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CPD Article

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Thermal Design Choices for Aluminium Fenestration Systems

Forty years ago we were installing solid aluminium frames in most applications with single glazing, today, designs and systems have changed a lot.

There are now various ways to insulate aluminium to ensure thermal efficiency. This CPD looks back at the history of thermal breaking of aluminium and brings the process up date with the latest technology. For the specifier it is important to note what type of thermal break should be used in which system and to determine the suitability of the system to be chosen for any given project.

Whilst we are not trying to make window designers of specifiers, it is important to understand what constitutes a competent aluminium fenestration system. These five learning objectives should give you a better understanding of the efficiencies that can be made by specifying modern aluminium fenestration systems.

Key Learning outcomes

- To understand the benefits of specifying thermally insulated aluminium.
- To have a basic knowledge of aluminium thermal break development.
- To be able to interpret basic thermal simulation graphics.
- To be able to identify issues of cold bridging and how to avoid.
- To be able to select a system design to suit the buildings' requirements.

1.0 So why insulate?

Well apart from the obvious legislative reasons, we can make our buildings more comfortable with the right product design.

The Building Regulations, Approved Document L is all about the conservation of fuel and power, basically insulation requirements, there are four documents:

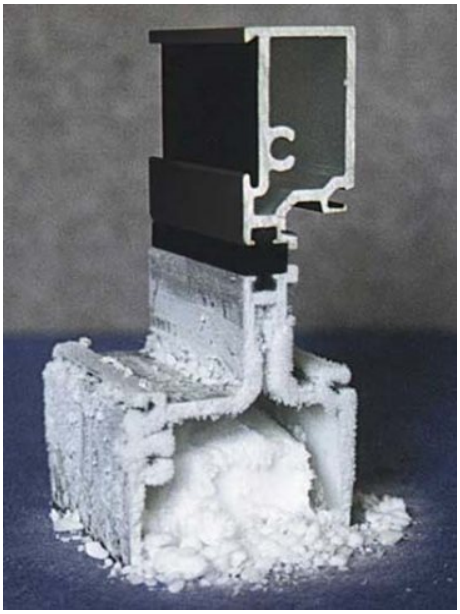
Approved Document L1A:
conservation of fuel and power in new dwellings, 2013 edition with 2016 amendments
Approved Document L1B:
conservation of fuel and power in existing dwellings, 2010 edition (incorporating 2010, 2011, 2013 and 2016 amendments)
Approved Document L2A:
conservation of fuel and power in new buildings other than dwellings, 2013 edition with 2016 amendments
Approved Document L2B:
conservation of fuel and power in existing buildings other than dwellings, 2010 edition (incorporating 2010, 2011, 2013 and 2016 amendments)

So where does the heat loss occur through a window system? There are three main areas, that of conduction, convection and radiation.

Convection - air circulation in a window profile cavity - about 35% of the energy flow.
Conduction - through solids - about 50% of the energy flow.
Radiation - from a warmer surface to a colder surface - about 15% of the energy flow.

There are many books written on the subject of condensation, but the control of condensation comes down to two basic criterion, that of good window insulation, which reduces heat loss and good ventilation, which reduces air moisture.

Used externally there is an issue of surface spread of flame if used over 18m in height where dwellings are concerned. All external finishes must be capable of achieving a rating of A2-s1, d0, a limited combustibility material or A1 a non-combustible material. Powder coating meets the requirement for the A2-s1, d0 rating. Window and door frames, including curtain walls are exempt, but infix panels and column casings for example are required to comply. The specifier should ensure that where dwellings are located within buildings over 18m in height that materials do meet a minimum rating of A2-s1,d0.



An example of the 'fill and de-bridge' design of thermal breaks which were introduced about 40 years ago.

2.0 The importance of profile design

Forty years ago we were installing solid aluminium frames in most applications with single glazing, today designs have changed a lot.

