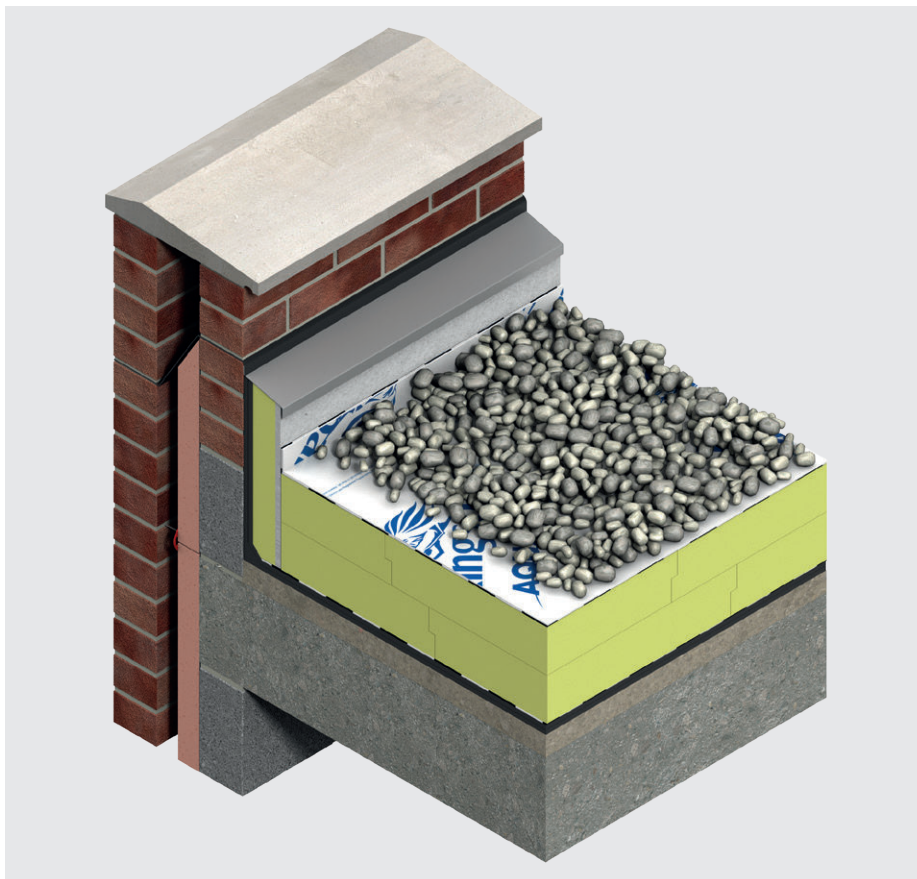


Kingspan **GreenGuard**[®] Inverted Roofs

Insulation for protected membrane flat roofs and green roofs



- Rigid extruded polystyrene insulation - thermal conductivities as low as 0.034 W/mK
- Protects waterproofing membrane
- Minimal water absorption
- High compressive stress
- Withstands freeze / thaw cycling
- Compatible with green roof systems
- Resistant to the passage of water vapour
- Easy to handle and install
- Ideal for new build and refurbishment
- Non-deleterious material
- Manufactured with a blowing agent that has zero ODP and low GWP

Typical constructions and U-values

Assumptions

The U-values in the tables that follow have been calculated using the method detailed in BS EN ISO 6946: 2017 (Building components and building elements. Thermal resistance and thermal transmittance. Calculation methods), and using the conventions set out in BR 443 (Conventions for U-value calculations). The method detailed in part F.4.2 of BS EN ISO 6946: 2017 and D.4.2 of I.S. EN ISO 6946: 2007 has been used to take account of the effect of the Kingspan Aquazone® (high performance, non-woven polyethylene membrane) over the insulation, and an (fx) factor of 0.0012 for a paving slab ballast application or 0.0010 for a green roof or gravel ballast application, has been assumed. They are valid for the constructions shown in the details immediately above each table.

They assume a nominal selection of post-codes, selected to represent the influence of geographical variations in rainfall on thermal performance.

The ceiling, where applicable, is taken to be a 3 mm skim coated 12.5 mm plasterboard with a cavity between it and the underside of the deck.

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

NB The figures quoted are for guidance only. A detailed U-value calculation together with condensation risk analysis should be completed for each project.

NB If your construction is different from those specified, and / or to gain a comprehensive U-value calculation along with a condensation risk analysis for your project, please consult the Kingspan Insulation Technical Service Department for assistance (see rear cover).

U-value table key

Further information on the applicable notional and area weighted average U-values is available in the relevant geographical documentation:

- Approved Documents L to the Building Regulations for England;
- Approved Documents L to the Building Regulations for Wales;
- Technical Handbooks Section 6 to the Building Standards for Scotland;
- Technical Booklets F1 & F2 to the Building Regulations for Northern Ireland; and
- Technical Guidance Document L (Dwellings) and Technical Guidance Document L (Buildings other than Dwellings) to the Building Regulations for the Republic of Ireland.

Concrete deck with paving slab ballast

Dense concrete deck with suspended ceiling

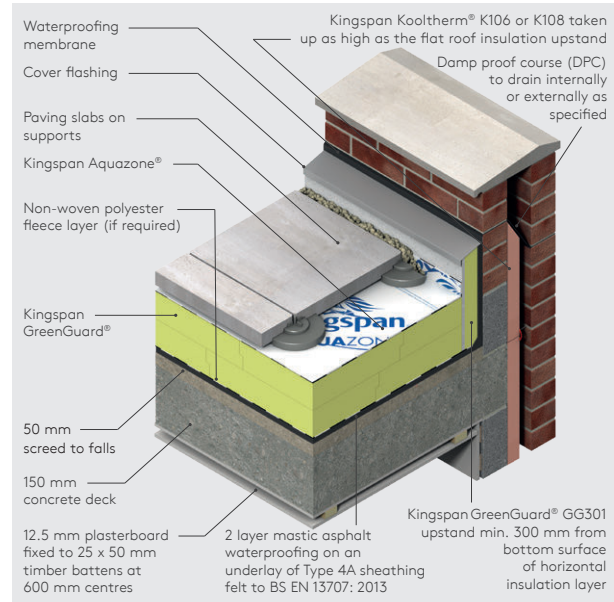


Figure 1

Insulant thickness (mm)	Postcode				
	London NW1	Birm'ham B1	Glasgow G1	Cardiff CF10	Ireland
Kingspan GreenGuard® GG300*					
120	-	-	-	-	-
180 (100 + 80)	0.18	0.18	0.18	-	0.18
190 (150 + 40)	0.17	0.17	0.17	0.18	0.17
200 (100 + 100)	0.16	0.16	0.17	0.17	0.16
210 (150 + 60)	0.16	0.16	0.16	0.16	0.16
220 (120 + 100)	0.15	0.15	0.16	0.16	0.15
230 (150 + 80)	0.14	0.14	0.15	0.15	0.14
240 (120 + 120)	0.14	0.14	0.14	0.15	0.14
250 (150 + 100)	0.13	0.13	0.14	0.14	0.13
260 (100 + 100 + 60)	0.13	0.13	0.13	0.14	0.13
270 (150 + 120)	0.12	0.12	0.13	0.13	0.12
280 (100 + 100 + 80)	0.12	0.12	0.13	0.13	0.12
300 (150 + 150)	0.11	0.11	0.12	0.12	0.11
320 (100 + 100 + 120)	0.11	0.11	0.11	0.11	0.11
340 (100 + 120 + 120)	0.10	0.10	0.11	0.11	0.10
360 (120 + 120 + 120)	0.09	0.09	0.10	0.10	0.10

* The above table contains figures for Kingspan GreenGuard® GG300 only. Please consult the Kingspan Insulation Technical Service Department (see rear cover) for calculations for other products in the range.

