Styropor®

22246 June 1992

Properties

Properties – general

Getting the best out of Styropor foam means knowing about its properties. Only that way can optimized products be developed. The properties of conventional materials are already well known: steel can rust, wood can rot, glass breaks and cardboard looses its strength when it becomes moist. But when it comes to Styropor, people are often ill-informed. This technical information leaflet tells you about important properties that are relevant to Styropor foam applications.

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BASF

1 Physical properties

Mechanical loads

One important property of Styropor foam is its mechanical strength when subjected to short-term and sustained loading.

Styropor foam is classed as a rigid foam according to DIN 7726. When under load it exhibits the type of visco-elasticity that is characteristic of brittle-rigid materials. It is for this reason that the compressive stress at 10 % compressive strain (DIN 53 421) is measured instead of the compressive strength (Table 1). However, because the compressive stress at 10 % strain lies in the plastic region (compression is irreversible) the value obtained is only of use for characterizing the sample being examined (eg, for quality control purposes), since mechanical properties also depend on foam density.

For sustained loading, the appropriate values of compressive stress are those corresponding to less than 2 % compressive strain.

The draft European standard on thermal insulation for buildings describes a method for determining stress values with respect to creep behaviour when Styropor foam (EPS) is subjected to sustained compressive loads. In future this method can be used for estimating the permissible loads in practical applications or for investigating how the material behaves under sustained loading.

The basis for the mathematical treatment of the system is the Findley equation.

For a defined set of conditions, the amount of deformation can be calculated for any loading period; note that the function is only permitted to be extrapolated up to 30 times the actual test period (see charts in Fig. 1).

Table 1 also contains values on shear, flexural and tensile strength. These also increase with foam density.

Because mechanical properties are density dependent, comparative assessments are only meaningful if density values are also quoted.

