

This invention relates to a moulding, preferably in the form of a panel, for use as heat insulation and to a process for its production.

5 It is known that heat insulation panels or flat heat insulation elements can be produced from precipitated silica. The panels are evacuated and provided with a multilayer envelope.

10 Thus, EP-A 0 190 582 and EP-A 0 254 993 describe an envelope of composite films which additionally contain a metal foil, for example of aluminium. These films are intended to be air-tight and water-tight.

15 EP-B 0 164 006 describes heat insulation panels which contain fine-particle metal oxides and are evacuated. The envelope material may be a composite film of thermoplastic material/metal foil/thermoplastic material in that order.

20 Published Japanese patent application Sho 62-207 777 (12.09.1987) describes heat-insulating elements which are produced by introducing perlite or other slightly porous materials into a container of heat-sealable plastic laminate and then evacuating the interior of the container. Heat-sealed heat insulating elements consist of 25  $\mu\text{m}$  thick plastic laminate having a permeability to water vapour of 1.0  $\text{g/m}^2 \cdot \text{d}$  at 38°C/90% relative air humidity and a permeability to oxygen of 2.0  $\text{cm}^3/\text{m}^2 \cdot \text{d}$  at 23°C/90% relative humidity. The laminates consist of vinylidene chloride/vinyl chloride copolymer to at least one side of which an aluminium layer between 1 and 1,000 Angströms thick is applied by vapour deposition. At least one laminate layer is used.

30 The known use of metal-coated composite films has the disadvantage that heat can be conducted parallel to the film surface. Where the composite films are used in insulation materials, this results in unwanted heat bridges at the edges of the heat insulation element between the cold side and the warm side.

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The accompanying adverse effect on the overall thermal conductivity of a heat insulation element is not taken into account in the measurement of thermal conductivity by the Kohlrausch absolute one-plate method with protective ring (F. Kohlrausch: "Praktische Physik", Vol. 1, 22nd Edition, B.G. Teubner Verlag, Stuttgart, 1968, pages 375 *et seq.*).

A heat insulation element produced in accordance with EP-A 0 190 582 using a metal-containing film has a thermal conductivity of 8 mW/(m.K) at 23°C, as measured by the method mentioned above. If a measuring arrangement without the protective ring is used, the thermal conductivity rises to higher values, in some cases considerably higher values, in dependence upon the geometry and size of the moulding and the thickness of the metal layer in the film envelope.

Accordingly, the insulation capacity of the heat insulation element as a whole also depends critically on whether or not the film envelope used in the production of the element contains metal.

Earlier patent applications DE-OS 39 15 170 and DE-OS 40 08 490.9 describe elements for use as heat insulation which consist of a fine-particle, powder-form or fibrous material, which has a water absorption capacity of 4 to 50% by weight at 23°C/85% relative humidity, and a metal-free envelope which surrounds this fine-particle, powder-form or fibrous material and has permeabilities to water vapour of 0.1 to 0.5 g/m<sup>2</sup>/d or 0.02 to 0.1 g/m<sup>2</sup>/d at 23°C/85% relative humidity and gas permeabilities of 0.1 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar or - for the gases N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> - a total gas permeability of 0.05 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C.

These known insulation elements only retain their low thermal conductivity for about 3 years or 7.2 years under the conditions mentioned.

However, when used in refrigerators, the heat insulation panels are required to retain their low thermal conductivity for longer periods.

Accordingly, the problem addressed by the present invention was to provide heat insulation elements which would have a long useful life and which, in addition, would not have any heat bridges produced by metallic constituents of the envelope at the edges of the heat insulation panel  
5 between the cold side and the warm side.

The present invention relates to a moulding, preferably in the form of a panel, for use as heat insulation produced from

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- a) a fine-particle, powder-form or fibrous material which has a water absorption capacity of 4 to 50% by weight at 23°C/85% relative humidity,
- b) an asymmetrical envelope of two parts which contains  
15 the fine-particle, powder-form or fibrous material, the first part of the envelope being a metal-free multilayer film having the following composition:

20

|       |                                  |
|-------|----------------------------------|
| LLPDE | linear polyethylene              |
| CA    | coupling agent                   |
| EVOH  | ethylene/vinyl alcohol copolymer |
| CA    | coupling agent                   |
| LLPDE | linear polyethylene              |
| PVDC  | polyvinylidene chloride          |

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and being recessed (thermoformed) in such a way that the resulting trough is completely filled by the optionally dried and optionally compressed powder-form or fibrous material and the second part ("cover") being a metal-containing multilayer film having the following composition:

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polyester  
CA  
Al foil

CA  
polyethylene

5 which may be flat and joined to the trough in such a way that a closure impermeable to gases and water vapour is guaranteed and both parts having water vapour permeabilities of 0 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative humidity and gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C,

10 with the capacity to absorb water in a quantity of 2 to 15% by weight without losing more than 25% of its thermal conductivity.

15 An asymmetrical envelope has the advantage that the cover films (second part of the envelope) may even be metal-containing flat films which have very low permeabilities to water vapour of 0 to 0.02 g/m<sup>2</sup>/d at 23°C/85% relative humidity and low gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C without any heat  
20 bridges occurring in the flat films, so that the life of the heat insulation elements can again be distinctly extended.

The heat insulation element according to the invention may be evacuated. The internal pressure is preferably of  
25 the order of 1 mbar.

The compacted bulk density of the fine-particle material present in the heat insulation element may be in the range from 40 to 200 g/l and is preferably in the range from 50 to 120 g/l.

30 The fine-particle, powder-form or fibrous material may be press-moulded in a microporous envelope.

The fine-particle, powder-form or fibrous material may be dried in a microporous envelope.

In one preferred embodiment, the microporous envelope  
35 which contains the fine-particle, powder-form or fibrous

material in press-moulded and dried form may be introduced into the two-part asymmetrical envelope, a metal-containing film preferably being used as the cover film.

5 The moulding according to the invention may be produced by

- 10 a) optionally drying a fine-particle, powder-form or fibrous material, which has a water absorption capacity of 4 to 50% by weight (at 23°C/85% relative humidity) under conditions which are sufficient to remove the surface water,
- b) optionally press-moulding the powder-form or fibrous material, optionally using a compression mould,
- 15 c) introducing the optionally dried and optionally press-moulded powder-form or fibrous material into the recessed (thermoformed) metal-free part of the envelope which has a permeability to water vapour of 0.02 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative humidity and gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0.05 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C,
- 20 d) evacuating the optionally dried and optionally press-moulded powder-form or fibrous material in the recessed (thermoformed) part of the envelope to a pressure of 0.1 to 1 mbar,
- 25 e) joining the second metal-free or metal-containing and flat part of the envelope, which has a permeability to water vapour of 0 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative humidity and gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C, *in vacuo* to the
- 30 first metal-free part of the envelope in such a way that the vacuum is maintained in the interior of the envelope and a closure impermeable as far as possible to gases and water vapour is formed.

