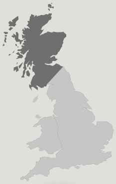
Insulation



First Issue October 2015

Building Standards for Energy

SCOTLAND - NON-DOMESTIC

2015 EDITION

Kingspan®

*Low Energy –
Low Carbon Buildings*

Contents

Introduction

Section 6 Technical Handbooks

Technical Handbooks, published by the Scottish Government's Building Standards Division (BSD), give technical guidance on how to meet the energy efficiency requirements of Section 6, as amended, for building work carried out in Scotland.

There are two Technical Handbooks for Section 6:

- Section 6 (energy) 2015 – Domestic
- Section 6 (energy) 2015 – Non–domestic

Each document sets out what, in ordinary circumstances, may be accepted as reasonable provision for compliance with the energy efficiency requirements of the Building Standards for the type of building work in question.

Developers can also refer to Section 7 (sustainability) which goes beyond the requirements of Section 6 (energy). Section 7 (sustainability) addresses the following issues:

- Climate change, energy and resource use
- Quality of life, material use and waste

For more information, please refer to the Scottish Government's Building Standards Division's website.

About this Document

Kingspan Insulation has produced this document as a simple guide to the 2015 edition of Section 6 (energy), including the salient changes from the 2011 edition. The guide is split into two parts: new buildings and existing buildings. It specifically concentrates on the parts that are relevant to the building fabric insulation, whilst showing how compliance can be achieved using Kingspan Insulation products for roofs, walls and floors and, for the purpose of comparison, thermally equivalent solutions using other common insulation materials.

Section 6 (Energy) - Non-domestic

Introduction

The 2015 edition of the Section 6 (energy) – Non–domestic standard (applicable for works from October 2015), gives guidance to ensure that effective measures for the conservation of fuel and power are incorporated into buildings. This is done through requirements for a better performing building fabric and improved carbon dioxide emission targets.

Types of Work Covered

Section 6 (energy) – Non–domestic is applicable to non–domestic buildings, including factories, offices, shops, warehousing, hotels, hospitals, hostels and also buildings used for assembly and entertainment.

It is recommended that heated stand–alone buildings with a floor area of less than 50 m^2 should meet the same level of performance that is expected of an extension.

The regulation does make provision for where there may be constraints on existing buildings. In these situations, individual standards might not apply.

There is a separate Technical Handbook for domestic properties.

New Buildings

Compliance with Building Standards

Demonstrating Compliance

Section 6 (Energy) – Non–domestic provides criteria that must be met in order to demonstrate compliance with the energy efficiency requirements of the Building Standards. These criteria comprise a mix of mandatory requirements and statutory guidance, some of which have little or no significance to insulation. Those that do are outlined below.

First and foremost, there is a need to show that the designed carbon dioxide (CO_2) emissions for the whole of the building (referred to as the 'building CO_2 emission rate' and expressed as 'BER'), does not exceed a defined maximum allowable emission rate (referred to as the 'target CO_2 emission rate' and expressed as 'TER'). TER and BER calculations, for buildings other than dwellings, should be carried out in accordance with the National Calculation Methodology (NCM) for Scotland e.g. using the Simplified Building Energy Model (SBEM), if the design features of the building are capable of being adequately modelled by SBEM.

Secondly, individual building fabric elements and fixed building services must achieve specified energy efficiency backstop standards, which limit design flexibility.

Thirdly, there is a need to show that the quality of construction is such that the energy performance of the building 'as built' matches or exceeds that 'as designed'.

Evidence of Compliance

Much of the evidence that demonstrates compliance with the energy efficiency requirements can comprise the results of calculations carried out using compliance software such as iSBEM.

On submitting a building regulations application, a carbon compliance calculation, commonly referred to as a 'design stage calculation', is required. The edition and version of the assessment current when the application is made is then set for the duration of the project for compliance purposes. So if a building was assessed at design stage under SBEM, then compliance at the as–built stage would be to the same edition and version.

At the post–construction ('as built') stage, the Energy Performance Certificate (EPC) should be produced by an accredited assessor, using approved software which implements the current edition and version of the calculation methodology. This ensures that building owners are presented with the most current and relevant information practicable.

Both the 'designed' and 'as built' submissions include the TER / BER calculation as well as a list of specifications, which demonstrate how compliance has been achieved.

NB The 'as built' submission used to produce the EPC must also include the assessed air–permeability of the building and any changes to the 'designed' specification.

The two submissions can be compared and used by Building Control to assist in checking whether what has been built matches or betters what was designed.

CO_2 Emissions & Fabric Energy Efficiency

Section 6 (energy) – Non–domestic adopts a 'whole building' approach to minimising CO_2 emissions and fabric energy efficiency. A new building must be designed and built such that its BER is no worse than its TER.

The TER and BER are expressed as the mass of CO_2 in kilograms per square metre of floor area per annum (kg/m^2/yr). TER and BER calculations take account of the CO_2 emission rate from space heating, hot water, ventilation and internal fixed lighting requirements using standardised assumptions for building occupancy set by the NCM.

Also considered in the calculations is the thermal mass of the building and minor heat gains from different sources, e.g. the sun, the occupants, appliances and artificial lighting.

A 'notional building' of the same size and shape as the 'actual building', built to a concurrent specification, is used to determine the TER. The notional building specification for 'Zoned Heated & Naturally Ventilated' and 'Zoned Heated & Mechanically Ventilated / Cooled' buildings is summarised in Section 6.1 of the non–domestic Technical Handbook. The main elements of the concurrent specification of the notional building that relate to the opaque building fabric are shown in Table 1. Whilst the concurrent specification helps to set the target, the actual specification will usually differ from this.

It is important to note that there is no formal requirement for low carbon equipment, although the feasibility of their use must be assessed. If the developer chooses this route, the building specification would need to compensate for the lack of such equipment.

New Buildings

Element or System	Zone Heated & Naturally Ventilated	Zone Heated & Mechanically Ventilated / Cooled
All Roofs	0.18 $W/m^2 \cdot K$	0.16 $W/m^2 \cdot K$
Walls	0.23 $W/m^2 \cdot K$	0.20 $W/m^2 \cdot K$
Floors	0.22 $W/m^2 \cdot K$	0.20 $W/m^2 \cdot K$
Windows	1.8 $W/m^2 \cdot K$ (10% FF) g–value 60% Transmittance 71%	1.6 $W/m^2 \cdot K$ (10% FF) g–value 50% Transmittance 71%
Rooflights	1.8 $W/m^2 \cdot K$ (15% FF) g–value 52% Transmittance 57%	1.8 $W/m^2 \cdot K$ (15% FF) g–value 52% Transmittance 57%
Vehicle Access and Similar Large Doors	1.50 $W/m^2 \cdot K$	1.50 $W/m^2 \cdot K$
Pedestrian Doors and High Usage Entrance Doors	2.20 $W/m^2 \cdot K$	2.20 $W/m^2 \cdot K$
Thermal Capacity of Element	Refer to NCM Modelling guide for details	
Thermal Bridging – Junctions	Refer to NCM Modelling guide for details	
Air Permeability	5 $m^3/hr/m^2$ @ 50 Pa	3 $m^3/hr/m^2$ @ 50 Pa
Lighting Efficiency (Luminaire lumens / Circuit watt)	60	65
Occupancy Control	Yes	Yes
Daylight Control	Yes	Yes
Heating and DHW	Fuel(s) for actual building applied to the notional building. Refer to NCM Modelling guide for details.	
Central Ventilation	N/A	1/8
Terminal Unit (SFP / W/l/s)	N/A	0.4
Cooling (SEER)	N/A	4.5
Heat Recovery (Efficiency)	N/A	70%
Variable Speed Control of Fans, Pumps and Circulators	Yes	Yes
Photovoltaic Panels (% of Floor Area)	4.5%	4.5%

Table 1: Selected Reference Values from the Section 6 (energy) – Non–domestic Notional Building Specification

Limits on Design Flexibility

Limiting Fabric Standards

Scottish Building Standards Section 6 sets out area weighted limiting U–value standards for the different fabric elements of the building. This provision, which is mandatory, is included to make the design of the building robust should the performance of one fabric element fail or perform less well than expected.