NB Where there are multiple layers of insulation of different thicknesses the thickest insulation board is installed first.

NB Refer to local distributor or Kingspan Insulation price list for current stock and non-stock sizes.

Typical constructions and U-values

Concrete deck with gravel ballast

Dense concrete deck with suspended ceiling

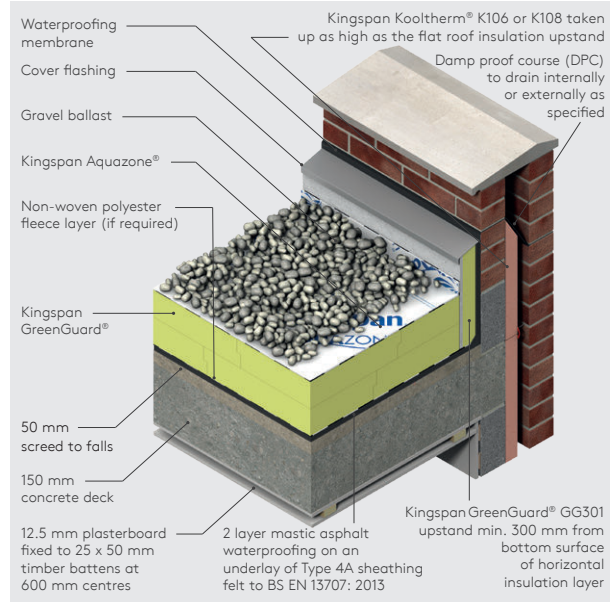


Figure 2

U-values (W/m ² K) for a nominal selection of postcodes					
Insulant thickness (mm)	Postcode				
	London NW1	Birm'ham B1	Glasgow G1	Cardiff CF10	Ireland
Kingspan GreenGuard® GG300*					
120	-	-	-	-	-
180 (100 + 80)	0.18	0.18	0.18	-	0.18
190 (150 + 40)	0.17	0.17	0.17	0.18	0.17
200 (100 + 100)	0.16	0.16	0.16	0.17	0.16
210 (150 + 60)	0.16	0.16	0.16	0.16	0.16
220 (120 + 100)	0.15	0.15	0.15	0.16	0.15
230 (150 + 80)	0.14	0.14	0.15	0.15	0.14
240 (120 + 120)	0.14	0.14	0.14	0.15	0.14
250 (150 + 100)	0.13	0.13	0.14	0.14	0.13
260 (100 + 100 + 60)	0.13	0.13	0.13	0.14	0.13
270 (150 + 120)	0.12	0.12	0.13	0.13	0.12
280 (100 + 100 + 80)	0.12	0.13	0.12	0.13	0.12
300 (150 + 150)	0.11	0.11	0.12	0.12	0.11
320 (100 + 100 + 120)	0.11	0.11	0.11	0.11	0.11
340 (100 + 120 + 120)	0.10	0.10	0.10	0.11	0.10
360 (120 + 120 + 120)	0.09	0.09	0.10	0.10	0.09

* The above table contains figures for Kingspan GreenGuard® GG300 only. Please consult the Kingspan Insulation Technical Service Department (see rear cover) for calculations for other products in the range.

NB Where there are multiple layers of insulation of different thicknesses the thickest insulation board is installed first.

NB Refer to local distributor or Kingspan Insulation price list for current stock and non-stock sizes.

Dense concrete deck with no ceiling

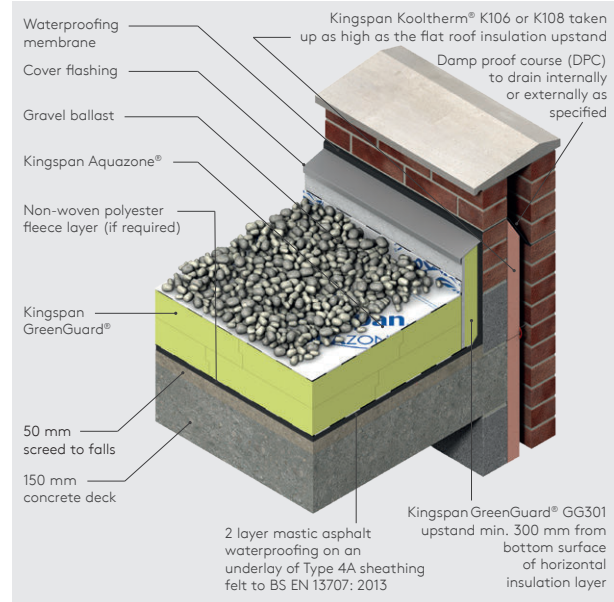


Figure 3

U-values (W/m ² K) for a nominal selection of postcodes					
Insulant thickness (mm)	Postcode				
	London NW1	Birm'ham B1	Glasgow G1	Cardiff CF10	Ireland
Kingspan GreenGuard® GG300*					
120	-	-	-	-	-
190 (150 + 40)	0.18	0.18	0.18	-	0.18
200 (100 + 100)	0.17	0.17	0.17	0.18	0.17
210 (150 + 60)	0.16	0.16	0.16	0.17	0.16
220 (120 + 100)	0.16	0.16	0.16	0.16	0.16
230 (150 + 80)	0.15	0.15	0.15	0.16	0.15
240 (120 + 120)	0.14	0.14	0.15	0.15	0.14
250 (150 + 100)	0.14	0.14	0.14	0.15	0.14
260 (100 + 100 + 60)	0.13	0.14	0.14	0.14	0.13
270 (150 + 120)	0.13	0.13	0.13	0.14	0.13
280 (100 + 100 + 80)	0.12	0.12	0.13	0.13	0.12
300 (150 + 150)	0.12	0.12	0.12	0.12	0.12
320 (100 + 100 + 120)	0.11	0.11	0.11	0.12	0.11
340 (100 + 120 + 120)	0.11	0.10	0.11	0.11	0.10
360 (120 + 120 + 120)	0.10	0.10	0.10	0.10	0.10

* The above table contains figures for Kingspan GreenGuard® GG300 only. Please consult the Kingspan Insulation Technical Service Department (see rear cover) for calculations for other products in the range.

NB Where there are multiple layers of insulation of different thicknesses the thickest insulation board is installed first.

