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® = Registered trademark

## Properties

# Resistance to aging and long-term performance

Styropor foam does not rot; and, if our instructions are observed, it is resistant to aging. These are facts that have been confirmed by independent experts and scientific institutes in many years of observation in all the feasible applications that arise in the building trade.

Some of the terms that are encountered in this connection are defined below.

### Aging

A material is said to age if its properties change under given natural ambient conditions despite the fact that the conditions of use lay within its performance limits. In our particular case, the expectations on performance and lifetime relate solely to the building trade. As a rule, aging becomes evident by failure or even by subsequent decomposition.

The reasons for these changes are the effects of ambient conditions, eg atmospheric oxygen, water, heat and light. The most effective is the radiation at the ultraviolet end of the spectrum. Many plastics may become brittle on exposure to ultraviolet radiation if they are not stabilized or protected from it. The method usually adopted for protecting insulation is to cover it with other materials when it is installed.

Aging and its consequences must be distinguished from premature damage or even destruction of a material by improper use, ie by exceeding its performance limits. An example is processing a material together with other substances that attack it (cf. “Performance limits”).

### Rotting

Natural organic substances, eg rubber, wood, leather and textiles, may rot when exposed to moisture and atmospheric oxygen. However, synthetic organic materials, eg plastics, do not rot.

Styropor foam is immune to rot.

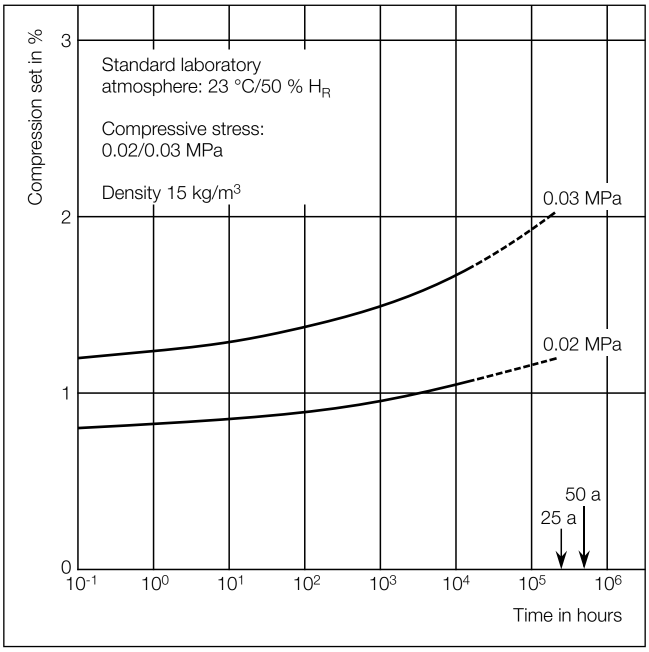
### Fatigue

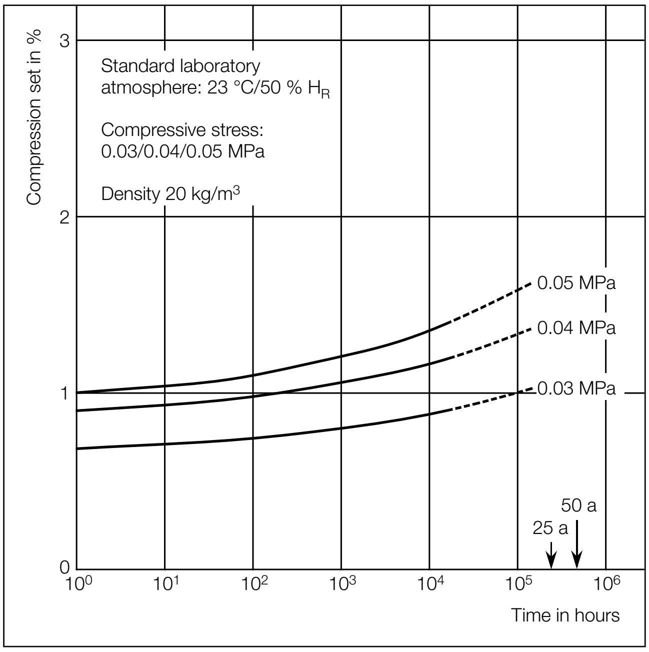
Fatigue is the failure of materials subjected to repeated cyclic loads. If rapidly alternating stresses are applied over long periods, an idea can be obtained of a material’s life under given conditions. Alternatively, it can be forecast whether a factor of safety is high enough for an intended application.

