases of heating and cooling, as there will be differences in the dependence on temperature in most cases. It will be tabulated in a pre-determined temperature range. This must be done in each case with respect to

- the sample mass in J/g
- sample volume in J/ml.

The values with respect to the sample volume will be calculated from the values with respect to the sample mass by multiplication with the minimum sample density in the operating temperature range. For example:

T-Intervall [°C]	stored heat [J/g]	stored heat [J/ml]
19,5 – 20,5	2,1	3,0
20,5 – 21,5	2,2	3,2
21,5 – 22,5	2,5	3,6
22,5 – 23,5	3,2	4,6
23,5 – 24,5	4,3	6,2
24,5 – 25,5	10,5	15,2
25,5 – 26,5	25,6	37,1
26,5 – 27,5	45,3	65,7
27,5 – 28,5	64,3	93,2
28,5 – 29,5	7,8	11,3
29,5 – 30,5	3,1	4,5
30,5 – 31,5	3,0	4,4
31,5 – 32,5	3,1	4,5
32,5 – 33,5	3,0	4,4
33,5 – 34,5	3,1	4,5

Density at 34°C [g/ml] 1,45

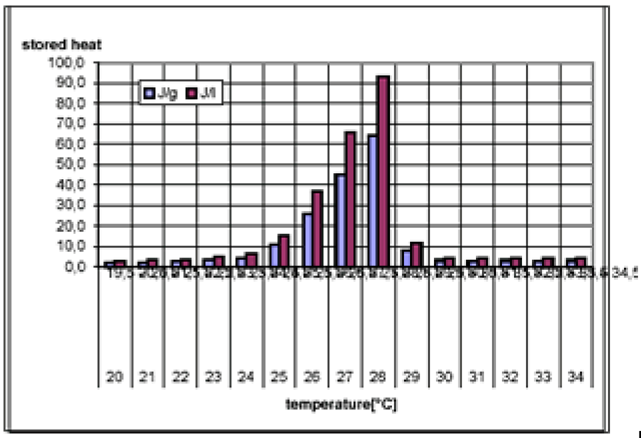


Bild 3.6.1.3: Example for presentation of the stored heat as a function of temperature for the heating case

In addition, the **degree of sub-cooling** is to be specified for the selected operating range according to the requirements of the quality-control association.

3.6.2 3.6.2 Reproducibility of the phase transition

No comparable national or international standards exist concerning the investigation of cycling stability. In practice, usually thermal cycling is done with equipment that has been designed specially for the relevant product, which can cycle many times in the shortest possible testing time.

3.6.2.1 Testing for damage criteria:

Total enthalpy:

The enthalpy, being an essential damage criterion, is to be determined analogously to the measurement requirements for the test according to Section 3.6.1 for phase transition temperature and stored heat. The control measurement is deemed to be successful if it deviates less than 10 % from the corresponding measurement at the beginning of cycling.

Enthalpy–temperature profile:

Deviations in the enthalpy-temperature profile of max. 1 K for each of the onset, offset and peak temperatures (supercooling) are permissible (see Fig. 3.6.2.3.1 for definitions). Larger deviations in at least one of these three temperatures are to be regarded as a case of damage. The measurement regulations are to be found in Section 3.6.1 on phase transition temperature and stored heat and must be applied. Changes in the enthalpy curves can be an indicator for changes in the composition of the PCM or changes in the nucleating agent.

Change in mass:

The density of encapsulated PCM can be monitored by determining changes in mass. The changes in mass can be caused by outgassing or incorporation of materials from the surroundings. If the mass changes by more than 3 % from the initial value, it can be assumed that the sample composition has changed significantly.

3.6.2.2 Cycling category

Before cycling is begun, it is recommended to decide on the intended category, as this determines the time and frequency of the control measurements.
In accordance with the intended category, the control measurements will be made every n cycles.
Depending on the number of cycles tested, a total of 6 different categories concerning cycling are achievable.
Control tests for the damage criteria presented in Section 3.6.2.1 are to be carried out initially and repeated after different numbers of cycles, depending on the intended category. The categories and the corresponding frequency for control measurements are documented in Table 3.6.2.1.
For the control measurements, parts of the samples will be removed from the cycling equipment and measured. The removed parts may not be cycled further after the control measurement. Sensitive samples (e.g. hygroscopic, encapsulated, etc.), for which the sample composition can be affected by removal of part of the sample for a control measurement, must be removed as a complete unit (e.g. pack) and may not be used thereafter for further cycling. For this reason, sufficient individual samples must be included from the beginning of the cycling process.
If the criteria for the intended category are not met successfully, a new test with the control criteria for the previously achieved category is to be conducted, if the number of control measurements for the lower class is insufficient.

Cycling category	Number of cycles	Control measurements for damage criteria every
A	10000 cycles	1000 cycles
B	5000 cycles	500 cycles
C	1000 cycles	200 cycles
D	500 cycles	100 cycles
E	100 cycles	20 cycles
F	50 cycles	10 cycles

Table 3.6.2.1: Cycling categories, required number of cycles and frequency of control measurements.

3.6.2.3 Making the measurement

Measurement principle

First of all, the temperature profile for cycling must be defined. To do this, a detailed measurement of the total enthalpy and the temperature-dependent enthalpy must be made analogously to the requirements of Quality Criterion 1. These measurement results are used to determine the switching temperatures and the upper and lower driving temperatures. The duration of the pauses at a given temperature and the lowest and highest temperatures should be taken from the manufacturer's specifications.
After the initial measurement, the samples are subjected to temperature cycling until the number of cycles for the first control measurement has been reached. The number of cycles must be documented by the time series of temperatures measured in the sample. The control measurements should be made as described.
The sequence of cycling and control measurements is continued until damage occurs or the desired number of cycles has been reached.

Temperature limits:

The PCM's are cycled through a pre-defined sequence of heating and cooling periods, with pauses between them under certain circumstances.
In order to ensure the greatest possible comparability of the results, the sequence of heating and cooling periods must follow a defined profile between temperature limits that have been determined specific to the material being tested. It is essential that the sample temperature at the position furthest away from the heating/cooling element must be sufficiently removed from the melting range to ensure a complete cycle. The following specifications of the material properties such as onset/offset refer to measurements according to Quality Criterion 1. The width of the melting peaks is understood to be the difference between the onset and offset.
Two possible sequences for the heating and cooling periods are defined in the following sections. In exceptional cases, different limits can be permitted by the quality-control committee.