NB Refer to local distributor or Kingspan Insulation price list for current stock and non-stock sizes.

Typical constructions and U-values

Green roofs

Semi-intensive green roof covering with no ceiling

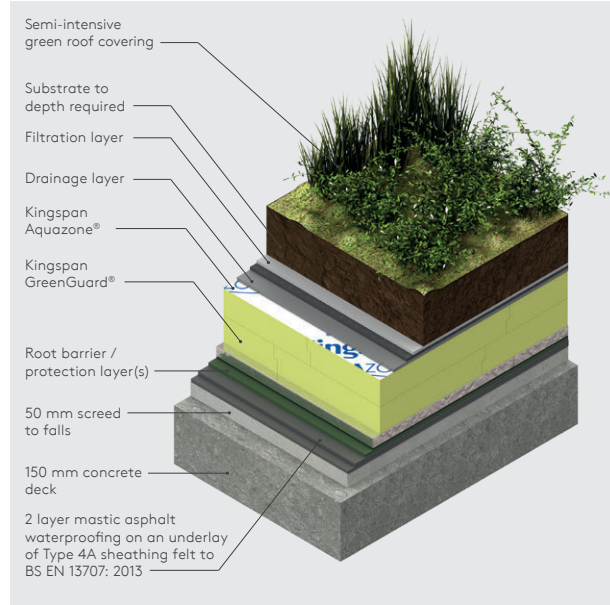


Figure 4

Intensive green roof covering with no ceiling

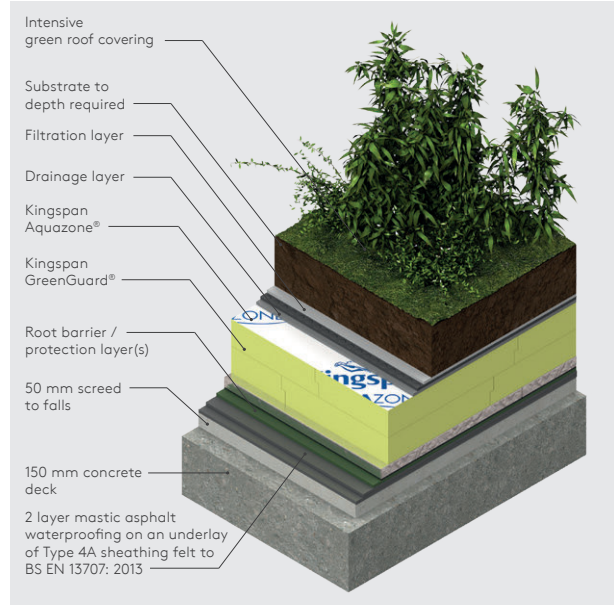


Figure 5

U-values (W/m ² K) for a nominal selection of postcodes					
Insulant thickness (mm)	Postcode				
	London NW1	Birm'ham B1	Glasgow G1	Cardiff CF10	Ireland
Kingspan GreenGuard® GG300*					
120	-	-	-	-	-
190 (150 + 40)	0.18	0.18	0.18	-	0.18
200 (100 + 100)	0.17	0.17	0.17	0.18	0.17
210 (150 + 60)	0.16	0.16	0.16	0.17	0.16
220 (120 + 100)	0.16	0.16	0.16	0.16	0.16
230 (150 + 80)	0.15	0.15	0.15	0.16	0.15
240 (120 + 120)	0.14	0.14	0.15	0.15	0.14
250 (150 + 100)	0.14	0.14	0.14	0.15	0.14
260 (100 + 100 + 60)	0.13	0.13	0.14	0.15	0.13
270 (150 + 120)	0.13	0.13	0.13	0.14	0.13
280 (100 + 100 + 80)	0.12	0.12	0.13	0.13	0.12
300 (150 + 150)	0.12	0.12	0.12	0.12	0.12
320 (100 + 100 + 120)	0.11	0.11	0.11	0.12	0.11
340 (100 + 120 + 120)	0.10	0.10	0.11	0.11	0.10
360 (120 + 120 + 120)	0.10	0.10	0.10	0.10	0.10

* The above table contains figures for Kingspan GreenGuard® GG300 only. Please consult the Kingspan Insulation Technical Service Department (see rear cover) for calculations for other products in the range.

NB Where there are multiple layers of insulation of different thicknesses the thickest insulation board is installed first.

NB Refer to local distributor or Kingspan Insulation price list for current stock and non-stock sizes.

U-values (W/m ² K) for a nominal selection of postcodes					
Insulant thickness (mm)	Postcode				
	London NW1	Birm'ham B1	Glasgow G1	Cardiff CF10	Ireland
Kingspan GreenGuard® GG300*					
120	-	-	-	-	-
190 (150 + 40)	0.18	0.18	0.18	-	0.18
200 (100 + 100)	0.17	0.17	0.17	0.18	0.17
210 (150 + 60)	0.16	0.16	0.16	0.17	0.16
220 (120 + 100)	0.16	0.16	0.16	0.16	0.16
230 (150 + 80)	0.15	0.15	0.15	0.16	0.15
240 (120 + 120)	0.14	0.14	0.15	0.15	0.14
250 (150 + 100)	0.14	0.14	0.14	0.15	0.14
260 (100 + 100 + 60)	0.13	0.13	0.14	0.15	0.13
270 (150 + 120)	0.13	0.13	0.13	0.14	0.13
280 (100 + 100 + 80)	0.12	0.12	0.13	0.13	0.12
300 (150 + 150)	0.12	0.12	0.12	0.12	0.12
320 (100 + 100 + 120)	0.11	0.11	0.11	0.12	0.11
340 (100 + 120 + 120)	0.10	0.10	0.11	0.11	0.10
360 (120 + 120 + 120)	0.10	0.10	0.10	0.10	0.10

* The above table contains figures for Kingspan GreenGuard® GG300 only. Please consult the Kingspan Insulation Technical Service Department (see rear cover) for calculations for other products in the range.

NB Where there are multiple layers of insulation of different thicknesses the thickest insulation board is installed first.

NB Refer to local distributor or Kingspan Insulation price list for current stock and non-stock sizes.

Design considerations

Linear thermal bridging

Basic principles

Linear thermal bridging describes the heat loss / gain that occurs at junctions between elements e.g. where an external wall meets the roof, or at junctions around openings in the building fabric where the thermal insulation layer is discontinuous e.g. sills, jambs and lintels.

Interruptions within the insulation layer by materials with poorer insulating properties can result in a thermal bridge, which in turn can lead to problems of condensation and mould growth, especially if there is a drop in surface temperature.

The heat flow at these junctions and opening locations, over and above that through the adjoining plane elements, is the linear thermal transmittance of the thermal bridge: measured in W/mK; referred to as a 'psi-value'; and expressed as a ' ψ -value'.

The lower the ψ -value, the better the performance. ψ -values are taken into account in the calculation methodologies e.g. the Standard Assessment Procedure (SAP), that are used to assess the operational CO₂ emissions and, where applicable, the fabric energy efficiency of buildings.