The limiting U–values for the different element types are shown in Table 2. It is of note that the use of the limiting U–values will almost certainly result in the building failing to achieve the required TER, thus U–values, significantly better than those shown, are likely to be required.

NB The values shown in Table 2 are **not** the U–values that should be adopted for compliance with the Building Standards. For guidance, see the 'Simplifying the Complex' section of this document.

Fabric Element	Area Weighted average U–value (W/m²·K) for all elements of the same type	Individual element U–value (W/m²·K)
Roofs	0.20	0.35
Walls	0.27	0.70
Floors	0.22	0.70
Windows, Roof Windows, Rooflights & Doors	2.00	3.30

Table 2: Limiting Fabric Parameters

Shell buildings have a separate set of limiting fabric parameters, as shown in Table 3.
For a 'shell and fit' building, as the eventual servicing regime is not necessarily known, the fabric requirements are set more stringently to offset potentially poorer overall specification.

Fabric Element	Area Weighted average U–value (W/m²·K) for all elements of the same type	Individual element U–value (W/m²·K)
Roofs	0.15	0.35
Walls	0.23	0.70
Floors	0.20	0.70
Windows, Roof Windows, Rooflights & Doors	1.60	3.30

Table 3: Limiting Fabric Parameters for Shell Buildings

Limits for Air–permeability & Building Services

For shell only buildings, air permeability should not exceed 7 $m^3/hr/m^2$ at 50 Pa. For all other buildings, there is no firm limiting value set for air–permeability, however a recommended limiting value of 10 $m^3/hr/m^2$ at 50 Pa is given. In addition, limits are also given for the energy performance of the fixed building services in the building, the minimum energy efficiency standards for which are set out in the Non–domestic Buildings Handbook – energy.

If satisfactory performance is not achieved, then remedial measures should be carried out on the building and additional tests carried out until the criteria set out above are achieved.

Linear Thermal Bridging

The building fabric should be constructed so that there are no reasonably avoidable thermal bridges: in the insulation layers caused by gaps within the various elements; at the joints between elements; and at the edges of elements such as those around windows and door openings.

Reasonable provision would be:

a. adoption of a default y–value of 0.10 (adding 10% to the calculated heat loss from the building's planar elements);
b. input of default ψ values for each junction listed within Appendix K of SAP 2012;
c. where construction of a junction follows the 'Accredited Construction Details (Scotland) 2015' or other published and substantiated construction detail sets, input of ψ values of the relevant junction(s) from that document;
d. input of ψ values calculated by a person with suitable expertise and experience following the guidance set out in BR 497; or
e. use a combination of the above.

Air-Permeability Testing

Achieving Acceptable Air–Permeability

A performance standard is selected at design stage to determine the design air–permeability of a building for use in the pre–construction BER calculation. The achieved air–permeability, measured by pressure testing at construction stage, is used in the post–construction BER calculation.

Compliance with the requirements would be demonstrated if the BER calculated using the measured air–permeability is not worse than the TER. If a building fails to achieve compliance, then remedial measure should be carried out on the building.

If it proves impractical to meet the design air–permeability, any shortfall must be compensated for by improvements to subsequent fit–out activities. It would therefore be wise to schedule pressure tests early enough to facilitate remedial work on the building fabric.

For shell and fit buildings, air tightness testing should be undertaken both at completion of the shell and again when the fit–out is completed.

Exemptions from Pressure Testing

All new non–domestic buildings and large buildings should be tested on completion, with the following exceptions:

a. Multiple units, under the same building warrant, of not more than 150 m^2 in floor area and of the same form and construction. In this instance a sample of 1 in 20 units should be tested.
b. Modular buildings of less than 500 m^2, where no site work is needed (other than connection of modules). Test results for similar modules will be required.
c. Large extensions, subject to section 6.1 of Section 6 (energy) 2015 – Non–domestic.
d. Buildings where size or complexity renders testing impractical. This will need to be agreed upon during the building warrant process.

Simplifying the Complex

The Section 6 (energy) – Non–domestic Technical Handbook sets out limiting fabric U–values for the building envelope. Developers may have to resort to higher performing insulants to meet such standards. This can reduce the overall demand of the building.

Such higher performing insulants also offer a thinner solution to meeting Building Standards, which could be particularly beneficial in wall applications for commercial real estate developments. The usable space within a building is a fundamental metric in understanding the valuation, thus the investment potential, of real estate. Property with greater internal floor area commands a higher rental return in addition to a higher overall financial value and could, therefore, give rise to a greater Return on Investment (ROI).

Modelling carried out by Kingspan Insulation suggests that the values shown in Table 4 are the best starting point U–values if adopting this approach.

Element	U–value (W/m²·K)
All Roofs	0.14
Walls	0.18
Floors	0.15

Table 4: Best Starting Point U–values

Constructions & U–values

Set out in the following pages are examples of constructions using Kingspan Insulation products, which are designed to achieve:

- the U–values given in the Section 6 (energy) – Non–domestic notional building specification, see Table 1; or
- the best starting point U–values, see Table 4, should the specification diverge from that given in the Section 6 (energy) – Non–domestic notional building specification.

Each example construction is accompanied by a table, which gives the corresponding U–values and shows the practical thicknesses of Kingspan Insulation products required to achieve them. It is important to note that these U–values are valid only for the illustrated construction. Furthermore, these constructions do not comprise an exhaustive list of Kingspan Insulation solutions. Contact the Kingspan Insulation Technical Service Department if calculations for other constructions are required.

In addition, possible alternative solutions using other common insulation materials are shown for the purpose of comparison.

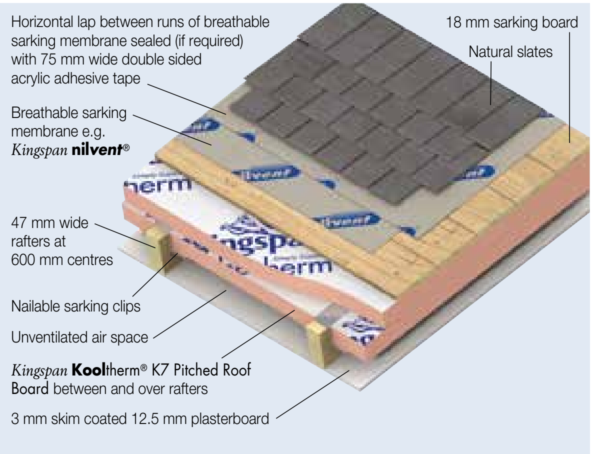
U–values have been calculated using the methods detailed in:

- BS EN ISO 6946: 2007 (Building components & building elements. Thermal resistance and thermal transmittance. Calculation method);
- BS EN ISO 13370: 1998 (Thermal performance of buildings. Heat transfer via the ground. Calculation methods); and
- using the conventions set out in BR 443 (Conventions for U–value calculations).

For the purpose of these calculations the standard of workmanship has been assumed good, and therefore the correction factor for air gaps has been ignored.

All figures quoted are for guidance only. A detailed U–value calculation and a condensation risk analysis should be carried out for each project. In which case, contact the Kingspan Insulation Technical Service Department for assistance.

