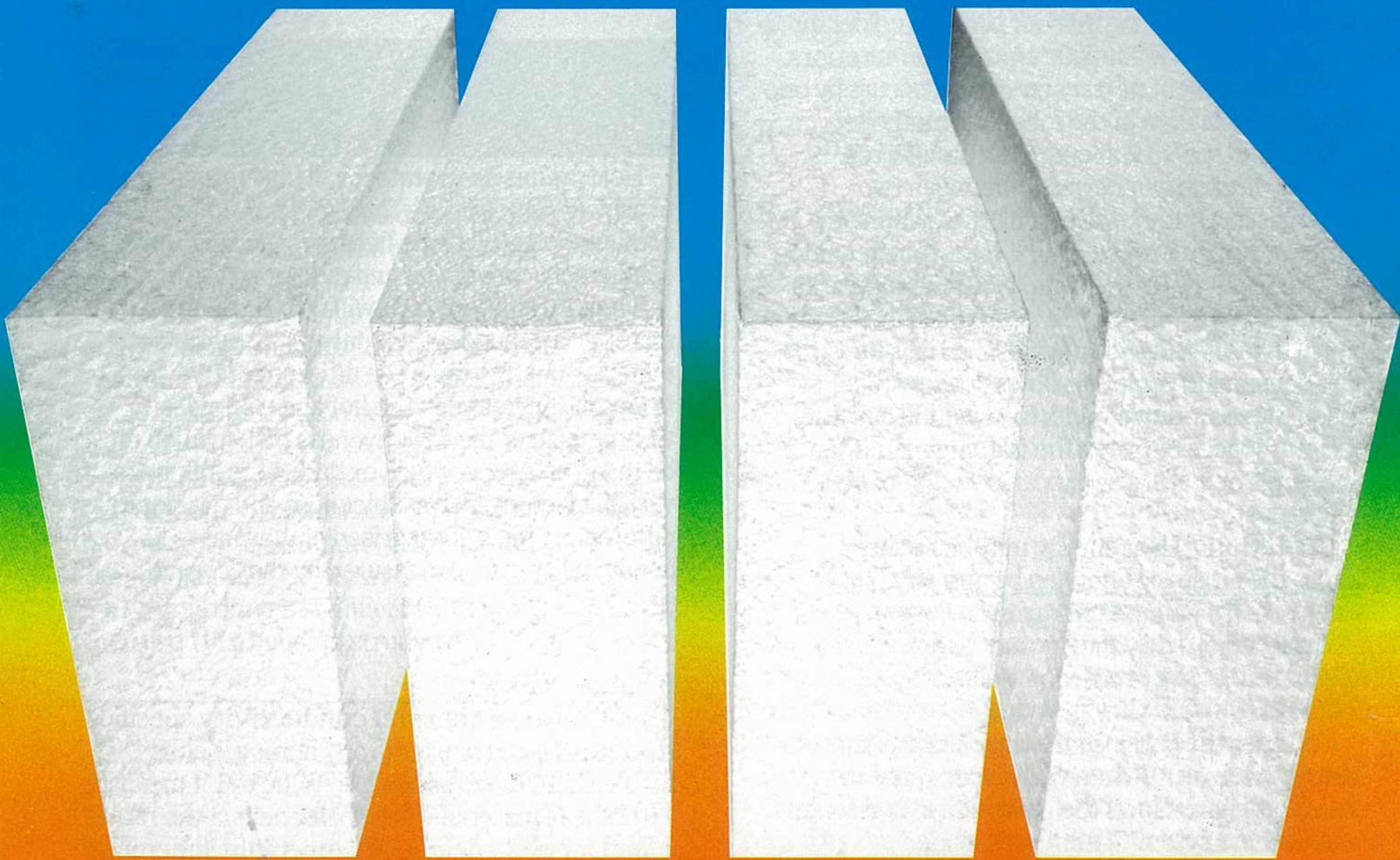
Number 3 of a series

Fundamentals, Symbols and Terminology of EPS Thermal Insulation



EPS
EXPANDED POLYSTYRENE INSULATION

The Ultimate Insulation

EPS(expanded polystyrene) is the only insulation material that in practical, economic and efficiency terms can be applied to all areas of building construction – ceilings, roofs, walls, floors and underslab – to provide superior standards of thermal insulation. That's why EPS is the Ultimate Insulation.