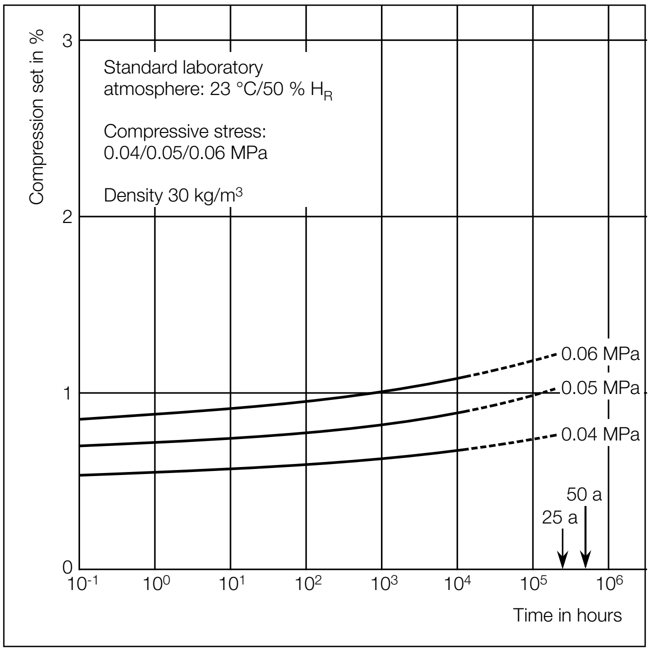
Wöhler tests under practical conditions on Styropor panels have revealed that fatigue does not occur under the normal conditions encountered in buildings, eg the stresses to which footstep sound insulation is subjected.

The draft European standard “Thermal insulation for the building trade” describes a method for determining the compressive creep strength of insulating materials. It can be applied to estimate permissible loads in practice and/or to check the long-term performance of certain products subjected to compressive loads.

The calculation is based on the Findley equation. Thus the compressive set under defined conditions for any given length of time can be determined, but extrapolation is allowed only for a period not exceeding the duration of the test by a factor of more than 30 (cf. Diagrams 1 – 3).




*Diagrams 1–3 Creep curves for expanded polystyrene*

## Performance limits

The performance limits of a material are governed by its chemical and physical properties. The main factor is its resistance to mechanical loads, heat, and chemicals. The corresponding properties of Styropor foam are described in detail in the Technical Information Bulletin TI 1-101.

Cement, lime, gypsum, anhydrite, and mortar modified by plastics dispersions do not exert any effect on Styropor foam. As a consequence, Styropor can be installed together with all the conventional types of mortar, plaster and concrete encountered in the building trade, with the exception of mastic asphalt.

Styropor foam must be protected from sustained exposure to solar radiation. Empty spaces in which Styropor foam is exposed, eg behind cladding or in ventilated flat roofs, must be sealed to exclude the entry of mice and other rodents.

Styropor foam must not be exposed to sustained temperatures higher than 95 °C and must not be allowed to come into contact with certain products that contain solvents. For instance, it is attacked by solvent-based cold bitumen, many surface coatings, paint thinners and their vapours, oily wood preservatives, and tar products (but not by bitumen). A particularly suitable adhesive in many applications, eg roofs and cold stores, is hot bitumen. It entails short-term exposure to temperatures above 100 °C, but this has practically no effect on the dimensional stability of the insulating material.

## Evidence of resistance to aging

### *Practical trials performed by BASF*

Laboratory studies often do not allow a definite conclusion to be formed on the long-term performance of materials under practical conditions that occur simultaneously but often cannot be simulated in the laboratory. For this reason, BASF have been running technical performance trials for several years on a practical scale and under practical conditions.

Numerous studies along these lines have been carried out on the application of Styropor foam in the building trade. The numerous buildings with flat roofs on the BASF production site provided the initial basis for these thermal insulation trials. Despite the severe exposure conditions, the insulation on all these roofs gave no grounds for complaint. No cases arose in which the Styropor foam failed or showed the effects of aging.