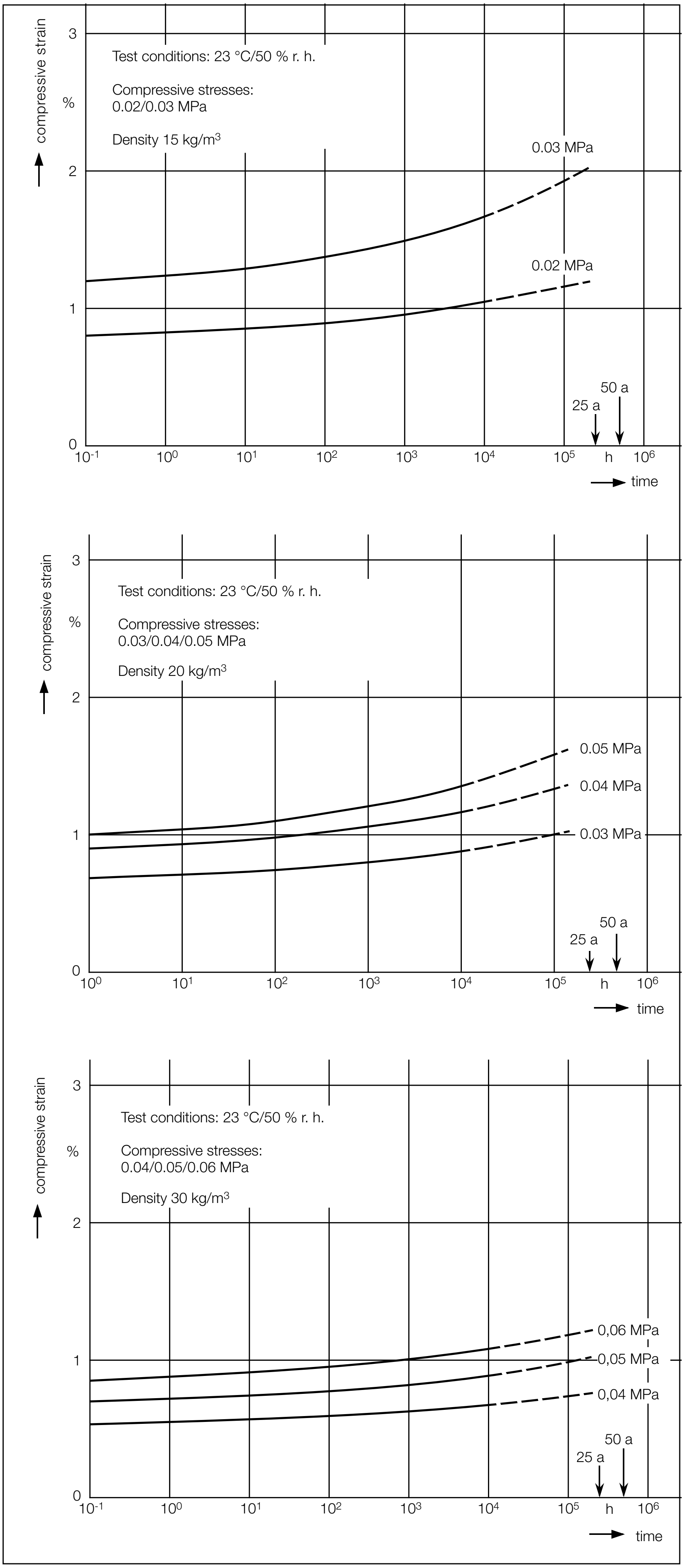

Fig. 1 Long-term behaviour of Styropor foam with densities 15, 20, 30 kg/m³ under various loads.

Heat insulation capacity

One of Styropor foam's other outstanding properties is heat insulation. Styropor foam is a polystyrene material made up of fully enclosed polyhedron-shaped cells, 0.2 – 0.5 mm in diameter with walls 0.001 mm thick. The foam consists of about 98 % air and 2 % polystyrene. As is well known, the air entrapped within the cells is a very poor heat conductor and so plays a decisive role in providing the foam with its excellent heat insulation properties. Unlike foams containing other gases, the air stays in the cells so that the insulation effect remains constant.

The heat insulation properties of a material are described by its thermal conductivity. The thermal conductivity is defined as the rate of heat flow in the material (joule per second, or watt) between two parallel planes of cross-section 1 m^2, placed 1 metre apart and having a temperature difference of 1 K. The unit is W/(m·K). DIN 52612 describes how to carry out the measurement. Fig. 2 shows that, provided all other parameters are constant, the thermal conductivity depends on the density (kg/m^3) of the foam. It can be seen that the thermal conductivity falls to a minimum at around 30 – 50 kg/m^3 and then increases again steadily. The thermal conductivity of Styropor foam of density 20 kg/m^3 is 0.033 – 0.036 W/(m·K) at 10 °C.