Pitched Roof – Insulation Between & Over Rafters



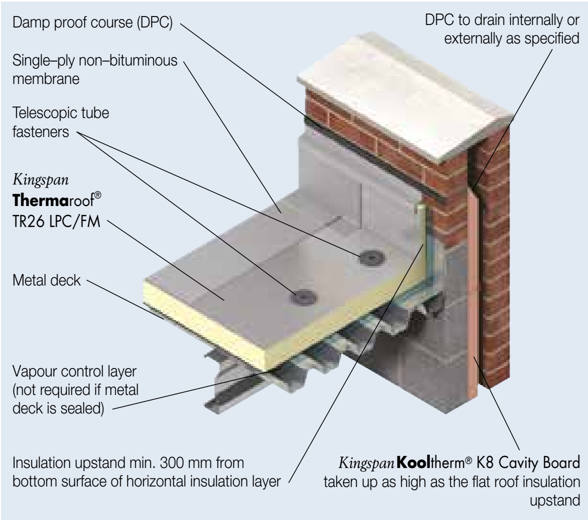
Insulation Thicknesses to Achieve Different U–values									
	U–value (W/m²·K)								
	0.16				0.14				
Insulation Material	Rafter Depth (mm)	Between Rafter Insulation Thickness (mm)	Over Rafter Insulation Thickness (mm)	Overall Thickness (mm)	Rafter Depth (mm)	Between Rafter Insulation Thickness (mm)	Over Rafter Insulation Thickness (mm)	Overall Thickness (mm)	
Kingspan **Kool**therm®	100	60	60	**160**	100	70	70	**170**	THINNER
Rock Fibre*	150	150	90	**240**	150	150	120	**270**	THICKER
XPS**	150	150	90	**240**	150	150	115	**265**	

**Assuming thermal conductivity 0.038 W/m·K for between & 0.036 W/m·K for over.*
***Assuming thermal conductivity 0.036 W/m·K.*
NB When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations assume the following:

- *for 61 – 80 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 7.9 mm², with 8.3 fixings per m²;*
- *for 81 – 100 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 7.9 mm², with 10.0 fixings per m²;*
- *for 101 – 125 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 9.1 mm², with 11.1 fixings per m²; and*
- *for 126 – 150 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 9.1 mm², with 14.3 fixings per m².*

Using *Kingspan* **Kool**therm® can result in a thinner overall construction, regardless of rafter depth, and is likely to have a prohibitive aesthetic effect on bargeboard / fascia board depth. There may be cost issues with the rafter depth required for some solutions.

Flat Roof – Metal Deck

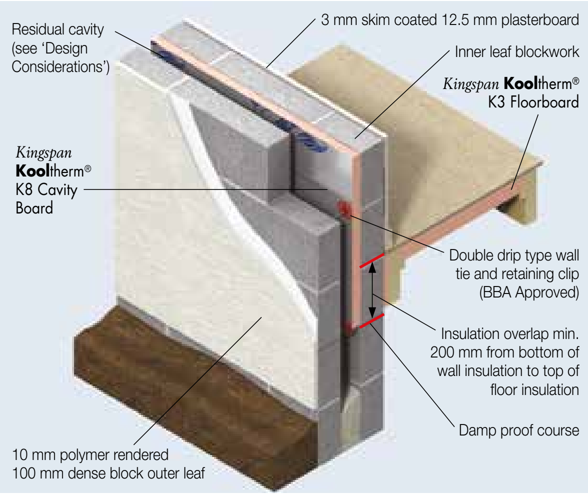


Insulation Thicknesses to Achieve Different U–values					
	U–value (W/m²·K)				
	0.16		0.14		
Insulation Material	Insulation Thickness (mm)	Overall Thickness (mm)	Insulation Thickness (mm)	Overall Thickness (mm)	
Kingspan OPTIM-R™ **Roofing System*** & *Kingspan* **Therma**roof® TR27 LPC/FM (Overlay)	45 + 25	70	50 + 25	75	THINNEST
Kingspan **Therma**roof® TR26 LPC/FM	135	135	150	150	THINNER
Rock Fibre**	225	225	260	260	THICKER

In the Kingspan OPTIM-R™* **Roofing System *a 12 mm cement particle board is installed over the metal deck and below the VCL. The bridging effect of the Kingspan OPTIM-R™ flex component of the System is taken as 10%.*
***Assuming thermal conductivity 0.038 W/m·K.*
NB Where multiple layers of insulation of different thicknesses are shown, the second thickness is the overlay board.
These calculations assume that the Kingspan OPTIM-R™ component of the Kingspan OPTIM-R™ **Roofing System** *is fully bonded to the vapour control layer, and that all other insulation boards are mechanically fixed. When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations assume thermally broken fasteners with a thermal conductivity of 1.00 W/m·K or less, the effect of which is insignificant.*

It can be seen from the table above that the *Kingspan* OPTIM-R™ **Roofing System** insulation thickness can be significantly less than that for rock mineral fibre – a third of the thickness, which may allow lower parapets and shorter fixings.

Cavity Wall – Cavity Insulation Only



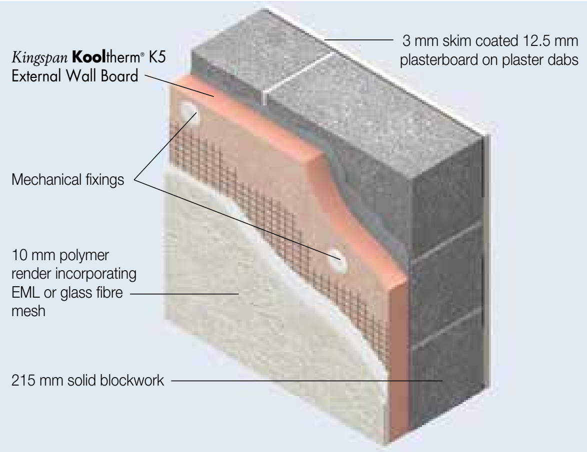
Insulation Thicknesses to Achieve Different U–values					
	U–value (W/m²·K)				
	0.20		0.18		
Insulation Material	Insulation Thickness (mm)	Overall Cavity Width (mm)	Insulation Thickness (mm)	Overall Cavity Width (mm)	
Kingspan **Kool**therm® (Partial Fill)	70	120	90	120	THINNER
Glass Fibre* (Full Fill)	165	165**	185	185**	THICKER

**Assuming thermal conductivity 0.037 W/m·K.*
***The insulation fully, rather than partially, fills the cavity and, so, the wall tie specification will differ and no retaining clips will be present.*
NB The calculations assume inner medium density blockwork with a λ–value of 0.51 W/m·K.
When calculating U–values to BS EN ISO 6946: 2007, the type of wall tie used may change the thickness of insulation required.
These calculations assume the following:

- *for 120 mm partial fill cavity widths, a stainless steel flexible tie with 2.5 ties per m² and a cross–sectional area of 12.50 mm²; and*
- *for 165 mm full fill cavity widths, a stainless steel flexible tie with 3.0 ties per m² and a cross–sectional area of 60.80 mm²*

A cavity of just 120 mm can be used with the *Kingspan* **Kool**therm® K8 Cavity Board solution, reducing the total wall width by at least 45 mm, compared with the glass mineral fibre full fill alternative shown above. A 185 mm wide cavity may require a much more onerous wall tie specification, which will increase thermal bridging.

Solid Blockwork Wall – External Wall Insulation



Insulation Thicknesses to Achieve Different U–values			
	U–value (W/m²·K)		
	0.20	0.18	
Insulation Material	Insulation Thickness (mm)	Insulation Thickness (mm)	
Kingspan OPTIM-R™ **External Wall System***	45 (+12 mm carrier board)	55 (+12 mm carrier board)	THINNEST
Kingspan **Kool**therm®	85	100	THINNER
Rock Fibre**	165	185	THICKER
EPS**	165	185	

The Kingspan OPTIM-R™* **External Wall System *is overlaid with a magnesium silicate render carrier board. This is mechanically fixed through the appropriate horizontal or vertical Kingspan OPTIM-R™ fix panels using carbon steel fasteners with a cross–sectional area of 7.44 mm², with 2.88 fasteners per m². The bridging effect of the Kingspan OPTIM-R™ flex & Kingspan OPTIM-R™ fix components of the System is taken as 30%.*

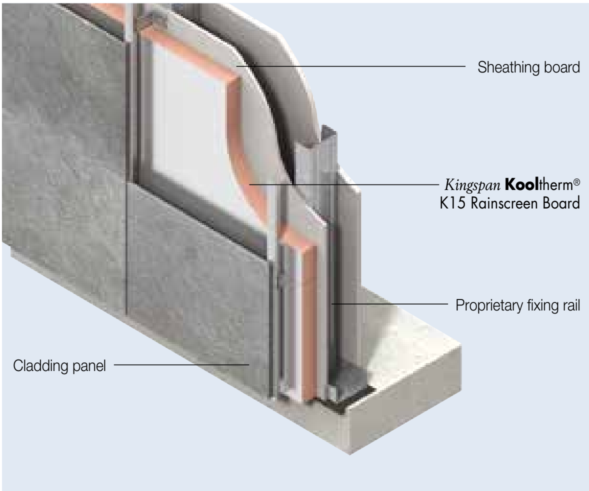
***Assuming thermal conductivity 0.038 W/m·K.*

NB The calculations assume the use of dense blockwork with a λ–value of 1.13 W/m·K. These calculations assume that the Kingspan OPTIM-R™ component of the Kingspan OPTIM-R™ **External Wall System** *is adhesive–fixed to the substrate, and that all other insulation boards (including the Kingspan OPTIM-R™ flex and Kingspan OPTIM-R™ fix) are mechanically fixed. When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. The calculations also assume thermally broken fasteners with a thermal conductivity 1.00 W/m·K or less, the effect of which is insignificant.*

Using *Kingspan* **Kool**therm® or the *Kingspan* OPTIM-R™ **External Wall System** can dramatically reduce the width of the overall wall construction compared with the alternatives shown above.

