Insulation

TECHNICAL BULLETIN

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Taking the Devil out of the Detail?

AN EVALUATION OF Ψ-VALUES FOR KINGSPAN KOOLTHERM® CAVITY CLOSER

Kingspan®

Low Energy – Low Carbon Buildings

Contents

Executive Summary

Background

The effects of linear thermal bridging around openings can lead to condensation on cold reveals, mould growth and eventual deterioration of plaster, wallpaper and / or paintwork.

Kingspan **Kool**therm® Cavity Closer provides a simple and effective method for closing cavities around openings in masonry and steel framed cavity walls. Its thermally efficient, rigid thermoset phenolic insulation core inhibits heat transfer, and thus reduces linear thermal bridging in these locations.

Unsightly Mould Growth as a Result of Thermal Bridging.

In order to demonstrate the effectiveness of *Kingspan* **Kool**therm® Cavity Closer, Kingspan Insulation commissioned BRE Scotland to carry out a thermal modelling study of jamb details for differing cavity wall constructions, where the cavity is closed using *Kingspan* **Kool**therm® Cavity Closer.

The results show that the depth of the overlap between the frame and *Kingspan* **Kool**therm® Cavity Closer has the greatest influence on jamb ψ–value. In BRE's opinion, the jamb psi-values (ψ–values) it calculated are equally applicable to the equivalent sill details.

For the purpose of simplicity, when calculating the energy and emissions performance of a building, the jamb and sill ψ–values in the table below can be used as a "safe approximation", for frame depths and overlaps (between the frame and *Kingspan* **Kool**therm® Cavity Closer) as shown, and for the full range of constructions described immediately following.

Frame Depth (mm)	Overlap (mm)	ψ–value (W/m·K)
≥ 75	30 – 49	0.027
≥ 75	50 – 74	0.018
≥ 75	75 – 99 *	0.012
≥ 100	≥ 100 *	0.007

The ψ–values set out in this table are applicable to the following range of wall constructions:

- *wall U–values ≥ 0.18 W/m²·K;*
- *internal finish of either lightweight plaster, standard plaster or plasterboard on dabs;*
- *wall cavity insulated with either partial fill cavity insulation with a residual air gap of ≥ 50 mm, or full fill (i.e. no residual cavity) cavity insulation;*
- *check or normal reveal;*
- *Kingspan* **Kool**therm® Cavity Closer *with a thermal conductivity ≤ 0.22 W/m·K and, either as a single section or coupled sections, fully filling the width of the wall cavity;*
- *inner leaf being either warm steel frame or ≥ 100 mm blockwork with a thermal conductivity ≥ 0.11 W/m·K; and*
- *outer leaf being either ≥ 100 mm brickwork with a thermal conductivity ≤ 0.77 W/m·K, or ≥ 100 mm rendered masonry with a thermal conductivity ≤ 1.13 W/m·K.*

** Frame depth must be ≥ overlap distance.*

Table 1: Safe Approximation ψ–values for Jamb & Sill Details Incorporating *Kingspan* **Kool**therm® Cavity Closer at Differing Frame Depths & Overlaps.

The fact that these "safe approximation" ψ–values are valid for a broad range of constructions, can assist designers by allowing a one–size–fits–most approach.

The "safe approximation" ψ–values for jamb and sill details incorporating *Kingspan* **Kool**therm® Cavity Closer are considerably better than the jamb and sill ψ–values given in the SAP Table K1 "Approved" column (which reflect the values given in "Accredited Construction Details".)

In order to quantify the significance of the improvement that can result from the adoption of *Kingspan* **Kool**therm® Cavity Closer, Kingspan Insulation compared the transmission heat transfer coefficient (H_{TB}) calculated using the "safe approximation" ψ–values from Table 1 with that calculated using jamb and sill ψ–values from the SAP Table K1 "Approved" column, for 4 different dwellings.

The H_{TB} calculated using the "safe approximation" ψ–values is significantly better (up to 13% better) than that calculated using ψ–values from the SAP Table K1 "Approved" column.

For those serious about designing low energy buildings, attention to detail is critical yet the devil need not always be in the detail.

Introduction

What is a Thermal Bridge?

A thermal bridge, can be defined as an area that has greater or lesser heat transfer than adjacent areas. When calculating the energy and emissions performance of a building, two types of thermal bridges are considered:

- repeating (linear & point);
- linear (non–repeating); and
- point (non–repeating).

