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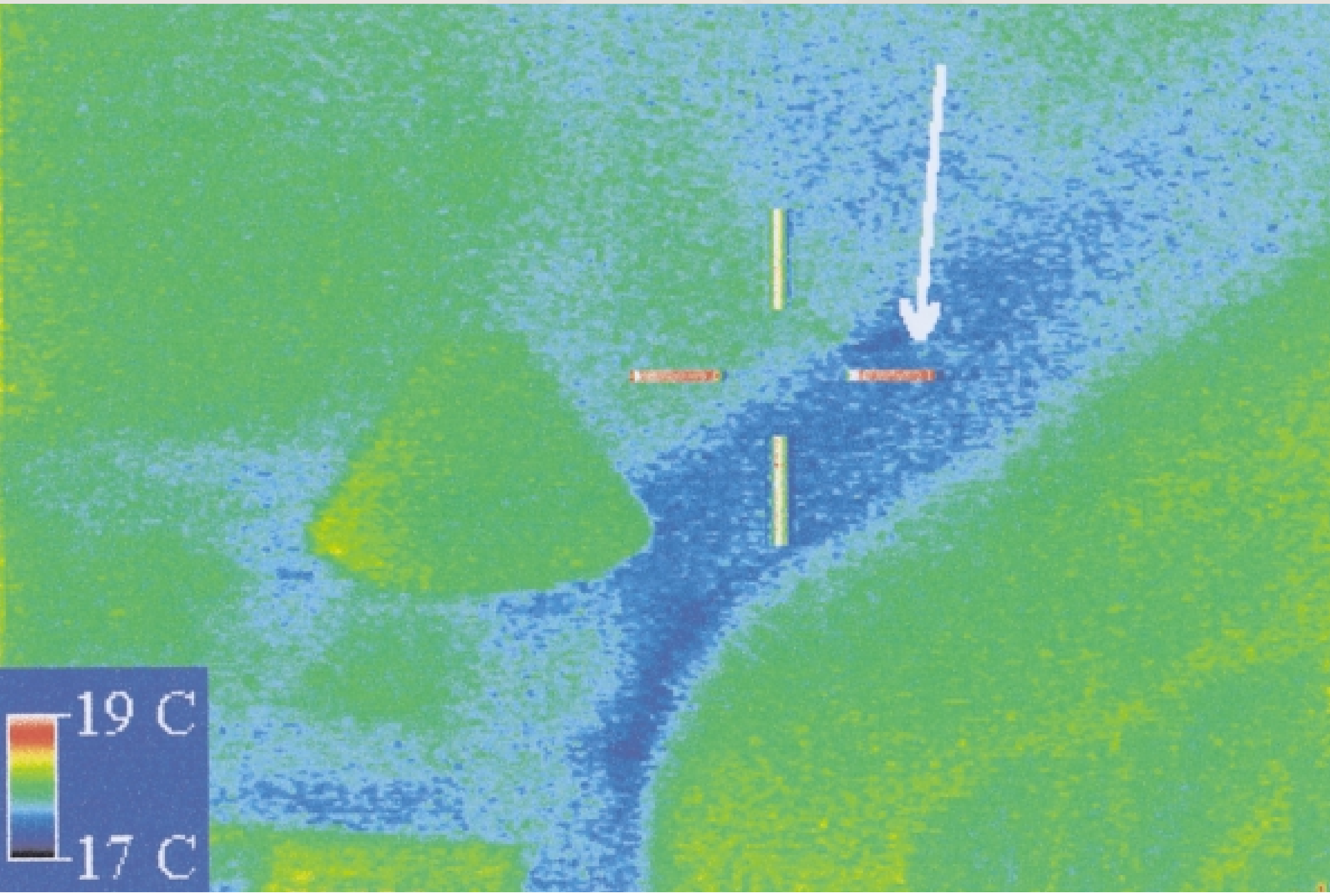
Mineral Fibre Loft Insulation, Cold Bridging, Ventilation & Heat Loss at the Eaves

A WHITE PAPER



Kingspan® Insulation Solutions

Contents

1 Executive Summary

1.1 Kingspan Insulation Ltd commissioned the School of Architecture, Planning and Landscape at the University of Newcastle upon Tyne to carry out research into the effects of air infiltration and insulation application defects in ventilated lofts insulated with man made mineral fibre loft insulation.