Limits relative to peak width

The upper driving temperature must exceed the offset temperature of the melting curve by at least three times the peak width. If the sample at the position furthest from the heating surface reaches a temperature which is higher than the offset temperature by at least 2.5 times the peak width (the so-called "switching temperature"), the heating cycle is considered to be complete (possibly after a pause period specified by the manufacturer). Analogously, in the cooling case, the lower driving temperature must be at least three times the peak width lower than the offset temperature of the solidification curve. If the sample at the position furthest from the cooling surface reaches a temperature which is lower than the offset temperature by at least 2.5 times the peak width (the so-called "switching temperature"), the cooling cycle is considered to be complete (possibly after a pause period specified by the manufacturer).

Absolute limits

For materials with very broad or several overlapping melting peaks, the definition above can lead to unrealistically large temperature ranges. In this case, a minimum driving temperature which is 5 K above the offset of the melting curve is permissible for the heating case. If the sample at the position furthest from the heating surface reaches a temperature which is at least 4 K higher than the offset temperature (the so-called "switching temperature"), the heating cycle is considered to be complete (possibly after a pause period specified by the manufacturer). Analogously, a maximum driving temperature which is 5 K lower than the offset of the solidification curve is permissible in the cooling case. If the sample at the position furthest from the cooling surface reaches a temperature which is at least 4 K lower than the offset temperature (the so-called "switching temperature"), the cooling cycle is considered to be complete (possibly after a pause period specified by the manufacturer).

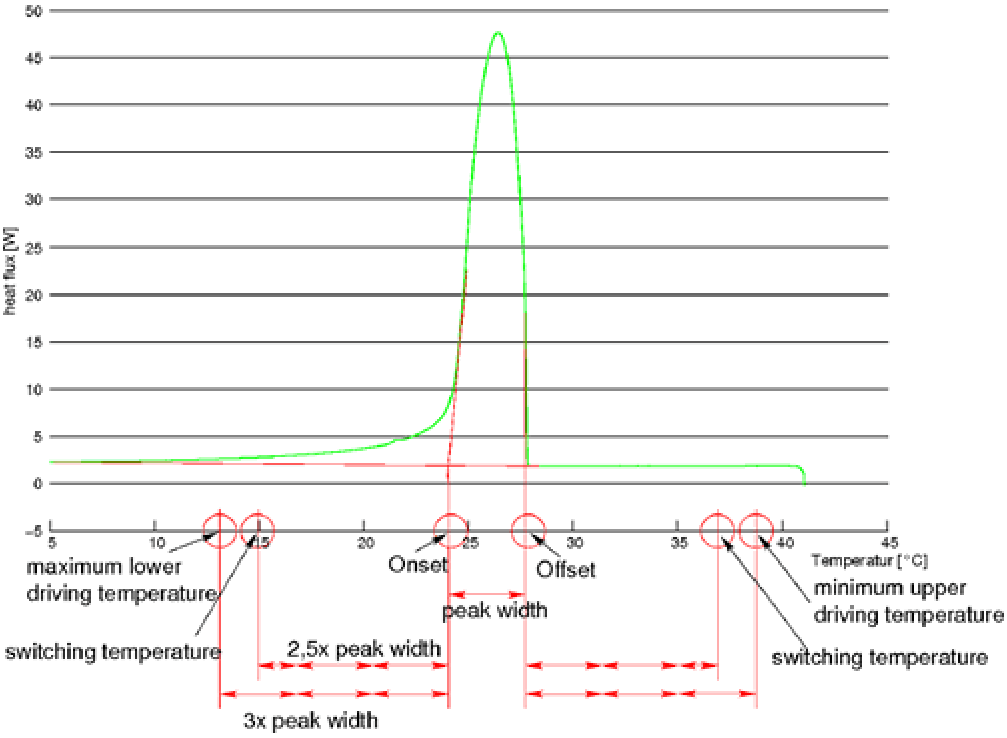


Fig. 3.6.2.3.1: Definition of the peak width and the resulting switching temperatures and extreme driving temperatures for cycling based on relative limits.

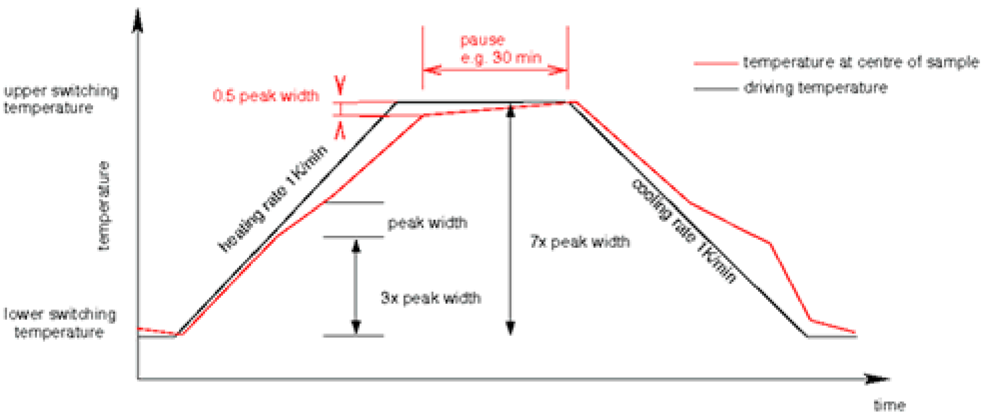


Fig. 3.6.2.3.2: Example of a complete cycle with pause phases.

Measurement of the sample temperature

If at least two heating surfaces on opposite sides of the sample are used, the temperature is measured with a sensor positioned in the centre of the sample. If the sample is heated from only one side, the temperature sensor must be placed at the position furthest removed from the heating surface.

Temperature profile

A heating rate of 1 K/min (± 0.1 K/min) at the metal contact or in the thermostat bath liquid is recommended. The quality-control committee can allow other values. However, the heating rate within the sample is lower. Furthermore, it can be necessary for some PCM's to include pause phases to allow thermal relaxation of the PCM. The manufacturer's specifications must be observed in this point. This must be noted in the documentation.