ψ -values can comprise either, or a combination of, approved, calculated or assumed values.

Reducing linear thermal bridging

Detailing at junctions to minimise the effects of thermal bridging and the associated risk of condensation or mould growth is important and there are some simple design considerations that can be adopted to help mitigate the risks and to reduce heat losses.

- Care is required to ensure continuation of insulation wherever possible between the wall and roof for best thermal performance. Where this is not possible, the roof and wall insulation should be overlapped and ideally, insulation material introduced between.
- Parapet detailing can represent a good, low heat loss approach, with insulation continuity maintained using an insulated upstand to reduce cold bridging. Kingspan GreenGuard® GG301 Upstand Board should be used around the perimeter of the roof on the internal façade of parapets. The upstand should extend a minimum of 150 mm above the roof insulation and achieve a minimum distance of 300 mm between the top of the insulation upstand and the bottom of the horizontal roof insulation. Wall insulation should be carried up into parapets at least as high as the flat roof insulation upstand.

- For best thermal performance, roof-lights and ventilator kerbs should be insulated with the same thickness of Kingspan GreenGuard® GG301, with a separate backing layer of Kingspan GreenGuard®, as the general roof area (see Figure 6).
- Where a parapet construction is not used, to achieve best performance, the roof insulation should overlap the wall to extend the thermal bridge path, if necessary by adding thermal insulation to edge beams to achieve continuity with external insulation (see Figure 7).
- Insulate internal rainwater downpipes and other pipes that penetrate the roof if they pass through spaces with a high humidity and if any condensate will damage the structure or internal finishes. Use Kingspan GreenGuard® around the pipe outlet and wrap joints with vapour resistant tape to restrict water vapour from reaching the pipe (see Figure 8).
- Where guttering is incorporated within a flat roof construction, this should be accounted for within the overall thermal design of the roof via an area-weighted calculation for the whole roof. The risk of localised interstitial condensation from reduced insulation provision at the gutter should be considered.
- Where an Internal gutter is formed, vertical insulation should be used to reduce thermal bridging, using Kingspan GreenGuard® GG301 with a separate backing layer of Kingspan GreenGuard® (see Figure 9). A similar approach can also reduce losses where a change in levels is required (see Figure 11).
- Lightweight aggregate blockwork to the inner leaf of wall constructions can help to improve thermal performance at junctions generally and where used for the inner leaf of parapet walls it can help to reduce losses (see Figure 10).

Responsible sourcing

Kingspan GreenGuard® GG300 produced at Kingspan Insulation's Selby, North Yorkshire manufacturing facility is manufactured under a management system certified to ISO 14001: 2015.

NB The above information is correct at the time of writing. Please confirm at the point of need by visiting the Kingspan Insulation website (see rear cover), from which copies of Kingspan Insulation's certificates can be obtained.

Design considerations

Sustainability & responsibility

Kingspan Insulation has a long-term commitment to sustainability and responsibility: as a manufacturer and supplier of insulation products; as an employer; as a substantial landholder; and as a key member of its neighbouring communities.

A report covering the sustainability and responsibility of Kingspan Insulation Ltd's British operations at its Pembridge, Herefordshire and Selby, North Yorkshire manufacturing facilities is available at www.kingspaninsulation.co.uk/sustainabilityandresponsibility.

Specification clause

Kingspan GreenGuard® should be described in specifications as:-

The roof insulation shall be Kingspan GreenGuard® GG300 / GG500 (delete as appropriate) (insert grade) _____ mm thick: comprising rigid extruded polystyrene insulation. The product shall be manufactured, with a blowing agent that has zero Ozone Depletion Potential (ODP) and low Global Warming Potential (GWP); under a management system certified to ISO 9001: 2015; and installed in accordance with the instructions issued by Kingspan Insulation Limited.

NBS classifications

The NBS classifications for this product are:
Pr_25_71_63_29 Extruded polystyrene (XPS) boards (Uniclass UK)
J42_415 Extruded polystyrene (XPS) insulation (CAWS - Architecture)

Protected membrane roofs

This literature describes the use of Kingspan GreenGuard® as a component of protected membrane roofing systems using either a gravel or paving slab finish, and as a component of green roof systems.

Protected membrane roofing systems place the insulation above the waterproofing, and offer several advantages over traditional warm flat roofs.

- The waterproofing system can be expected to have a life in excess of that obtained in an exposed situation, as it is protected from mechanical damage, UV degradation from solar radiation and temperature extremes (both daily and seasonal).
- The roof is safe from condensation risk.

- The roof achieves the national requirements for external fire exposure when covered with an inorganic material i.e. 50 mm gravel or 40 mm paving slabs.
- Insulation can be lifted to allow inspection of the waterproofing system.
- Additional insulation can be added at a later date.
- The installation of the insulation is not weather dependant.

Rigid extruded polystyrene insulation has minimal water absorption, due to its closed cell structure, and is one of only a few materials suitable and approved for this application, where it will be subject to wetting / drying and freeze / thaw cycles.

Product selection

Consideration must be given to which Kingspan GreenGuard® product is most appropriate for the required application. A table of the key distinguishing features is shown below.

Product	Thermal conductivity (W/mK)	Compressive stress (kPa)
Kingspan GreenGuard® GG300	0.034 W/mK (30 - 150 mm)	300
Kingspan GreenGuard® GG500	0.034 W/mK (40 - 60 mm) 0.036 W/mK (> 60 mm)	500

Design loads & roof structure

The suitability of the structure under consideration to accept design loads, including the increased dead load from ballast, snow and roof traffic, should be verified in accordance with BS EN 1991-1-3: 2003 + A1: 2015 (Eurocode 1. Actions on structures. General actions. Snow loads).

The additional load from ballast can be considerable.

Ballast layer	Dead load
50 mm thick paving slabs	125 kg/m ²
Gravel (16-32 mm diameter)	16 kg/m ² per 10 mm depth
Soil (intensive green roof)	180 - 500 kg/m ²
Soil (semi-intensive green roof)	120 - 200 kg/m ²
Soil (extensive green roof)	60 - 150 kg/m ²

The ballast layer resists wind uplift, prevents floatation of the boards after heavy rain and prevents UV degradation of the boards.

Design considerations

Wind loads

The resistance of the waterproofing system, insulation and ballast to wind uplift should be assessed in accordance with BS EN 1991-1-4: 2005 + A1: 2010 (Eurocode 1. Actions on structures. General actions. Wind actions). BRE Digest 295 gives specific design guidelines for loose-laid insulation systems.

For constructions located in sheltered exposure zones, or on buildings of up to 10 storeys, the self weight of a minimum 50 mm gravel ballast layer (minimum 80 kg/m²), installed over a non-woven polyethylene membrane, is generally sufficient to ensure that both the insulation boards and waterproofing system remain stable under the full design load.

For constructions located in moderate exposure zones, or on buildings of up to 10 to 15 storeys, this gravel ballast specification is generally sufficient, but the perimeter should be loaded with 50 mm thick paving slabs.

