Thermal bridges may occur at junctions in the thermal envelope of a building. If the insulation layers are interrupted by a poor insulator, a 'bridge' is formed by which excessive heat escapes. Thermal bridging commonly occurs:

- Where a wall meets the ground floor or the roof.
- Around windows and doors.

The rate at which heat flows across a thermal bridge is given by the equation:

\[
\text{Heat flow} = \Psi \times \text{length of bridge} \times \text{temperature difference across bridge},
\]

where \( \Psi \) is the linear thermal transmittance. (\( \Psi \), psi, is pronounced as 'sigh'.)

\( \Psi \) (or \( \Psi \)-value) applies to a length; it is comparable to a U-value for an area. The smaller the value of \( \Psi \), the better.

Much better U-values are being achieved nowadays, and so the heat losses at thermal bridges have become significant. Thermal bridging must now taken into account in the Standard Assessment Procedure (SAP).

**Examples**

The thermal image below makes the cold bridging visible. (In this example, there appears to be no thermal bridging at the lintel over the window.)

![Image of thermal image](coldbridges.png)

**Cold bridges at gable, eaves, corner and window**

(From BRE's Passivhaus Primer)

Below is a representation of a thermal bridge at a gable. Heat escapes via the blockwork that is between the loft insulation and the cavity insulation:

![Diagram of thermal bridge](diagram.png)

**Diagram from NHBC's Technical Extra, September 2011 (modified)**
Calculation of heat losses

A SAP assessor has a choice of four methods for evaluating the heat losses due to thermal bridging:

- **Global heat loss factor, y.**
  A y-value is applied to the total area of the thermal envelope. (Details of the four methods are given below.)
  This simple method is likely to grossly over-estimate the actual heat losses, especially for a well insulated house.

- **Default values for Ψ**
  At any particular thermal bridge, the heat loss is calculated by multiplying an appropriate default value for Ψ by the length of the bridge.

- **Approved Design Details**
  If the construction at a thermal bridge is in accord with an Approved Design Detail, then the heat loss at the bridge is calculated using an approved value for Ψ. (This will be better than the corresponding default value mentioned above).

- **Calculated values for Ψ**
  An individually calculated value for Ψ is used in the calculation of the heat loss.

The last three methods can be mixed. Ie, calculated Ψ-values can be used for some bridges, approved values for others, and default values for the remainder.

Let's consider all four methods in turn.

**Global heat loss factor, y**

A value for y is specified in the SAP documentation: 0.15 W/m²°C.
– Notice that the units are the same as those of a U-value.

The aggregate rate of heat loss due to all the thermal bridging is crudely estimated by:

\[
\text{Aggregate rate of heat loss} = y \times \text{Total Fabric Area} \times \text{temperature difference}
\]

The Total Fabric Area is simply the sum of the areas through which heat is lost by conduction, ie, it is the area of the external walls, doors, windows, ground floor, and roof. (In the case of a cold loft, the area of the 'roof' is the area of the loft floor.)

How significant are the heat losses at thermal bridges?

We saw in an earlier article (April 2014) that the main U-values for the Notional Dwelling used in SAP are:

- Walls: 0.18
- Ground floor, roof: 0.13
- Windows: 1.4.

If Aw, Af, Ar, Awin are the areas of the Walls, Floor, Roof, and Windows of a Notional Dwelling (ignoring doors), then, for 1°C temperature difference between inside and outside:
Rate of heat loss through fabric area = 0.18Aw + 0.13Af + 0.13Ar + 1.4Awin

And:

Rate of heat loss through thermal bridges = \( y \ (Aw + Af + Ar + Awin) \)

Hence in total:

Rate of heat loss = \((0.18+y)\ Aw + (0.13 +y)\ Af + (0.13 + y)\ Ar + (1.4 + y)\ Awin.\)

Effectively, thermal bridging appears to have increased all the U-values by \( y \). Since \( y = 0.15 \), we can regard three out of the four U values of the Notional Dwellings to have been more or less doubled. As much heat is being lost through thermal bridging of the walls, floor and roof as is being lost through their areas.

However, this simple method of estimating the heat losses is likely to be a gross over-estimate – to encourage the house designer and SAP assessor to use better methods. A more accurate method requires the heat loss at each bridge to be calculated using an appropriate value for \( \Psi \) – derived by one of the following three methods.

**Default values for \( \Psi \)**

Table K1 of the SAP documentation gives a list of the default values to be used for \( \Psi \). Here are the main ones:

<table>
<thead>
<tr>
<th>Bridge Type</th>
<th>( \Psi ) (W/m.°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lintel</td>
<td>1.0</td>
</tr>
<tr>
<td>Sill</td>
<td>0.08</td>
</tr>
<tr>
<td>Jamb</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Ground floor</strong></td>
<td><strong>0.32</strong></td>
</tr>
<tr>
<td>Upper floor</td>
<td>0.14</td>
</tr>
<tr>
<td>Eaves (with the loft floor insulated)</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Gable (with the loft floor insulated)</strong></td>
<td><strong>0.48</strong></td>
</tr>
<tr>
<td>Corner of wall</td>
<td>0.18</td>
</tr>
</tbody>
</table>

*Default values for \( \Psi \) (The three worst bridges are in *bold type*.)*

The thermal bridges are all linear. So the length of the ground floor bridge, for example, is the length of the junction of the floor and the external walls, ie, the perimeter of the floor.