3.6.2.4 Contents of the test result and the test report

The formulation is based on DIN EN ISO 11357-1, "Polymers, Dynamic Scanning Calorimetry (DSC), Part 1: General principles".
The test report must include the following points, if applicable:

1. reference to this "Recommendation for carrying out the initial audit or external inspection by the quality-control association, Gütegemeinschaft PCM",
2. all necessary information for complete identification of the investigated material,
3. preparation of the test samples for cycling,
4. cycling method (air, liquid or metal contact),
5. cycling category achieved,
6. initial measurement and control measurements,
    a. number of cycles up to measurement,

   a. preparation of the test samples,
      i. preparation procedure for the test samples,
   b. determination of the sample density
      i. description of the measurement procedure,
      ii. result,
   c. determination of the stored heat as a function of temperature,
      i. selection of the sample container,
         1. material and
         2. dimensions,
      ii. selection of the measurement method,
         1. measurement procedure used,
         2. type of equipment used,
      iii. conduction of measurement,
         1. temperature range,
         2. measurement procedure, parameters of the temperature profile, including initial temperature, heating rate, final temperature and cooling rate,
         3. result of testing whether sample is isothermal,
      iv. result,
         1. number of samples, mass,
         2. measurement curves and result of individual analysis,
         3. stored heat as a function of temperature as tables for the heating and cooling cases after averaging the individual results
         relative to the sample mass in J/g,
         relative to the sample volume in J/l,
         4. standard deviation of the measurement results,
   d. determination of the sample mass,
      i. result,
7. cycling,
   a. parameters of the temperature profile, including switching temperatures, driving temperatures, duration of pause phases,
   b. proof of number of cycles (graph),

   date of testing.

3.6.3 Thermal conductivity

3.6.3.1 Thermal conductivity as a function of temperature
The thermal conductivity is determined as a function of temperature with an accuracy of at least:

± 5 % in the thermal conductivity,

± 0,5 °C in the temperature.

This accuracy corresponds to the currently known state of the art. More stringent demands on accuracy can be made in future by the quality-control association, Gütegemeinschaft PCM e.V., if the state of the art develops further.

3.6.3.2 Determination of the thermal conductivity above and below the melting point According to the current state of knowledge, suitable measurement methods are:

Type of sample	**Measurement method (solid**	**Measurement method (liquid**

	PCM)	PCM)
Paraffins	Hot wire, GHP (Guarded Hot Plate) to a limited extent	Hot wire
Salt hydrates	Hot wire, GHP to a limited extent	Hot wire
Micro-encapsulated PCM	Hot wire GHP	Hot wire
Composite panel of carbon/PCM	Rod instrument according to DIN 51908, hot wire, if sample isotropic	Rod instrument according to DIN 51908, hot wire, if sample isotropic
Composite panel of matrix material/ micro-encapsulated PCM	GHP, hot wire, if sample isotropic, rod equipment, if sample has high thermal conductivity (> 0.4 W/(mK))	GHP, hot wire, if sample isotropic, Rod equipment, if sample has high thermal conductivity (> 0.4 W/(mK))

Table 3.6.3.2: Suitable measurement methods

Due to their individual characteristics, the measurement methods are not equally well suited for all PCM's. The most suitable measurement method for the relevant sample should be selected. The quality-control committee can specify testing for only one state for certain products.
Other measurement methods can be authorised by the quality-control association, Gütegemeinschaft PCM e.V., as new knowledge becomes available.
In all of the listed measurement methods, the temperature measurement points and the measurement parameters must be chosen such that melting processes in the sample do not affect the determination of the thermal conductivity. This selection must be based on a mandatory enthalpy curve for the material to be tested.
At the beginning of each individual measurement, it must be ensured that thermal equilibrium exists within the sample.
To ensure the reliability of test results, the functionality and accuracy of the measurement system used must be checked by test measurements of standard materials and documented immediately before an initial audit or external inspection.

3.6.3.3 Making the measurement
When the measurements are made, the requirements of the quality-control association, Gütegemeinschaft PCM e.V., must be observed particularly with regard to

- number of samples and measurements and
- special aspects of sample preparation or preparation of the measurement method used.

3.6.3.4 Contents of the test result and the test report
The following points should be observed during the test and specified in the test report:

1. Identification of the measurement method used with process-specific parameters
2. Specification of the thermal conductivity at pre-determined temperatures above and below the melting point or the melting range
3. Specification of the sample density at the beginning and end of the measurements
4. Documentation of the air humidity, air temperature and normal pressure during the measurement
5. Documentation of specific observations during the measurement, e.g. "precipitation" or "phase separation".

3.7 Special testing regulations for PCM objects

1. **PCM constituents**
   The PCM constituents must be confirmed in writing by a PCM manufacturer who has been awarded the quality certificate for PCM's that are included in PCM objects.

2. **Phase transition temperature and stored heat**
   Phase transition temperature and stored heat should be calculated from the data for the tested PCM constituents and specified. In addition, the degree of supercooling for the selected operating range is to be specified according to the requirements for PCM objects of the quality-control association

3.7.3 Reproducibility of the phase transition

As for PCM/ PCM composites in encapsulated form. It must be tested that the capsules do not leak. A negative effect of the encapsulation on the PCM constituent must be excluded.

3.8 Special testing regulations for PCM systems

1. PCM constituents
   The PCM constituents of PCM, PCM composites or PCM objects and their cycling category must be confirmed in writing by a PCM manufacturer who has been awarded the quality certificate for PCM composites or PCM objects that are included in the PCM systems.
2. Product specifications
   The specified fundamental utility must be confirmed, without quantitative differentiation, in the test report of a testing institution that has been accredited by the quality-control association.

4 Control

4.1 General

The following forms of control are distinguished:

- **External control**
  - initial audit,
  - external inspection,
  - repeat external audits.
- **In-house control**
  The external inspection institution selects the test samples. The candidate for the quality certificate can make suggestions. A variety of products should be subjected to external inspection. The aim is that the scope of tests, as defined in Section 3.1, should cover the largest number of products.