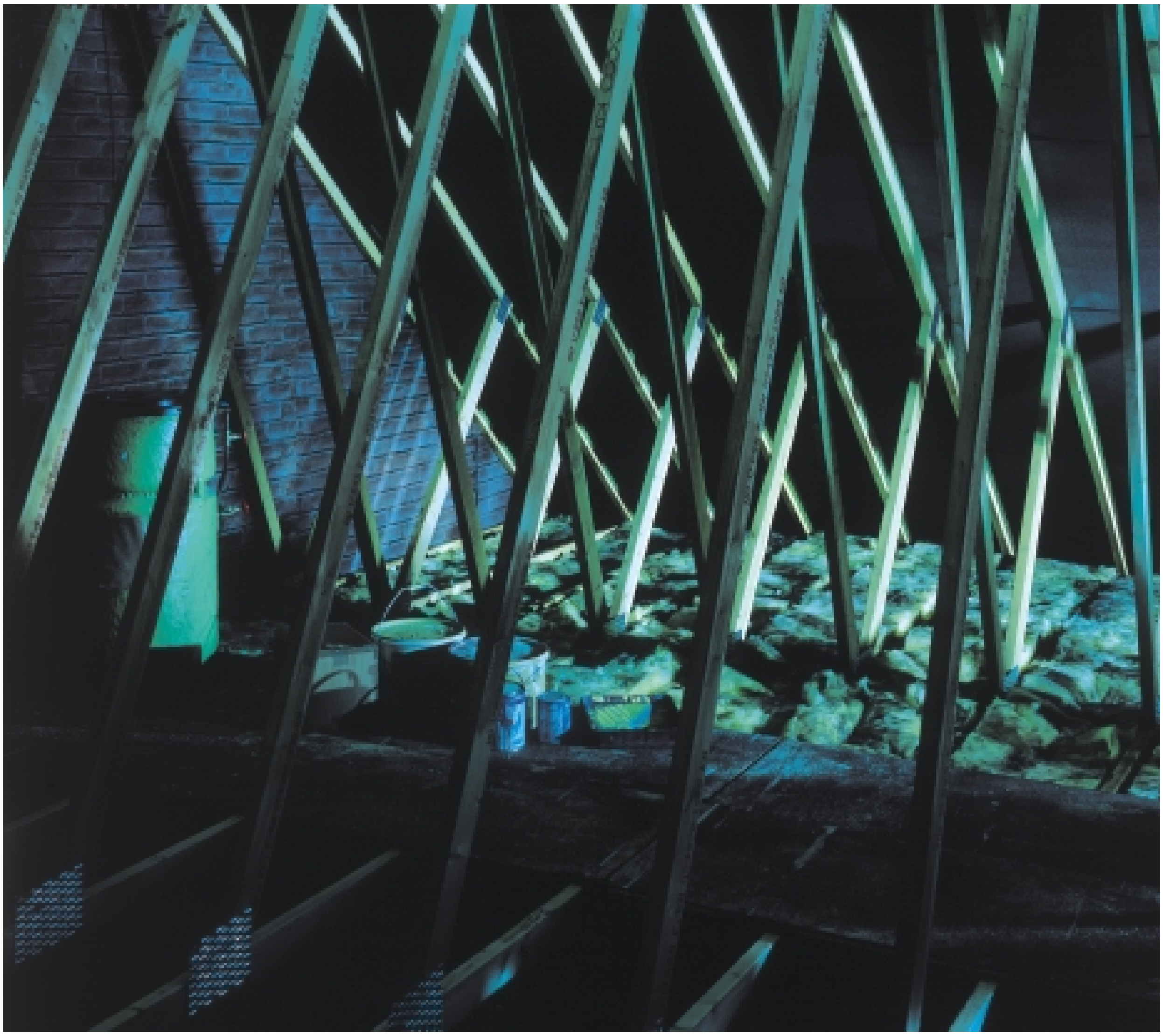
1.2 The research showed that at the eaves position in a loft, pulling the second layer of insulation back by 250 mm, so as to avoid blocking eaves ventilation, could double the U–value at the eaves, significantly affecting the thermal performance.

