The Art of Layers in Construction!

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The Top Layer: Following a correct recipe results in an amazingly delicious cake. The same applies for the layers of your building to ensure the, floors, walls and roof, look right, perform correctly, and deliver comfort for the occupant. Following the wrong recipe can have long term consequences - sometimes unseen!

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The Middle Layer:
The impact of our staff's cakes wouldn't be the same if they looked slapdash. The same could be said of a construction.

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The Bottom Layer:
Building, like baking, is a science. The best results come from following the recipe precisely and accurately, with care and attention to detail……

EAL Consult - Building Sustainability

Ingredients

1. Project details and construction type.
2. Materials.
3. Material data and bridging details.
4. Result and corrections.

The Preparation

At EAL Consult we have a weekly cake to keep morale and office wellbeing high. After all, a little bit of what you fancy does you good! Our staff put love and soul into their creations, presenting the results to their colleagues with pride - and that got us thinking about the links between baking and building.

If you've worked on building sites over the last decade or so, there have probably been times when you've felt like the insulation requirements have changed every five minutes or so.

It hasn't been quite that often but, in England and Wales, new building regulations relating to thermal performance have come into effect in 2006, 2010 and 2014. That's a regular four-year cycle, only broken by the lack of a change in 2018.

Thanks to this consistent schedule of updates, energy efficiency is arguably now the biggest driver in building design and construction. The thermal insulation market has become dominant, coming up with better products and offering solutions to - theoretically - make life as easy as possible. Do they succeed? When you think about insulation, what goes through your mind?

How can I make sure my client gets the best possible installation so they enjoy the benefits of a comfortable and energy efficient building for years to come?

Or is it more like:

What's the minimum I can get away with? How can I make this specification do the same but cheaper?

Insulation isn't the only thing that makes a building energy efficient, but it is one of the most important, most talked about - and, yes, most expensive - things. For more on how insulation fits into the bigger picture, download our e-book, *In it for the long haul: why it pays to take a fabric first approach*. To make sense of what insulation is and how its effect on building performance is calculated, please read on and discover ...

- What is insulation?
- How is insulation performance measured?
- How is a U-value calculated?
- How to read a U-value calculation.
    1. Project details and construction type.
    2. Materials.
    3. Material data and bridging details.
    4. Result and corrections.
- How do I trust U-value calculations?

What is insulation?

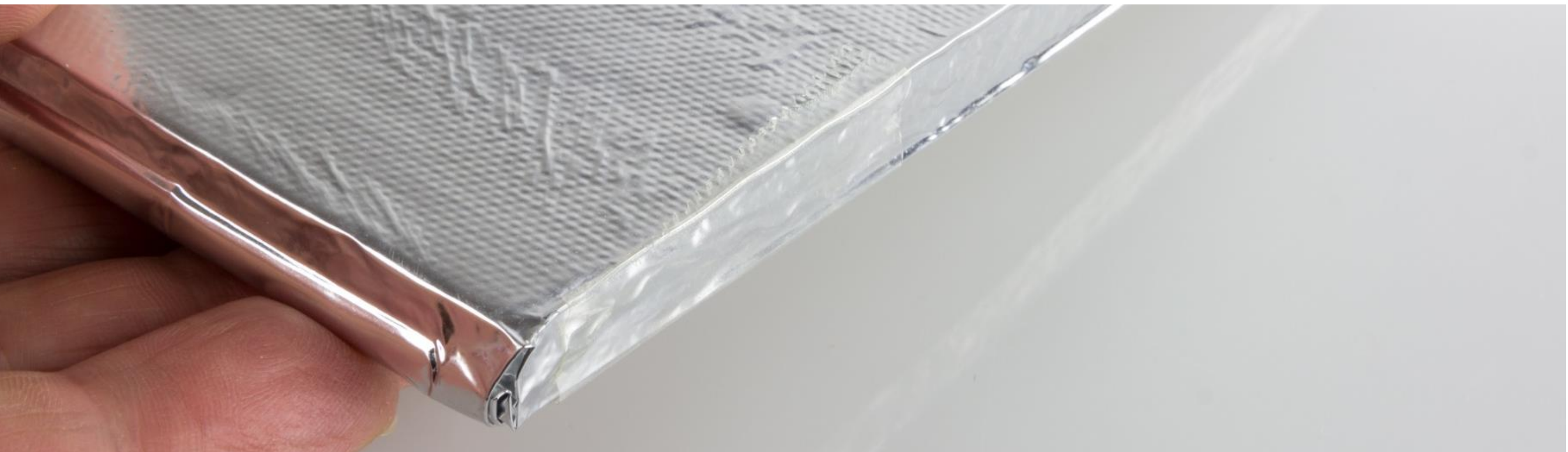
It's tempting to think of insulation only as something that provides thermal performance, but there are other types of insulation. Acoustic insulation, for example, reduces the transmission of sound, but in this Ebook we're concentrating on thermal insulation.