4.2 Initial audit

Passing the initial audit is the pre-condition for being awarded and using the quality certificate of the quality-control association. As part of the initial audit, it will be tested whether the candidate PCM products presented by the applicant for the quality certificate fulfil the requirements specified in the quality and testing regulations in all respects. The applicant is obliged to submit all documents required for initiating and carrying out the audit to the quality-control association and to provide products for external testing according to Section 4.1.
The initial audit will be ordered by the quality-control committee of the quality-control association, which will commission the Bayerische Zentrum für angewandte Energieforschung e.V. or the Fraunhofer-Institute for Solar Energy Systems or an officially recognised testing authority or an expert under oath to carrying out the audit.
Further, the initial audit serves to determine whether the pre-conditions exist for regular compliance with the quality and testing regulations.
Initial audits must be carried out when

- an application for the quality certificate for a product is submitted for the first time,
- relevant changes in the product have been made.
  The external auditor will prepare a test report on the initial audit. For PCM, PCM composites and PCM objects, this includes:
- name and function of the auditor,
- name and function of the laboratory manager,
- date of sample selection,
- exact name of sample,
- origin of sample,
- date of testing,
- specifications of sample preparation,
- measurement procedure applied, with complete specification of all relevant measurement parameters,
- test result.

The applicant and the quality-control committee of the quality-control association will each be sent a signed copy of the test report.

4.3 In-house control

To comply with the quality and testing regulations, each holder of the quality certificate must carry out continuous in-house control, which must be reproducible at all times, of all approved-quality PCM products.
The holder of the quality certificate must prepare thorough documentation of the in-house control. For PCM and PCM composites, these include at least

- name and function of the person responsible for testing,
- name and function of the laboratory manager,

- date of sample selection,
- exact name of sample,
- origin of sample,
- date of testing,
- specifications of sample preparation,
- measurement procedure applied, with complete specification of all relevant measurement parameters,
- test result,
- comparison with the initial audit and statement on fulfilment of the quality criteria

These documents (without samples) are to be kept in a suitable form for five years and must be presented during subsequent external audits.

4.4 External inspection
External inspection serves to determine whether the quality and testing regulations and the specified requirements for correct implementation of the tests are still fulfilled by the certificate holder.
The certificate holders are required to grant the external inspector access to the company for selection of samples.
As part of the external inspection, the inspector must check the implementation of the in-house control and must evaluate the completeness and consistency of the results.
The protocol forms specified by the quality-control association should be used for this purpose. They can be downloaded from the Internet home page: www.pcm-ral.de
External inspection will be carried out on the basis of random samples. Samples will be selected in accordance with statistical principles.

4.5 Repeat external audit
If, during the external inspection, the commissioned external inspector finds deficiencies in quality control by the certificate holder as specified by the quality and testing regulations, he/she is obliged to report this without delay to the quality-control association, independently of the corresponding test report.
In response, after consultation with the quality-control committee, the executive of the quality-control association can order a repeat external audit, whereby the date, content and extent of the audit will be determined by the quality-control committee of the quality-control association.
If the certificate holder also fails to pass the repeat external audit, the executive of the quality-control association, in consultation with the quality-control committee, can order that further measures be taken in compliance with Section 5 of the implementation regulations.

4.6 Auditing costs
The costs for each initial, subsequent or repeat audit are to be borne by the applicant or certificate holder.

4.7 Audit reports
An audit report must be written by the commissioned external auditor on each initial, subsequent or repeat audit carried out. The auditor must send signed copies of the test report to the applicant or certificate holder and the office of the quality-control association.

5 Product marking
Products which have been manufactured in compliance with the quality and testing regulations and which have been awarded the certificate of the quality-control association may be marked with the quality seal as illustrated here:

The quality certificate and seal may be awarded and used solely in accordance with the implementation regulations of the quality-control association, "Gütegemeinschaft PCM e.V".

6 Changes
Changes to the quality and testing regulations, also of an editorial nature, require prior written approval of RAL to become effective. After an appropriate transition period, they will put into force by the executive of the quality-control association, after prior approval by a General Meeting of the members, by information sent to the certificate holders.

7 Glossary
Abbreviations
Phase Change Material PCM

Phase Change Material composites PCM composites
Phase Change Material objects PCM objects
Phase Change Material systems PCM systems
Differential Scanning Calorimeter DSC

Definitionen
Terms relating to testing and measurement procedures
Enthalpy
The change in enthalpy is equal to the heat which is absorbed or released in a system under constant pressure. Thus, it is also used for the amount of energy which is stored or released during the phase change in the form of both latent and specific heat. The units are J (or kJ) per mass unit or per volume unit.

Differential Scanning Calorimetry
Differential scanning calorimetry (DSC) allows measurement of the change in the heat flux difference between the sample and a comparison sample while these are subjected to a temperature change. Information can be obtained on the stored amount of latent and specific heat as a function of temperature.
The following types of DSC are distinguished:

Heat Flux DSC (hf-DSC)
Heat flux DSC is a dynamic measurement with a constant heating and cooling rate or a quasi-stationary measurement achieved with a stepped heating profile. Heat is fed to or extracted from the sample via a defined heat-conducting path, changing the sample temperature. The measurement is made with individual spot or plate thermoelements.
Calvet DSC (CALVET Calorimeter)
Calvet DSC (CALVET Calorimeter) is a special and uncommon version of hf-DSC for very large samples. In a CALVET calorimeter, heat is conducted to the sample via a large number of thermoelements (thermopile), changing the sample temperature. The thermopile displays an average surface temperature. Losses are assumed to be symmetric and are determined by using a reference.

Temperature-modulated DSC (m-DSC)
In m-DSC, the sample temperature is scanned following e.g. a linear temperature ramp. Small values of the intrinsic heat capacity and resistance of the equipment allow a relatively small temperature modulation to be superimposed on the linear ramp. The stored heat can be determined from the sample reaction to this temperature modulation. The measurement is made with individual spot or plate thermoelements.

Triple-layer calorimeter procedure
In the triple-layer calorimeter procedure, a relatively large sample is placed in a special accessory in a commercially available climatic chamber. The analysis is made by comparison with a reference material.

T-History method
The T-history method is an alternative procedure. The heating and cooling behaviour of the sample and a reference in a defined environment are recorded during a pre-determined temperature step. The sample properties are determined from the temperature profiles of the sample and the reference.

Characteristic parameters of the measurement procedures
Onset or peak onset temperature
is the temperature at which the measured curve begins to deviate from the extrapolated initial baseline. It marks the beginning of the melting or crystallisation process.

Offset or peak end temperature
is the temperature at which the measured curve rejoins the extrapolated final baseline. It marks the end of the melting or crystallisation process.