For severe exposure zones or tall buildings over 15 storeys, specialist advice should be sought. BRE Digest 311 (Wind scour of gravel ballast on roofs) should be used when a calculation is required for a specific building project.

Flotation

The ballast specifications detailed in the 'Wind Loads' section (above) will be sufficient to prevent flotation of the insulation boards after heavy rain.

Falls

The fall on a flat roof, constructed using Kingspan GreenGuard®, is normally provided by the supporting structure being directed towards the rainwater outlets. The fall should be smooth and steep enough to prevent the formation of rainwater ponds. In order to ensure adequate drainage, BS 6229: 2018 (Flat roofs with continuously supported flexible waterproof coverings. Code of practice) recommends uniform gradients of not less than 1 in 80. However, because of building settlement, it is advisable to design in even greater falls.

Protected membrane roofing systems incorporating Kingspan GreenGuard® can be laid on roofs with a finished fall of less than 1:80, but the waterproofing system must be of a tanking specification.

Design details

Paving slab ballasted protected membrane roof details

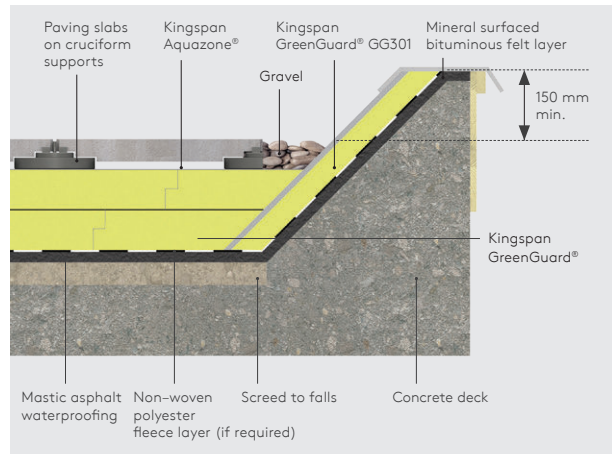


Figure 6 - Eave / kerb detail

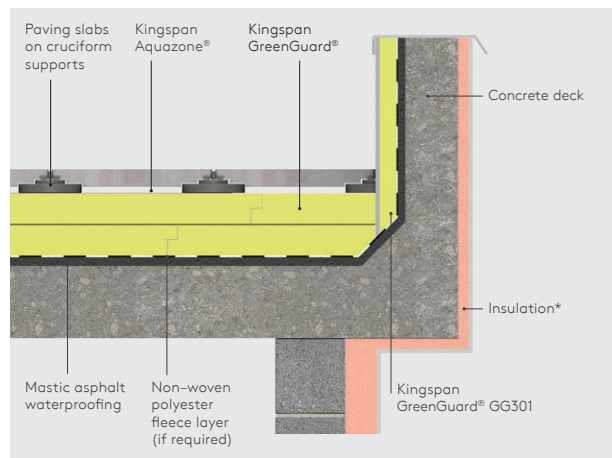


Figure 7 - Eave / gutter detail

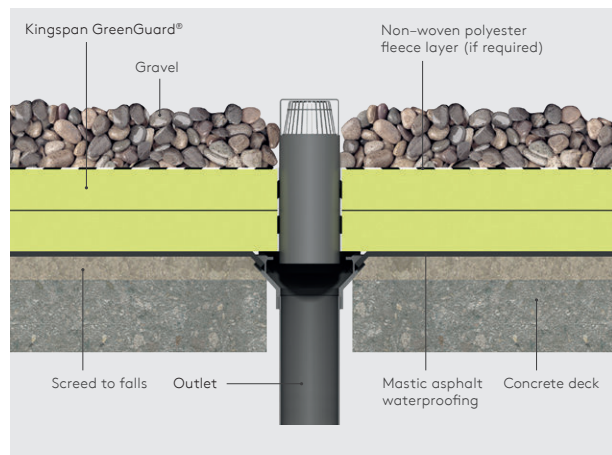


Figure 8 - Two level drainage

* The insulation specification will depend on the full build up and facade finish.

Design considerations

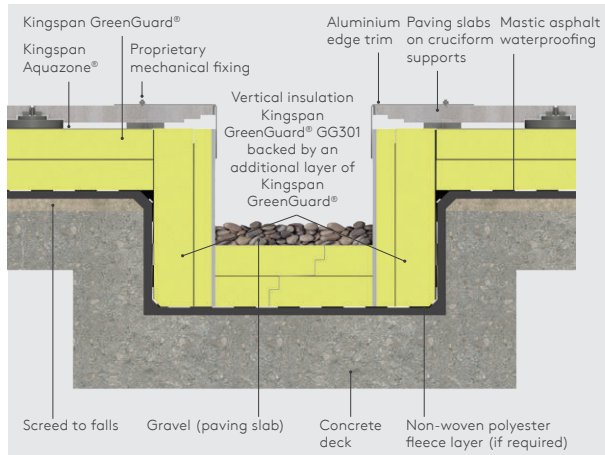


Figure 9 - Internal gutter

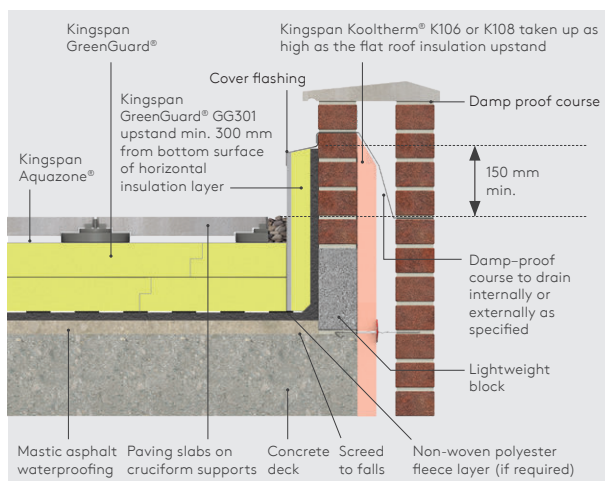


Figure 10 - Parapet abutment

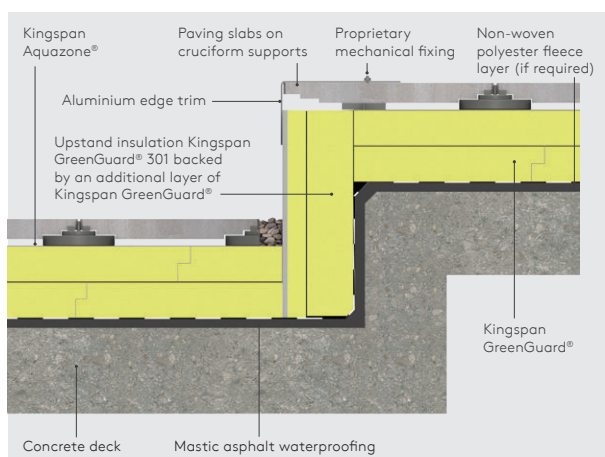


Figure 11 - Change in level

Rainfall factors

The requirements of part F.4.2 of BS EN ISO 6946: 2017 and D.4.2 of I.S. EN ISO 6946: 2007 dictate that inverted roof constructions are subject to a geographical rainfall analysis. The cooling effect of rainwater flowing between and beneath the insulation boards, can mean that greater thicknesses of insulation are required to meet desired U-values, particularly in locations that receive high levels of rainfall.