1.3 The research also showed that if the insulation was butted up to an eaves ventilation tray, the U–value of the eaves area could degrade by 500%.

1.4 With the addition of air movement through the ventilated eaves, with a wind speed of just 0.15 m/s, the thermal performance of the eaves area could be degraded by 900%.

1.5 Other issues discussed in this paper are: dust and dirt entering the loft through ventilation openings and reducing the thickness of the in-situ man made mineral fibre loft insulation; missing and compressed insulation; health and safety; and cold bridging.

1.6 The solution to these problems is to specify a sealed unventilated loft using a breathable sarking membrane (e.g. *Kingspan* **nil*vent***®) and an insulated dry-lining plasterboard (e.g. *Kingspan* **Kool**therm K18 Insulated Dry-lining Board) on the underside of the loft floor joists. This can reduce the need for loft insulation quilt to 150 mm between joists.



2 Ventilated Lofts – Traditional Construction

2.1 In the UK, a typical new-build loft construction consists of tiles or slates fixed to tile/slate battens over sarking felt with a loft space below.

2.2 The floor of the loft is typically insulated with two layers of man made mineral fibre quilt. The first layer of quilt runs between the timber joists (normally 100 mm deep) and is held in place by the plasterboard ceiling below. The second layer runs at 90 degrees to the first, over the top of the joists. The thickness of the second layer is such that the current Building Regulations/Standards U–value of 0.16 $W/m^2.K$ is achieved. This is typically 170 mm assuming joists at 600 mm centres.

2.3 Air carries water vapour. As the water vapour content of air increases so does the vapour pressure. Water vapour migrates from higher vapour pressure parts to lower vapour pressure parts of a building.

2.4 The maximum amount of water vapour that air can carry at a given temperature is reached at its saturation point. The warmer the air, the more water vapour it can contain before its saturation point is reached. The colder the air, the less water it can contain. As the temperature of air decreases, its saturation point will reduce until it matches the water vapour content of the air. Any further temperature reduction will result in condensation. This explains why condensation can form on cold surfaces when warm moist air is incident upon them.

2.5 Insulation in a loft void keeps the habitable area of a property warm and the loft space and roofing felt cold. Loft insulation, therefore, can increase the potential for condensation.

2.6 The traditional way of controlling the potential for condensation is to introduce ventilation at the eaves and occasionally the ridge allowing a free movement of air so as to disperse the water vapour.

3 Ventilated Lofts – The Problems

3.1 Blocked Ventilation

3.1.1 If eaves ventilation becomes blocked, a not un-common occurrence when insulation is being pushed into the eaves, free movement of air may be restricted. When the water vapour in air cannot be dispersed it has the potential to condense.

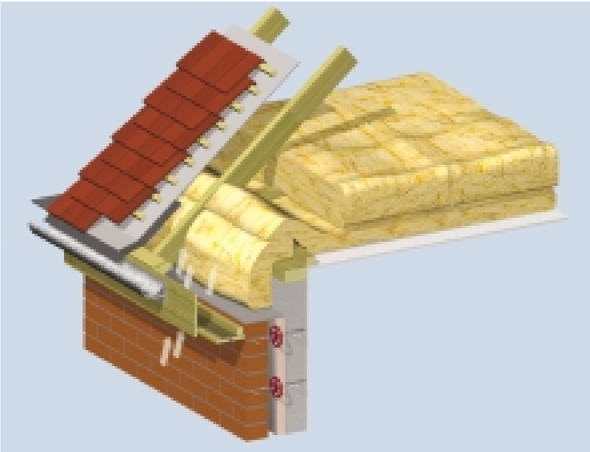


Figure 1 If eaves ventilation becomes blocked because of insulation pushed into the eaves, free movement of air may be restricted, and this could result in condensation.