Insulation products have a very low thermal conductivity and are designed almost exclusively for the purposes of restricting the flow of heat through a construction. As a result, they have to be designed into constructions in conjunction with other materials that fulfil the rest of a building's functions.

There are many different insulation types. Some of the more common and better-known ones include:

- Vacuum insulated panels.
- Phenolic foam.
- Polyisocyanurate (PIR) foam.
- Expanded polystyrene (EPS).
- Extruded polystyrene (XPS).
- Stone wool.
- Mineral wool.
- Multi-foils.

Vacuum panels rely on an absence of air to stop the flow of heat, and if the vacuum is compromised then the performance dramatically worsens. Plastic-based foams rely on gases within the cells, while stone and mineral wool products utilise air trapped between the fibres. Multi-foils work through a combination of air and reflective surfaces.



Other solutions include blown insulation (using mineral wool fibres, EPS beads or recycled newspaper), natural materials (such as wood fibre, sheep's wool or straw bales), and structural insulated panels.

In general terms there is no right or wrong answer when it comes to choosing insulation. Some are breathable, some are non-breathable; some are combustible, some are non-combustible; some are compressible, some have a good load-bearing capability; and so on.

The right product should be selected for the right reasons and for the right applications - not just based on cost and availability. If an insulation supplier cannot assist with detailed and unbiased advice then speak to manufacturers of the different insulation types under consideration, or ask the opinion of an experienced energy assessor or building control officer.

How is insulation performance measured?

Virtually all construction products and materials have thermal properties, conducting heat through them to a greater or lesser extent. The ability to conduct heat - a material's thermal conductivity - is usually the headline figure quoted for insulation products. The lower the number the better.

Thermal conductivity is expressed in the units W/mK, or the number of Watts (W) per metre thickness of the material (m), per degree of temperature difference (in Kelvin, K) between one side of the material and the other. It remains the same regardless of thickness, so a 25mm version and a 250mm version of the same insulation product have the same thermal conductivity.

To compare different thicknesses of the same product, or equal thicknesses of different products, means working out their thermal resistance, or R-value, expressed in the units m^2K/W.

R = thickness (m) / thermal conductivity (W/mK)

As its name suggests, the R-value is a measure of resistance to heat flow through a given thickness of a material. Using the same example as above, the 250mm version of an insulation product will have a thermal resistance ten times greater than its 25mm counterpart.

A common complaint, especially from people who have worked on construction sites for a long time, is about the insulation thicknesses they're expected to fit within the building. Typical solutions have changed a lot over the last ten or twenty years, but so has the technology that goes into creating insulation products, and we can use R-values to illustrate that.

When people look at, say, a modern polyurethane-based rigid insulation board and think 100mm (approximately four inches) is a lot, it ignores how that thickness of rigid board offers the same R-value as around 6m (yes, *six metres*!) of dense blockwork. Imagine constructing walls that thick!

How is a U-value calculated?

Whether the calculation is for a floor, wall, pitched roof or flat roof, the thermal resistance of every layer of the construction has to be worked out. The resistances are then added together, and 1 is divided by the total to give the thermal transmission, or U-value.

$U = 1 / R_{TOTAL}$

A U-value is the amount of heat energy calculated to transfer through the building fabric from warm side to cold side. It is expressed in the units W/m^2K, or the number of Watts (W), per square metre of the construction fabric (m^2), per degree of temperature difference (in Kelvin,K).

That means the larger the surface area of the element, and the greater the temperature difference between the internal and external sides, the greater the flow of heat energy.