35 In a preferred embodiment of the process according to

the invention, the asymmetrical two-part envelope may be evacuated to between 0.1 and 1 mbar.

In a preferred embodiment of the process according to the invention, the fine-particle, powder-form or fibrous material may be dried in a microporous envelope.

In a particularly preferred embodiment of the process according to the invention, the fine-particle, powder-form or fibrous material may be press-moulded and optionally dried in a microporous envelope.

In a preferred embodiment of the invention, the fine-particle, powder-form or fibrous material may be dried by microwaves.

A film or a nonwoven, for example of polypropylene, polyester or filter paper (cellulose), may be used as the microporous envelope which, in principle, performs the function of holding the fine-particle, powder-form material together during drying and press-moulding.

In general, a film or a material which is permeable to gases (for example air) and moisture and which retains the fine-particle, powder-form material may be used for this purpose.

In principle, any material of which the chemical properties do not change with time and which has a water absorption capacity of 4 to 50% by weight at 23°C/85% relative humidity may be used as the fine-particle, powder-form material.

The quantity of water which the moulding according to the invention may absorb corresponds to the quantity of water at which the thermal conductivity of the moulding is not increased by more than 25%. Accordingly, the permitted water content of the moulding is from 2 to 15% by weight and is generally lower than the water absorption capacity of the powder-form material used for the production of the moulding.

In a preferred embodiment, the quantity of water which

may be absorbed by the moulding is between 5 and 12% by weight and more particularly between 6 and 7% by weight.

5 The quantity of gas which may permeate into the heat insulation elements according to the invention corresponds to the quantity of gases (such as for example  $N_2$ ,  $O_2$  and  $CO_2$  at which the thermal conductivity is increased by no more than 25%.

10 Accordingly, the permitted internal pressure in the heat insulation element is at most 20 mbar for an initial pressure of 1 mbar.

15 A preferred embodiment is characterized by the use of a fine-particle silicon dioxide material which is produced by reaction of an alkali waterglass and a mineral acid to precipitate the silicon dioxide which is used either on its own or in admixture with other silicas or powder-form or fibrous materials.

Precipitated silicas of this type are described, for example, in Ullmann's Enzyklopädie der technischen Chemie, 4th Edition, Vol. 21, pages 462 *et seq.*

20 The following precipitated silicas, for example, are suitable for the production of the mouldings according to the invention: Sipernat 22 S, Sipernat 22 LS, Sipernat 50 S, FK 500 LS, FK 500 DS, FK 320 DS, FK 310, FK 700 DS.

25 Precipitated silicas which have been spray-dried and ground are particularly suitable.

Precipitated silicas such as these are commercially available under the names FK 500 LS, FK 500 DS or Sipernat 22 LS.

30 Other suitable precipitated silicas are described in US-PS 4,495,167 (Degussa).

35 The following materials or combinations of materials may be used, optionally after incorporation of organic or inorganic fibers, such as glass, ceramic or synthetic fibers, for mechanically stabilizing the heat insulation elements:

- mixtures of various precipitated silicas, such as for example Sipernat 22 LS and FK 500 LS, Sipernat 22 LS and FK 320 DS, FK 500 LS and FK 320 DS, FK 500 LS and FK 500 DS, FK 500 LS and FK 700 DS, FK 700 DS and FK 310;
- 5 mixtures of precipitated and pyrogenic silicas, such as for example Sipernat 22 LS, FK 320 DS, FK 310, FK 700 DS and/or FK 500 LS with Aerosil A 200 and/or Aerosil A 300;
- mixtures of precipitated silicas and silica gels, such as Sipernat 22 LS, FK 320 DS and/or FK 500 LS with silica gels (for example the types Syloid 72 and Syloid 244, products of Grace, Worms);
- 10 mixtures of precipitated silicas and mineral materials, such as for example Sipernat 22 LS, FK 320 DS and/or FK 500 LS with perlites, kaolinite, montmorillonite, mica and/or calcium sulfate (gypsum);
- 15 mixtures of precipitated silicas and ground glasses or glass-like materials, such as for example Sipernat 22 LS, FK 320 DS, FK 500 DS and/or FK 500 LS with glass powder and/or very fine glass wool;
- 20 mixtures of precipitated silicas and carbon blacks, such as for example Sipernat 22 LS, FK 320 DS, FK 500 DS and/or FK 500 LS with furnace blacks, lamp blacks and/or gas blacks;
- mixtures of precipitated silicas and synthetic or natural silicate materials, such as for example Sipernat 22 LS, FK 320 DS, FK 500 DS and/or FK 500 LS with synthetic or natural zeolites or aluminium silicates or other silicate materials (calcium silicate, kieselguhr, Extrusil);
- 25 mixtures of precipitated silicas and synthetic waste materials, such as for example Sipernat 22 LS, FK 320 DS, FK 500 DS and/or FK 500 LS with flue dust, power station ash, ash from incineration plants of all kinds;
- 30 mixtures of precipitated silicas and non-metallic elements, such as for example Sipernat 22 LS, FK 320 DS, FK 500 DS and/or FK 500 LS with sulfur and/or ground coal;
- 35 mixtures of precipitated silicas and fibers, such as for

example Sipernat 22 LS, FK 320 DS, FK 500 DS and/or FK 500 LS with inorganic or organic fibers (rayon staple or fine synthetic fibers of all kinds);

5 mixtures of precipitated silicas, such as for example Sipernat 22 LS, FK 320 DS, FK 500 LS and/or FK 500 DS, and organic powder-form super-absorbers, such as polyacrylates for example;

10 mixtures of precipitated silicas and pyrogenic metal oxides, such as for example Sipernat 22 LS, FK 320 DS, FK 500 DS and/or FK 500 LS, with pyrogenic aluminium oxide, iron oxide and/or titanium dioxide;

pyrogenic silicas, such as for example Aerosil 200, Aerosil 300, Aerosil 380, Aerosil 450, OX 50, specially pretreated Aerosils, Aerosil MOX types, Aerosil COK 84;

15 mixtures of different pyrogenic silicas, such as for example Aerosil 200 or Aerosil 300, with specially pretreated Aerosils;

mixtures of pyrogenic silicas and silica gels, such as for example Aerosil 200 and/or Aerosil 300 with silica gels

20 (for example the types Syloid 72 and Syloid 244, products of Grace, Worms);

mixtures of pyrogenic silicas and mineral materials, such as for example Aerosil 200 and/or Aerosil 300 with perlites, kaolinite, montmorillonite, mica and/or calcium sulfate (gypsum);