Kingspan Insulation Solutions

Rainscreen Cladding on Steel Frame

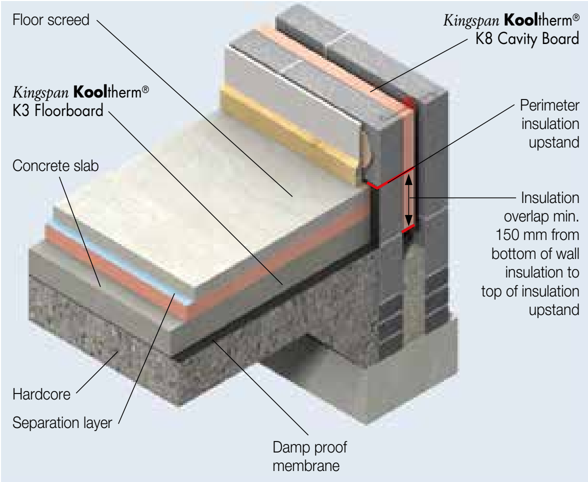


Insulation Thicknesses to Achieve Different U–values					
	U–value (W/m²·K)				
	0.20		0.18		
Insulation Material	Insulation Thickness (mm)	Overall Thickness (mm)	Insulation Thickness (mm)	Overall Thickness (mm)	
Kingspan OPTIM-R™ Rainscreen System*	30 + 40	70	40 + 45	85	THINNEST
Kingspan **Kool**therm®	140	140	160	160	THINNER
Rock Fibre**	230	230	270	270	THICKER

**The bridging effect of the Kingspan OPTIM-R™ flex & Kingspan OPTIM-R™ fix components of the System is taken as 30%.*
***Assuming thermal conductivity 0.035 W/m·K.*
NB Where multiple layers of insulation of different thicknesses are shown, the second thickness is the outer layer. These calculations assume that the Kingspan OPTIM-R™ component of the Kingspan OPTIM-R™ **Rainscreen System** *is adhesive–fixed to the substrate, and that all other insulation boards (including the Kingspan OPTIM-R™ flex) are mechanically fixed. When calculating U–values to BS EN ISO 6946: 2007, the type of discrete 'helping hand' bracket may change the thickness of insulation required. These calculations assume carbon steel fasteners of cross-sectional area 16.98 mm² at a density of 3.13 per m² and that 'helping hand' brackets are installed at 600 mm centres horizontally and vertically.*

Using *Kingspan* **Kool**therm® or the *Kingspan* OPTIM-R™ **Rainscreen System** solution can result in a thinner overall construction. The rock mineral fibre solutions shown above require considerably deeper discrete helping hand brackets to accommodate the required thickness of insulation.

Ground Floor – Solid Concrete with Insulation below Floor Screed

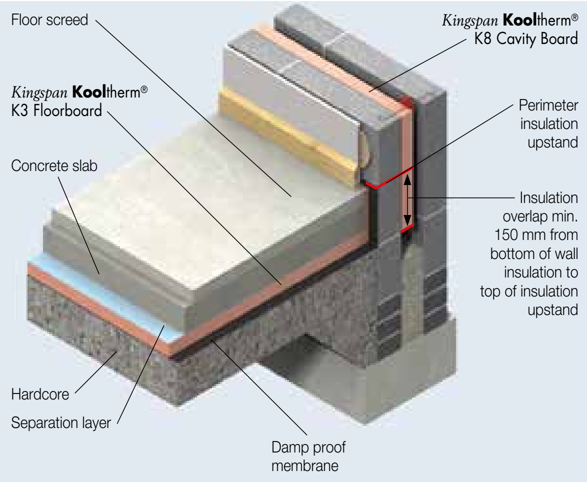


Insulation Thicknesses to Achieve Different U–values			
	U–value (W/m²·K)		
	0.20	0.15	
Insulation Material	Insulation Thickness (mm)	Insulation Thickness (mm)	
Kingspan OPTIM-R™ Flooring System*	30	50	THINNEST
Kingspan **Kool**therm®	65	100	THINNER
EPS**	120	180	THICKER

The bridging effect of the Kingspan OPTIM-R™ flex components of the System is taken as 15%.
***Assuming thermal conductivity 0.038 W/m·K.*
NB For the purposes of these calculations, using the method as detailed in BS EN ISO 13370: 1998, the soil has been assumed to be clay or silt, and the wall insulation is assumed to overlap the floor insulation by minimum 150 mm. The P/A ratio is taken as 0.5.

Using *Kingspan* **Kool**therm® or the *Kingspan* OPTIM-R™ **Flooring System** rather than the expanded polystyrene solution, in the floor construction illustrate above, can result in having to dig out, and dispose of, less soil to make the space to accommodate the insulation.

Ground Floor – Solid Concrete with Insulation below Floor Slab

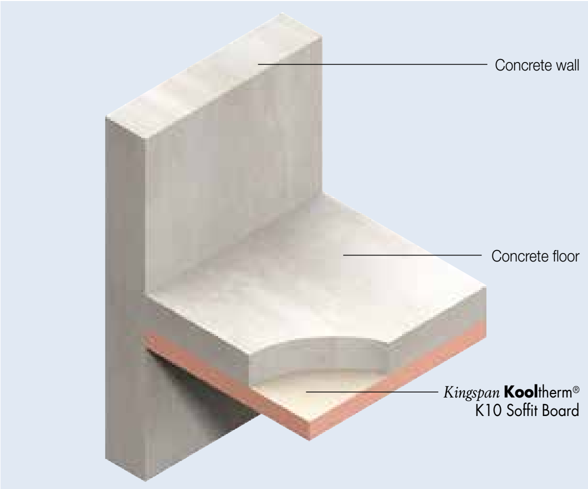


Insulation Thicknesses to Achieve Different U–values			
	U–value (W/m²·K)		
	0.20	0.15	
Insulation Material	Insulation Thickness (mm)	Insulation Thickness (mm)	
Kingspan **Kool**therm®	65	100	THINNER
EPS**	120	180	THICKER

**Assuming thermal conductivity 0.038 W/m·K.*
NB For the purposes of these calculations, using the method as detailed in BS EN ISO 13370: 1998, the soil has been assumed to be clay or silt, and the wall insulation is assumed to overlap the floor insulation by minimum 150 mm. The P/A ratio is taken as 0.5.

Using *Kingspan* **Kool**therm® rather than the expanded polystyrene solution, in the floor construction illustrated above, can result in having to dig out, and dispose of, less soil to make the space to accommodate the insulation.

Soffit – Directly Fixed to Concrete



Insulation Thicknesses to Achieve Different U–values					
	U–value (W/m²·K)				
	0.20		0.15		
Insulation Material	Insulation Thickness (mm)	Overall Thickness (mm)	Insulation Thickness (mm)	Overall Thickness (mm)	
Kingspan **Kool**therm®	95	95	75 + 50	125	THINNER
Rock Fibre	175	175	235	235	THICKER

***Assuming thermal conductivity 0.038 W/m·K.*

NB When calculating U–values to BS EN ISO 6946: 2007, the type of fixing used may change the thickness of insulation required. These calculations assume the use of thermally broken fasteners with a thermal conductivity of 1.00 W/m·K or less, the effect of which is insignificant.

At almost half the thickness of fibre, using *Kingspan* **Kool**therm® helps to maximise headroom in soffit applications. Coupled with a reduced weight and a reduced number of fixings, the *Kingspan* **Kool**therm® solution has many advantages over the competition.

Existing Buildings

Section 6 (energy) – Non–domestic provides guidance for both new elements and refurbished / retained elements.