Repeating thermal bridges occur where there are regular interruptions within the building fabric, by materials with poorer insulating properties e.g. timber studwork or I–beams in a timber frame wall construction, or fixings and fasteners. The differing (typically additional) heat flow incurred by a repeating thermal bridge is accounted for in the U–value calculation for the building element containing the bridge. These U–values are then used in SAP calculations.

Linear (non–repeating) thermal bridges occur at intermittent points in the building fabric where either:

- the thermal insulation layer is discontinuous, e.g. sills and jambs around the windows in a masonry cavity wall construction; or
- where the inside surface area of a construction is different from that of inside surface area, e.g. at the corner of two adjoining external walls.

The differing heat flow (typically, but not always, greater than that through the adjoining plane elements) attributable to the thermal bridge, is the linear thermal transmittance of the bridge, measured in W/m·K, referred to as 'psi–value' and expressed as 'ψ–value'. The lower the ψ–value, the better the performance. These ψ–values are accounted for in SAP as described below.

SAP & Linear Thermal Bridging

A building's overall heat loss due to linear (non–repeating) thermal bridging is accounted for in SAP by the transmission heat transfer coefficient (or H_{TB}), which is expressed in units of W/K.

To calculate this, individual thermal bridges are considered. Firstly, the length, in metres, of each thermal bridge is multiplied by its respective ψ–value (see below). Then, the overall heat loss due to linear (non–repeating) thermal bridging is determined by adding the resultant figures together to give a value for H_{TB}.

When calculating H_{TB}, there are a number of options regarding which ψ–values to adopt since ψ–values can comprise either *uncalculated*, *approximated* or *calculated* values, or any combination thereof.

NB In England & Wales, the overall heat loss due to linear (non–repeating) thermal bridging may be estimated rather than calculated. In this case, individual thermal bridge heat losses are not considered. A default 'y-value' of 0.15 W/m²·K is multiplied by the exposed surface area of the building, and this is taken as an estimation for the additional losses beyond those through the roofs, walls, floors and openings. This approach is no longer allowed for in Scottish building standards.

Ψ-values

Uncalculated ψ–values, from the SAP Table K1 'Default' column, can be used in circumstances where an approximated or a calculated ψ–value for a junction detail is not available.

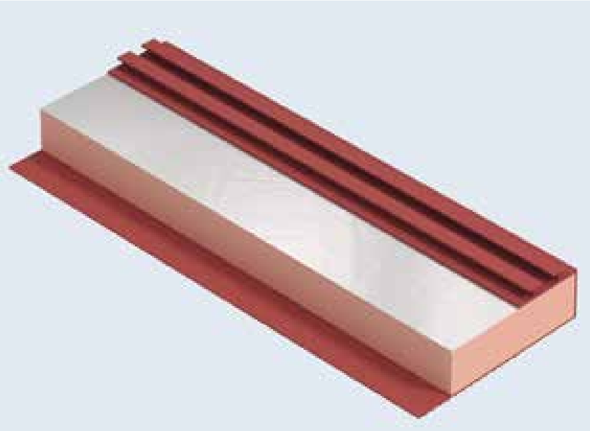
Approximated ψ–values can found in the SAP Table K1 "Approved" column. These SAP Table K1 "Approved" column ψ–values are derived from standardised construction details known as "Accredited Construction Details", which were produced by DCLG. The use of these SAP Table K1 "Approved" column ψ–values, is permissible for England, Wales & Scotland. However, Scotland has also produced a more recent set of "Accredited Construction Details" and their own ψ–values. These "Approved" Scottish ψ–values are not, as yet, reflected in the SAP Table K1 "Approved" column, but the relevant ψ–values are given on the "Approved Construction Details" themselves. "Accredited Construction Details" enable a ψ–value to be assigned to each linear thermal bridge within a building, so long as the build is confirmed as matching the "Accredited" detail. They provide a better estimate (but still, in most cases, an over-estimate) of the ψ–value for a junction detail. That over–estimate will have to be compensated for elsewhere in the design.

Calculated ψ–values are obtained from the independent assessment of numerically 'modelled' junction details carried out by a person of suitable expertise and experience. Although calculated ψ–values present designers with a potentially bewildering array of calculations, they are a considerably more accurate measure of heat flow than *approximated* and *uncalculated* values.