### *Report on flat roof insulation after 31 years' service*

One of the oldest applications for Styropor foam in buildings is the thermal insulation for a flat roof on a BASF Aktiengesellschaft factory building. The panels were laid in 1955 and were dismantled for inspection on 20 June, 1986, in the presence of an authenticated specialist at the request of the *Industrieverband Hartschaum e. V., Heidelberg.*

The visual inspection revealed that the joints between the individual insulating panels were still tightly sealed. No irreversible changes in dimensions were observed that

*Fig. 1 Removing the roof covering to inspect Styropor foam panels that had been installed 31 years before. The joints between the panels were still tight.*

*Fig. 2 Specimen taken from flat roof as shown in Fig. 1. No changes can be discerned in the Styropor.*

could have been caused by shrinkage or contraction. Likewise, there were no signs of any deformation or buckling that may have been caused by exposure to heat. The unreserved verdict given in the visual examination was that the Styropor foam panels were still in excellent condition.

Many specimens of the thermal insulation taken during the course of the inspection were sent to a research institute in Munich *(Forschungsinstitut für Wärmeschutz e.V.)* for determination of

1. thermal conductivity
2. moisture content.

Results

1. The thermal conductivity, as determined by the DIN 52 612 method, for a panel of 17.4 kg/m$^3$ density was 0.0345 W/mK (test report F.2-351/86 of 16 October 1986). This figure conforms to the German standard on thermal insulation in buildings (DIN 4108), in which the calculated value is 0.04 W/mK.

2. The volume fraction of water in panels of 20 kg/m$^3$ density was 0.02 %.

The results of other tests also verified that the performance of Styropor foam panels remained absolutely unimpaired after 31 years of service and still satisfied the requirements laid down in the German standard on “Foamed plastics as insulating building materials” (DIN 18164, Part 1).

***Studies by officially recognized test institutes***

The practical experience gained on buildings in the BASF production site was supplemented by the results of studies on numerous other buildings in which Styropor foam panels had been installed many years before. In all cases, the test institutes and consultants

*Fig. 3 Taking a sample of Styropor from an outdoor composite insulating system consisting of Styropor and a fabric-reinforced textured finish.*

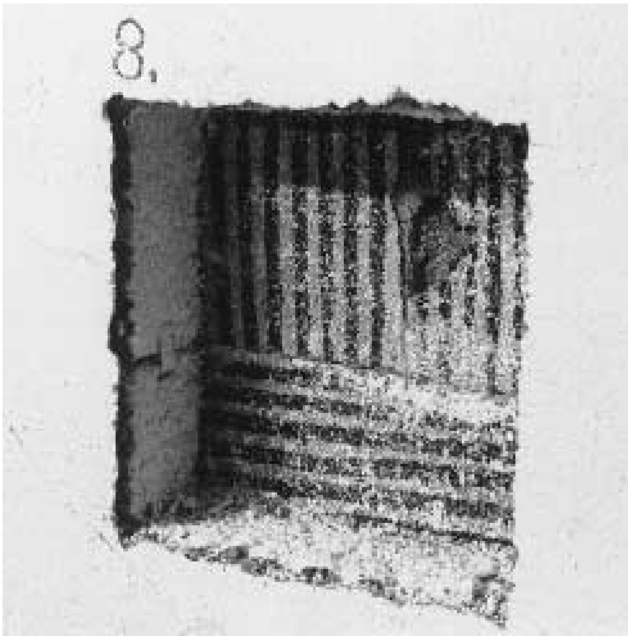



*Fig. 4 Styropor foam panels in the outer wall of a fruit warehouse*

| | |
|---|---|
| *Age of exposure* | *10 years* |
| *Density* | *14.9 kg/m$^3$* |
| *Moisture content* | *0.021% vol.* |
| *Make-up of wall from the inside to the outside Cement mortar plaster* | *1:3* |
| *Styropor P foam* | *100 mm* |
| *Normal concrete* | *400 mm* |

entrusted with the studies verified that the condition of Styropor foam panels did not undergo any perceptible change nor did the property suffer any deterioration even after more than 20 years of service. The panels still conformed to the requirements of DIN 18164 Part 1 after this period of time (Fig. 5). The moisture content of the foamed plastic insulation in all the structures tested in residential and factory buildings was less than the value considered to be acceptable in practice, viz. 0.1% expressed in terms of volume.

A particularly interesting comprehensive study concerned outdoor composite insulation systems containing Styropor board. It was carried out by the Holzkirchen branch of the Fraunhofer Institute of Physics. The long-term performance of the thermal insulation was determined in 93 buildings that were selected from a list of manufacturers.