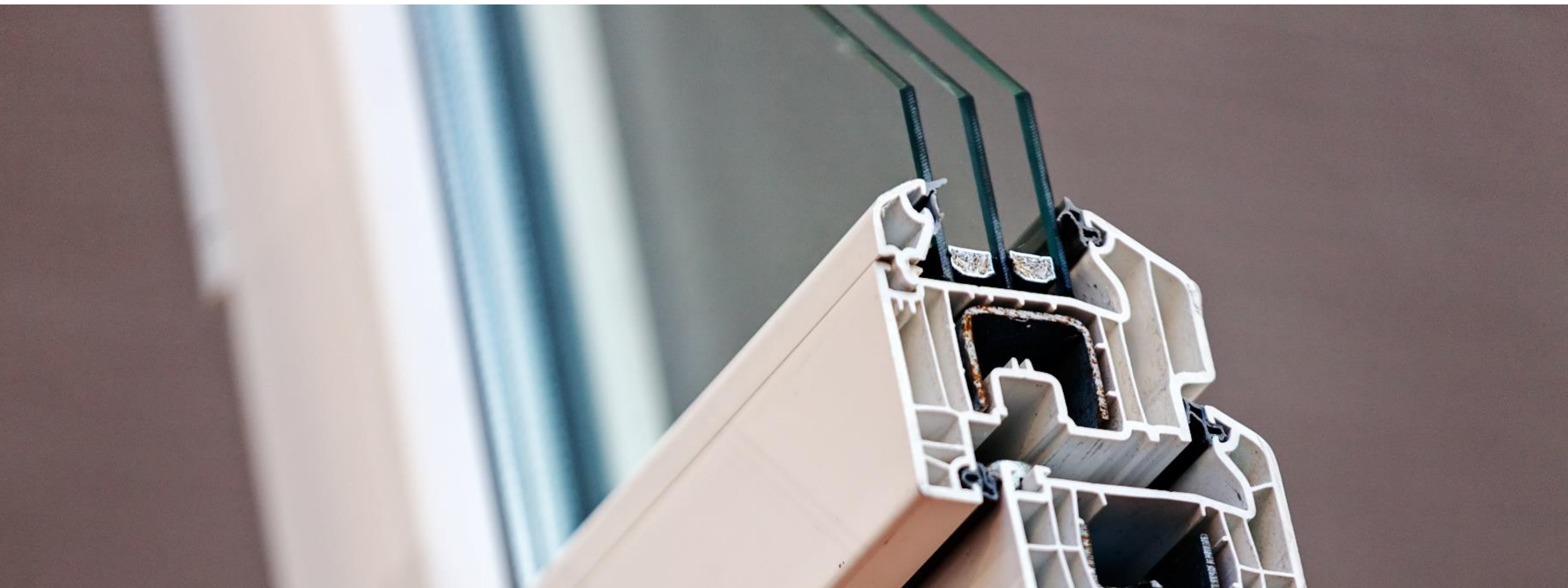
U-values have become a key measure by which a building's design is assessed, but most people have no reason to understand the maths behind them. The downside of that is a widespread use of documents that are not fully understood by the majority of people using them.

In turn, that leads to assumptions: mainly, that the calculation is accurate and automatically correct. If the piece of paper shows the right number, then all is well. If it shows the wrong number, then either there are problems to solve or too much insulation has been included.

U-values of doors, windows and rooflights

The thermal performance of doors and glazed elements is also expressed as a U-value and describes the heat loss through them in exactly the same way.

Compared to other parts of the building fabric, however, they are calculated and declared in different ways. The U-value of a door or window is based on the complete unit, essentially as supplied by the manufacturer. U-values for floors, walls and roofs depend on the combination of components that make them up, and the quality of workmanship on site - understanding that is the focus of this ebook.



How to read a U-value calculation

To help reduce assumptions, we're going to show how to read the fundamental information in a U-value calculation. Calculations come from a variety of software packages, which display their workings in slightly different ways. Even so, the following should be a feature of any calculation, and therefore is a useful guide to what to look for:

1. Project details and construction type

U-values should be calculated for the specific project, while stating the type of construction makes clear what exactly is being calculated.

Generic calculations can be used for an idea of the insulation required to achieve a U-value, but relating the calculation to a project leaves no room for doubt as to what has been specified and what should be constructed.

2. Materials

This section lists the construction layer by layer to help the reader understand what is going to be, or has been, built. The description of each layer and material (including product references) should be detailed enough to achieve that understanding.

Extra clarification isn't always required, but the quality of a calculation is enhanced when layer descriptions include appropriate details such as assumptions. It shows the calculation is specific to the project, the specifier's intentions have been represented as accurately as possible, and the calculation is a fair attempt to represent what is likely to be built.

Materials don't have to be listed in the right order to calculate the U-value, because the thermal resistance of each layer is independent. It certainly helps though! To compare the calculation to a specification or as-built construction, it is common sense and good practice for calculations to reflect the correct sequence of layers.

3. Material data and bridging details

A U-value is calculated from the thermal performance of every material layer in a construction. Insulation provides most of that performance, but the other materials all contribute to the result.

Thermal resistance is calculated from the thickness and thermal conductivity of a material, both of which are displayed in this section. Some layers, like membranes, have no meaningful thickness or thermal conductivity, so figures are not quoted. Other layers, particularly insulation, often have to be interrupted - or bridged - by other materials, and the difference in thermal performance must be accounted for.