Analysis

Introduction

Kingspan **Kool**therm® Cavity Closer comprises a uPVC J–section with a premium performance rigid thermoset fibre–free phenolic insulation core. It provides a simple and effective method for closing cavities around openings in masonry and steel framed cavity walls. Its thermally efficient insulation core inhibits heat transfer and thus reduces thermal bridging, whilst the uPVC casing provides a damp proof barrier and forms a key for the direct application of plaster.



In order to demonstrate the effectiveness of *Kingspan* **Kool**therm® Cavity Closer, Kingspan Insulation set out to calculate a series of ψ–values, for jamb and sill details incorporating *Kingspan* **Kool**therm® Cavity Closer, that can be used across a broad range of constructions.

Kingspan Insulation commissioned BRE Scotland to carry out a thermal modelling study of jamb details for differing cavity wall constructions, where the cavity is closed using *Kingspan* **Kool**therm® Cavity Closer.

Since sill details are normally identical in build–up to jamb detail (except for the use of a sill board in lieu of the standard plaster or plasterboard on dabs internal finish to the jamb), the heat flow through a sill is less than that through a jamb. Therefore, in BRE's opinion, ψ–values calculated for jamb details are applicable also to the equivalent sill details.

ψ-values

Study Approach

A number of parameters influence the ψ–value of a jamb and sill. These are shown in Table 2. The approach of the BRE study was to test these parameters one by one, each time identifying which alternative yielded the worst ψ–value, and then to use this worst case parameter in the ψ–value calculations for subsequent parameter test. Thus the calculations were able to define a series of worst case ψ–values and the range of constructions for which they are valid.

Parameter	Description
Internal finish	Lightweight plaster and plasterboard on dabs
Cavity wall insulation	Partial and full fill
Reveal	Normal and check
Kingspan **Kool**therm® Cavity Closer	Single section and two sections coupled back–to–back
Masonry wall inner leaf	100 mm deep warm steel frame / 100 mm blockwork with a thermal conductivity of 0.11 & 1.13 W/m·K
Masonry wall outer leaf	100 mm brickwork with a thermal conductivity of 0.77 W/m·K / 100 mm rendered blockwork with a thermal conductivity of 0.51 & 1.13 W/m·K.
Frame depth (mm)	75 & 100
Overlap between frame and *Kingspan* **Kool**therm® Cavity Closer (mm) See Figure 1 (below).	30, 50, 75 & 100
Design U–value (W/m²·K)	0.15, 0.18, 0.20 & 0.25

Table 2: Parameters Investigated.

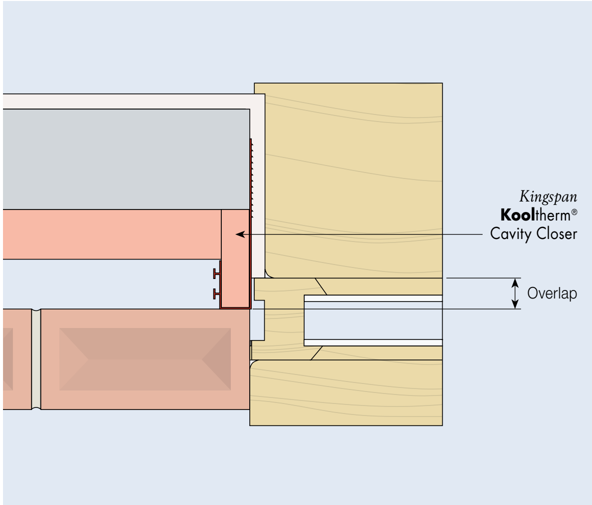


Figure 1: Overlap between frame and cavity closer

Analysis

Stage 1: Internal Finish Comparison
In all scenarios, it was found that the lightweight plaster finish resulted in marginally higher ψ–values. This parameter was therefore taken forward as the worst case internal wall finish.

Stage 2: Cavity Wall Insulation Comparison
It was found that partial fill cavity wall insulation resulted in marginally higher ψ–values. This parameter was therefore taken forward as the worst case cavity wall insulation type.