25 mixtures of pyrogenic silicas and ground glasses or glass-like materials, such as for example Aerosil 200 and/or Aerosil 300 with glass powder and/or very fine glass wool;

mixtures of pyrogenic silicas and carbon blacks, gas blacks, such as for example Aerosil 200 and/or Aerosil 300

30 with furnace blacks, lamp blacks and/or gas blacks;

mixtures of pyrogenic silicas and synthetic or natural silicates, such as for example Aerosil 200 and/or Aerosil 300 with synthetic or natural zeolites or aluminium silicates or other silicate materials (calcium silicate,

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- kieselguhr, Extrusil);
- mixtures of pyrogenic silicas and synthetic waste materials, such as for example Aerosil 200 and/or Aerosil 300 with flue dusts, power station ash, ash from incineration plants of all kinds;
- 5 mixtures of pyrogenic silicas and non-metallic elements, such as for example Aerosil 200 and/or Aerosil 300 with sulfur and/or ground coal;
- mixtures of pyrogenic silicas and fibers, such as for example Aerosil 200 and/or Aerosil 300 with inorganic or organic fibers (rayon staple or fine synthetic fibers);
- 10 mixtures of pyrogenic silicas, such as for example Aerosil 200 and/or Aerosil 300, and powder-form super-absorbers, such as polyacrylates for example;
- 15 mixtures of pyrogenic silicas and pyrogenic metal oxides, such as for example Aerosil 200 and/or Aerosil 300 with pyrogenic aluminium oxide, iron oxide, titanium dioxide;
- mixtures of carbon blacks and silica gels, such as for example carbon blacks or carbon black mixtures with silica gels (for example the types Syloid 72 and Syloid 244, products of Grace, Worms);
- 20 mixtures of carbon blacks and mineral materials, such as for example carbon blacks or carbon black mixtures with montmorillonite and/or calcium sulfate (gypsum);
- 25 mixtures of carbon blacks and synthetic or natural silicate materials, such as for example carbon blacks or carbon black mixtures with synthetic or natural zeolites or aluminium silicates or other silicate materials (calcium silicate, kieselguhr, Extrusil);
- 30 mixtures of carbon blacks and powder-form super-absorbers, such as polyacrylates for example;
- mixtures of carbon blacks and pyrogenic metal oxides, such as for example carbon blacks or carbon black mixtures with pyrogenic aluminium oxide, iron oxide, titanium dioxide;
- 35 zeolites (zeolitic molecular sieves), such as for example

- zeolite A, zeolite X, zeolite Y, pretreated zeolites;  
mixtures of different zeolites, such as for example zeolite X with zeolite Y;  
mixtures of zeolites and silica gels, such as for example  
5 zeolites or zeolite mixtures with silica gels (for example the types Syloid 72 and Syloid 244, products of Grace, Worms);  
mixtures of zeolites and mineral materials, such as for example zeolites or zeolite mixtures with perlites, kaolin-  
10 ite, montmorillonite, mica and/or calcium sulfate (gypsum);  
mixtures of zeolites and ground glasses or glass-like materials, such as for example zeolites or zeolite mixtures with glass powder and/or very fine glass wool;  
mixtures of zeolites and synthetic or natural silicate  
15 materials, such as for example zeolite or zeolite mixtures with synthetic aluminium silicates or other silicate materials (calcium silicate, kieselguhr, Extrusil);  
mixtures of zeolites and synthetic waste materials, such as for example zeolites or zeolite mixtures with flue dusts,  
20 power station ash, ash from incineration plants of all kinds;  
mixtures of zeolites and non-metallic elements, such as for example zeolites or zeolite mixtures with sulfur and/or ground coal;  
25 mixtures of zeolites and fibers, such as for example zeolites or zeolite mixtures with inorganic or organic fibers (rayon staple or fine synthetic fibers);  
mixtures of zeolites and powder-form super-absorbers, such as polyacrylates for example;  
30 mixtures of zeolites and pyrogenic metal oxides, such as for example zeolites or zeolite mixtures with pyrogenic aluminium oxide, iron oxide, titanium dioxide;  
silica gels, such as for example Syloid 72 (a product of Grace, Worms) Syloid 244 (a product of Grace, Worms);  
35 mixtures of different silica gels, such as for example

- Syloid 72 with Syloid 244 (products of Grace, Worms), differently pretreated silica gels;
- 5 mixtures of silica gels and mineral materials, such as for example silica gels or silica gel mixtures with perlites, kaolinite, montmorillonite, mica and/or calcium sulfate (gypsum);
- 10 mixtures of silica gels and ground glasses or glass-like materials, such as for example silica gels or silica gel mixtures with glass powder and/or very fine glass wool;
- 10 mixtures of silica gels and synthetic or natural silicate materials, such as for example silica gels or silica gel mixtures with synthetic aluminium silicates or other silicate materials (calcium silicate, kieselguhr, Extrusil);
- 15 mixtures of silica gels and synthetic waste materials, such as for example silica gels or silica gel mixtures with flue dust, power station ash, ash from incineration plants of all kinds;
- 20 mixtures of silica gels and non-metallic elements, such as for example silica gels or silica gel mixtures with sulfur and/or ground coal;
- mixtures of silica gels and fibers, such as for example silica gels or silica gel mixtures with inorganic or organic fibers (rayon staple or fine synthetic fibers);
- 25 mixtures of silica gels and powder-form super-absorbers, such as polyacrylates for example;
- mixtures of silica gels and pyrogenic metal oxides, such as for example silica gels or silica gel mixtures with pyrogenic aluminium oxide, iron oxide, titanium dioxide;
- 30 mixtures of different aluminium silicates, such as for example various aluminium silicate types, differently pretreated aluminium silicates;
- mixtures of aluminium silicates and mineral materials, such as for example aluminium silicates or aluminium silicate
- 35 mixtures with perlites, kaolinite, montmorillonite, mica