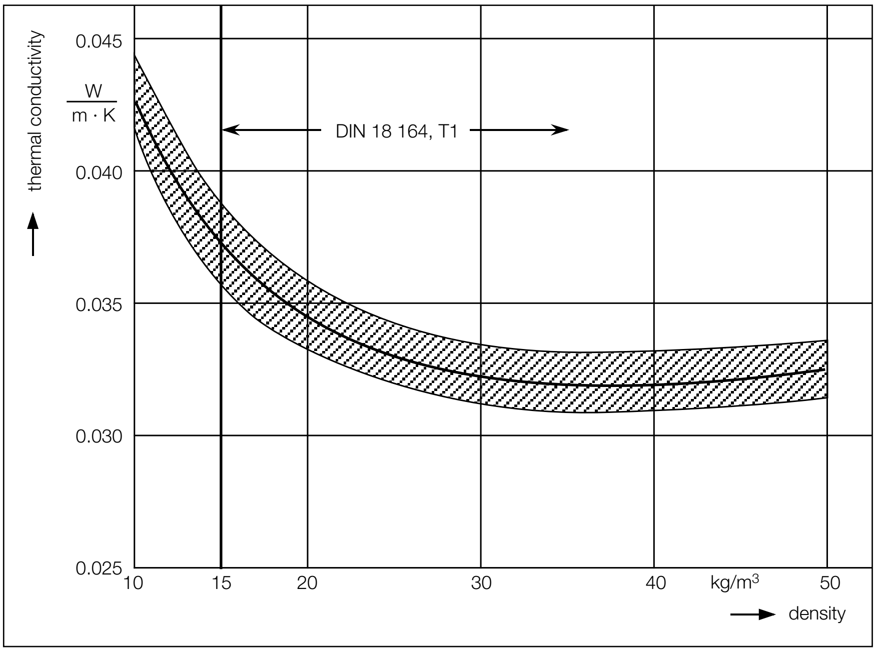

Fig. 2 Thermal conductivity of Styropor foam as a function of density at a mean temperature of 10 °C.

Water and water vapour

There is a basic difference between water absorption and water vapour transmission.

Water absorption

Styropor foam is not hygroscopic, unlike many other foams. Even when immersed in water it absorbs only a small amount of water. As the cell walls are waterproof, water can only penetrate the foam through the tiny channels between the fused cells. This implies that the amount of water taken up depends on how the EPS raw material behaves when processed and upon the processing conditions (especially during expansion).

We measured the water absorption by the DIN 53434 method. For the test, it is always preferable to use specimens of finished or semi-finish mouldings intended for practical applications. After 28 days, the foam absorbs about 3 % of its own volume of water and, as seen from Table 1, this is independent of the density.

For most applications, the water absorbed by submersed foam is of little significance and is only of interest in special cases such as earthworks, foundation construction, floats and buoyancy aids, etc.

Water vapour transmission

In contrast to water, water vapour, which is present in the air as moisture, can, given an appropriate temperature gradient, slowly diffuse into the cells of the foam where it condenses on cooling. Different materials have varying degrees of resistance to the transmission of water vapour. The resistance is found by multiplying the thickness of the barrier (s) by the transmission resistance factor (μ). The resistance factor (μ) is a dimensionless number and says how many times greater is the resistance of a material compared with a layer of air of the same thickness (For air: $\mu = 1$).

Metals have extremely high resistance factors, which is why metal foil is used in vapour barriers. Between these two extremes, air and metal, lie the values of all the other materials. Values for Styropor foam range from $\mu = 20$ to $\mu = 100$, depending on the density (see Table 1, measured according to DIN 4108).

When determining the dew point for building purposes, always use the worst-case value.

Temperature behaviour

There is practically no lower temperature limit for Styropor applications.

Temperature-induced volume changes (eg, in cold room construction) must be considered at the design stage. Styropor's behaviour at higher temperatures depends on the duration of the temperature effect and on the mechanical loading on the foam (see Table 1).

Styropor can sometimes withstand short exposure to temperatures well above 100 °C (eg, bonding with hot bitumen); for longer periods, however, the foam structure begins to soften due to sintering.

Dimensional stability

All materials – raw material, prefabricated parts or moulding – undergo a certain amount of dimensional change. With Styropor foam, we differentiate between dimensional changes due to the effect of heat and due to after-shrinkage.

Dimensional change due to heat effects

Styropor has a thermal expansion coefficient of 0.05 – 0.07 mm per metre per degree Celsius. This means that a temperature change of about 17 °C causes a (reversible) change in dimension of 0.1 % (1 mm/m).

Special design considerations must be shown for applications in which dynamic temperature loads occur.

The effect of contraction due to cold must also be considered. For example, a part of length 400 mm at 20 °C would contract by about 1 mm when cooled down to – 20 °C.

Dimensional change due to after-shrinkage

Freshly expanded foam shrinks partly due to cooling. The dimensional changes that occur more than 24 hours after the foam has been expanded are referred to as after-shrinkage.

At first, the rate of contraction is relatively rapid and afterwards subsides to a limiting value, so that additional design considerations to take into account shrinkage are then unnecessary.

The after-shrinkage of Styropor foam boards is 0.3 % to 0.5 % depending on the processing conditions and the density of the raw material.

A considerable part of after-shrinkage of foam board can be expected to occur during storage at the manufacturers.