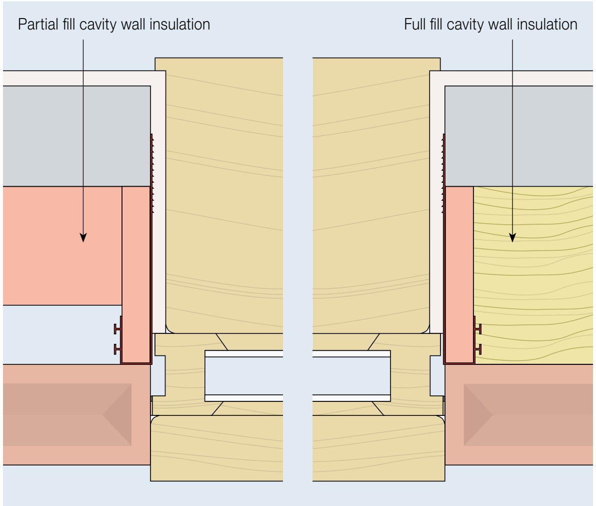


Figure 2: Partial vs Full Fill.

Stage 3: Reveal Comparison
The normal reveal was taken forward as the worst case option since the check reveal was found to result in a lower ψ–value owing to a small reduction in heat flow stemming from an additional amount of resistance at the outside of the reveal.

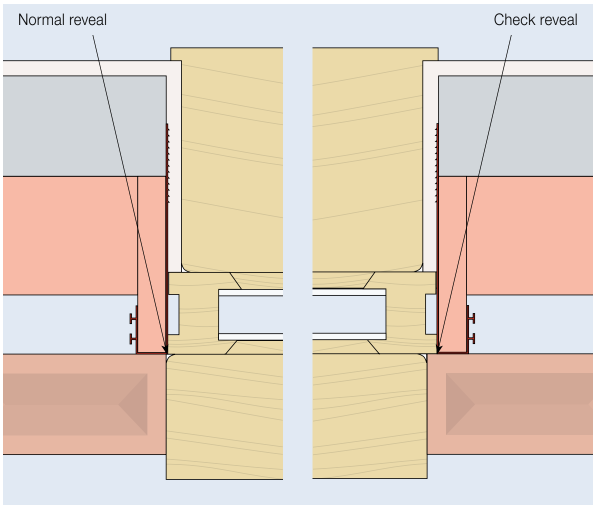


Figure 3: Normal Reveal vs Check Reveal.

Stage 4: Single Section vs Coupled Section Cavity Closer Comparison
The coupled sections were also taken forward as the small airspace between the closer and the partial fill cavity insulation led to an increase in heat flow.

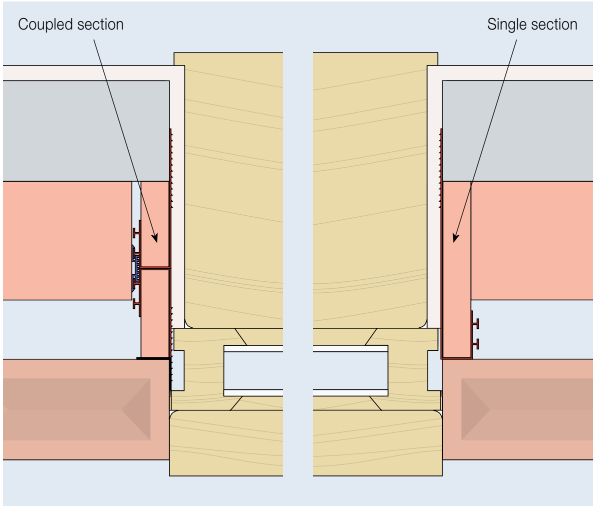


Figure 4: Coupled Section vs Single Section.

Stage 5: Inner Leaf Comparison
The results between lightweight (λ – 0.11W/m·K) blockwork, dense (λ – 1.13 W/m·K) blockwork and steel–frame inner leaf were compared. Lightweight blockwork gave the worse ψ–value and so that was taken forward.

Stage 6: External Leaf Comparison
The results between brickwork, rendered dense concrete blockwork (λ – 1.13 W/m·K) and rendered medium dense blockwork (λ – 0.51 W/m·K) external leaf were compared. It was revealed that the brickwork finish gave the higher ψ–value and so that was taken forward.

Stage 7: Worst Case ψ–value Matrix

The worst case construction from Stages 1 to 6 was used to calculate ψ–values for differing frame depths and overlaps at design U–values of 0.18, 0.20 and 0.25 W/m²·K.