Due to the increased complexity of refurbishing or converting buildings, particularly historic, listed or traditional buildings, the regulation does make provision for where there may be constraints on existing buildings. Whilst it is expected that developers aim for the U–values that can be found in the following sections, there is a degree of flexibility surrounding tricky refurbishments. It is advised that the individual properties of the building and the feasibility of any works are taken into account.

Conversion of Unheated Buildings

Where an existing unheated building is to be converted and heating is to be introduced, the following U–values should be targeted.

Element	Area–weighted average U–value (W/m²·K) for all elements of the same type	Individual element U–value (W/m²·K)
Roofs	0.15	0.35
Walls	0.25	0.70
Floors	0.20	0.70

Table 5: Conversion of an Unheated Building

There may be instances where conversion of part of a building takes place. Thought should be given to further opportunities for improvement that may arise as a result of work, for example when converting a roof space there may be a need to extend the insulation envelope and at this point it would be advantageous to upgrade any remaining poorly performing parts of the roof which are adjacent to the conversion (such as parts of the ceiling ties at the eaves).

Conversion of Heated Buildings

Where an existing heated building is to be converted, the U–values shown in Table 6 should be used.

Element	Area–weighted average U–value (W/m²·K) for all elements of the same type	Individual element U–value (W/m²·K)
Roofs	0.25	0.35
Walls	0.30	0.70
Floors	0.25	0.70

Table 6: Conversion of a Heated Building

Refurbishment & Extensions to the Insulation Envelope

For large extensions with an area greater than 100 m^2 and greater than 25% of the area of the existing building, the guidance for new buildings should be followed.

Section 6 (energy) – Non–domestic sets out area weighted average U–value standards and individual element U–values for refurbishment and extensions to the insulation envelope.

The provision is included to make the design of the building robust should the performance of one fabric element fail or perform less well than expected.

The values should be used for renovation of thermal elements. A thermal element is defined as the part of a wall, floor or roof which separates a thermally conditioned part of the building from: the external environment; another unconditioned part of the building; or another part of the building which is used for a different purpose from the conditioned space, and is conditioned to a different temperature.

Element	Area–weighted average U–value ($W/m^2{\cdot}K$) for all elements of the same type	Individual element U–value ($W/m^2{\cdot}K$)
Roofs	0.15	0.35
Walls	0.25	0.70
Floors	0.20	0.70

Table 7: Refurbishing or Extending the Insulation Envelope

Compensatory approaches may be used to vary from the above values, provided individual elements are no worse than the limiting ones.

For extensions, the performance of elements can be varied, providing that the overall heat loss from the extension is no greater than a notional one that did comply, for example an area of glazing greater than 25% of the floor area could be shown to still comply by the compensatory approach, if the performance of other elements was improved to compensate.

Where refurbishing or converting a building, the area weighted U–value compensatory approach can also be used to compensate for a greater area of openings than the 25% of floor area allowance. However, such a trade–off approach cannot be used where values are only being met as far as is reasonably practicable.

A whole building approach can be adopted where the existing building and its extension are modelled in SBEM. This could show that the BER of the existing building plus its extension will be no higher than its TER. SBEM can also be used to demonstrate compliance of the extension alone, in isolation from the existing building.

Existing Buildings

Ventilation

The provision of ventilation to buildings should be considered when upgrading, extending or converting buildings.

Limits for Air-permeability & Building Services

Unless the SBEM methodology is being used to demonstrate compliance, air–tightness testing is not necessary for work to existing buildings. A default value of 10 $m^3/hr/m^2$ at 50 Pa can be adopted.

Linear Thermal Bridging

The building fabric should be constructed so that there are no reasonable avoidable thermal bridges: in the insulation layers caused by gaps within the various elements; at the joints between elements; and at the edges of elements such as those around windows and door openings.

Reasonable provision would be to adopt the provisions as outlined in the 'New Buildings' section of this document.

U-value Calculations

All U–values should be calculated using the methods and conventions set out in BR 443 (Conventions for U–value calculations) and should include allowances for any repeating thermal bridges.

Constructions & U–values

Set out in the following pages are constructions using Kingspan Insulation products, which are designed to meet the area–weighted average U–values for unheated buildings. These U–values are valid for the constructions shown in the details immediately above.

Also shown, is a range of alternative solutions that other insulation manufacturers might offer.

The constructions shown do not comprise an exhaustive list of Kingspan Insulation solutions. Please contact the Kingspan Insulation Technical Service Department (see rear cover), if you require similar calculations for other constructions.

U–values have been calculated using the methods detailed in:

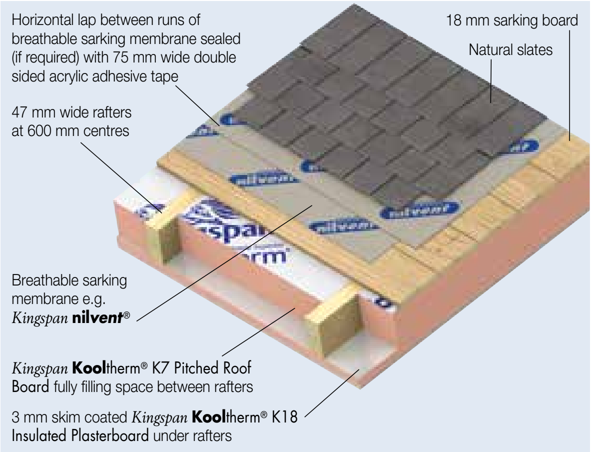
- BS EN ISO 6946: 2007 (Building components & building elements. Thermal resistance and thermal transmittance. Calculation method);
- BS EN ISO 13370: 1998 (Thermal performance of buildings. Heat transfer via the ground. Calculation methods); and
- using the conventions set out in BR 443 (Conventions for U–value calculations).

For the purpose of these calculations the standard of workmanship has been assumed good, and therefore the correction factor for air gaps has been ignored.

The figures quoted are for guidance only. A detailed U–value calculation and a condensation risk analysis should be completed for each project. Please contact the Kingspan Insulation Technical Service Department (see rear cover).

Kingspan Insulation Solutions – Existing Buildings

Pitched Roof – Insulation Between & Under Rafters (Extensions & Existing Buildings)

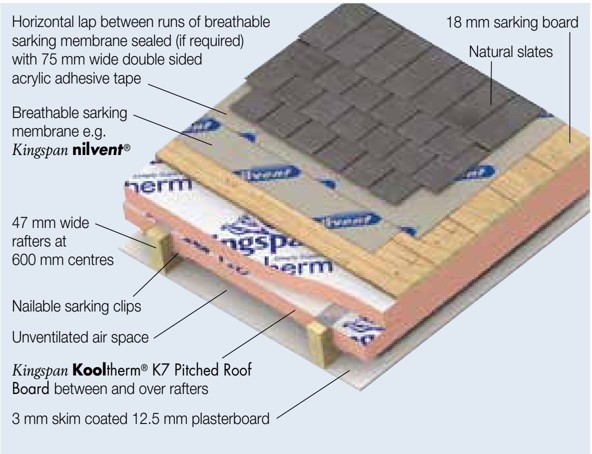


Insulation Thicknesses to Achieve a U–value of $0.15\ W/m^2{\cdot}K$					
Insulation Material	Rafter Depth (mm)	Between Rafter Insulation Thickness (mm)	Under Rafter Insulated Plasterboard Thickness (mm)***	Overall Thickness (mm)	
Kingspan **Kool**therm®	125	125	47.5	172.5	THINNER
Glass Fibre* (Between) & XPS** (Under)	150	150	112.5	277.5	THICKER

**Assuming thermal conductivity 0.038 W/m·K.*
***Assuming thermal conductivity 0.036 W/m·K.*
NB When calculating U-values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. The effect of fixings for the insulated plasterboard assumed in the calculations above is insignificant, since the insulation layer penetrated is not the main insulation layer.

Using *Kingspan* **Kool**therm® can result in a much thinner overall construction, regardless of rafter depth, and is less likely to have a prohibitive effect on headroom. There may be practicality issues with fixing a 112.5 mm insulated plasterboard product. Alternatively, it could be costly and impractical to extend rafter depths.