Fig. 3 shows the after-shrinkage 14 days after the foam has been produced. The final value is reached after about 150 days and lies in the range 1.5 – 2.0 mm/m (0.15 – 0.2 %). These dimensional changes can be tolerated for almost all building applications and, in contrast to temperature-induced dimensional changes, are irreversible.

In cases requiring a low amount of after-shrinkage, the boards must be stored for an appropriate length of time before being used.

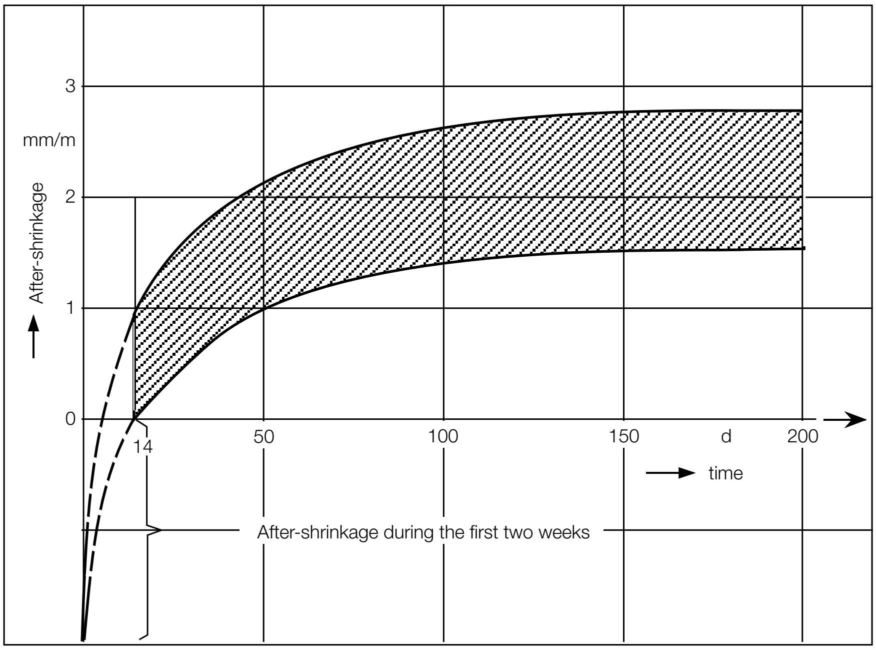

Fig. 3 After-shrinkage of Styropor foam boards over time, 14 days after manufacture.

Table 1 Physical data for Styropor foam

	Test standard	Unit	Test result		
Quality assured types	GSH-quality conditions		PS 15 SE	PS 20 SE	PS 30 SE
Application types	DIN 18 164, Part 1		W	WD	WD + WS
Minimum density	DIN 53 420	kg/m^3	15	20	30
Building material class	DIN 4102		B 1, Difficultly flammable	B 1, Difficultly flammable	B 1, Difficultly flammable
Thermal conductivity Measured value at + 10 °C	DIN 52 612	W/(m · K)	0.036–0.038	0.033–0.036	0.031–0.035
Calculated value according to DIN 4108		W/(m · K)	0.040	0.040	0.035
Compressive stress at 10 % compressive strain	DIN 53 421	N/mm^2*	0.06 –0.11	0.11 –0.16	0.20 –0.25
Resistance to sustained compressive loads at < 2% strain		N/mm^2	0.015–0.025	0.025–0.050	0.050–0.070
Flexural strength	DIN 53 423	N/mm^2	0.06–0.30	0.15–0.39	0.33–0.57
Shear strength	DIN 53 427	N/mm^2	0.08–0.13	0.12–0.17	0.21–0.26
Tensile strength	DIN 53 430	N/mm^2	0.11–0.29	0.17–0.35	0.30–0.48
Modulus of elasticity (compressive test)	DIN 53 457	N/mm^2	1.6 –5.2	3.4 –7.0	7.7 –11.3
Heat deformation temperature					
short-term	based on DIN 53 424	°C	100	100	100
long-term at 5000 N/m^2	based on DIN 18 164	°C	80–85	80–85	80–85
long-term at 20000 N/m^2	based on DIN 18 164	°C	75–80	80–85	80–85
Coefficient of linear expansion		1/K	$5 - 7 \cdot 10^{-5}$	$5 - 7 \cdot 10^{-5}$	$5 - 7 \cdot 10^{-5}$
Specific heat capacity	DIN 4108	J/(kg · K)	1210	1210	1210
Water absorption on immersion (by volume)					
after 7 days	DIN 53 434	%	0.5–1.5	0.5–1.5	0.5–1.5
after 28 days		%	1.0–3.0	1.0–3.0	1.0–3.0
Water vapour transmission rate	DIN 52 615	$g/(m^2 \cdot d)$	40	35	20
Water vapour transmission resistance factor	Calculated according to DIN 4108	1	20/50	30/70	40/100