- and/or calcium sulfate (gypsum);  
mixtures of aluminium silicates and ground glasses or glass-like materials, such as for example aluminium silicates or aluminium silicate mixtures with glass powder  
5 and/or very fine glass wool;  
mixtures of aluminium silicates and synthetic or natural silicate materials, such as for example aluminium silicates or aluminium silicate mixtures with other silicate materials (calcium silicate, kieselguhr, Extrusil);  
10 mixtures of aluminium silicates and synthetic waste materials, such as for example aluminium silicates or aluminium silicate mixtures with flue dust, power station ash, ash from incineration plants of all kinds;  
mixtures of aluminium silicates and non-metallic elements,  
15 such as for example aluminium silicates or aluminium silicate mixtures with sulfur and/or ground coal;  
mixtures of aluminium silicates and fibers, such as for example aluminium silicates or aluminium silicate mixtures with inorganic or organic fibers (rayon staple or fine  
20 synthetic fibers of all kinds);  
mixtures of aluminium silicates and powder-form superabsorbers, such as polyacrylates for example;  
mixtures of aluminium silicates and pyrogenic metal oxides, such as for example aluminium silicates or aluminium  
25 silicate mixtures with pyrogenic aluminium oxide, iron oxide, titanium dioxide;  
metal oxides (pyrogenic or precipitated), such as for example aluminium oxide, iron oxides, titanium dioxide, zirconium dioxide;  
30 mixtures of different metal oxides (pyrogenic or precipitated), such as for example aluminium oxide with various iron oxides, aluminium oxide with titanium dioxide, titanium dioxide with various iron oxides;  
mixtures of metal oxides (pyrogenic or precipitated) and  
35 mineral materials, such as for example aluminium oxide,

various iron oxides, titanium dioxide and/or zirconium dioxide with perlites, kaolinite, montmorillonite, mica and/or calcium sulfate (gypsum);

5 mixtures of metal oxides (pyrogenic or precipitated) and ground glasses or glass-like materials, such as for example aluminium oxide, various iron oxides, titanium dioxide and/or zirconium dioxide with glass powder and/or very fine glass wool;

10 mixtures of metal oxides (pyrogenic or precipitated) and synthetic or natural silicate materials, such as for example aluminium oxide, various iron oxides, titanium dioxide and/or zirconium dioxide with silicate materials (calcium silicate, kieselguhr, Extrusil);

15 mixtures of metal oxides (pyrogenic or precipitated) and synthetic waste materials, such as for example aluminium oxide, various iron oxides, titanium dioxide and/or zirconium dioxide with flue dust, power station ash, ash from incineration plants of all kinds;

20 mixtures of metal oxides (pyrogenic or precipitated) and non-metallic elements, such as for example aluminium oxide, various iron oxides, titanium dioxide and/or zirconium dioxide with sulfur and/or ground coal;

25 mixtures of metal oxides (pyrogenic or precipitated) and fibers, such as for example aluminium oxides, various iron oxides, titanium dioxide and/or zirconium dioxide with inorganic or organic fibers (rayon staple or fine synthetic fibers of all kinds);

30 mixtures of metal oxides such as for example aluminium oxides, various iron oxides, titanium oxide and/or zirconium oxide (pyrogenic or precipitated) and super-absorbers, such as polyacrylates for example.

The following precipitated silicas may also be used:

HISIL T 600, HISIL T 690, products of PPG  
Tixosil 333, a product of Rhône-Poulenc  
35 Hoesch SM 614, a product of AKZO

Zeothix 265 and Zeothix 177, products of Huber.

The envelopes of two asymmetrical parts which may be used in accordance with the invention may have a permeability to water vapour of 0.02 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative humidity and gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0.05 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar in the region of the metal-free and recessed (thermoformed) envelope and a permeability to water vapour of 0 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative air humidity and gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C in the region of the metal-containing flat cover. The gas permeabilities have to be gauged in such a way that the internal pressure in the heat insulation element does not exceed 20 mbar over the life of the element. Since the gas permeabilities are lower by a factor of approximately 1,000 than the permeability to water vapour, the maximum life of the heat insulation element is reached when no more water vapour can be absorbed by the filler or if there is a drastic increase in thermal conductivity through the continuing absorption of water vapour.

The metal-free envelope used in accordance with the invention may with advantage be a multilayer film having the following structure:

|    |       |                                  |
|----|-------|----------------------------------|
| 25 | LLPDE | linear polyethylene              |
|    | HV    | coupling agent                   |
|    | EVOH  | ethylene/vinyl alcohol copolymer |
|    | HV    | coupling agent                   |
|    | LLPDE | linear polyethylene              |
| 30 | PVDC  | polyvinylidene chloride          |

More particularly, the multilayer film may have the following structure (Example 1):

|    |       |                                                |
|----|-------|------------------------------------------------|
| 35 | LLPDE | linear polyethylene, thickness 65 μm, specific |
|----|-------|------------------------------------------------|

|    |       |                                                                                            |
|----|-------|--------------------------------------------------------------------------------------------|
|    |       | gravity 0.92 g/cm <sup>3</sup>                                                             |
|    | HV    | coupling agent, thickness 5 μm, specific gravity 0.92 g/cm <sup>3</sup>                    |
| 5  | EVOH  | ethylene/vinyl alcohol copolymer, thickness 10 μm, specific gravity 1.17 g/cm <sup>3</sup> |
|    | HV    | coupling agent, thickness 5 μm, specific gravity 0.92 g/cm <sup>3</sup>                    |
|    | LLPDE | linear polyethylene, thickness 65 μm, specific gravity 0.92 g/cm <sup>3</sup>              |
| 10 | PVDC  | polyvinylidene chloride, thickness 12 μm, specific gravity 1.35 g/cm <sup>3</sup>          |

15 The metal-containing envelope ("cover") used in accordance with the invention may advantageously be a multilayer film having the following structure:

Polyester  
HV  
Al foil  
20 HV  
Polyethylene

25 More particularly, the multilayer film (cf. H. Hinksen, Kunststoffe 77 (1987/5) may have the following structure (Example 2):

|    |         |                                                                                      |
|----|---------|--------------------------------------------------------------------------------------|
|    | PETP    | polyethylene terephthalate, thickness 12 μm, specific gravity 1.37 g/cm <sup>3</sup> |
| 30 | HV      | coupling agent, thickness 5 μm, specific gravity 1.37 g/cm <sup>3</sup>              |
|    | Al foil | aluminium foil, thickness 9 μm, specific gravity                                     |
|    | HV      | coupling agent, thickness 5 μm, specific gravity 0.92 g/cm <sup>3</sup>              |
| 35 | PE      | polyethylene, thickness 75 μm, specific gravity 0.92 g/m <sup>3</sup>                |

Any fine-particle, powder-form or fibrous materials which have a water absorption capacity of 4 to 50% by weight (at 23°C/85% relative humidity) are suitable for the mouldings according to the invention. The quantity of water which the fine-particle materials may absorb during their use in the element according to the invention is generally smaller than their water absorption capacity. The limit to the permitted water absorption in the heat insulation element corresponds to the quantity of water at which the thermal conductivity of the element has increased by no more than 25% in relation to the dry element. A fine-particle material dried in accordance with DIN 55 921 is used for the production of a dry element. The corresponding quantity of water which a heat insulation element may absorb is preferably between 2 and 15% by weight, based on the dry filler.