The use of Kingspan Aquazone® over the insulation (see Figures 6-11), can dramatically minimise heat loss by reducing the amount of rainwater that flows between and beneath the insulation boards.

This reduction in rainwater flow is represented by the infiltration (fx) factor of the membrane. The fx factor of a membrane is fall (gradient) specific, and an fx factor measured on a fall can not be used to represent the performance of a membrane if installed horizontally.

Drainage

The number and type of rainwater outlets should be assessed in accordance with BS EN 12056-3: 2000 (Gravity drainage systems inside buildings. Roof drainage, layout and calculation). The rainwater outlets should be double entry type, to allow rainwater to be drained from the roof surface at both the membrane level and the upper surface level. When using paving slabs as ballast, on a roof with a finished fall of less than 1:80, they must be laid on supports, in order to aid drainage.

The drainage of green roofs should be carefully considered, especially in the case of intensive systems, which may require a moisture retention layer to ensure adequate moisture levels for the system but still allow the rapid drainage of excess rainwater. Dam type rainwater outlets that hold water in the system are not recommended, as the depth of water may create a moisture vapour impermeable layer above the insulation.

Design considerations

Roof waterproofing

Kingspan GreenGuard® is suitable for use over some fully adhered single-ply waterproofing membranes.

Kingspan GreenGuard® is also suitable for use over mastic asphalt waterproofing systems. Mastic asphalt waterproofing should be laid, where applicable, in accordance with BS 8218: 1998 (Code of practice for mastic asphalt roofing). Mastic asphalt should always be laid over an isolating layer of loose-laid Type 4A sheathing felt to BS EN 13707: 2013 (Flexible sheets for waterproofing. Reinforced bitumen sheets for roof waterproofing. Definitions and characteristics).

Kingspan GreenGuard® is also suitable for use over some hot and cold liquid applied waterproofing systems.

Mastic asphalt, some single-ply and some hot liquid applied waterproofing systems require a separation layer (non-woven polyester fleece layer, 130 - 140 g/m², with an overlap of 250 - 300 mm) positioned between the membrane and the insulation.

Waterproofing systems containing solvents should be allowed to fully cure before installing Kingspan GreenGuard® insulation.

Water vapour control

Protected membrane roofs are inherently safe in respect of condensation risk. The roof design can be assessed for the risk of interstitial condensation using BS 5250: 2021 (Management of moisture in buildings. Code of practice) or BS 6229: 2018.

Green roofs

Benefits

Green roofs, are an alternative to the standard protected membrane roof that offer many advantages but require precise design and detailing.

Specifically they can:

- reduce dust levels;
- provide a habitat for wildlife;
- create usable areas for recreational activities;
- retain rainfall thus prevent water surges into the drainage system;
- improve sound insulation; and
- provide a visually more attractive finish than protected membrane roofs with gravel or paving slab ballast.

Types of green roof

Green roof systems can be divided into three main categories.

Extensive green roofs comprise a relatively shallow growing medium and low maintenance vegetation such as grass. They are lightweight, simple to design, construct and maintain, but should not be considered suitable for regular traffic or recreational activities. Extensive systems are especially useful in creating green areas for both ecological and aesthetic reasons.

Semi-intensive green roofs comprise a deeper growing medium and vegetation such as grass, perennials and shrubs. They are designed to be more garden-like and to accommodate limited access for maintenance and recreation.

Intensive green roofs have a much deeper growing medium and a wider variety of flora, including grass, shrubs and smaller trees. They are comparable with normal gardens in respect of maintenance, and can be used for recreation activities. The self weight of the system can be very high, due to the increased soil depth.

Careful design and detailing of all roof types is important and includes the following elements.

Growing medium

In its simplest form this is normal soil. Specialist mixtures are available, incorporating expanded clay and lava rock, which form the growing medium and have filtration, drainage and moisture retention functions.

Drainage layer

The drainage layer normally consists of either: a layer of washed gravel 8/16; expanded clay; or a specialist 'egg carton' or castellated plastic (HDPE) sheeting; all overlaid with a filtration membrane. The drainage layer allows the rapid removal of excess rainwater from the roof, thus avoiding saturation of the soil and the associated increase in weight.

Moisture retention layer

The limited depth of soil, especially in the extensive type of roof, may require the use of a moisture retention layer to ensure sufficient water is available for the vegetation.

Root barrier

The roots of growing plants can seriously damage waterproof membranes, by growing into any small cracks, lap joints or other discontinuities. A root barrier may be formed by a separate cap sheet of polythene, or bitumen felt incorporating a thin copper film. The cap sheet is either adhered or loose-laid onto the waterproof membrane, with all joints sealed by bonding or welding, and must be continued up vertical faces of upstands.

Sitework

Waterproofing

- Prior to installing the insulation, it is essential to ensure that the waterproofing system has been installed correctly and that the roof is watertight and clean.
- Single-ply membranes, in particular, need careful attention to ensure that there has been no damage from following trades, and that puncturing from below the membrane (from nail heads or debris) cannot occur.
- If a single-ply membrane or mastic asphalt waterproofing system has been installed, a non-woven polyester fleece separation layer, with 250 - 300 mm overlaps, should be laid on top of the membrane prior to the installation of the insulation.

Insulation boards

- Start laying the Kingspan GreenGuard® insulation boards from the point of access to the roof.
- Insulation boards should always be loose-laid break-bonded, either with their long edges at right angles to the edge of, or diagonally across the roof, and with joints lightly butted. There should be no gaps at abutments.
- If two or more layers of insulation are required, they should be horizontally offset relative to each other so that, as far as possible, the board joints in any two adjacent layers do not coincide with each other (see Figure 12).

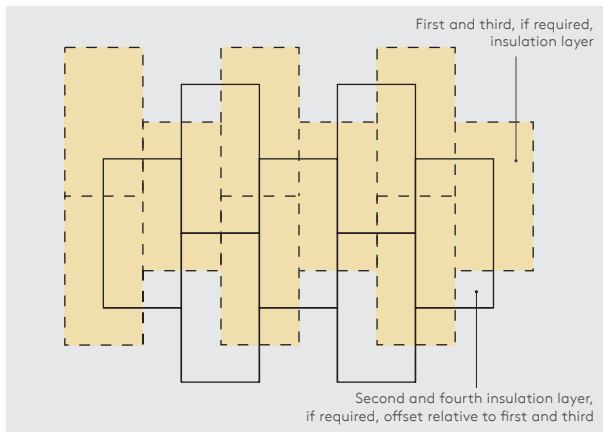


Figure 12 - Offsetting of multiple insulation layers

- Roof-light or ventilator kerbs, gutter etc. should always be insulated (Kingspan GreenGuard® GG301 with a separate backing layer of Kingspan GreenGuard®) to meet the same U-value as the general roof area.
- A Kingspan GreenGuard® GG301 upstand should be used around the perimeter of the roof on the internal façade of parapets.
- A minimum distance of 300 mm should be maintained between the top of the insulation upstand and the bottom of the horizontal roof insulation.
- Boards can be laid in any weather but, due to the boards being lightweight, care must be taken in windy conditions.