Peak
is the section of the measurement plot of amount of heat versus the temperature which corresponds to the melting / crystallisation process.

Peak width
is the temperature interval in °C over which the melting or crystallisation process takes place.

Appendix 1 Page: 1/1

Template for a Product Data Sheet
(Minimum requirements)

1. Identification of material, preparation and company

Application: Raw material
Phase Change Materials
Company:
Emergency information:

Phase transition temperature and stored heat
Reproducibility of the phase transition
Thermal conductivity
PCM encapsulated or not encapsulated
Operating range
Maximum permissible temperature

Appendix 2 (informative)

Equipment for cycling
The figure in Appendix 2 serves as an example. It shows the schematic configuration of universal cycling equipment, in which air, water or metal contact can be used for temperature cycling, depending on the requirements of the application. The samples are inserted into the sample chamber, which can be thermostatted from four sides. It is possible to cycle encapsulated samples both via a direct metal contact and with a water bath. Powder samples can be filled into separate recesses of a block that can be inserted into the equipment. The height of the cover is adjustable. The cover seals the sample chamber as tightly as possible to minimise the heat loss to the surroundings. If samples of only one material are cycled simultaneously, one temperature sensor in the centre of the samples is sufficient. If samples of several similar materials are tested simultaneously, correspondingly more temperature sensors are required. The metal surfaces of the sample chamber are kept at the required temperature via a hydraulic circuit which is controlled by a thermostat.
No particular equipment is specified for cycling. All types of equipment are permissible which technically implement the required measurement regulations. In general, it is recommended to cycle encapsulated PCM and mixed products with integrated PCM by contact to metal, whereas larger numbers of samples of pure PCM can be cycled very efficiently in a glass flask in a water bath.

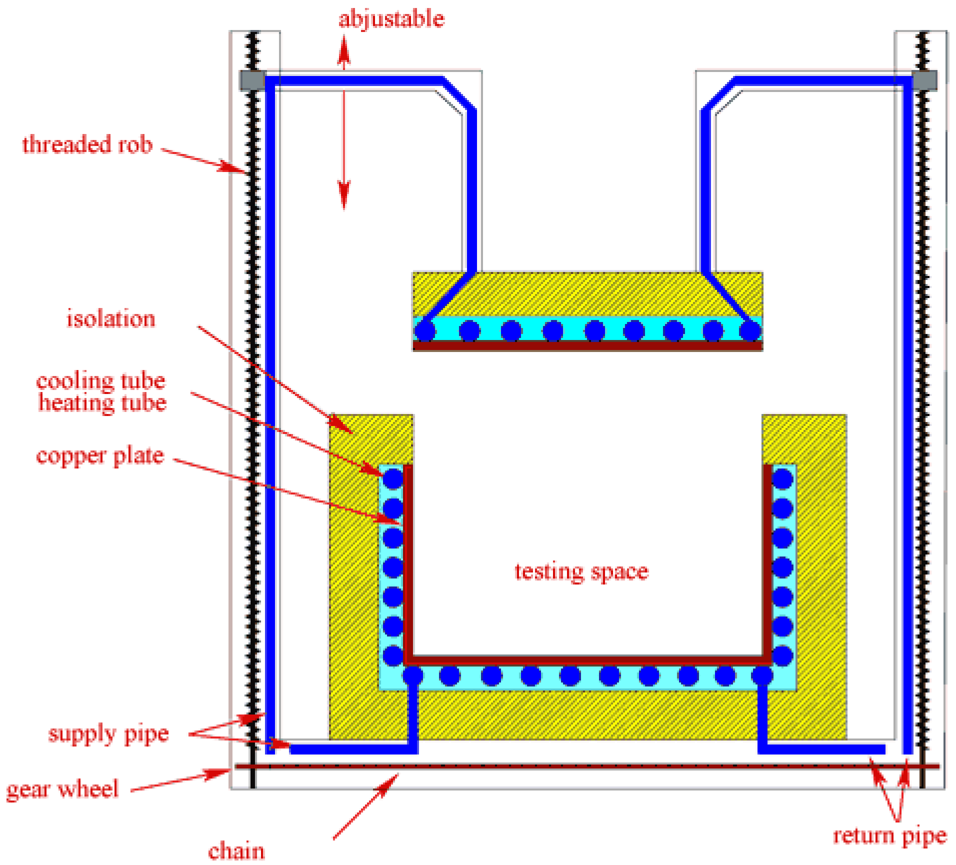


Figure for Appendix 2: Schematic configuration of equipment for temperature cycling

Use and publication of the testing methods with reference to the source only.

Bijlage D

<u>Emissiecoefficient (Ɛ)</u>

Absoluut zwart voorwerp	1
Edelmetaal, gepolijst	0,02-0,05
Niet-edelmetaal, gepolijst	0,05-0,25
Aluminium, onbewerkt	0,12
Aluminium, gepolijst	0,04
Staal, onbewerkt	0,80
Staal, geoxideerd	0,65
Staal, verzinkt	0,25
Koper, gepolijst	0,04
Koper, zwart geoxideerd	0,75
Messing, gepolijst	0,04
Messing, geoxideerd	0,60
Aluminium/bronsverf	0,5
Emaillelak, radiatorlak	0,9
Olieverf	0,95
beton, baksteen	0,95
gips, hout, porselein	0,9
water, ijs, rijp	0,85
menselijke huid	0,85
papier	0,9
Glas	0,95

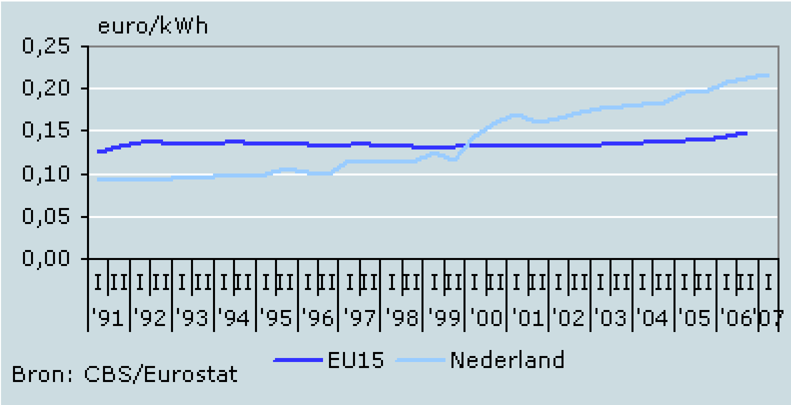
Bijlage E

<u>Warmtegeleidingscoeffficient (λ) W/m.K</u>	
Water	0,60
Lucht	0,026
Beton	1,7-2,3
Baksteen	0,6-0,9
Mineraal wol	0,04
Glas	0,81
Hout	0,17-0,23
PVC-hard (PVC)	0,16
Polyetheen (PE)	0,23-0,29
Polystyreeen (PS)	0,04
Polypropyleen (PP)	0,22-0,24
Staal	46
Aluminium	240
Koper	400
Paraffine	0,18
Zouthydraten	0,57