The full set of ψ–values set out in Table 3 are thus applicable to the following range of wall constructions:

- internal finish of either lightweight plaster, standard plaster or plasterboard on dabs;
- wall cavity insulated with either partial fill cavity insulation with a residual air gap of ≥ 50 mm, or full fill (i.e. no residual cavity) cavity insulation;
- check or normal reveal;
- *Kingspan* **Kool**therm® Cavity Closer with a thermal conductivity ≤ 0.22 W/m·K and, either as a single section or coupled sections, fully filling the width of the wall cavity;
- inner leaf being either ≥ 100 mm warm steel frame or ≥ 100 mm blockwork with a thermal conductivity ≥ 0.11 W/m·K; and
- outer leaf being either ≥ 100 mm brickwork with a thermal conductivity ≤ 0.77 W/m·K, or ≥ 100 mm rendered masonry with a thermal conductivity ≤ 1.13 W/m·K.

	ψ–value (W/m·K)		
Overlap (mm)	Wall U–value (W/m²·K)		
	0.25	0.20	0.18
	75 mm Frame Depth		
30	0.024	0.024	0.027
50	0.014	0.017	0.018
75	0.007	0.010	0.012
	100 mm Frame Depth		
30	0.023	0.025	0.027
50	0.015	0.017	0.018
75	0.008	0.010	0.011
100	0.004	0.005	0.007

Table 3: Full Set of Calculated ψ–values for Jamb & Sill Details Incorporating *Kingspan* **Kool**therm® Cavity Closer at Differing Frame Depths & Overlaps.

Summary

The results show that the depth of the overlap between the frame and *Kingspan* **Kool**therm® Cavity Closer has the greatest influence on jamb and sill ψ–value.

For the purpose of simplicity, when calculating the H_{TB} for a building, the red ψ–values in Table 3 can be used as a "safe approximation", for the full range of constructions described, for frame depths and overlaps (between the frame and *Kingspan* **Kool**therm® Cavity Closer) as shown, and wall U–values ≥ 0.18 W/m²·K. These are repeated below in Table 4.

Frame Depth (mm)	Overlap (mm)	ψ–value (W/m·K)
≥ 75	30 –49	0.027
≥ 75	50 – 74	0.018
≥ 75	75 – 99 *	0.012
≥ 100	≥ 100 *	0.007

Table 4: "Safe Approximation" ψ–values for Jamb & Sill Details Incorporating *Kingspan* **Kool**therm® Cavity Closer at Differing Frame Depths & Overlaps. * Frame depth must be ≥ overlap distance.

Analysis

For those wishing to perform a more precise H_{TB} calculation, linear interpolation can be used to determine intermediate ψ–values over the range of U–values and frame overlaps.

Figures 5 & 6 show plots of the ψ–values from Table 4 at frame depths of 75 & 100 mm respectively.