Appearing about forty years ago was the method of ‘fill and de-bridge’. Simply done, a channel in a single window profile extrusion was produced separating the inside from the outside. Into this channel was poured a thermo-setting polyurethane resin. Once set the profile was turned over and the base of the channel machined away leaving the resin to insulate the profile, typically 3 to 5mm in width. As shown in the thermal break picture, image 1, above, it was efficient at the time and many systems adopted this thermal break technology. In the UK today few, if any, windows are now supplied with this technology as it does not meet the requirement for high levels of insulation required today.

As an alternative to, or in conjunction with an alternative material, aluminium systems can be clad with timber. This gives the long life expectancy of aluminium to the outside and the natural look of timber to the inside. Used primarily in the residential sector, the two systems are known as, a ‘timber clad aluminium system', or an ‘aluminium clad timber system’ depending of which material forms the structure of the window. These windows are used successfully in the UK today and are often thermally improved with additional thermal insulation. Aluminium clad systems are also available in other materials such as an ‘aluminium clad PVC systems’.

So to polyamide, now the most advanced type of insulation material used with commercial aluminium profiles. Polyamide insulation is available in a wide range of types which include foamed profiles, bio-based polyamides and low lambda polyamide which offers greater thermal efficiencies. By adding further insulation foam profiles and sections, such as polyethylene ropes and Aerogel’s, insulation can be further enhanced by reducing air movement within a profile cavity or around a window opening such as a vent. Utilising these specialist materials, very high levels of insulation are achievable which continue to position aluminium systems as the specifiers choice for door, window and curtain wall applications.

As can be seen in the example below, image 2, the polyamide designs are intricate. This is one of the first aluminium systems to employ silica aerogel foamed profiles and together with the captured air spaces, helps this window design achieve a U value of just 0.57, making it suitable for Passivhaus applications. These systems are the certified by the Passivhaus Institute.

A high insulation Passivhaus frame design using high insulation materials to offer a window U value of down to just 0.57.

3.0 Thermal calculations

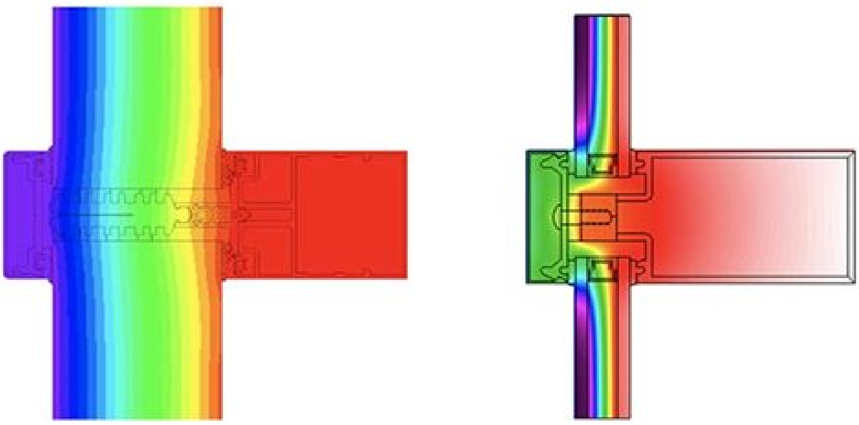
So how do we determine the insulation levels achieved by certain system designs?

Today all systems are calculated, but is was not always the case. The original ‘hot box’ method simply placed the product between two chambers one producing heat and the other chamber measuring the heat that transferred through the product. Whilst the test was quite simple, it was expensive to test and took some time to complete.

Today, most companies use a thermal calculation system called ‘Therm’. The software takes the various material properties and constants then uses these to show the contours of heat across a given combination. These contours are known as Isotherm lines.

In image 3 below, blue to the left, is obviously the cold side and the red indicates the warm side. These graphical outputs are important as the best designs are ones where the isothermal lines are straight. On the left, the curtain wall is shown with fairly straight isothermal lines, whilst to the right there is shown an older more basic curtain wall system which indicates a poorer insulation.