The criteria adopted in selecting the 93 buildings were the conditions to which the insulating systems were exposed and which arose from the geographical location, the altitude, the type of building, and differences in age. At the time of the study, ie in 1974–1976, the most frequent age of the outdoor composite insulating system was 3–4 years, but some were as many as 16 years old. Almost all the buildings were undamaged. Certain damages were observed in only three of the 93 cases investigated. However, these were ascribed to errors in laying and not to the insulating system itself. In all cases, the Styropor foam panels remained dimensionally stable and completely retained their functions.

In all the random samples that were taken in some cases, the moisture content was very low, viz. less than 0.05%, expressed in terms of volume.

In 1983, a further study was made on the same buildings by the same institute. The aim was to gain information further to that obtained in the previous tests on the long-term performance of the outdoor composite insulating system containing Styropor foam.

Hence the effect of a further eight years of outdoor exposure on the insulating material and the protective layer of fabric-reinforced textured finish could be determined.

In the institute's report, it was stated that only 20% of the buildings investigated had been renovated but that the work concerned was confined almost exclusively to renewing the coats of textured finish for aesthetic reasons. The average age of the composite systems before these fresh coats of textured finish were applied was 11 years. It is thus safe to assume that the time that elapses before renewal work is required is comparable to that required in renewing a mineral plaster and paint, viz. 10–25 years*.

** Figures submitted by Professor Künzel, Institut für Bauphysik der Fraunhofer Ges. e. V.*


*Fig. 5 Test report on the long-term performance of Styropor foam in various applications in the building trade.*

The report stated that the moisture content of the expanded polystyrene insulating board was subcritical, ie 0.06% maximum, expressed in terms of volume. Thus the results obtained after a further eight years' exposure confirm the evaluation given in the previous study to the effect that composite thermal insulating systems consisting of Styropor board and textured finishes represent a practicable and reliable means for the efficient thermal insulation of outdoor walls.

## Practical experience gained with Styropor foam in earthwork and foundations

The features of closed-cell Styropor foam are great stability and durability, immunity to moisture and soil organisms, and biological neutrality, ie no threat to groundwater. They have been convincingly verified by the experience gained in earthwork and foundations.

Since the mid-1960s, Styropor foam has provided excellent frost protection in foundations, pipeline systems, and the substructures of roads and railroads (Fig. 6). The relevant construction techniques are standard practice in Scandinavian countries with severe winter and deep ground frost. The good experience thus obtained gave rise to a new construction method that was developed in Norway in 1972 and has since been successfully adopted in other countries.

Substructures consisting of Styropor blockware allow loads to be evenly distributed under causeways and bridges in regions with poor load-bearing soil (Fig. 7). The height to which the Styropor blocks are stacked may be as much as eight meters, and their permanent compressive strength permits pressure to be evenly distributed over marshy soils. A lightweight embankment of this nature prevents the road structure from subsiding and potholing, particularly in critical access zones at structures with deep foundations, eg bridges (cf. Technical Information Bulletin TI 800).

The many years of good experience represent a reliable source of information on the resistance to aging and long-term performance of Styropor foam and formed the basis upon which many countries accepted and adopted this road construction technique.

*Fig. 6 Styropor foam board for frost protection in road construction. Samples taken 11 years after installation. The Styropor foam panels were in the same condition as that in which they were installed.*

*Fig. 7 Styropor blockware in the construction of causeways and bridge ramps in regions with poor load-bearing soils (European Highway E6, Ljungskile, Sweden).*

**Resistance to aging of non-readily ignitable Styropor foam panels**

The sustained efficiency of the flame retardant system in Styropor F foam has been verified by fire tests performed by the official German centre for materials testing*. The test certificate states that the flame retardance of Styropor F specimens did not deteriorate after $7^1/_2$ years (ca. 4 years in a standard laboratory atmosphere of 20 °C and 65 % relative humidity, as defined in DIN 50014, followed by ca. $3^1/_2$ years under a roof but exposed to outdoor conditions). The summary of the results given in Table 5 of the certificate demonstrates that the foamed plastic conforms to the demands imposed on non-readily ignitable (low flame spread) building materials. A copy of the test certificate BAM No. 2.41/14271 will be sent on request.

* *Bundesanstalt für Materialprüfung (BAM, Berlin)*

**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.