3.1.2 Condensation occurs when warm moist air escaping from a building makes contact with a cold surface (e.g. roofing felt). The air is cooled below its saturation point and water vapour changes into liquid water.

3.1.3 When prolonged condensation occurs, mould, usually the black spot mould Aspergillus Niger, can form. Several studies have raised health concerns about buildings where this mould is found.[1,2]

3.1.4 Another symptom of prolonged condensation is timber rot. If the timbers of the roof absorb moisture and their moisture content is consistently above 20% the dry rot Serpula Lacrymans can occur. At high moisture contents, between 40 and 50%, wet rot Coniophora Puteana can occur.

Dry rot. Fine grey strands (hyphae) of the fungus spread over and through the timber. As it develops, fruiting bodies (sporophores) form and these give off spores which spread the fungus further. Timber attacked by dry rot becomes dry and brittle with cuboidal fractures. It is usually so weak that it can be broken up by hand.

Wet rot. It does not usually spread over other materials. It leaves the timber a dark brown colour with small cuboidal splits or longitudinal cracks.

3.2 Compressed Insulation in the Eaves

3.2.1 The easiest method of installing quilt type insulation at the eaves without blocking the ventilation is with the use of an eaves ventilation tray. Simply put, an eaves ventilation tray is a preformed plastic tray with integral fins that are pushed up against the sarking felt. When the over-joist layer of insulation and the layer over the wall plate are pushed up against the eaves ventilation tray the fins maintain a clear ventilation gap between the sarking felt and the tray.

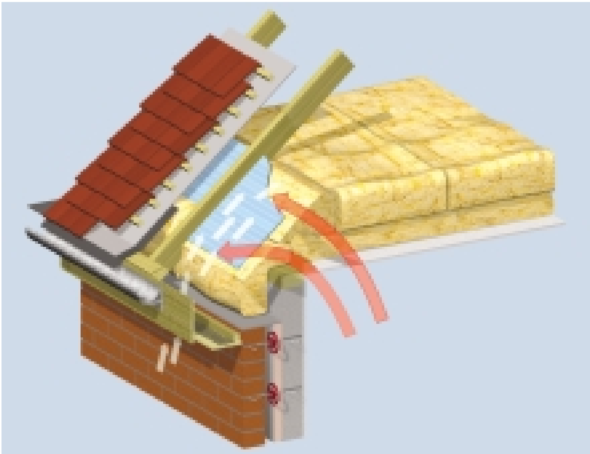
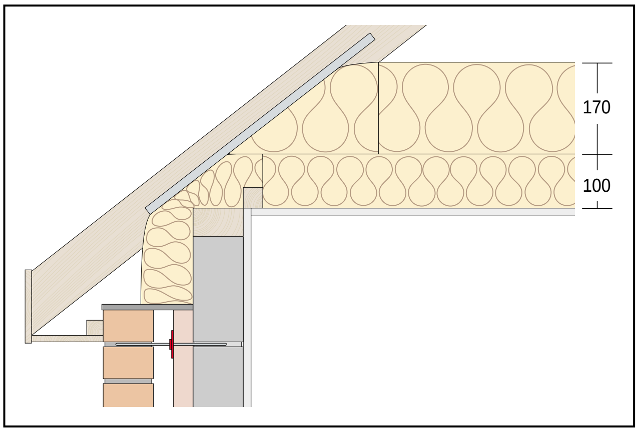


Figure 2 An eaves ventilation tray is a preformed plastic tray with integral fins that are pushed up against the sarking felt. When the insulation is pushed up against the eaves ventilation tray the fins maintain a clear ventilation gap between the sarking felt and the tray.

3.2.2 When the over-joist layer of insulation and the layer over the wall plate are pushed up against the eaves ventilation tray they will be locally compressed at the eaves and a cold bridge can be created. However, because of the geometry of the roof, achieving this extent of coverage can be extremely difficult.



1. Manual of Medical Mycologyby John Thorne Crissy, Heidi Lang, Lawrence Charles Parish, Blackwell Sciences, Cambridge, Massachusettes, 1995. 263p.
2. Mould Allergy, Yousef Al-Doory and Joanne F. Domson, Lea and Febiger, Philadelphia, 1984,287p.