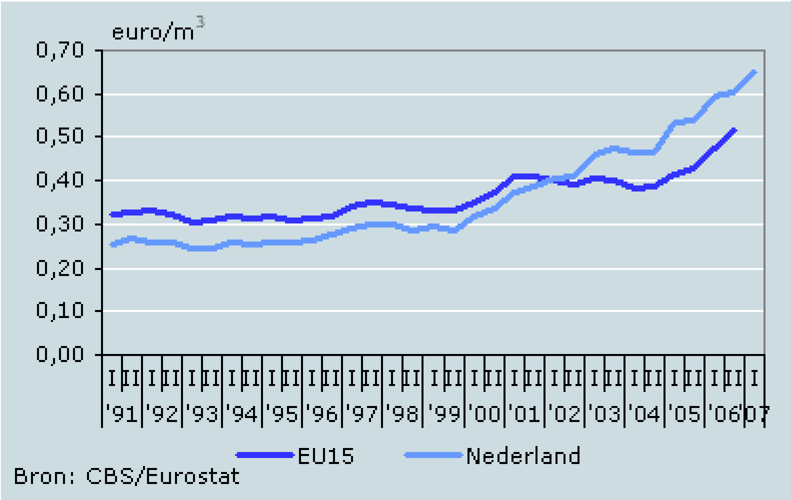
Bijlage F

Overzicht pH waardes 0 t/m 14

pH 14	: natronloogoplossing van 1 mol/L
pH 15	: natronloogoplossing of kaliloogoplossing van 0,1 mol/L
pH 11,5	: huishoudammonia
pH 10,5	: zeepsop
pH 9,5	: bleekwater
pH 8,5:	: zeewater
pH 7,5	: eieren
pH 7,4	: menselijk bloed
pH 7	: zuiver, gedemineraliseerd water(neutraal)
pH 6,7	: melk
pH 6,5	: speeksel
pH 6	: natuurlijke regen
pH 5	: lichte zure regen
pH 4,5	: tomaten
pH 4	: zure regen
pH 3	: consumptieazijn
pH 2	: maagzuur
pH 1	: zwavelzuur
pH 0	: zoutzuur



Stroomprijs



Gasprijs

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PCM klimaatplafond

Door toepassing van PCM klimaatplafonds worden de leefzones van een gebouw op een comfortabele, gezonde en duurzame wijze geklimatiseerd. PCM is de Engelse afkorting voor Phase Change Material. In het Nederlands: fase-overgangsmateriaal. Het toegepaste PCM gaat bij opname en afgifte van warmte over van een vaste naar een vloeibare aggregatietoestand. Het smelten en bevriezen van het PCM vindt plaats bij een smelttemperatuur van 21 °C en een stoltemperatuur van 20 °C. Het fase overgangsmateriaal wordt op een gepatenteerde wijze verpakt in polipropyleen panelen. Deze PCM panelen worden als maatwerk klimaatplafondeilanden geïnstalleerd.

De werking

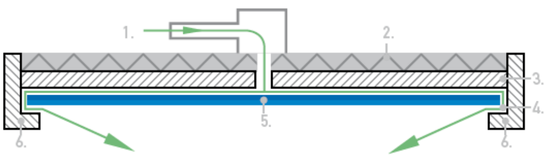
Het PCM materiaal wordt als klimaatplafondeilanden gemonteerd in een ruimte. De beleggingsgraad van het PCM klimaatplafond hangt af van de koellastberekening volgens NEN 5067. Voor een optimaal en gezond binnenklimaat wordt elk PCM klimaatplafondeiland aangesloten op een gebalanceerde mechanische ventilatie-installatie.

Koelen

Als de ruimtetemperatuur overdag tengevolge van de vrije interne warmteproductie hoger wordt dan 20 °C, dan zal er een warmtestroom optreden vanuit de ruimte richting het PCM klimaatplafond. Het PCM materiaal neemt dan, gezien vanuit de ruimte, warmte op en zal gaan smelten. Het PCM materiaal koelt de ruimte.

Verwarmen

Als 's nachts de vrije interne warmtebronnen niet meer aanwezig zijn, zal de ruimtetemperatuur dalen tot onder de 19 °C en treedt er een warmtestroom op van PCM klimaatplafond naar de ruimte. Het PCM materiaal zal dan weer invriezen en gelijktijdig de ruimte verwarmen.



1. Primaire ventilatielucht
2. Thermische - Akoestische isolatie
3. Multiplex paneel
4. Luchtstromings spleet
5. PCM materiaal
6. Houten kader

Voordelen

Door toepassing van PCM klimaatplafonds zijn de volgende voordelen te behalen:

- Een duurzaam klimaatplafond passend bij het plan van de binnenhuisarchitect
- Een reductie van het te installeren mechanische koelvermogen
- Een reductie van het te installeren verwarmingsvermogen
- Een reductie van de elektrische voeding en trafovermogen
- Een besparing op de elektriciteit en gas kosten
- Besparing op de onderhoudskosten, door een geringere koudemiddelinhoud van de koelmachine.
- Een volledig houten recyclebare "Cradle to Cradle" PCM klimaatplafond

Energiebesparing

Uitgaande van een kantoorbezetting van 60% resulteren de volgende besparingen:

- Een vermogensreductie van de koelmachine van minimaal 40%
- Elektriciteitsbesparing van 6,2 kWh(e) per m^2 per jaar.
- Gasbesparing van 2,8 m^3 aardgas per m^2 per jaar.
- Een reductie van 7,8 Kg CO^2 per m^2 per jaar.