The heat insulation elements according to the invention have the advantage over state-of-the-art heat-insulation elements that, through the use of metal-free film envelopes or asymmetrical envelopes, the thermal conductivity at the edges of the heat insulation elements is so low that the very good overall thermal conductivity of the elements of the order of 8 mW/(m.K) (as measured by the absolute one-plate method with protective ring on heat insulation materials produced from the precipitated silica FK 500 LS) is only minimally affected, if at all.

For example, insulation layers for the insulation of refrigerators and freezers may be produced from the heat insulation elements according to the invention.

Examples of the thermal conductivities of heat insulation elements produced with a metal-free film envelope or asymmetrical envelopes are shown in the following Table. The thermal conductivities were measured by the absolute one-plate method with protective ring and by a method with no protective ring. In the second method (no protective

ring), heat flows passing through the film envelope from one side of a panel-like heat insulation element to the other are not compensated and the measured value obtained represents the overall thermal conductivity of the heat insulation element (dependent upon the geometry and size of the element).

Filling: FK 500 LS

Dimensions: 250 mm x 250 mm x 20 mm

Thermal conductivities of various heat insulation elements as a function of the measuring method (average temperature: approx. 0°C)

| Type of heat insulation element                                          | Method for measuring thermal conductivity      |                                          |
|--------------------------------------------------------------------------|------------------------------------------------|------------------------------------------|
|                                                                          | Absolute one-plate method with protective ring | One-plate method with no protective ring |
| Heat insulation element                                                  |                                                |                                          |
| Metal-free envelope or asymmetrical envelopes according to the invention | 8 mW/m/K                                       | approx. 9 mW/m/K                         |

The powder-form or fibrous materials used in accordance with the invention are characterized, for example, by the physical/chemical data listed in Tables 1, 2, 3 and 4 below:

Table 1

| AEROSIL                                                | AEROSIL | AEROSIL | AEROSIL           | AEROSIL | 200     | 300     | 380     | OX 50   | COK 84  |
|--------------------------------------------------------|---------|---------|-------------------|---------|---------|---------|---------|---------|---------|
| BET surface                                            |         |         | m <sup>2</sup> /g |         | 200±25  | 300±30  | 300±30  | 50±15   | 170±30  |
| Average primary particle size                          |         |         | Nanometers        |         | 12      | 7       | 7       | 40      | -       |
| Compacted bulk density 1)                              |         |         | g/l               |         | ca. 50  | ca. 50  | ca. 50  | ca. 130 | ca. 50  |
| Drying loss 2) (2h at 105°C) on<br>leaving the factory |         |         | %                 |         | < 1.5   | < 1.5   | < 1.5   | < 1.5   | < 1.5   |
| Ignition loss 2) 7) (2H at 1,000°C)                    |         |         | %                 |         | < 1     | < 2     | < 2.5   | < 1     | < 1     |
| pH value 3) (4% aqueous dispersion)                    |         |         |                   |         | 3.6-4.3 | 3.6-4.3 | 3.6-4.3 | 3.8-4.5 | 3.6-4.3 |
| SiO <sub>2</sub> 5)                                    |         |         | %                 |         | > 99.8  | > 99.8  | > 99.8  | > 99.8  | 82-86   |
| Al <sub>2</sub> O <sub>3</sub> 5)                      |         |         | %                 |         | < 0.05  | < 0.05  | < 0.05  | < 0.08  | 14-18   |
| Fe <sub>2</sub> O <sub>3</sub> 5)                      |         |         | %                 |         | < 0.003 | < 0.003 | < 0.003 | < 0.01  | < 0.1   |
| TiO <sub>2</sub> 5)                                    |         |         | %                 |         | < 0.03  | < 0.03  | < 0.03  | < 0.03  | < 0.03  |
| HCl 5) 10)                                             |         |         | %                 |         | < 0.025 | < 0.025 | < 0.025 | < 0.01  | < 0.1   |
| Mocker sieving residue (45 μm) 4)                      |         |         | %                 |         | < 0.05  | < 0.05  | < 0.05  | < 0.1   | < 0.1   |

- 1) according to DIN 52 194
- 2) according to DIN 55 921
- 3) according to DIN 53 200
- 4) according to DIN 53 580
- 5) based on the substance calcined for 2 hours at 1,000°C
- 7) based on the substance dried for 2 hours at 105°C
- 10) the HCl content is part of the ignition loss

## 10 Table 2

## Extrusil

|    |                                                     |                   |      |
|----|-----------------------------------------------------|-------------------|------|
|    | BET surface 1)                                      | m <sup>2</sup> /g | 35   |
|    | Average agglomerate size                            | μm                | 5 8) |
| 15 | Compacted bulk density 2)                           | g/l               | 300  |
|    | Drying loss (2h at 105°C) on leaving the factory 3) | %                 | 6    |
|    | Ignition loss (2h at 1,000°C) 4) 10)                | %                 | 7    |
|    | pH value (5% aqueous dispersion) 5)                 |                   | 10   |
| 20 | DBP absorption 6) 10)                               | g/100 g           | 160  |
|    | SiO <sub>2</sub> 11)                                | %                 | 91   |
|    | Al <sub>2</sub> O <sub>3</sub> 11)                  | %                 | 0.2  |
|    | CaO 11)                                             | %                 | 6    |
|    | Na <sub>2</sub> O 11)                               | %                 | 2    |
| 25 | Fe <sub>2</sub> O <sub>3</sub> 11)                  | %                 | 0.03 |
|    | SO <sub>3</sub> 11)                                 | %                 | -    |
|    | Cl- 11)                                             | %                 | 0.8  |
|    | Mocker sieving residue (45 μm) 7)                   | %                 | 0.2  |

- 30 1) according to DIN 66 131
- 2) according to DIN ISO 787/XI, JIS K 5101/78, (not sieved)
- 3) according to DIN ISO 787/II, ASTM D 280, JIS K 5101/21
- 35 4) according to DIN 55 921, ASTM D 1208, JIS K 5101/23

- 5) according to DIN ISO 787/IX, ASTM D 1208, JIS K 5101/24
- 6) according to DIN 53 601, ASTM D 2414
- 7) according to DIN ISO 787/XVIII, JIS K 5101/20
- 5 8) Coulter Counter, 100  $\mu\text{m}$  capillary
- 10) based on the substance dried for 2 hours at 105°C
- 11) based on the substance calcined for 2 hours at 1,000°C