Fundamentals of thermal insulation.

The level of living comfort is determined by the quantity of heat that must be added to or removed from a building; and insulation is designed to control these factors.

Heat always flows from warmer to colder areas – from a heated building interior towards colder air outside, or from hot outside air to cooler interiors.

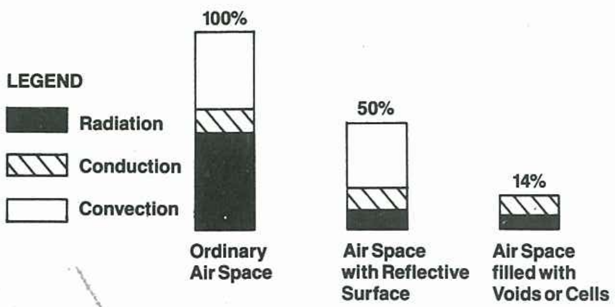
This movement or transfer of heat occurs by one or any combination of the following methods:

Conduction – Heat energy is transferred directly through a material, or between two materials, in contact with each other, where a temperature difference exists. Heat transfer along a metal rod is a simple example of conduction.

Convection – Air, when heated, becomes less dense than the surrounding air, and rises upwards. The denser and cooler air flows downwards. When these air movements (convection currents) occur in spaces between the framing members of ceilings or walls, a significant amount of heat may be lost.

Radiation – Heat energy may be radiated across the air space and then be absorbed by another body. Radiant energy from the sun is an example, where this energy may be absorbed as heat or reflected by roofs and walls even on cool days.

Consider the options for controlling horizontal heat flow across a 50 mm vertical air space in a wall. This chart shows the reduction of horizontal heat flow in a typical 50 mm wall space.



As indicated here, heat transfer by convection is a major consideration, which can be almost eliminated by the use of insulation material, such as EPS.

Thermal conductivity of EPS.

The low thermal conductivity of expanded polystyrene is made up from the conductivity of air within the cellular structure, the conduction of the solid polystyrene, and radiation across the fine cellular structure of each bead that forms the sheet.

The smallest contributor to thermal conductivity of expanded polystyrene is the polystyrene itself, and this contribution is in the order of 10% of the total only.

Still air is an excellent insulating material. Because of this, the permanently entrapped air within the cells of expanded polystyrene ensures its very low conductivity.

It is these factors which give EPS its outstanding thermal insulation properties.

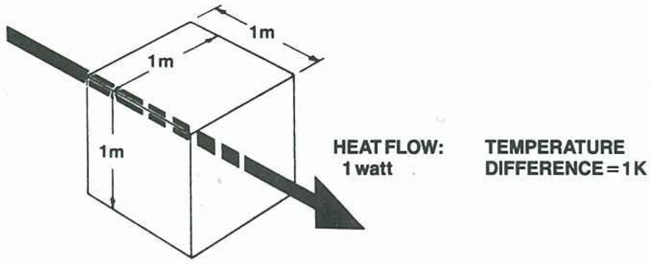
Heat flow terms and comparisons.

Heat, as has been stated, will flow from a higher to a lower temperature through one, or any combination of all three heat transfer methods – conduction, convection and radiation.

The rate at which heat will flow through a material is dependent not only on the nature of the material, but also upon the difference in temperature between the hot and cold sides. Comparison of the effectiveness of insulation must be made on a basis which excludes the influence of variable factors such as thickness and temperature differences. This comparison of thermal conductivity can be measured by the 'k' value.