Pitched Roof – Insulation Between & Over Rafters (Extensions & Existing Buildings)



Insulation Thicknesses to Achieve a U–value of 0.15 W/m²·K				
Insulation Material	Rafter Depth (mm)	Between Rafter Insulation Thickness (mm)	Over Rafter Insulation Thickness (mm)	Overall Thickness (mm)
Kingspan **Kool**therm®	100	60	70	170
Rock Fibre*	150	150	100	250
XPS**	150	150	100	250

THINNER

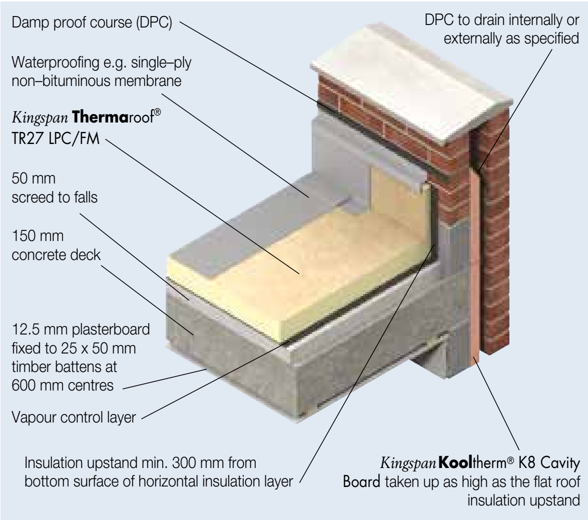
THICKER

**Assuming thermal conductivity 0.038 W/m·K for between & 0.036 W/m·K for over.*
***Assuming thermal conductivity 0.036 W/m·K.*
NB When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations assume the following:

- *for 61 – 80 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 7.9 mm², with 8.3 fixings per m²;*
- *for 81 – 100 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 7.9 mm², with 10.0 fixings per m²;*
- *for 101 – 125 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 9.1 mm², with 11.1 fixings per m²; and*
- *for 126 – 150 mm insulation thicknesses, a stainless steel fixing of cross–sectional area 9.1 mm², with 14.3 fixings per m².*

Using *Kingspan* **Kool**therm® can result in a thinner overall construction, regardless of rafter depth, and is likely to have a prohibitive aesthetic effect on bargeboard / fascia board depth. There may be cost issues with the rafter depth required for some solutions.

Flat Roof – Concrete Deck (Extensions & Existing Buildings)

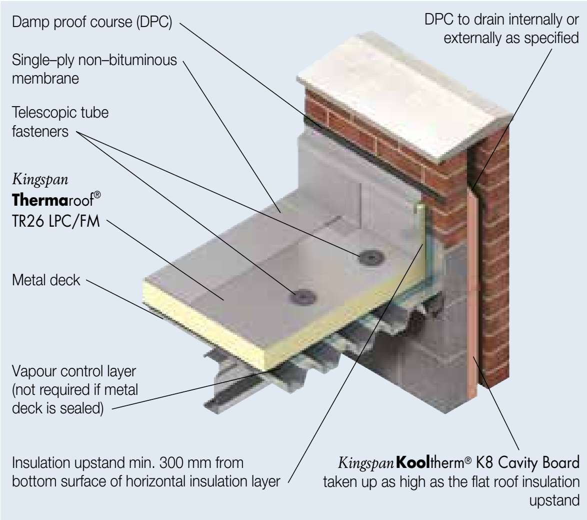


Insulation Thicknesses to Achieve a U–value of 0.15 W/m²·K			
Insulation Material	Insulation Thickness (mm)	Overall Thickness (mm)	
Kingspan OPTIM-R™ Roofing System* & *Kingspan* **Therma**roof® TR27 LPC/FM (Overlay)	45 + 25	70	THINNEST
Kingspan **Therma**roof® TR27 LPC/FM	150	150	THINNER
Rock Fibre**	230	230	THICKER

**The bridging effect of the Kingspan OPTIM-R™ flex component of the System is taken as 10%.*
***Assuming thermal conductivity 0.038 W/m·K.*
NB Where multiple layers of different thicknesses are shown, the second thickness is the overlay board. These calculations assume that insulation boards are fully bonded to the vapour control later. Where multiple layers of insulation of different thicknesses are shown, the second thickness is the overlay board.

It can be seen from the table above that the *Kingspan* OPTIM-R™ **Roofing System** insulation thickness can be significantly less than that for rock mineral fibre – over 3 times thinner, which may allow lower parapets and shorter fixings.

Flat Roof – Metal Deck (Extensions & Existing Buildings)

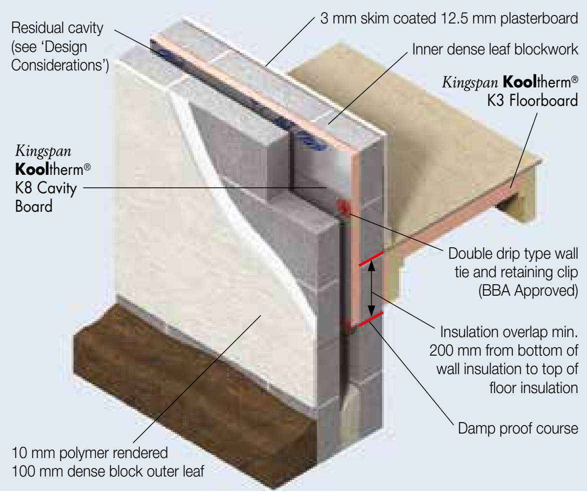


Insulation Thicknesses to Achieve a U–value of 0.15 W/m²·K			
Insulation Material	Insulation Thickness (mm)	Overall Thickness (mm)	
Kingspan OPTIM-R™ Roofing System* & *Kingspan* **Therma**roof® TR27 LPC/FM (Overlay)	50 + 25	75	THINNEST
Kingspan **Therma**roof® TR26 LPC/FM	140	140	THINNER
Rock Fibre**	240	240	THICKER

In the Kingspan OPTIM-R™ **Roofing System a 12 mm cement particle board is installed over the metal deck and below the VCL. The bridging effect of the Kingspan OPTIM-R™ flex component of the System is taken as 10%.*
***Assuming thermal conductivity 0.038 W/m·K.*
NB Where multiple layers of insulation of different thicknesses are shown, the second thickness is the overlay board.
*These calculations assume that the Kingspan OPTIM-R™ component of the Kingspan OPTIM-R™ **Roofing System** is fully bonded to the vapour control layer, and that all other insulation boards (including Kingspan OPTIM-R™ flex) are mechanically fixed. When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations assume thermally broken fasteners with a thermal conductivity of 1.00 W/m·K or less, the effect of which is insignificant.*

It can be seen from the table above that the *Kingspan* OPTIM-R™ **Roofing System** insulation thickness can be significantly less than that for rock mineral fibre – over 3 times thinner, which may allow lower parapets and shorter fixings.

Cavity Wall – Cavity Insulation Only (Extensions)



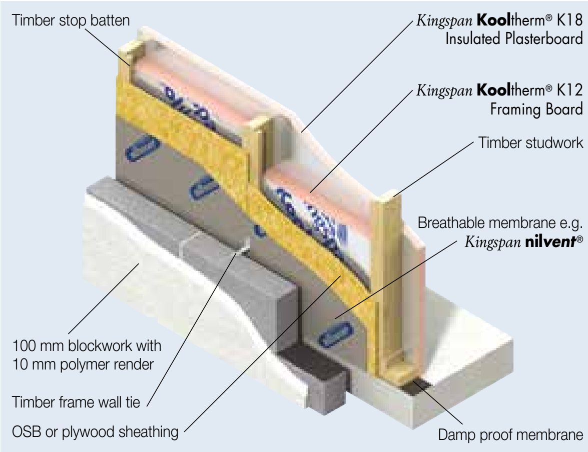
Insulation Thicknesses to Achieve a U–value of 0.25 W/m²·K			
Insulation Material	Insulation Thickness (mm)	Overall Cavity Width (mm)	
Kingspan **Kool**therm® (Partial Fill)	55	105	THINNER
Glass Fibre* (Full Fill)	130**	130	THICKER

**Assuming thermal conductivity 0.037 W/m·K.*
***The insulation fully, rather than partially, fills the cavity and, so, the wall tie specification will differ and no retaining clips will be present.*
NB When calculating U–values to BS EN ISO 6946: 2007, the type of wall tie used may change the thickness of insulation required. These calculations the following:

- *for 105 mm partial fill cavity widths, a stainless steel flexible tie with 2.5 ties per m² and a cross–sectional area of 12.50 mm², and*
- *for 130 mm full fill cavity widths, a stainless steel flexible tie with 4.9 ties per m² and a cross–sectional area of 23.00 mm².*

Cavities of just 105 mm can be used with the *Kingspan* **Kool**therm® solution, reducing the total wall width by 25 mm, compared with the glass mineral fibre full fill alternative shown above.