3 Ventilated Lofts – The Problems

3.3 Missing Insulation at the Eaves

3.3.1 The majority of new-build lofts are created using a trussed rafter system. A trussed rafter is a triangulated plane roof frame that does not require ridge boards or purlins for structural support.

3.3.2 The combination of the triangular construction of a trussed rafter and the relatively low pitch of the roof (e.g. 30° degrees) can result in significant areas of the loft being difficult, if not impossible, to insulate effectively.

3.3.3 If the loft is insulated without compressing the over-joist layer of insulation into the void below the eaves ventilation tray, an even more significant cold bridge can be created than detailed in 3.2. Assuming a 30° pitch, a perimeter run 208 mm wide could be left under-insulated with only 100 mm of insulation between joists. On a typical 45 m^2 loft this can relate to **7.4%** of the loft being under-insulated (see page 10).

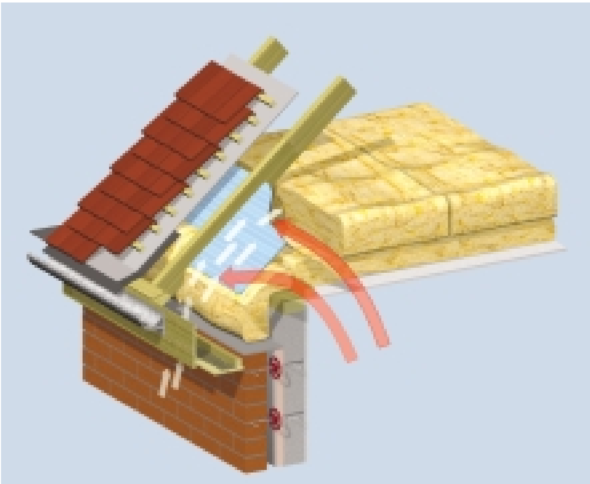


Figure 3 If the loft is insulated without compressing the over-joist layer of insulation into the void below the eaves ventilation tray, an even more significant cold bridge can be created.

3.4 Air Infiltration of the Insulation

3.4.1 A recent study, commissioned by Kingspan Insulation and carried out by the School of Architecture, Planning and Landscape at the University of Newcastle upon Tyne, set out to quantify the loss of thermal performance as a result of: defects in the installation of loft insulation; and air penetration of the insulation when used in a ventilated loft application. It found that when ventilation air penetrates mineral fibre loft insulation its thermal performance can be seriously degraded.

3.4.2 In the study a number of scenarios were tested (see page 7). The loft construction for the tests comprised a traditional horizontal ceiling of 12.5 mm plasterboard with two layers of rock mineral fibre insulation creating a total depth of 130 mm, a loft space and an airtight membrane running over the top of the pitched rafter.

3.4.3 By measuring heat fluxes through the test loft an actual thermal transmittance was calculated. Thermographic images provided a pictorial reference that clearly showed the effect that air-penetration has on the insulation.

3.4.4 Thermal transmittance measurements where taken at three points. Measurement point 1 was 150 mm from the inner edge of the wall, measurement point 2 was 300 mm and measurement point 3, 1000 mm.

3.4.5 As expected, when the defects in the insulation layer were increased it was found that the measured thermal transmittance increased significantly, i.e. the structure lost its ability to retain heat to varying degrees.

3.4.6 The thermographic imaging clearly shows the degradation in thermal performance. The horizontal blue line running across the images is in the position of the wall plate. It can be seen clearly that as the defects in the rock mineral fibre insulation were introduced the area of heat loss was increased.