Kingspan Aquazone®

- Kingspan Aquazone®, a high performance, non-woven polyethylene membrane, should be laid over the insulation boards.
- Where one run of the membrane laps another, there should be a minimum 300 mm side and end overlaps.
- The membrane should be terminated flush with the paving slabs / ballast.

Gravel ballast

- Install the ballast layer as soon as possible, to ensure that Kingspan Aquazone® is always protected and excessive heat build up or high winds do not damage the insulation boards.
- Gravel ballast should be washed, rounded, nominal 20 - 40 mm diameter, and of minimum depth 50 mm.
- The diameter of the gravel is important as this size has been found to be the most resistant to wind scour, BRE Digest 311 gives advice.

Paving slab ballast

- Min. 50 mm thick paving slabs should be laid, over Kingspan Aquazone®, on proprietary paving slab supports of minimum diameter 175 mm (or equivalent base area), in order to maintain drainage below the slabs, and to ensure that moisture vapour can escape.
- Install paving slabs and supports as soon as possible, to ensure that Kingspan Aquazone® is always protected and excessive heat build up or high winds do not damage the insulation boards.
- Gaps between the paving slabs and upstands should be filled with washed, rounded gravel, nominal 20 - 40 mm diameter.

Sitework

Roof gardens

- Having chosen the type of planting system and correctly detailed the various filter layers, moisture retention layers and growing medium, the installation, especially of extensive systems, is quick and simple.
- A root barrier (unless provided by the waterproofing layer) should be loose-laid on or bonded to the waterproofing membrane with all the laps sealed.
- The root barrier should be turned up at the edge of the roof insulation and sealed under the flashing.
- Kingspan GreenGuard® should be installed as described previously.
- Boards should be overlaid with Kingspan Aquazone®, which should be installed as described previously.
- A filtration layer or combined filtration layer / drainage mat is then installed, per its manufacturer's instructions.
- The growing medium, generally 50 - 200 mm deep is then installed. Specialist spray systems are available, which allow the application of growing medium and grass / plant seed to be applied in one operation.
- The depth of growing medium should be assessed for wind loads in accordance with BS EN 1991-1-4: 2005 + A1: 2010 (Eurocode 1. Actions on structures. General actions. Wind actions). BRE Digest 295 gives specific design guidelines for loose-laid insulation systems.

Mechanical fixings (Kingspan GreenGuard® GG301 only)

- Cutting Kingspan GreenGuard® GG301 should be carried out by using a TCT saw. Ensure correct FFP2 or 3 grade PPE is used to protect against inhalation of dust during cutting.
- A minimum of 3 fixings, with a minimum head diameter of 25 mm, are required to secure 1200 mm long boards of Kingspan GreenGuard® GG301 to the parapet.
- The requirement for additional fixings should be assessed in accordance with BS EN 1991-1-4: 2005 + A1: 2010 (National Annex to Eurocode 1. Actions on structures. General Actions. Wind Actions).
- Mechanical fixings must be arranged in an even pattern.
- Fixings for Kingspan GreenGuard® GG301 should be positioned across the top edge of the board and at a maximum of 600 mm centres.
- Fixings at insulation board edges must be located > 50 mm and < 200 mm from edges and corners of the board and not overlap board joints.
- Each fixing should incorporate a square or circular plate washer (minimum 25 x 25 mm or 25 mm diameter).
- Fixings should be driven straight.
- Care should be taken not to overdrive fixings.
- The bottom of the board should be supported and held in place by the Kingspan GreenGuard® and ballast / paving slabs on supports.

- Additional fixings should be used if the Kingspan GreenGuard® GG301 is not supported, following the same specification as detailed in the previous bullet point.

- For details on fixings refer to:

Ejot UK Limited +44 (0) 1977 687 040
www.mejot.co.uk

Fixfast +44 (0) 1732 882 387
www.fixfast.com

MAK Fasteners +353 (0) 1 451 9004
www.makfasteners.com

SFS Intec +44 (0) 1132 085 500
www.sfsintec.biz/uk

General

Cutting

- Cutting should be carried out either by using a fine toothed saw, a hot wire system or by scoring with a sharp knife and snapping the board over a straight edge.
- Ensure accurate trimming to achieve close-butting joints and continuity of insulation.

Availability

- Kingspan GreenGuard® is available through specialist insulation distributors and selected roofing merchants throughout the UK and Ireland.

Packaging and storage

- Kingspan GreenGuard® may be delivered in packaging bearing alternative product branding.
- The polyethylene packaging of Kingspan Insulation products, which is recyclable, should not be considered adequate for outside protection.
- Ideally, boards should be stored inside a well ventilated building. If, however, outside storage cannot be avoided, then the boards should be stacked clear of the ground and covered with a pale pigmented polythene sheet or weatherproof tarpaulin.
- Kingspan GreenGuard® should not be left in the sun covered by either a transparent or a dark plastic sheet, since in both cases, board temperatures can build up to a level hot enough to appreciably alter their dimensions or warp them.

Health and safety

- Kingspan Insulation products are chemically inert and safe to use.
- A Safety Information Data Sheet for this product is available from the Kingspan Insulation website
www.kingspaninsulation.co.uk/safety or
www.kingspaninsulation.ie/safety.

Warning - do not stand on or otherwise support your weight on this product unless it is fully supported by a load-bearing surface.

Product details

Composition

Kingspan GreenGuard® GG300 and GG500 are rigid extruded polystyrene insulants with a fibre-free core. They are manufactured with a blowing agent that has zero Ozone Depletion Potential (ODP) and low Global Warming Potential (GWP) and has a smooth, dense skin on both faces.



Standards and approvals

Kingspan GreenGuard® GG300 produced at Kingspan Insulation's Selby, North Yorkshire manufacturing facility is manufactured to the highest standards under a management system certified to ISO 9001: 2015 (Quality management systems. Requirements), ISO 14001: 2015 (Environmental Management Systems. Requirements), ISO 45001: 2018 (Occupational Health and Safety Management Systems. Requirements with guidance for use) and ISO 50001: 2018 (Energy management systems. Requirements with guidance for use).

The use of Kingspan GreenGuard GG300 in inverted roofs (in thicknesses of 30, 40, 50, 60, 70, 80, 100, 120, 140 or 150 mm) is covered by BBA Certificate 22/6048.