Timber Frame Wall – Insulation between Timber Studs & Insulated Dry-Lining (Extensions)

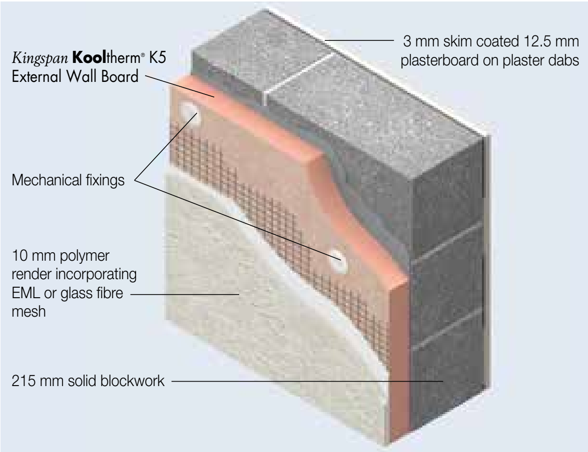


Insulation Thicknesses to Achieve a U–value of 0.25 W/m²·K					
Insulation Material	Stud Depth (mm)	Between Studs Insulation Thickness (mm)	Insulated Plasterboard Thickness (mm)******	Overall Thickness (mm)****	
Kingspan **Kool**therm®	140 89	85 60	0.0 32.5	140.00 121.50	THINNER
Glass Fibre* (Between Studs) & XPS** (Insulated Sheathing)	89	89***	62.5	151.50	THICKER
Glass Fibre* (Between)	160	160	15.0*****	175.00	

**Assuming thermal conductivity 0.035 W/m·K.*
***Assuming thermal conductivity 0.036 W/m·K.*
****No timber stop battens as insulation fully fills studs.*
*****Including redundant air–space between studs and plasterboard thickness.*
******A different lining specification – 15 mm plasterboard*
*******All insulated plasterboard thicknesses include 12.5 mm plasterboard.*
NB The effect of fixings for insulated plasterboard has been ignored in these calculations as the insulation layer penetrated is not the main insulation layer. A 15% bridging factor has been assumed for the timber stud. The thermal conductivity of the timber has been assumed to be 0.12 W/m·K.

Using *Kingspan* **Kool**therm® can result in a thinner overall construction. The glass mineral fibre solutions shown above require considerably deeper studwork to accommodate the required thickness of insulation. This may have a cost implication.

Solid Blockwork Wall – External Wall Insulation (Extensions & Existing Buildings)

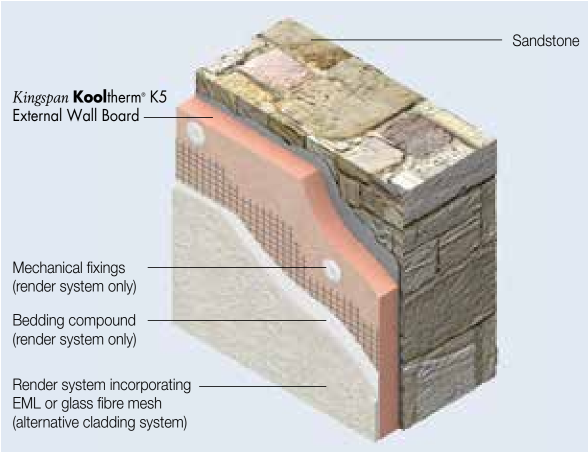


Insulation Thicknesses to Achieve a U–value of 0.25 W/m^2·K			
Insulation Material	Insulation Thickness (mm)	Overall Thickness (mm)	
Kingspan OPTIM-R™ External Wall System*	40	40 (+ 12 mm carrier board)	THINNEST
Kingspan **Kool**therm®	70	70	THINNER
Rock Fibre**	125	125	THICKER
EPS**	125	125	

*The *Kingspan* OPTIM-R™ **External Wall System** is overlaid with a magnesium silicate render carrier board. This is mechanically fixed through the appropriate horizontal or vertical *Kingspan* OPTIM-R™ *fix* panels using carbon steel fasteners with a cross–sectional area of 7.44 mm^2, with 2.88 fasteners per m^2. The bridging effect of the *Kingspan* OPTIM-R™ *flex* & *Kingspan* OPTIM-R™ *fix* components of the System is taken as 30%.
**Assuming thermal conductivity 0.038 W/m·K.
NB The calculations assume the use of lightweight blockwork with a λ–value of 0.15 W/m·K. These calculations also assume that the *Kingspan* OPTIM-R™ component of the *Kingspan* OPTIM-R™ **External Wall System** is adhesive fixed to the substrate, and that all other insulation boards (including *Kingspan* OPTIM-R™ *flex* and *Kingspan* OPTIM-R™ *fix*) are mechanically fixed. When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations assume thermally broken fasteners with a thermal conductivity 1.00 W/m·K or less, the effect of which is insignificant.

Using *Kingspan* **Kool**therm® or the *Kingspan* OPTIM-R™ **External Wall System** can dramatically reduce the width of the overall wall construction compared with the alternatives shown above. In refurbishment projects, where space under the eaves may be constrained, this could be critical.

Solid Stonework Wall – External Wall Insulation (Existing Buildings)



Insulation Thicknesses to Achieve a U–value of 0.25 W/m²·K	
Insulation Material	Insulation Thickness (mm)
Kingspan **Kool**therm®	75
Rock Fibre*	135
EPS*	135

THINNER

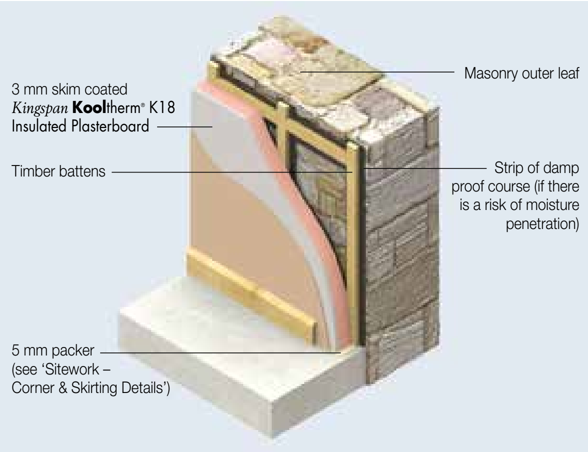
THICKER

**Assuming thermal conductivity 0.038 W/m·K.*

NB Calculations assume a 300 mm thick sand stone. When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations assume thermally broken fasteners with a thermal conductivity 1.00 W/m·K or less, the effect of which is insignificant.

Using *Kingspan* **Kool**therm® can result in a thinner overall construction, compared with the alternatives shown above. In refurbishment projects, where floor space may be constrained, this could be critical.

Solid Stonework Wall – Internal Wall Insulation (Existing Buildings)



Insulation Thicknesses to Achieve a U–value of 0.25 W/m²·K		
Insulation Material	Insulation Thickness (mm)**	
Kingspan **Kool**therm®	82.5	THINNER
XPS*	147.5	THICKER

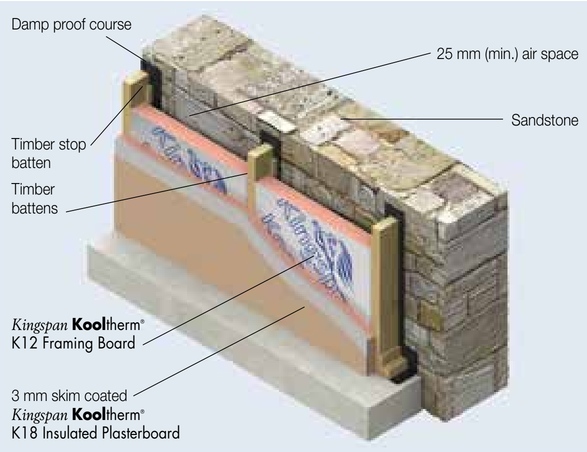
**Assuming thermal conductivity 0.036 W/m.K.*

*** Includes a 12.5 mm plasterboard.*

NB When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations assume the use of stainless steel fasteners of cross sectional area 7.44 mm² is assumed at a density of 4.4 per m².