10 Table 3

|    |                                                     |                   | FK 320<br>DS | FK 500<br>LS | SIPERNAT<br>22 LS |
|----|-----------------------------------------------------|-------------------|--------------|--------------|-------------------|
| 15 | BET surface 1)                                      | m <sup>2</sup> /g | 170          | 450          | 190               |
|    | Average agglomerate size                            | $\mu\text{m}$     | 4 9)         | 3.5 9)       | 4.5 9)            |
|    | Compacted bulk density 2)                           | g/l               | 80           | 80           | 80                |
| 20 | Drying loss (2h at 105°C) on leaving the factory 3) | %                 | 6            | 3            | 6                 |
|    | Ignition loss (2h at 1,000°C) 4) 10)                | %                 | 5            | 5            | 5                 |
| 25 | pH value (5% aqueous dispersion) 5)                 |                   | 6.3          | 6.5          | 6.3               |
|    | DBP absorption 6) 10)                               | g/100 g           | 230          | 330          | 270               |
|    | SiO <sub>2</sub> 11)                                | %                 | 98           | 98.5         | 98                |
|    | Na <sub>2</sub> O 11)                               | %                 | 1            | 0.6          | 1                 |
| 30 | Fe <sub>2</sub> O <sub>3</sub> 11)                  | %                 | 0.03         | 0.03         | 0.03              |
|    | SO <sub>3</sub> 11)                                 | %                 | 0.8          | 0.7          | 0.8               |
|    | Mocker sieving residue (45 $\mu\text{m}$ ) 7)       | %                 | 0.01         | 0.02         | 0.1               |

- 35 1) according to DIN 66 131
- 2) according to DIN ISO 787/XI, JIS K 5101/78, (not sieved)
- 3) according to DIN ISO 787/II, ASTM D 280, JIS K

5101/21

4) according to DIN 55 921, ASTM D 1208, JIS K 5101/23

5) according to DIN ISO 787/IX, ASTM D 1208, JIS K  
5101/24

5 6) according to DIN 53 601, ASTM D 2414

7) according to DIN ISO 787/XVIII, JIS K 5101/20

9) Coulter Counter, 50  $\mu$ m capillary

10) based on the substance dried for 2 hours at 105°C

10 11) based on the substance calcined for 2 hours at  
1,000°C

Table 4

| Manufacturer                |                     | Hoesch | Huber          |                | PPG            |                | Rhone<br>Poulenc | Grace        |               |
|-----------------------------|---------------------|--------|----------------|----------------|----------------|----------------|------------------|--------------|---------------|
| Type                        |                     | SM 614 | Zeothix<br>265 | Zeothix<br>177 | HiSil<br>T 600 | HiSil<br>T 690 | Tixosil<br>333   | Syloid<br>72 | Syloid<br>244 |
| SiO <sub>2</sub> content 1) | (%)                 | 87     | -              | -              | -              | -              | 97               | 99           | 99.5          |
| Drying loss 2)              | (%)                 | 6      | 7              | -              | 1-2            | 10             | -                | 1            | 4             |
| Ignition loss 2)            | (%)                 | 9      | -              | -              | -              | -              | ± 11             | 5            | 7             |
| pH value 3)                 |                     | 6      | 7              | 7              | 3.5            | 7              | 6.8              | 6            | 6             |
| BET surface                 | (m <sup>2</sup> /g) | -      | 260            | 175            | 200            | 150            | 300              | -            | -             |
| Average particle<br>size 4) | (μm)                | 8      | 1.7            | 1.5            | 0.015          | 0.021          | 2.3              | 4            | 2             |
| Oil absorption              | (m//100g)           | -      | 220            | 235            | -              | -              | 37-              | -            | -             |
| Wet sieving<br>residue 5)   | (%)                 | -      | -              | -              | -              | -              | -                | 0.02         | 0.02          |
| Pore volume                 | (ml/g)              | -      | -              | -              | -              | -              | -                | 1.2          | 1.6           |
| Type                        |                     | FK 6)  | FK 6)          | FK 6)          | FK 6)          | FK 6)          | FK 6)            | KG 7)        | KG 7)         |

1) based on the substance calcined at 1,000°C

2) DIN 55 921

3) DIN 53 200

4) Coulter Counter, 100 μm capillary

5) Mocker

6) precipitated silica

7) silica gel

Examples are given in the following to illustrate the effect which the water content of a heat insulation element has on its thermal conductivity, as measured by the Kohlrausch absolute one-plate method with protective ring (cold side: - 20°C; warm side + 20°C).

# 1. FK 500 LS

Effect of moisture content on thermal conductivity

Compacted density: 200 g/l

Moisture content adjusted with microwaves

| Moisture content* (%) | Thermal conductivity ((mW/m/K) | Internal pressure** (mbar) |
|-----------------------|--------------------------------|----------------------------|
| 0.3                   | 8.8                            | < 4                        |
| 0.5                   | 8.9                            | < 4                        |
| 1.3                   | 9.4                            | < 4                        |
| 2.3                   | 9.1                            | < 4                        |
| 4.1                   | 9.4                            | < 4                        |
| 7.0                   | 11.0                           | Approx. 10                 |
| 9.6                   | 14.0                           | Approx. 20                 |

\* Moisture content in % by weight, based on dry matter

\*\* Internal pressure (pressure in the heat insulation element), measured after thermal conductivity

These results are shown in the form of a graph in Figure 1.

# 2. FK 500 LS

Effect of moisture content on thermal conductivity

Compacted density: 200 g/l

Moisture content adjusted by drying in a recirculating-air drying cabinet (105 - 110°C)

|    | Moisture<br>content*<br>(%) | Thermal<br>conductivity<br>( (mW/m/K) | Internal<br>pressure**<br>(mbar) |
|----|-----------------------------|---------------------------------------|----------------------------------|
| 5  | 0                           | 9.5                                   | < 4                              |
|    | 0.2                         | 10.0                                  | < 4                              |
| 10 | 0.5                         | 10.5                                  | < 4                              |
|    | 0.8                         | 9.7                                   | < 4                              |
|    | 1.0                         | 10.0                                  | < 4                              |
|    | 1.1                         | 10.3                                  | < 4                              |
|    | 2.1                         | 9.7                                   | < 4                              |
| 15 | 3.6                         | 10.7                                  | < 4                              |
|    | 4.0                         | 9.8                                   | < 4                              |
|    | 5.1                         | 10.6                                  | < 4                              |
|    | 7.0                         | 11.0                                  | Approx. 10 <sup>4</sup>          |
|    | 9.6                         | 14.0                                  | Approx. 20                       |

20

\* Moisture content in % by weight, based on dry matter

\*\* Internal pressure (pressure in the heat insulation element), measured after thermal conductivity

25 These results are shown in the form of a graph in Figure 2.

### 3. FK 320 DS

Effect of moisture content on thermal conductivity

30 Compacted density: 210 g/l

Moisture content adjusted by drying in a recirculating-air drying cabinet (105 - 110°C)

|    | Moisture<br>content*<br>(%) | Thermal<br>conductivity<br>( (mW/m/K) | Internal<br>pressure**<br>(mbar) |
|----|-----------------------------|---------------------------------------|----------------------------------|
| 5  | 0                           | 8.6                                   | < 4                              |
|    | 0.6                         | 9.1                                   | < 4                              |
| 10 | 1.5                         | 9.2                                   | < 4                              |
|    | 2.5                         | 9.5                                   | < 4                              |
|    | 3.4                         | 9.3                                   | < 4                              |
|    | 4.5                         | 9.7                                   | Approx. 8                        |
|    | 5.5                         | 9.7                                   | Approx. 10                       |
| 15 | 7.4                         | 10.8                                  | Approx. 15                       |

\* Moisture content in % by weight, based on dry matter

\*\* Internal pressure (pressure in the heat insulation  
20 element), measured after thermal conductivity

These results are shown in the form of a graph in  
Figure 3.