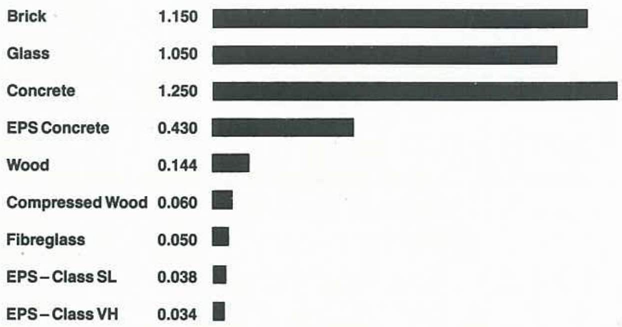
k Value (W/mK)

The 'k' value, **or thermal conductivity,** specifies the rate of heat transfer in any homogeneous material. If a material has a 'k' value of 1 it means a 1 m cube of material will transfer heat at the rate of 1 Watt for every degree of temperature difference between opposite faces. The 'k' value is expressed as 1W/mK.



ILLUSTRATING UNIT CONDUCTIVITY = 1W/mK

TYPICAL k VALUES (W/mK)



Note: The lower the value the more effective the insulant.

These values can vary depending on the moisture content of the materials.

EPS expanded polystyrene has a remarkably low k value compared with most other insulating materials used in similar applications.

C Value (W/m^2K)

C value, or **thermal conductance**, refers to any thickness of a material or structural component such as a wall or floor.

Thermal conductance is the amount of heat energy transmitted through unit area of a structural component or of a structure per unit temperature difference between the hot and cold faces. The value of C is expressed in W/m^2K. Where a thickness of material other than 1 m is used the term conductance C must apply and the thickness of the structure, or structural component, must be stated.

EPS contributes significantly to low C values when used in a building structure.

r Value (1/k)

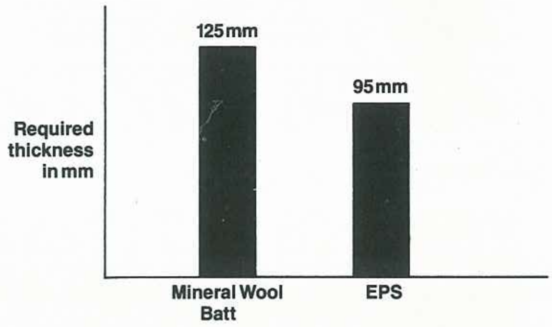
r value, or **thermal resistivity**, is the symbol that refers to unit thickness and is defined to be the reciprocal of thermal conductivity (k value).

R Value (m^2K/W)

The R value, or **thermal resistance of a material,** expresses the ability of a particular thickness of that material to resist heat flow.

The definition of R value is the reciprocal of the material's thermal conductance (C value). The R value refers to the thermal resistance of a building material, or assembly of building materials, and is the means of calculating the overall thermal resistance of a building section, by simply adding individual component R values.

Approximate thickness of insulation required to give a minimum R value of 2.5.



Practical calculation of 'R' for a homogeneous insulating material of 100mm thickness.
Design data: d (thickness) = 100mm
k = 0.038 (W/mK)–EPS Class SL

$$\text{'R' value} = \frac{\text{d (thickness) m}}{\text{k (thermal conductivity) W/mK}}$$

$$R = \frac{0.100\,\text{m}}{0.038\,\text{W/mK}}$$

$$R = 2.63\,m^2K/W$$

Conversely, to determine the thickness required of an insulation material for a specified 'R' value, say 2.5, the calculation is as follows, using EPS Class SL.

$$d = R \times k$$
$$= 2.500 \times 0.038\,\text{m}$$
$$= .095\,\text{m} = 95\,\text{mm of EPS}$$

U Value (W/m^2K)

The 'U' value, **or heat transfer coefficient,** of a wall, roof, ceiling or floor is quite similar to the 'k' value in that it is a measure of the quantity of heat which will flow through a specific building section one square metre in area during one hour when there is a hot to cold side temperature difference of 1K. 'U' value is the "heat loss" or "heat gain" figure used by the heating or air conditioning engineer for equipment design purposes. 'U' value is expressed as W/m^2K.