PCM klimaatplafond					
Gezondheid 1)	Klasse	II		I	
Thermische behaaglijkheid 1)	Klasse	II	I	II	I
Ventilatielucht	m^3/h per m^2	5,0 2)	5,0 2)	7,5	7,5
Luchttoevoer temperatuur	°C	16	16	16	16
Primair koelvermogen	W/m^2	17	16	25	24
Secundair PCM koelvermogen 4) 5)	W/m^2	36	32	36	32
Totaal koelvermogen 3)	W/m^2	53	48	61	56
Verwarmingsvermogen	W/m^2	35	40	35	40

1) Kwaliteitsklasse volgens NEN 15251 • 2) Minimaal ventilatiedebiet volgens het Nederlands bouwbesluit
3) Meetnorm klimaatplafonds EN-14240 • 4) Meetprocedure volgens RAL PCM Gütegeimschaft
5) Voor een 100% beleggingsgraad

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Bijlage I


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PCM inductie-unit

Door toepassing van PCM inductie-units worden de leefzones van een gebouw op een comfortabele, gezonde en duurzame wijze geklimatiseerd. PCM is de Engelse afkorting voor Phase Change Material. In het Nederlands: fase-overgangsmateriaal. Het toegepaste PCM gaat bij opname en afgifte van warmte over van een vaste naar een vloeibare aggregatietoestand. Het smelten en bevriezen van het PCM vindt plaats bij een smelttemperatuur van 20°C en een stoltemperatuur van 19°C. Het fase-overgangsmateriaal wordt op een gepatenteerde wijze verpakt in polipropyleen panelen. Deze PCM panelen worden op een gepatenteerde wijze als koelbatterij geïnstalleerd in plafond inductie convectoren.

De werking

Een PCM-warmtewisselaar bestaat uit samengestelde PCM panelen die samen de PCM batterij vormen. Voor de benodigde inducerende werking van de PCM inductie-unit wordt intern een nozzle plaat toegepast. Doordat de primaire lucht door deze nozzles wordt geïnjecteerd, ontstaat er een onderdruk boven de PCM warmtewisselaar. Deze onderdruk zorgt voor een luchtstroom vanuit de ruimte langs de panelen van de PCM warmtewisselaar, waardoor de lucht gekoeld wordt.

Koelen

Als de ruimtetemperatuur overdag ten gevolge van de vrije interne warmteproductie hoger wordt dan 20°C, dan zal er een warmtestroom optreden vanuit de recirculatielucht uit de ruimte richting de PCM warmtewisselaar. Het PCM materiaal neemt dan, gezien vanuit de ruimte warmte op en zal smelten. Het PCM materiaal koelt de ruimte.

Verwarmen

Als 's nachts de vrije interne warmtebronnen niet meer aanwezig zijn, zal de ruimtetemperatuur dalen tot onder de 19°C en treedt er een warmtestroom op van de PCM warmtewisselaar naar de ruimte. Het PCM materiaal zal dan weer invriezen en gelijktijdig de ruimte verwarmen.

Voordelen

Met PCM inductie-units zijn de volgende voordelen te behalen:

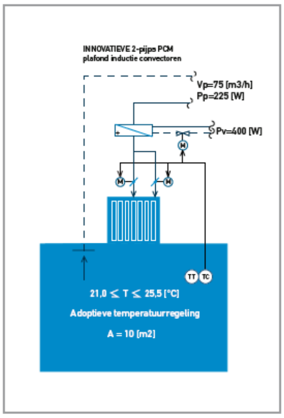
- Een gezond en thermisch comfortabel binnenklimaat.
- Een reductie van het te installeren koel- en verwarmingsvermogen
- Een besparing op de elektriciteit en gas kosten
- Maar 2 leidingen voor verwarming, i.p.v. 4 leidingen voor verwarmen en koelen.
- Reductie van de elektrische voeding en trafovermogen.
- Een reductie van het energiegebruik door beter gebruik van vrije nachtkoeling.
- Lagere installatie- en onderhoudskosten voor de koelmachine
- Besparing op de onderhoudskosten, geringere koudemiddelinhoud van de koelmachine.
- De polipropyleen PCM batterij zal minder vervuilen minder.
- Een volledig recyclebare "Cradle to Cradle" PCM inductie-unit.

Energiebesparing

Indien wij uitgaan van een kantoor met 1 stuks PCM inductie-unit per 10 m² en 2600 gebruiksuren per jaar dan bedraagt de energiebesparing:

- Op koeling 9,3 kWh(e) per m² NVO per jaar.
- Op verwarming 1,9 m³ aardgas per m² NVO per jaar.

PCM inductie unit		Type	50			75		
Type			50-12	50-18	50-24	75-12	75-18	75-24
Primair	Luchthoeveelheid primair (Vp)	m³/h	50			75		
	Intrede luchtconditie	°C	16,0			16,0		
	Voelbaar koelvermogen1) (Pp)	W	170			250		
Secundair	Luchthoeveelheid secundair (Vs)	m³/h	150			225		
	PCM smelt / stoltemperatuur3)	°C	20 / 18			20 / 18		
	PCM panelen	stuks	12	18	24	12	18	24
	Voelbaar koelvermogen1) (Ps)	W	80	130	180	100	150	200
Totale luchthoeveelheid (Vt)		W	200			300		
Totaal koelvermogen1) (Pt)		W	250	300	350	350	400	450
Koelvermogen per (m²) 2)		W/m²	25	30	35	35	40	45
Benodigde primaire voordruk		Pa	75			160		
Geluiddrukniveau 4)		dB(A)	32			32		
Afmetingen		mm	595x1195x410			595x1195x410		
Gewicht inductie-unit		kg	44	58	70	44	58	70
Gewicht PCM batterij		kg	43	61	79	43	61	79
Kleur rooster		kleur	Standaard in RAL 9010			Standaard in RAL 9010		
Aansluiting primaire lucht		mm	ø 100			ø 100		
Aansluiting regeneratielucht		mm	ø 125			ø 125		
Elektrische aansluiting		V/A/Hz	n.v.t.			n.v.t		



1) Koelvermogens op basis van NEN 15251, prestatiekwaliteit II • 2) Voelbaar koelvermogen op basis van ISSO 48, één unit per 10 m² vloeroppervlak
3) Smelt- en stoltemperatuur op basis van RAL PCM Gütegemeinschaft • 4) Op basis van LP ISO tabel totaal geluiddruk niveau in de leefzone