25 Since the internal pressure in the heat insulation  
element gradually increases under the effect of gases  
diffusing into the element (the sum total of the gas  
permeabilities of the envelope films is in the range from  
0 to 0.5 cm<sup>3</sup>/(m<sup>2</sup>·d·bar), examples illustrating the effect of  
30 the pressure in the moulding on the thermal conductivity of  
the insulation element are given in the following.

#### 1. FK 500 LS

Effect of pressure on thermal conductivity

35 Compacted density: 200 g/l

|    | Internal pressure<br>(mbar) | Thermal conductivity<br>(mW/(m·K)) |
|----|-----------------------------|------------------------------------|
| 5  | 2                           | 8.1                                |
|    | 5                           | 8.2                                |
|    | 10                          | 9.2                                |
| 10 | 20                          | 10.1                               |
|    | 50                          | 12.9                               |
|    | 100                         | 16.1                               |
|    | 200                         | 20.0                               |
|    | 450                         | 25.8                               |
| 15 | 1000                        | 30.8                               |

The results are shown in the form of a graph in Figure 4.

20

## 2. FK 320 DA

Effect of pressure on thermal conductivity

Compacted density: 210 g/l

25

30

35

|  | Internal pressure<br>(mbar) | Thermal conductivity<br>(mW/(m·K)) |
|--|-----------------------------|------------------------------------|
|  | 2                           | 7.2                                |
|  | 5                           | 7.9                                |
|  | 10                          | 8.0                                |
|  | 20                          | 9.3                                |
|  | 50                          | 11.1                               |
|  | 100                         | 13.8                               |
|  | 200                         | 17.6                               |
|  | 500                         | 22.5                               |
|  | 1000                        | 29.5                               |

The results are shown in the form of a graph in Figure 4.

5 Examples for calculating the useful life of heat insulation elements

The limiting value for water absorption can be determined from the graphic illustration of the dependence of thermal conductivity on the moisture content of the particular filler.

10 Heat insulation elements containing silica as filler and having a moisture content corresponding to the limiting values still have good insulation properties. With a higher moisture content, both thermal conductivity and internal pressure (pressure in the heat insulation element) increase. The result is a gradual decline in the insulation properties.

15 The moisture contents permitted where the thermal conductivities of the heat insulation elements may deteriorate by at most 25% with the water absorption can be determined for the silicas FK 500 LS and KF 320 DS from Figs. 1, 2 and 3. The silicas in question were dried in accordance with DIN 55 921.

#### Results:

25 FK 500 LS limiting value at 7% moisture content  
FK 320 DS limiting value at 6% moisture content

30 Where the weighed amount of silica and the dimensions of the heat insulation element are known, these limiting values (maximum permitted quantity of water) may be calculated in accordance with the following equation:

$$\begin{aligned} \text{maximum quantity of water (g)} = & \\ 35 & \frac{\text{limiting value (\%)}}{100 (\%)} \times \text{weight of silica} \end{aligned}$$

## 1. FK 500 LS limiting value: 7% moisture content

a) Compacted density: 180 g/l (dimensions 100 x 50 x 2 cm)

volume: 10 l

weight of silica: 1800 g

max. quantity of water: 126 g

b) Compacted density: 200 g/l (dimensions 100 x 50 x 2 cm)

volume: 10 l

weight of silica: 2000 g

max. quantity of water: 140 g

## 2. FK 320 DS limiting value: 6% moisture content

a) Compacted density: 200 g/l (dimensions 100 x 50 x 2 cm)

volume: 10 l

weight of silica: 2000 g

max. quantity of water: 132 g

b) Compacted density: 220 g/l (dimensions 100 x 50 x 2 cm)

volume: 10 l

weight of silica: 2200 g

max. quantity of water: 132 g

Where the permeability of the films to water vapour is known, the life of heat insulation elements can be estimated from the limiting value on the basis of the following equation:

$$\text{Useful life} = \frac{\text{limiting value (maximum quantity of water)}}{\text{exchange area} * \text{permeability to water vapour}}$$

Dimensions:

Limiting value (maximum quantity of water): (g)

Exchange area: (m<sup>2</sup>)

5 Permeability to water vapour:  $\frac{g}{m^2 \cdot d}$

Useful life: (d)

10 With an envelope film having a permeability to water vapour of 0.05  $\frac{g}{m^2 \cdot d}$  at 23°C/85% relative air humidity, the following useful life may be calculated, for example, for a heat insulation element produced using FK 500 LS:

15 Fillers: FK 500 LS  
 Compacted density: 180 g/l  
 Dimensions: 100 cm x 50 cm x 2 cm  
 Limiting value (moisture content): 7% by weight (= 126 g)  
 Maximum quantity of water: 126 g  
 20 Exchange area: 1.06 m<sup>2</sup>  
 Permeability to water vapour: 0.05 g/m<sup>2</sup>/d  
 Useful life =  $126 \text{ g} \cdot m^2 \cdot d$  = 2377 d = 6.5 a  
 $1.06 \text{ m}^2 \cdot 0.05$   
 at 23°C/85% relative humidity

25

The following Table shows examples of the useful lives which can be achieved with metal-free and metal-containing covers based on known films (having low permeabilities to water vapour) for heat insulation elements containing the precipitated silicas FK 500 LS and FK 320 DS.