The U value of a building element depends on the 'k' or 'R' value of the products which make up that section, and because it measures heat transmission or conductivity, the lower the 'U' the better the insulation value.

Additionally, the overall U value takes into consideration the effect of any air spaces within the building element (e.g. cavity walls) and, the resistance of exposed surface air films to absorption or heat transfer.

Mathematically, the designer cannot merely add 'k's for each component of the system to arrive at a

U value because each factor in itself is a measure of heat transfer. However, if he adds R values for each component, he then arrives at a total resistance value (R_t) for the element. The reciprocal of R_t then provides him with a U value, being the "overall heat transfer coefficient" measured in terms of W/m^2K per square metre of surface per hour per 1K difference in temperature.

Long-term R value.

The moisture content of an insulating material at the time of testing can have a considerable effect on the value of thermal conductivity obtained, and is probably responsible for some of the variation in published 'k' values.

Water has a thermal conductivity more than 10 times that of common insulating materials, and increased moisture content can lead to a marked reduction in the efficiency of insulation or the long-term R value after installation.

Structures with little or no insulation are at times prone to condensation of water vapour in walls or on the underside of roofing materials. This can cause staining, rotting, of timbers, or corrosion of metals, as well as the loss of insulation efficiency.

The long-term minimum R value of many insulating materials is often below that claimed by respective manufacturers, because the insulating value of the material is reduced by dust deposits, 'settling' of the insulation, or the uptake of moisture.

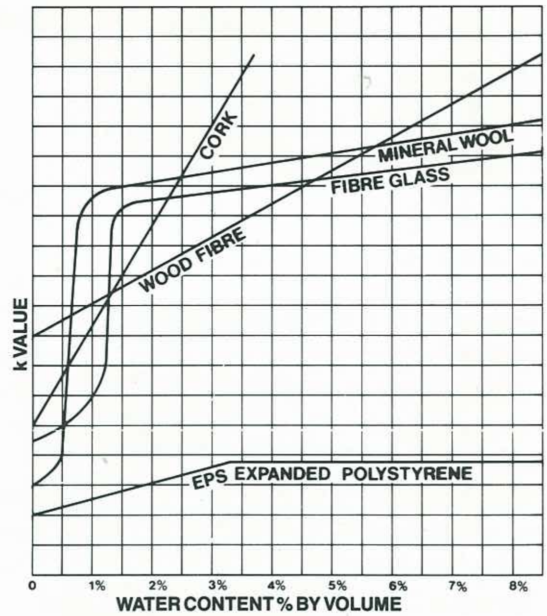
Moisture resistance.

EPS has a low water vapour transmission rate. It has no capillary action. However it must not be considered as a vapour barrier in the same sense as polyethylene film.

It has excellent breathability characteristics and allows moisture to escape from a wall or floor element, and does not form vapour dams.

In spite of the low moisture transmission rate, it is still proper to use a vapour barrier under conditions of high humidity and high temperature differentials. Normally, the vapour barrier should be installed on the warm side of the structural component, with insulation as near as possible to the cold side.

Of all materials used for insulation applications, EPS is one of the most resistant to the adverse effects of moisture. Condensation, which may build up within any insulation material under critical vapour flow conditions, only marginally affects the thermal performance of EPS. Even if condensation develops through improper use EPS will retain its dimensional stability and superior insulation values. The following chart demonstrates the effect of moisture on k values on several commonly used insulation materials.



Technical data from
ASHRAE and International Institute of Refrigeration,
"The Effect of Moisture on Insulating Materials . . ."

The EPS Divisions of the Plastics Institute of Australia and New Zealand are actively supporting the Standards Associations of Australia and New Zealand to publish thermal insulation standards which will be of direct benefit to the building industry and consumers.

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