Standard dimensions

All products in the Kingspan GreenGuard® range are available in the following standard size:

Nominal dimension		Availability
Length	(m)	1.25 and 2.5
Width	(m)	0.6
Insulant thickness	(mm)	Refer to local distributor or Kingspan Insulation price list for current stock and non-stock sizes.
Edge profile		Straight and rebated

Compressive stress

The compressive stress of Kingspan GreenGuard® products typically exceeds the following values:

Kingspan GreenGuard® GG300 – 300 kPa; and
Kingspan GreenGuard® GG500 – 500 kPa,

when tested to EN 826: 2013 (Thermal insulating products for building applications. Determination of compression behaviour).

Water vapour resistivity

The products typically achieve a resistivity greater than 400 MNs/gm, when tested in accordance with BS EN 12086: 2013 (Thermal insulating products for building applications. Determination of water vapour transmission properties).

Absorption of moisture

Kingspan GreenGuard® is highly resistant to water absorption and the effects of freeze-thaw cycling.

Durability

If correctly installed, Kingspan GreenGuard® can have an indefinite life. Its durability depends on the supporting structure and the conditions of its use.

Resistance to solvents, fungi & rodents

Kingspan GreenGuard® is resistant to most commonly occurring construction materials such as lime, cement, plaster, anhydrous gypsum, solvent-free bituminous compounds, water-based wood preservatives, as well as alcohols, acids and alkalis. Certain organic materials such as solvent-based wood preservatives, coal tar and derivatives (creosote), paint thinners and common solvents (e.g. acetone, ethyl acetate, petrol, toluene and white spirit) will attack Kingspan GreenGuard®, resulting in softening, shrinkage and possible dissolution, with a consequent loss of performance.

Kingspan GreenGuard® does not provide any food value to vermin and is not normally attractive to them.

Fire performance

Under System 4 AVCP, Kingspan GreenGuard® GG300 and GG500 have a Euroclass rating of F.

Roof covering products (and/or materials) defined in Commission Decision 2000/553/ EC of 6 September 2000, implementing Council Directive 89/106/EEC, can be considered to fulfil all of the requirements for the performance characteristic 'external fire performance' without the need for testing, provided that any national provisions on the design and execution of works are fulfilled, and can be used without restriction. This applies to products intended to be fully covered in normal usage by the inorganic coverings listed below.

- Loose laid gravel with a thickness of at least 50 mm or a mass $\geq 80 \text{ kg/m}^2$ (minimum aggregate size 4 mm, maximum 32 mm).
- Sand/cement screed to a thickness of at least 30 mm.
- Cast stone or mineral slabs of at least 40 mm thickness.

For other configurations of coverings, please contact the system supplier.

Further details on the fire performance of Kingspan Insulation products may be obtained from the Kingspan Insulation Technical Service Department (see rear cover).

Maximum service temperature

Kingspan GreenGuard® should not be brought into direct contact with high temperature heat sources. The maximum service temperature of Kingspan GreenGuard® is 75°C.

Product details

Thermal properties

The λ -values and R-values detailed below are quoted in accordance with BS EN 13164: 2012: + A1: 2015 (Thermal insulation products for buildings. Factory made extruded polystyrene foam (XPS) products. Specification).

Declared thermal conductivity

The boards achieve a declared thermal conductivity (λ -value) of Kingspan GreenGuard® GG300 is:

0.034 W/mK (insulant thickness 30 - 150 mm).

Kingspan GreenGuard® GG500 is:

0.034 W/mK (insulant thickness 40 - 60 mm); and

0.036 W/mK (insulant thickness > 60 mm).

Thermal resistance

Thermal resistance (R-value) varies with thickness and is calculated by dividing the thickness of the board (expressed in metres) by its thermal conductivity. The resulting number is rounded down to the nearest 0.05 (m²K/W).

Insulant thickness (mm)	Thermal resistance (m ² K/W)	
	GG300	GG500
30	0.85	-
40	1.15	-
50	1.45	1.45
60	1.75	1.75
75	2.20	-
80	2.35	2.20
100	2.90	2.75
120	3.50	3.30
150	4.40	-

NB Multiple layers of insulation are required for higher thermal resistances.

NB Refer to local distributor or Kingspan Insulation price list for current stock and non-stock sizes.

NB Where a hyphen is shown the thickness is not available.

Design thermal conductivity

In applications where Kingspan GreenGuard® could come into contact with moisture, a design thermal conductivity is taken into account within U-value calculations. The boards achieve a design thermal conductivity (λ -value) of Kingspan GreenGuard® GG300 is:

0.036 W/mK (insulant thickness 30 - 150 mm).

Kingspan GreenGuard® GG500 is:

0.036 W/mK (insulant thickness 40 - 60 mm); and

0.038 W/mK (insulant thickness > 60 mm).

About Kingspan Insulation

Company details

Kingspan Insulation Ltd is part of the Kingspan Group plc., one of Europe's leading construction product manufacturers. The Kingspan Group was formed in the late 1960s and is a publicly quoted group of companies headquartered in Kingscourt, County Cavan, Ireland.

Kingspan Insulation Ltd is a market leading manufacturer of premium and high performance rigid insulation products and insulated systems for building fabric and building services applications.

Products & solutions

Optimum, premium and high performance rigid insulation products for building fabric applications, including roofs, walls and floors.

- Kingspan OPTIM-R® - optimum performance vacuum insulation panel (VIP) systems.
- Kingspan Kooltherm® - premium performance phenolic insulation.
- Kingspan Therma™ - high performance PIR insulation.
- K-Roc® - rock mineral fibre insulation.
- Kingspan GreenGuard® - extruded polystyrene insulation (XPS).
- Kingspan TEK® - structural insulated panels (SIPs).
- Cavity closers - PVC-U extrusions with an insulation core.
- Membranes - for pitched roofs and walls.

Services

We are proud to offer one of the most advanced support services in the construction industry, designed to give fast and accurate advice no matter what your role is. Visit our website to access the following services.

- U-value calculations - free, quick and easy U-value calculations with our U-value Calculator.
- Help and advice on your projects, including stockists, how to guides, regulatory guidance and e-learning.
- Building Information Modelling (BIM) - download BIM objects for our products.
- Tapered roofing service - Kingspan Insulation's tapered roofing systems come with a supporting design service to ensure the most cost-effective solution for a roof is identified.
- CPDs - Kingspan Insulation offer a number of free CPD seminars for architects and specifiers covering a wide range of industry topics. CPDs can be booked or a range of online learning courses can be found online.

Planet Passionate

Planet Passionate is our 10-year group wide global sustainability strategy aims to impact on three big global issues: climate change, circularity and protection of our natural world.

The Planet Passionate strategy is made up of 12 ambitious targets, addressing the impact of Kingspan's business operations and manufacturing on the four key areas of energy, carbon, circularity and water, with commitments by 2030 to include:

- energy: powering 60% of all Kingspan operations directly from renewable energy with a minimum of 20% of this energy generated on manufacturing sites;
- carbon: achieving net zero carbon manufacturing and a 50% reduction in product CO₂ intensity from primary supply partners;
- circularity: upcycling of 1 billion PET bottles per annum into insulation products plus zero company waste to landfill across all sites; and
- water: harvesting 100 million litres of Kingspan's water usage from rainwater.

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