30

The calculations apply above all to a heat insulation element having an asymmetrical envelope. Where a metal-containing and flat cover is used, the following composition is obtained:

Maximum quantity of water : 126 g  
 Exchange area :  
     trough :  $\approx 0.56 \text{ m}^2$   
     cover :  $\approx 0.50 \text{ m}^2$   
 5 Permeability to water vapour :  
     trough :  $0.05 \text{ g/m}^2/\text{d}$   
     cover :  $0 \text{ g/m}^2/\text{d}$   
 useful life =  $126 \text{ m}^2 \cdot \text{d}$        $\frac{\quad}{0.56 \text{ m}^2 \cdot 0.05 \text{ g} + 0.5 \text{ m}^2 \cdot 0 \text{ g}} = 4500 \text{ d} = 12.5 \text{ a}$

**Useful life of heat insulation elements in dependence upon the permeabilities to water vapour of different films**

FK 500 LS: maximum permitted moisture content 7%  
 FK 320 DS: maximum permitted moisture content 6%

Dimensions: 100 cm x 50 cm x 2 cm  
 Exchange area: 1.06 m<sup>2</sup>

| Film types                                                                                                                                        | Permeability to<br>water vapour*<br>(g/m <sup>2</sup> /day) | Useful life                            |                                 | Useful life                            |                                 | Useful life                            |                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------|---------------------------------|----------------------------------------|---------------------------------|----------------------------------------|---------------------------------|
|                                                                                                                                                   |                                                             | FK 500 LS<br>180 g/l<br>metal-<br>free | metal-<br>contain-<br>ing cover | FK 500 LS<br>200 g/l<br>metal-<br>free | metal-<br>contain-<br>ing cover | FK 320 DS<br>200 g/l<br>metal-<br>free | metal-<br>contain-<br>ing cover |
| Combitherm XX 8/12 K 12 50<br>(Wolff-Walsrode),<br>biaxially stretched vinyl-<br>based film lacquered on<br>both sides with PVDC/<br>polyethylene | 0.4                                                         | 297 d.                                 | 563 d.                          | 330 d.                                 | 625 d.                          | 283 d.                                 | 536 d.                          |
| 4 P Ronsberg packs:<br>PVDC-coated plastics<br>PVC/PE/PVDC<br>PVC/PVDE/PE<br>PVC/PVDC                                                             | 0.15                                                        | 2.2 y.                                 | 4.2 y.                          | 2.4 y.                                 | 4.6 y.                          | 2.1 y.                                 | 4.0 y.                          |

\* as measured at 23°C/85% relative air humidity

**Useful life of heat insulation elements in dependence upon the permeabilities to water vapour of different films**

FK 500 LS: maximum permitted moisture content 7%  
 FK 320 DS: maximum permitted moisture content 6%

Dimensions: 100 cm x 50 cm x 2 cm  
 Exchange area: 1.06 m<sup>2</sup>

| Film types                       | Permeability to<br>water vapour*<br>(g/m <sup>2</sup> /day) | Useful life    |                                 | Useful life    |                                 | Useful life    |                                 |
|----------------------------------|-------------------------------------------------------------|----------------|---------------------------------|----------------|---------------------------------|----------------|---------------------------------|
|                                  |                                                             | FK 500 LS      | FK 500 LS                       | FK 500 LS      | FK 500 LS                       | FK 320 DS      | FK 320 DS                       |
|                                  |                                                             | 180 g/l        | 200 g/l                         | 200 g/l        | 200 g/l                         | 200 g/l        | 200 g/l                         |
|                                  |                                                             | metal-<br>free | metal-<br>contain-<br>ing cover | metal-<br>free | metal-<br>contain-<br>ing cover | metal-<br>free | metal-<br>contain-<br>ing cover |
| Film according to the<br>Example | 0.05                                                        | 6.5 a          | 12.5                            | 7.2            | 13.8                            | 6.2 a          | 12.0                            |

\* as measured at 23°C/85% relative air humidity

**CLAIMS**

1. A moulding, preferably in the form of a panel, for use as heat insulation produced from

- 5 a) a fine-particle, powder-form or fibrous material which has a water absorption capacity of 4 to 50% by weight at 23°C/85% relative humidity,
- b) an asymmetrical envelope of two parts which contains the fine-particle, powder-form or fibrous material, the first part of the envelope being a metal-free multilayer film having the following composition:
- 10

|         |                                  |
|---------|----------------------------------|
| LLPDE   | linear polyethylene              |
| CA      | coupling agent                   |
| 15 EVOH | ethylene/vinyl alcohol copolymer |
| CA      | coupling agent                   |
| LLPDE   | linear polyethylene              |
| PVDC    | polyvinylidene chloride          |

- 20 and being recessed by thermoforming in such a way that the resulting trough is completely filled by the optionally dried and optionally compressed powder-form or fibrous material and the second part being a metal-containing multilayer film having the following composition:
- 25

|              |
|--------------|
| polyester    |
| CA           |
| Al foil      |
| 30 CA        |
| polyethylene |

- which may be flat and joined to the trough in such a way that a closure impermeable to gases and water vapour is guaranteed and both parts having water
- 35



vapour permeabilities of 0 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative humidity and gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C,

5 with the capacity to absorb water in a quantity of 2 to 15% by weight without losing more than 25% of its thermal conductivity.

10 2. A moulding as claimed in claim 1, characterized in that the powder-form or fibrous material in a microporous envelope is introduced into the asymmetrical two-part envelope.

3. A process for the production of the heat insulation moulding claimed in claim 1, comprising the steps of

15 a) optionally drying a fine-particle, powder-form or fibrous material, which has a water absorption capacity of 4 to 50% by weight (at 23°C/85% relative humidity) under conditions which are sufficient to remove the surface water,

20 b) optionally press-moulding the powder-form or fibrous material, optionally using a compression mould,

c) introducing the optionally dried and optionally press-moulded powder-form or fibrous material into the recessed (thermoformed) metal-free part of the envelope which has a permeability to water vapour of 0.02 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative humidity and gas permeabilities for N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> of, in all, 0.05 to 0.5 cm<sup>3</sup>/m<sup>2</sup>/d/bar at 23°C,

25 d) evacuating the optionally dried and optionally press-moulded powder-form or fibrous material in the recessed part of the envelope to a pressure of 0.1 to 1 mbar,

30 e) joining the second metal-free or metal-containing and flat part of the envelope, which has a permeability to water vapour of 0 to 0.2 g/m<sup>2</sup>/d at 23°C/85% relative

35



5 humidity and gas permeabilities for  $N_2$ ,  $O_2$  and  $CO_2$  of, in all, 0 to  $0.5 \text{ cm}^3/\text{m}^2/\text{d}/\text{bar}$  at  $23^\circ\text{C}$ , *in vacuo* to the first metal-free part of the envelope in such a way that the vacuum is maintained in the interior of the envelope and a closure impermeable as far as possible to gases and water vapour is formed.

10 4. A process as claimed in claim 3, characterized in that the powder-form or fibrous material is dried in a microporous envelope.

5. A process as claimed in claim 3, characterized in that the powder-form or fibrous material is press-moulded in a microporous envelope and then optionally dried.

15 6. The use of the moulding claimed in claim 1 as a storage, packaging and/or transport container for temperature-sensitive goods.

7. The use of one or more of the mouldings claimed in claim 1 for the heat insulation of refrigerators or deep-freeze cabinets.