Guidance
No 55

Thermal Conductivity and 90/90 values

What is thermal conductivity (λ)?

Thermal conductivity is a measure of the rate at which heat passes through a material. The units are watts per unit thickness per degree temperature difference across that unit thickness.

For example, a material with a conductivity of 0.040 $W{\cdot}m^{-1}{\cdot}K^{-1}$ will allow 0.04 watts to pass through a 1 metre thickness (with an area of 1 square metre) when the temperature difference across it is 1 degree centigrade.

Similarly, if the material is 250 mm thick the rate of heat transfer would be:

0.040/0.25 = 0.16 $W{\cdot}m^{-2}{\cdot}K^{-1}$.

Why is it important?

The thermal conductivity of the insulation used in a building element largely defines that elements calculated U value which is essential to show compliance with Regulations for limiting excessive heat loss and limiting carbon emissions, not to mention future energy bills for the life of that building.

What is lambda 90/90 ($\lambda_{90/90}$)?

This is a conductivity value that 90% of production should equal or better with a 90% confidence limit.

How is it measured/calculated?

In general manufactures use heat flow meters, instruments that set up a temperature gradient across a production sample and measure the rate at which heat flows through the sample.

By measuring conductivity regularly the manufacturer builds up a range of values.

They can then calculate a mean value and a standard deviation (ie an average deviation from the mean). This calculation should be repeated every 3 months and should not include data more than 12 months old. This can be extended to up to 3 years if that is the only way to achieve the minimum number of results required for a 90/90 calculation, which is ten.

The standard deviation is then multiplied by a confidence factor ‘k’, which is added to the mean conductivity to estimate a value which 90% of production is less than, with a 90% confidence factor.

It is important to recognise that this statistical method of quote quoting thermal conductivity means that a lambda 90/90 value will always be higher (ie ‘worse’) than a mean figure calculated from the same set of data.

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This worked example of a lambda 90/90 calculation is taken from BS EN 13162 : 2008.

	λ ($W \cdot m^{-1} \cdot K^{-1}$)
	0.0366
	0.039
	0.0382
	0.0378
	0.041
	0.0412
	0.0397
	0.0417
	0.0415
	0.0402
	0.0417
	0.0406
	0.0408
	0.0421
λ_{mean}	0.0402
s_λ	0.00164
count	14
k	1.9
$\lambda_{90/90}$	0.0433
λ_D	0.044

As a manufacturer increases the number of results they have, the *k* factor reduces. This is because the more results you have, the more likely it is that your results reflect your whole population, ie including unmeasured samples, and your confidence increases.

These values for k are taken from Table C.1 of BS EN ISO 10456 : 2007 but can also be found in the harmonised product standards EN 13162-13171.

n	*k*
10	2.07
15	1.87
20	1.77
30	1.66
50	1.56
100	1.47
1000	1.34

As the number of results increases, the standard deviation should also reduce as high and low values have less effect on the average deviation from the mean.

This allows manufacturers to improve their declared value, or optimise their production process.

What is Lambda declared (λ_D)?

This is the $\lambda_{90/90}$ rounded up to the nearest 0.001 $W \cdot m^{-1} \cdot K^{-1}$, but see next item about ageing. For example:

$\lambda_{90/90}$	λ_D
0.0299	0.030
0.03001	0.031

This value is the value declared by the party placing the product on the market and is the value used in U value calculations (unless in a few cases a different ‘design’ conductivity is indicated by the specified end use).

What about ageing?

Some insulations retain a significant amount of low conductivity (ie lower than air) blowing agents within the foam cells. These are termed ‘permanent’ blowing agents and they help to improve (lower) the rate at which heat passes through the material.

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These materials includes many PIR/PUR and phenolic foams and extruded polystyrene and the applicable harmonised product standards require that this ageing is taken into account to reflect an average performance over 25 years.

The ageing can be included in the 90/90 calculation or (more commonly) added as an increment to the $\lambda_{90/90}$ value (based on 'fresh' conductivity values) before it is rounded up into a λ_D value.

Typical ageing increments for blowing agents used in polyurethane foam insulation are given in Table C.2 of EN 13165 and depend on the actual blowing agent used and the insulation thickness but include, in $W \cdot m^{-1} \cdot K^{-1}$:

diffusion open or no facings:

0.0038 to 0.055,	hydrocarbon and hydro flourocarbons
0.010	Carbon dioxide

diffusion tight facings:

0.0015 to 0.025,	hydrocarbon and hydro flourocarbons
0.006	Carbon dioxide

The same suite of harmonised product standards assume that other insulations, such as EPS and mineral wool do not age significantly with time, provided they are dimensionally stable.

What is a diffusion tight facing?

In EN 13165 for polyurethane, these are defined as:

- a metal sheet not less than 50 µm thick
- facings for foam cores that do not change λ value by more than 0.001 $W \cdot m^{-1} \cdot K^{-1}$ after 175 days at 70°C
- facings (minimum 10 samples) with an oxygen diffusion rate of less than 4.5 ml per m^2 per day when tested to ASTM 3985.

What is design Lambda value (λ_U)?

Very often this is the same as λ_D, but sometimes it is higher.

For example, XEPS insulation used on an inverted roof is subject to moisture absorption by diffusion and by freeze/thawing during the heating season and this increases the average moisture content of the insulation when compared to samples that are conditioned for a thermal conductivity test.

EN 10456 has equations for calculating the factor increase in conductivity that should be applied to the declared conductivity where the XEPS insulation moisture content has been measured and declared in accordance with EN 12088 and 12091.

This can add around 0.002 $W \cdot m^{-1} \cdot K^{-1}$ to the λ_D value and λ_U and not λ_D is used in U value calculations.

Whose responsibility is it to declare a $\lambda_{90/90}$ value?

The party placing the product on the market, usually the manufacturers, or their agents.

BBA policy on thermal conductivity

The BBA has declared a policy of only including $\lambda_{90/90}$ values in all new Certificates and is updating all existing Certificates on a sector by sector basis. This will enable a 'level playing field' to be maintained during this period of transition. Where no 90/90 value is available, a 0.005 $W \cdot m^{-1} \cdot K^{-1}$ increment is being added to the value previously quoted to enable a fair comparison to be made to other Certificates and to prevent Certificate holders claiming an unrealistic advantage by quoting mean values.

Further information is available via the BBA's website.

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