Kingspan **Kool**therm® can dramatically reduce the thickness of insulation compared with the alternatives shown above. In refurbishment projects, where floor space may be constrained, this could be critical.

Solid Stonework Wall – Internal Dry Lining (Existing Buildings)



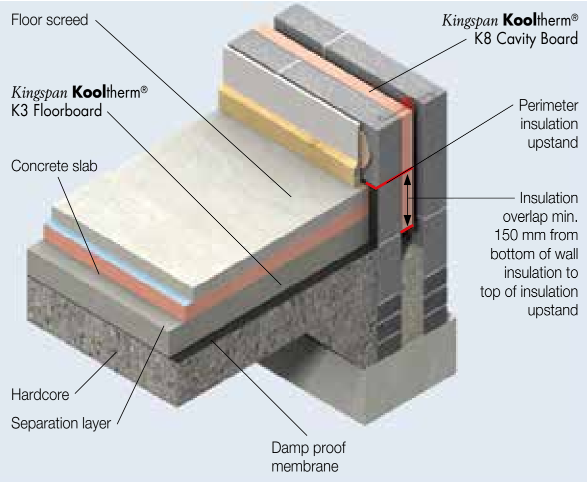
Insulation Thicknesses to Achieve a U–value of 0.25 W/m²·K					
Insulation Material	Stud Depth (mm)	Between Studs Insulation Thickness (mm)	Inside Battens Insulation Thickness (mm)***	Overall Thickness (mm)	
Kingspan **Kool**therm®	75	50	42.5	117.5	THINNER
Glass Fibre* (Between) & XPS** (Inside)	100	100	62.5	162.5	THICKER

**Assuming thermal conductivity 0.035 W/m·K.*
***Assuming thermal conductivity 0.036 W/m·K.*
****All insulated plasterboard thicknesses include 12.5 mm plasterboard.*
NB A 15% bridging factor has been assumed for the timber stud framework. The thermal conductivity of the timber has been assumed to be 0.12 W/m·K. When calculating U–values to BS EN ISO 6946: 2007, the type of mechanical fixing used may change the thickness of insulation required. These calculations also assume thermally broken fasteners with a thermal conductivity of 1.00 W/m·K or less, the effect of which is insignificant.

Kingspan **Kool**therm® can dramatically reduce the thickness of insulation compared with the alternative shown above. In refurbishment projects, where floor space may be constrained, this could be critical.

Kingspan Insulation Solutions – Existing Buildings

Ground Floor – Solid Concrete with Insulation below Floor Screed (Extensions & Existing Buildings)

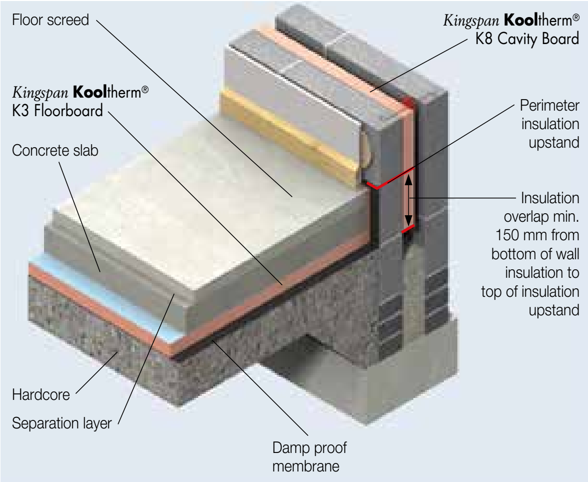


Insulation Thicknesses to Achieve a U–value of 0.20 W/m²·K		
Insulation Material	Insulation Thickness (mm)	
Kingspan OPTIM-R™ Flooring System*	30	THINNEST
Kingspan **Kool**therm®	65	THINNER
EPS**	120	THICKER

**The bridging effect of the Kingspan OPTIM-R™ flex & Kingspan OPTIM-R™ fix components of the System is taken as 15%.*
***Assuming thermal conductivity 0.038 W/m·K.*
NB For the purposes of these calculations, using the method as detailed in BS EN ISO 13370: 1998, the soil has been assumed to be clay or silt, and the wall insulation is assumed to overlap the floor insulation by minimum 150 mm. The P/A ratio is taken as 0.5.

Using *Kingspan* **Kool**therm® or the *Kingspan* **OPTIM-R™ Flooring System** rather than the expanded polystyrene solution, in the floor construction illustrated above, can result in having to dig out, and dispose of, less soil to make the space to accommodate the insulation.

Ground Floor – Solid Concrete with Insulation below Floor Slab (Extensions)

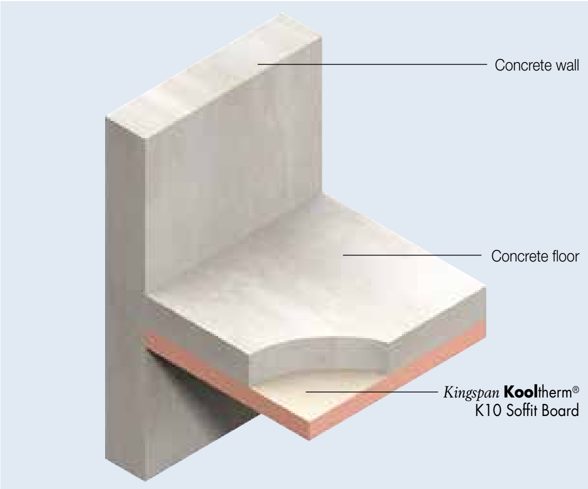


Insulation Thicknesses to Achieve a U–value of 0.20 W/m²·K		
Insulation Material	Insulation Thickness (mm)	
Kingspan **Kool**therm®	65	THINNER
EPS*	120	THICKER

**Assuming thermal conductivity 0.038 W/m·K.*
NB For the purposes of these calculations, using the method as detailed in BS EN ISO 13370: 1998, the soil has been assumed to be clay or silt, and the wall insulation is assumed to overlap the floor insulation by minimum 150 mm. The P/A ratio is taken as 0.5.

Using *Kingspan* **Kool**therm® rather than the expanded polystyrene solution, in the floor construction illustrated above, can result in having to dig out, and dispose of, less soil to make the space to accommodate the insulation.

Soffit – Directly Fixed to Concrete (Extensions & Existing Buildings)



Insulation Thicknesses to Achieve a U–value of 0.20 (W/m²·K)		
Insulation Material	Insulation Thickness (mm)	
Kingspan **Kool**therm®	95	THINNER
Rock Fibre*	175	THICKER

***Assuming thermal conductivity 0.038 W/m·K.*
NB When calculating U–values to BS EN ISO 6946: 2007, the type of fixing used may change the thickness of insulation required. These calculations assume the use of thermally broken fasteners with a thermal conductivity of 1.00 W/m·K or less, the effect of which is insignificant.

At almost half the thickness of fibre, using *Kingspan* **Kool**therm® helps to maximise headroom in soffit applications. Coupled with a reduced weight and a reduced number of fixings, the *Kingspan* **Kool**therm® solution has many advantages over the competition.

Customer Service

Tel: 01544 388 601
Fax: 01544 388 888
email: customerservice@kingspaninsulation.co.uk

Technical Advice

Tel: 01544 387 382
Fax: 01544 387 482
email: technical@kingspaninsulation.co.uk

Literature & Samples

Tel: 01544 387 384
Fax: 01544 387 484
email: literature@kingspaninsulation.co.uk

General Enquiries

Tel: 01544 388 601
Fax: 01544 388 888
email: info@kingspaninsulation.co.uk

Tapered Roofing

Tel: 01544 387 383
Fax: 01544 387 483
email: tapered@kingspaninsulation.co.uk

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Kingspan Insulation Ltd
Pembridge, Leominster, Herefordshire HR6 9LA, UK
www.kingspaninsulation.co.uk