Lintels are beams (of steel, concrete, etc) that support the wall above a window or door opening. Using the default value for \( \Psi \) (1.0 W/m.°C, as in the table), a one-metre length of lintel loses 20 watts for a temperature difference of 20°C.

Let's compare that with the rate of heat loss through a wall of the Notional Dwelling (with \( U = 0.18 \)).

For a 20°C temperature difference between inside and outside:
Heat flow through a square metre of the wall = 0.18 \times 20
= 3.6\text{ watts.}

So a one metre length of lintel loses about the same amount of heat as 6 square metre of the wall (6 \times 3.6 \approx 20). Note: to reduce thermal bridging at a lintel in a cavity wall, use a separate lintel for each leaf, rather than one lintel supporting both leaves (as is common practice).

Measuring the lengths of thermal bridges is not difficult. (But note that a SAP convention is that the length of a lintel is taken to be the width of the opening, not the actual length of the lintel.) In order to improve your SAP ratings, make sure that your assessor uses this method (or a method below) rather than the global heat loss factor, \( y \).

The thermal bridges listed in the table above are the most common ones. SAP lists other bridges, too. But if a bridge is not of a listed type, then SAP allows it to be ignored. For example, the chimney and external air intake for a wood stove may well form thermal bridges. But figures for these bridges are not given in SAP, and so the thermal bridging is ignored – something of an omission in the methodology.

**Build with Accredited Construction Details**

The government has published some Accredited Construction Details (ACD's) for thermal bridges found in house building. (See Further Info.) In addition to the default values shown above, SAP's Table K1 gives the values of \( \Psi \) to be used for ACD's. In almost all cases, these are exactly half the default values. ('Exactly half' is an indication of the rather arbitrary nature of the values being given for \( \Psi \). In the real world, it is most unlikely that one set of \( \Psi \)-values would be exactly half of another.) Note that there is nothing outstanding about ACD's. They are satisfactory, common building practice – but they don't include any special measures to combat thermal bridging.

**Other government-approved details**

There is provision in SAP for the use of other government-approved sources of details, with corresponding values for \( \Psi \). A couple of official-looking schemes are:

- Enhanced Construction Details, by the Energy Saving Trust
- Constructive Details, by Constructive Details Ltd.

The details of both schemes include measures to combat thermal bridging, resulting in better \( \Psi \) values than those for Accredited Construction Details. However, the official status of the schemes is not as it might appear.

(We will look at both schemes more closely next month.)

**Calculated values for \( \Psi \)**

You may require your architect to minimise thermal bridging by producing custom designed details. In such cases, the calculation of the heat flow involves very sophisticated mathematics. Fortunately, there is computer software (eg, THERM) which does the sums effortlessly – though such software is not for the amateur, and not, indeed, for some SAP assessors. So if you want a SAP assessment to be based on
individually calculated values for the thermal bridges, engage a SAP assessor who can do the calculations – at a price. (The calculations should be done in accordance with the conventions published by BRE – See Further Info.)

Of course, you could build the enhanced details, but require your SAP assessor merely to use the default y-value – thereby reducing the cost of the assessment. You need to ask yourself how concerned you are about gaining the highest possible SAP rating. The certificate is only a piece of paper. It is what you build that is the reality that will affect your future comfort and fuel bills. (However, if and when you come to sell your selfbuild, a prospective buyer might be influenced by the ratings on a SAP certificate.)

How much heat is lost at thermal bridges?

Earlier in the article, we saw that if the simplistic global heat loss factor, y, is used, then about half of the heat losses through the fabric appear to be due to thermal bridging. But that is a gross over-estimate. A university study (see Further Info) shows that a more realistic figure for heat losses with poor details is about 30% of total fabric losses. That figure is reduced to about 20% by the use of Accredited Construction Details, and further reduced to about 10% by the use of Enhanced Construction Details. Using calculations (via software) for well designed details, the figure can be reduced yet further, to a mere 5% of fabric heat losses.

So, thermal bridging can be more or less designed out – if you press your designer to do so. But of course, better detailing is likely to cost somewhat more both to design and to build.

FURTHER INFO:

Technical Extra September 2011
The NHBC publish regular issues of 'Technical Extra' (formerly 'Standards Extra'). This particular issue deals with thermal bridging and other Part L topics. Free download:
www.nhbc.co.uk.

Assessing the effects of thermal bridging at junctions and around openings
Published 2006 by BRE Press as Information Paper IP 1/06, 6 pages. £9.

Accredited Construction Details for Part L
Some people – though not a the reader of this magazine! – confuse planning control and building regulations. The government is not helping the situation by giving information about both types of regulations on a new website called 'The Planning Portal'. So, to find out about building regulations, go to the Planning Portal! The ACD's there can be freely downloaded. The website's search facility is currently useless. Use Google or similar.
www.planningportal.gov.uk.

Conventions for calculating linear thermal transmittance and temperature factors
Published 2007 by BRE Press as BR 497. 48 pages. £37-50.

Detailing to Minimise Heat Loss at Junctions of Building Elements
By D Comiskey, University of Ulster, 2010.
Includes estimates for percentage heat losses due to thermal bridging. Free
download:
http://eprints.ulster.ac.uk.

**THERM**
The Lawrence Berkeley National Laboratory in the USA publish free software,
THERM, for two dimensional modelling of heat transfer – for SAP assessors,
designers, or even an advanced enthusiast!

**SAP 2012**
Free download, currently at:
www.bre.co.uk/sap2012/page.jsp?id=2759.

**SAP Conventions**
www.bre.co.uk/accreditation/page.jsp?id=2296.

Words: 1950.