** 1 N/mm^2 ≙ 1 MPa*

Table 2 Resistance of Styropor foam to chemical agents

Active agent	Styropor P + F
Salt solutions (sea water)	+
Soaps solution and wetting agents	+
Bleach agents, such as hypochloride, chlorine water, hydrogen peroxide solutions	+
Dilute acids	+
35 % hydrochloric acid, 50 % nitric acid	+
Anhydrous acids, (eg, fuming sulfuric acid, 100 % formic acid)	–
Sodium hydroxide, potassium hydroxide and ammonia solution	+
Organic solvents such as acetone, ethylacetate, benzene, xylene, paint thinner, trichloroethylene	–
Saturated aliphatic hydrocarbons, surgical spirit, white spirit	–
Paraffin oil, Vaseline	+ –
Diesel oil	–
Motor fuel (normal and super gasoline)	–
Alcohols (eg, methanol, ethanol)	+ –
Silicone oil	+

+ – *Resistant: the foam remains unaffected even after long exposure.*
+ – *Limited resistance: the foam may shrink or suffer surface damage on prolonged exposure.*
– *Not resistant: the foam shrinks or is dissolved.*

Styropor FH is a grade for making foam with enhanced resistance to aromatic-free hydrocarbons compared with other Styropor grades. The suitability of this product for a specific applications must be tested in each case.

Effects of radiation and weathering

The foam becomes brittle after long exposure to high-energy radiation (eg, short-wave UV, x-rays and γ–rays). The process depends on the type of radiation, its intensity and the exposure time. In practice, only UV is of any interest. Long-term exposure to UV turns the surface of the foam yellow and brittle, rendering it liable to erosion by wind and rain. Such effects can be safely prevented by simple means such as painting, coating and lamination. Indoors, the amount of UV is so small that the foam is unaffected: decades of experience with ceiling tiles have shown this to be the case.

2 Chemical properties

Styropor foams are resistant to many chemical substances.

Paints, solvents and concentrated vapours thereof may damage the foam. See Table 2 for details of the resistance of Styropor foam to chemicals.

3 Biological aspects

Styropor foam is not a breeding ground for microorganisms. It does not rot or putrefy. Only under special conditions can microorganisms take up residence on the foam (eg, if it is heavily soiled); in such a case, it acts merely as a substrate and plays no part in the biological processes. Soil bacteria also do not attack the foam. The composition of properly manufactured Styropor foam fulfils the various recommendations of the German health ministry and can therefore be used for the production of articles for food-contact applications. It has no environmentally harmful effects and does not endanger groundwater. It may be disposed of in landfill or by incineration in accordance with local regulations.

Styropor foam can withstand temperatures of up to 85 °C. At this temperature, it does not decompose or form harmful fumes. You can find more information about Styropor's high-temperature performance, fire behaviour and about the toxicity of thermal decomposition products in our technical information TI 130 "Fire behaviour of expanded Styropor".

Note

The information submitted in this publication is based on our current knowledge and experience. In view of the many factors that may affect processing and application, these data do not relieve processors of the responsibility of carrying out their own tests and experiments; neither do they imply any legally binding assurance of certain properties or of suitability for a specific purpose. It is the responsibility of those to whom we supply our products to ensure that any proprietary rights and existing laws and legislation are observed.

Printed in Germany

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