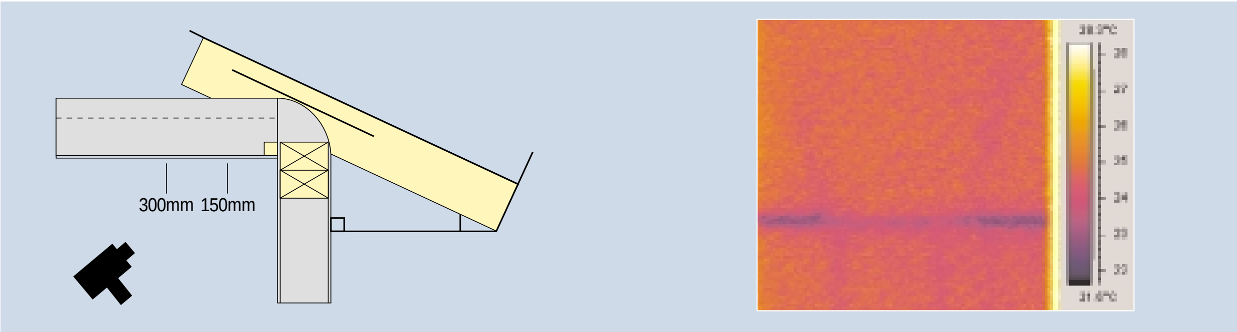
3.4.7 Having measured the performance loss as a result of defects in the loft insulation, an airflow of 0.15 m/s was introduced into construction 3b and thermal transmittance measurements taken. At these very low levels of air movement the thermal performance was severely affected, degrading the U–value at measurement point 1 by 900% to 2.2 $W/m^2.K$.

3.4.8 The School of Architecture, Planning and Landscape at the University of Newcastle upon Tyne concluded that when there was no bulk airflow and the insulation was installed correctly, the measured and predicted U–values were in good agreement.

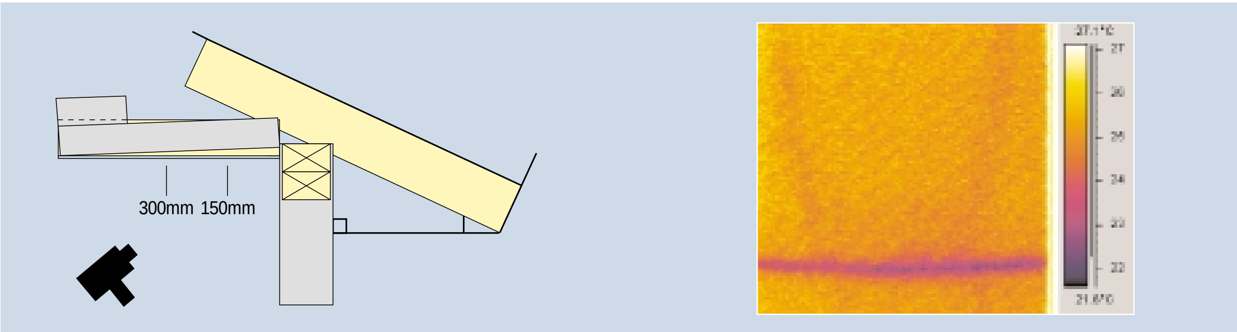
3.4.9 Incorrectly installed insulation resulted in an increase in the U–value.

3.4.10 If an airflow is allowed to pass through the insulation, then the U–value increases locally at the point of entry.