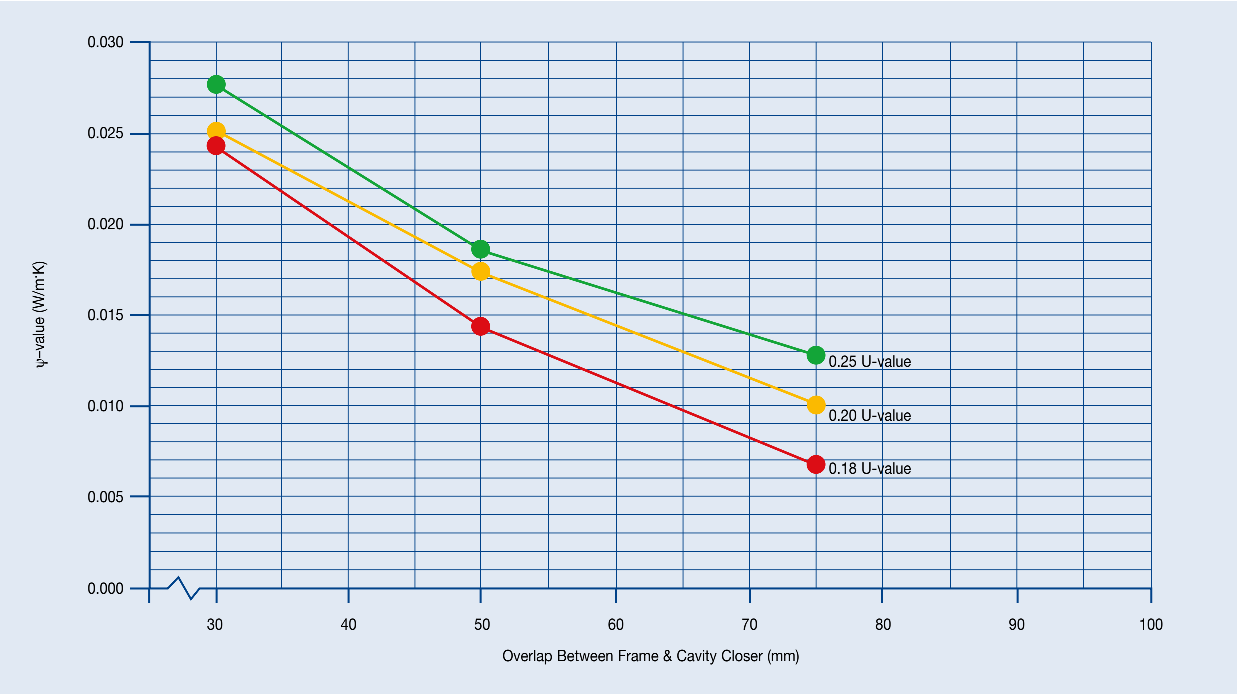


Figure 5: ψ–values for Jamb & Sill Details incorporating *Kingspan* **Kool**therm® Cavity Closer at a Frame Depth of 75 mm & Differing Overlaps between the Frame & Closer.

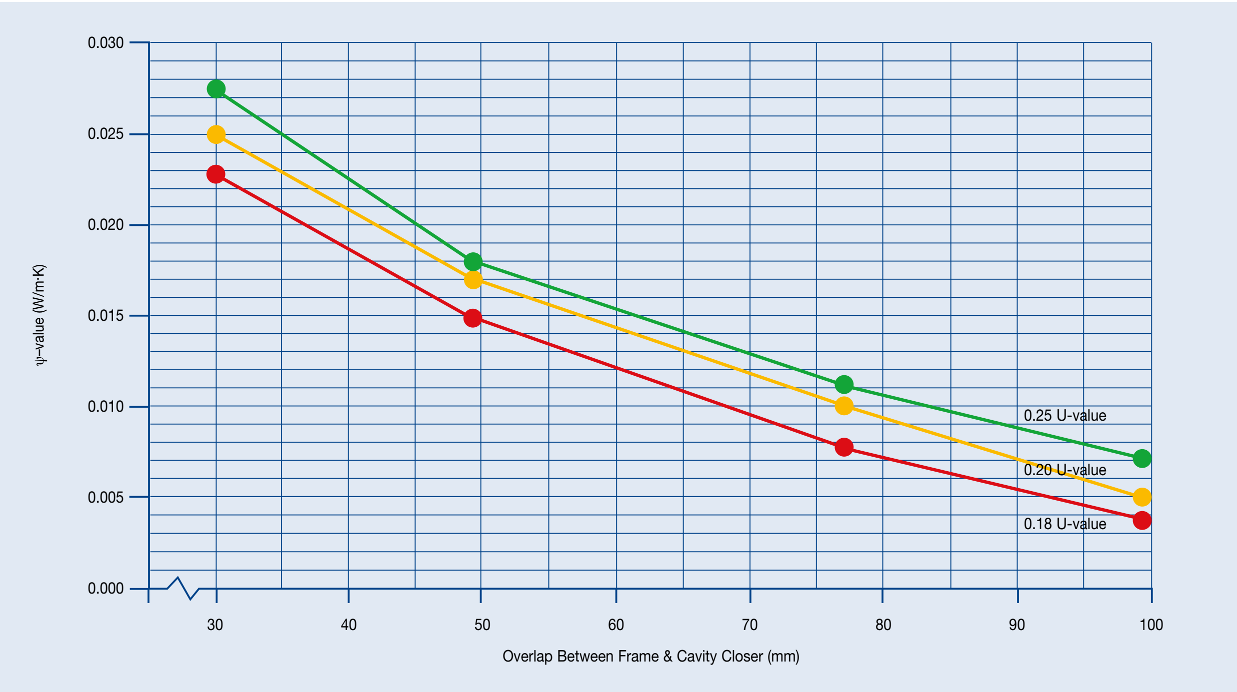


Figure 6: ψ–values for Jamb & Sill Details incorporating *Kingspan* **Kool**therm® Cavity Closer at a Frame Depth of 100 mm & Differing Overlaps between the Frame & Closer.