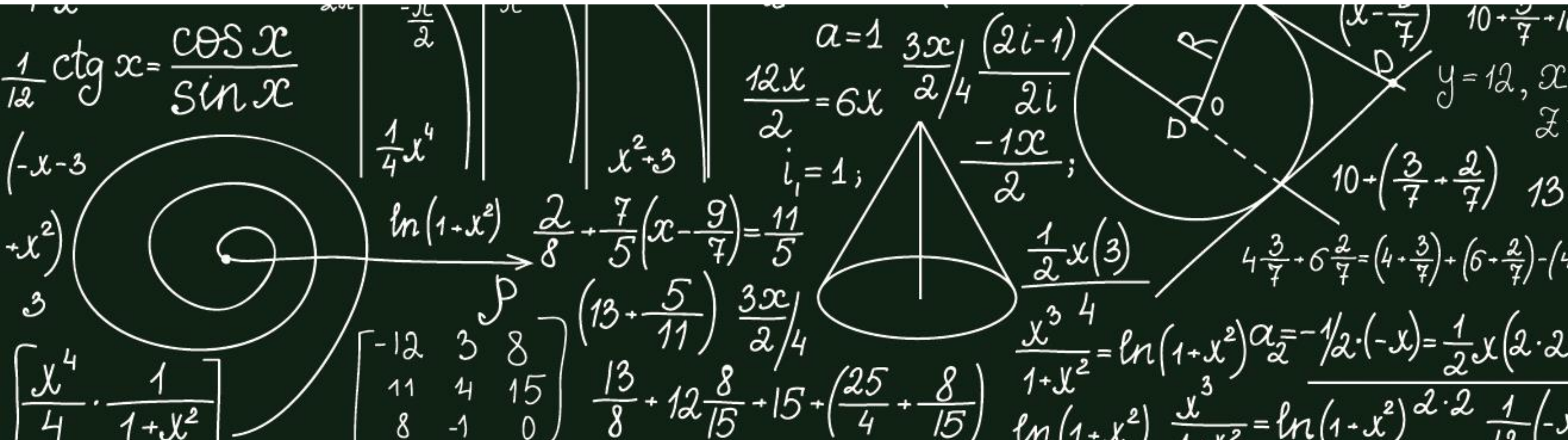
Bridging is stated as the percentage of the layer made up of the bridging material, but it might not be clear to readers. “12.5% timber bridging” makes more sense if the layer description also says, “bridged by 50mm wide timber rafters at 400mm centres”.

4. Result and corrections

For many people, this is one of two parts of the calculation they look at (the thickness of insulation being the other). If the figure in bold matches what has been asked for then all is well.

A series of other numbers are listed with the result, showing the outcome of various processes during the calculation that influence the final U-value. Corrections can be applied to calculations to reflect the realities of installing insulation, and those corrections are included in this section.

There are several types of correction, but the most common are for mechanical fixings, such as nails or screws, penetrating the insulation layer, and to account for air gaps in the insulation layer. If two calculations for the same construction are compared, it’s important that the same corrections are included for a fair comparison.



How do I trust U-value calculations?

U-value calculations come from various sources. Insulation manufacturers offer free calculations in return for their products being specified, but there are also independent consultants who provide calculation services.

Some manufacturers offer online calculators, allowing you to perform your own calculations. The calculators are generally designed to be easy to use, but the risk remains that someone tries to calculate a design that can't be covered by the calculator - and generates a calculation anyway, which is then widely accepted as 'correct'.

There is no qualification for producing U-value calculations - accuracy almost entirely depends on the knowledge and the understanding of the person undertaking the task, though some outside reassurance is available.

The British Board of Agrement (BBA) operate a competency scheme under which people who regularly produce calculations are tested, certified as competent, and audited each year after. The cost of scheme membership means it is almost exclusively supported by large manufacturers.

A lack of certification certainly doesn't mean that someone lacks the knowledge to produce quality calculations, but if that reassurance is important then a scheme logo is something to ask for.

Trust and communication is important. Anybody asking for a calculation should be prepared to provide as much information as possible to help the person doing the calculation; anybody calculating U-values should ask questions where relevant information is missing. The joint aim should be confidence that a design has been accurately calculated, or that what is being constructed reflects what a calculation shows.

About EAL Consult

Established in 2008, EAL Consult is a London-based company providing energy assessment services for sustainability compliance. They aim to provide clear, concise and transparent information that inspires clients to engage with new ideas, and a high level of service prioritising appropriate, efficient and cost-effective solutions.

Throughout 2018, in celebration of its 10th birthday, EAL Consult is releasing a series of E-books covering various aspects of energy-related construction practice and regulatory compliance.

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