Normally once the correct glazed unit and frame combination has been selected and calculated, the specification is complete. But, there are a few areas to watch. Unless the designs call for a Passivhaus standard of window, then a high specification double glazed unit will often suffice. Triple glazed or quad glazed systems are expensive, and above all a heavy unit to incorporate into an opening window system. Most important is choosing the right glazing for the right window system. Either systems company or fabricator/installer can advise on the best combinations to specify.



Isothermal lines in MB-TT50 curtain wall

The importance of straight Isotherm lines can be seen in this thermal break design giving the design on the left much higher insulation capabilities.

4.0 How to reduce the effects of cold bridging between frame and structure

The detailing of a window installation is crucial in order to get the best benefits of a high performance window system. The design of the envelope construction that the window/curtain wall fits into has a large bearing on thermal bridging of the profile insulation. High insulation cavity closers and insulated reveals can assist greatly in ensuring thermal integrity.

Often the structure of a building is considered to be a ‘warm’ structure, a structure that insulates and supports the building. In some cases where a structure is of a monolithic material such as concrete frame, the structure can be considered as a cold structure with the windows inset from the structure. This type of construction is often used in the refurbishment of existing structures. The problems begin when a cold structure attempts to become a ‘warm’ structure and extensive cold bridging can occur around the window frame reveals as can be seen in image 4 below.

Older buildings, where the DPC is the only membrane which separates the inside blockwork from the external brickwork are prone to cold bridging and it would be highly recommended to cut back block/brick returns to insert thermal insulation in cavity walls.

What can be seen as black mould is not generally a leak in the structure, or with the interface between window and structure, but the incidence of condensation. With internal heating and points where there is moisture generation such as cooking, bathing or just people, a cold area will be the first place where condensation will appear. Moisture laden air has a ‘dew point’ at a lower temperature where the air can simply not hold the moisture. This happens mostly on surfaces and when the surfaces are porous, such as plaster reveal, it attracts bacterial growth, seen as black mould. The key to resolving these issues is both good insulation and frequent ventilation.

Interesting to note that our bodies each produce up to 0.25 litres of water per hour.

Mould on a cold bringing reveal.

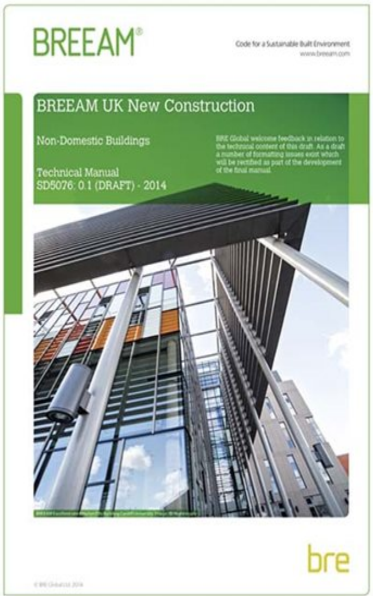
5.0 BREEAM points - how to maximise

Using high performance aluminium windows can help achieve high levels of BREEAM points, the higher level of points the greater sustainability of the construction can be achieved together with the higher rating. Credits of 119 or more, depending on scheme, are awarded across ten categories based on the outcomes of the assessment. Depending on the overall score, the building is then rated as a Pass, Good, Very Good, Excellent or Outstanding BREEAM rating. The ten measures are, Management, Health & Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use & Ecology, Pollution and Innovation.

Depending on its source, aluminium can provide additional credits in the Materials and Health & Wellbeing categories. Fenestration advisors can further assist the specifier in meeting the requirements of responsible material sourcing, thereby achieving further credits. Using advanced thermal modelling of high thermal performance aluminium windows and curtain walls can help the specifier achieve up to a further 13 credits within the Ene 1 category. Systems suppliers can also develop additional features and benefits to gain further credits within Innovation category.

The importance of a close working relationship between systems supplier, fabricator/installers and the specifier will help generate additional points within the BREAAM process.

It is aim of Aluprof to be one of the most sustainable aluminium systems suppliers in Europe.



BREEAM points contribute to a buildings sustainability and the use of high performance aluminium windows can add to the total points attainable.