H_{TB} Comparison

Introduction

In order to quantify the significance of the improvement that can result from the adoption of *Kingspan* **Kool**therm® Cavity Closer, Kingspan Insulation compared the transmission heat transfer coefficient (H_{TB}) calculated using the "safe approximation" ψ–values from Table 4 with that calculated using jamb and sill ψ–values from the SAP Table K1 "Approved" column.

Using SAP 2012, Kingspan Insulation calculated H_{TB} for four different new–build dwellings, representative of current new–build dwellings.

Firstly, the H_{TB} for each dwelling type was calculated using the ψ–value from the SAP Table K1 "Approved" column. H_{TB} was then calculated using the "safe approximation" ψ–values (shown in Table 4) for jamb and sill details incorporating *Kingspan* **Kool**therm® Cavity Closer. The % improvement was then calculated.

Results

The comparison between H_{TB} calculations is detailed in Table 5. It shows clearly that the H_{TB} calculated using the "safe approximation" ψ–values (shown in Table 4) is significantly better than that calculated using the ψ–value from the SAP Table K1 "Approved" column. It can also be seen that the greater the depth of overlap between the frame and the closer, the greater the improvement.

% Improvement in H_{TB} for different Frame Depths and Overlaps					
ψ–value (W/m·K)					
		SAP Table K1 "Approved" Column		*Kingspan* **Kool**therm® Cavity Closer	
Frame Depth (mm)	Overlap (mm)	Jamb	Sill	Jamb & Sill	HTB Improvement (%)
≥ 75	30	0.040	0.050	0.027	4.05 – 6.76
≥ 75	50	0.40	0.50	0.018	5.80 – 9.67
≥ 75	75	0.040	0.050	0.012	6.97 – 11.61
≥ 100	100	0.040	0.050	0.007	7.94 – 13.22

Table 5: Percentage Improvement in HTB from Substitution of *Kingspan* **Kool**therm® Cavity Closer "Safe Approximation" ψ–values for SAP Table K1 "Approved" Column Jamb & Sill ψ–values.

For more details of the assessments, refer to the Appendix section of this document.

Conclusion

The "safe approximation" ψ–values for jamb and sill details incorporating *Kingspan* **Kool**therm® Cavity Closer are considerably better than the ψ–values for the SAP Table K1 "Approved" column.

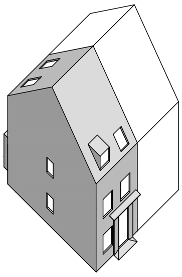
The validity of these "safe approximation" ψ–values for a broad range of constructions, can assist designers by allowing a one–size–fits–most approach.

For those serious about designing low energy buildings, attention to detail is critical yet the devil need not always be in the detail.

Kingspan **Kool**therm® Cavity Closer should therefore be considered the product of choice where significant reductions in linear thermal bridging at sill and jamb locations is a key requirement.

Appendix – Detailed H_{TB} Calculations

End Terrace

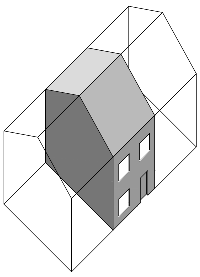


Glazing % of total floor area	17.87%
Glazing % of exposed wall area	16.20%
Jamb length (m)	52.53
Sill length (m)	14.055

H_{TB} For Different ψ–values from Different Sources					
	SAP Table K1 "Approved" Column ψ–values	ψ–values for *Kingspan* **Kool**therm® Cavity Closer in Sills or Jambs with Different Overlaps (mm) between Door / Window Frame & Closer			
Overlap (mm)		30	50	75	100
ψ–values (W/m·K)	0.040 (Sill) 0.050 (Jamb)	0.027	0.018	0.012	0.007
H_{TB} (W/K)	20.590	19.199	18.599	18.200	17.867
% better than that calculated with SAP Table K1 "Approved" column ψ–values	–	6.760	9.670	11.610	13.220

NB ψ–values for all other junctions within the dwelling were taken from the SAP Table K1 "Approved" column. All modelling was carried out in accordance with SAP 2012 NCM, using JPA Designer Version 6.02a1 Build 009.