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Bijlage J

TERUGVERDIENTIJD/OPBRENGSTEN			
Prijsontwikkeling	6%		
Terugverdientijd (gelijkblijvend energietarief)	-627,9	jaar	
INVESTERINGEN	-€ 1.780		
Meer		Minder	
inductie-units	€ 5.950	koudeopwekking	-€ 3.660
		distributie	-€ 4.070
Totaal:	€ 5.950	Totaal:	-€ 7.730
VARIABELEN	€ 3		
verwarming			
verbruik met PCM	14410	kWh/jaar	
verbruik zonder PCM	14960	kWh/jaar	
COP	4	-	
Energieprijs	0,27	€/kWh of €/m3	
	-€ 37	€/jaar	
koeling			
verbruik met PCM	1950	kWh/jaar	
verbruik zonder PCM	3150	kWh/jaar	
COP	100	-	
Energieprijs	0,27	€/kWh of €/m3	
	-€ 3	€/jaar	
Ventilatie			
verbruik met PCM	570	kWh/jaar	
verbruik zonder PCM	410	kWh/jaar	
Energieprijs	0,27	€/kWh	
	€ 43	€/jaar	
OPBRENGSTEN			
0 jaar	€ 1.780		
5 jaar	€ 1.777		
10 jaar	€ 1.774		
15 jaar	€ 1.771		
30 jaar	€ 1.768		

Invoer		
T,pcm	22	°C
Warmtecap. gebouw	110000	J/m²
Warmtecap. PCM	3000000	J/m²

Uitvoer voorjaar		
Tmax	25	°C
Tgem	19	°C
Tmin	15	°C
T>25,5°C	0	u
Q,secundair	38	kWh
Q,pcm, verwarmen	4	kWh
Q,pcm, koelen	3	kWh
Q,pcm,totaal	7	kWh
Cycli,vollast	4	stuks
Cycli per dag	0,0	stuks

Uitvoer zomer		
Tmax	30	°C
Tgem	21	°C
Tmin	15	°C
T>25,5°C	110	u
Q,secundair	11	kWh
Q,pcm, verwarmen	12	kWh
Q,pcm, koelen	12	kWh
Q,pcm,totaal	24	kWh
Cycli,vollast	14	stuks
Cycli per dag	0,1	stuks

Uitvoer najaar		
Tmax	26	°C
Tgem	20	°C
Tmin	15	°C
T>25,5°C	14	u
Q,secundair	26	kWh
Q,pcm, verwarmen	7	kWh
Q,pcm, koelen	6	kWh
Q,pcm,totaal	13	kWh
Cycli,vollast	8	stuks
Cycli per dag	0,1	stuks

Uitvoer winter		
Tmax	24	°C
Tgem	19	°C
Tmin	15	°C
T>25,5°C	0	u
Q,secundair	43	kWh
Q,pcm, verwarmen	1	kWh
Q,pcm, koelen	1	kWh
Q,pcm,totaal	1	kWh
Cycli,vollast	1	stuks
Cycli per dag	0,0	stuks

Uitvoer jaar		
Tmax	30	°C
Tgem	20	°C
Tmin	15	°C
T>25°C	124	u
Q,secundair	118	kWh
Q,pcm, verwarmen	24	kWh
Q,pcm, koelen	22	kWh
Q,pcm,totaal	46	kWh
Cycli,vollast	27	stuks
Cycli per dag	0,3	stuks
Pkoelbatterij	13	kWh
Pverw. Batterij	12	kWh

GTO uren	121	u

Bijlage L

Invoer		
T,pcm	21	ºC
Tot. warmtecap. gebouw	11440000	J
Tot. warmtecap. PCM	232200000	J

Uitvoer voorjaar		
Tmax	23	ºC
Tgem	19	ºC
Tmin	15	ºC
T>25,5ºC	0	u
Q,secundair	4249	kWh
Q,pcm, verwarmen	472	kWh
Q,pcm, koelen	196	kWh
Q,pcm,totaal	668	kWh
Cycli,vollast	402	stuks
Cycli per dag	4,1	stuks

Uitvoer zomer		
Tmax	24	ºC
Tgem	21	ºC
Tmin	15	ºC
T>25,5ºC	0	u
Q,secundair	1654	kWh
Q,pcm, verwarmen	641	kWh
Q,pcm, koelen	509	kWh
Q,pcm,totaal	1151	kWh
Cycli,vollast	18	stuks
Cycli per dag	0,2	stuks

Uitvoer najaar		
Tmax	24	ºC
Tgem	20	ºC
Tmin	15	ºC
T>25,5ºC	0	u
Q,secundair	3014	kWh
Q,pcm, verwarmen	450	kWh
Q,pcm, koelen	288	kWh
Q,pcm,totaal	738	kWh
Cycli,vollast	445	stuks
Cycli per dag	4,5	stuks

Uitvoer winter		
Tmax	23	ºC
Tgem	19	ºC
Tmin	14	ºC
T>25,5ºC	0	u
Q,secundair	5497	kWh
Q,pcm, verwarmen	265	kWh
Q,pcm, koelen	204	kWh
Q,pcm,totaal	469	kWh
Cycli,vollast	283	stuks
Cycli per dag	2,9	stuks

Uitvoer jaar		
Tmax	23,9	ºC
Tgem	19,8	ºC
Tmin	14,4	ºC
T>25ºC	0,0	u
Q,secundair	14414	kWh
Q,pcm, verwarmen	1828	kWh
Q,pcm, koelen	1197	kWh
Q,pcm,totaal	3026	kWh
Cycli,vollast	23,5	stuks
Cycli per dag	0,1	stuks
Pkoelbatterij	1953	kWh
Pverw. Batterij	2950	kWh

GTO uren	0	u

Bijlage M

Invoer		
Tpcm	22	°C
Qmin voor regenereren	99	kWh

Uitvoer		
Ppcm koelen	1317	kWh
Qpcm max	119	kWh
Pkoelbatterij	9798	kWh
Pvent, PCM	1128	kWh
Pref	10979	kWh
Pvent, ref	1001	kWh
Besparing	1181	kWh
procentuele reductie	11	%
Besparing elektriciteit in zomer	13,17	€