Mid Terrace

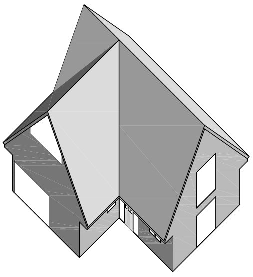


Glazing % of total floor area	15.23%
Glazing % of exposed wall area	31.27%
Jamb length (m)	25.84
Sill length (m)	5.674

H_{TB} For Different ψ–values from Different Sources					
	SAP Table K1 "Approved" Column ψ–values	ψ–values for *Kingspan* **Kool**therm® Cavity Closer in Sills or Jambs with Different Overlaps (mm) between Door / Window Frame & Closer			
Overlap (mm)		30	50	75	100
ψ–values (W/m·K)	0.040 (Sill) 0.050 (Jamb)	0.027	0.018	0.012	0.007
H_{TB} (W/K)	10.878	10.210	9.926	9.737	9.579
% better than that calculated with SAP Table K1 "Approved" column ψ–values	–	6.140	8.750	10.490	11.940

NB ψ–values for all other junctions within the dwelling were taken from the SAP Table K1 "Approved" column. All modelling was carried out in accordance with SAP 2012 NCM, using JPA Designer Version 6.02a1 Build 009.

Lodge

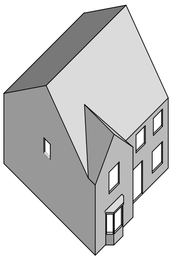


Glazing % of total floor area	30.87%
Glazing % of exposed wall area	32.08%
Jamb length (m)	40.304
Sill length (m)	5.502

H_{TB} For Different ψ–values from Different Sources					
	SAP Table K1 "Approved" Column ψ–values	ψ–values for *Kingspan* **Kool**therm® Cavity Closer in Sills or Jambs with Different Overlaps (mm) between Door / Window Frame & Closer			
Overlap (mm)		30	50	75	100
ψ–values (W/m·K)	0.040 (Sill) 0.050 (Jamb)	0.027	0.018	0.012	0.007
H_{TB} (W/K)	22.985	21.987	21.574	21.299	21.070
% better than that calculated with SAP Table K1 "Approved" column ψ–values	–	4.340	6.140	7.340	8.330

NB ψ–values for all other junctions within the dwelling were taken from the SAP Table K1 "Approved" column. All modelling was carried out in accordance with SAP 2012 NCM, using JPA Designer Version 6.02a1 Build 009.

Detached



Glazing % of total floor area	19.09%
Glazing % of exposed wall area	15.75%
Jamb length (m)	45.15
Sill length (m)	12.358

H_{TB} For Different ψ–values from Different Sources					
	SAP Table K1 "Approved" Column ψ–values	ψ–values for *Kingspan* **Kool**therm® Cavity Closer in Sills or Jambs with Different Overlaps (mm) between Door / Window Frame & Closer			
Overlap (mm)		30	50	75	100
ψ–values (W/m·K)	0.040 (Sill) 0.050 (Jamb)	0.027	0.018	0.012	0.007
H_{TB} (W/K)	29.588	28.389	27.871	27.526	27.239
% better than that calculated with SAP Table K1 "Approved" column ψ–values	–	4.050	5.800	6.970	7.940

NB ψ–values for all other junctions within the dwelling were taken from the SAP Table K1 "Approved" column. All modelling was carried out in accordance with SAP 2012 NCM, using JPA Designer Version 6.02a1 Build 009.

Contact Details

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For quotations, order placement and details of despatches please contact the Kingspan Insulation Customer Service Department on the numbers below:

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Literature & Samples

Kingspan Insulation produces a comprehensive range of technical literature for specifiers, contractors, stockists and end users. The literature contains clear 'user friendly' advice on typical design; design considerations; thermal properties; sitework and product data.

Kingspan Insulation technical literature is an essential specification tool. For copies please contact the Kingspan Insulation Marketing Department, or visit the Kingspan Insulation website, using the details below:

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Kingspan Insulation supports all of its products with a comprehensive Technical Advisory Service for specifiers, stockists and contractors.

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The Kingspan Insulation Technical Service Department can also give general application advice and advice on design detailing and fixing etc... Site surveys are also undertaken as appropriate.

The Kingspan Insulation British Technical Service Department operates under a management system certified to the BBA Scheme for Assessing the Competency of Persons to Undertake U–value and Condensation Risk Calculations.

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