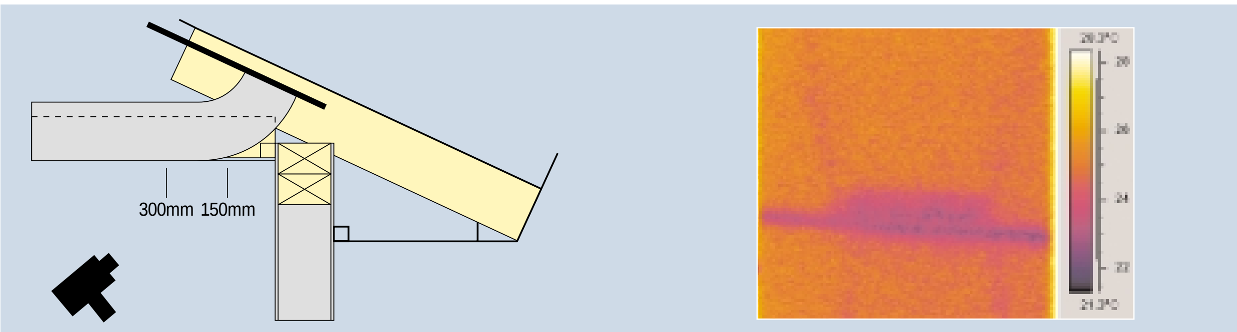
3 Ventilated Lofts – The Problems



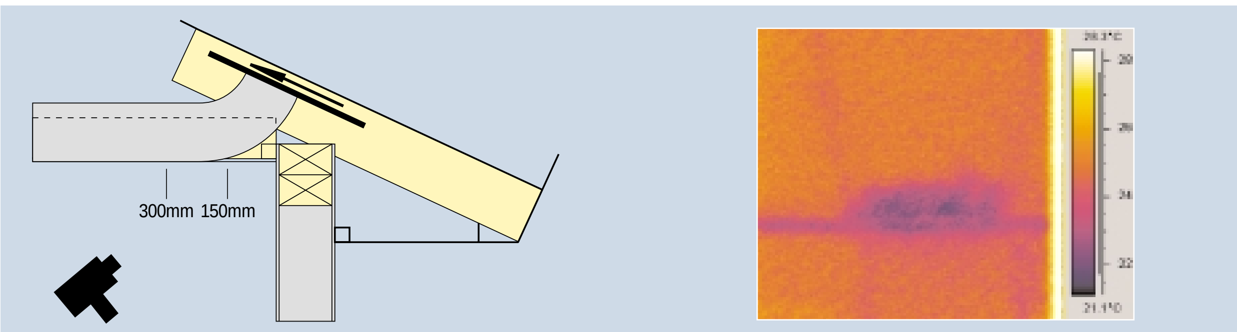
Construction 1 The rock mineral fibre insulation was fitted tight over the wall plate. The measured thermal transmittance at all three measurement points was in agreement with the design values.



Construction 2 The first layer of rock mineral fibre insulation was fitted over the plasterboard noggin and the second layer pulled back 250 mm. This resulted in a doubling of the U–value at position 1 and a 50% increase at position 2.



Construction 3a Both layers of rock mineral fibre insulation were pushed up against the ventilated eaves tray. At measurement point 1, this resulted in a 500% increase in U–values.



Construction 3b Same physical construction as 3a but with the introduction of air movement as detailed by the arrow. This resulted in a 900% increase in U–value to 2.2 W/m^2.K.

3 Ventilated Lofts – The Problems

3.5 Missing Insulation in General

3.5.1 In a survey carried out by Kingspan Insulation in conjunction with a Local Authority in the West Midlands, 35 properties (28 in street A and 7 in street B) had their lofts inspected. Of the 35, more than half of the lofts had areas that were under-insulated as a result of missing mineral fibre.

3.5.2 The survey showed that, on average, the 28 houses from street A were missing insulation from **2.4%** of their total loft area and the 7 houses from street B were missing an average of **4.4%**.

3.5.3 Alarmingly the survey showed that in street A **65.6%** of the total loft area was under-insulated and street B **68.6%**, compared with the intended thickness.

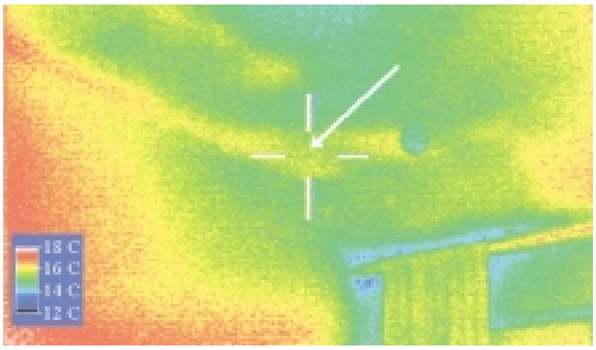


Figure 4 This thermographic image shows the rear bedroom ceiling from one of the properties. There is a small area 1 metre long (arrowed) where the mineral fibre stops short of the eaves. This is seen as the yellow rectangular pattern. The narrow yellow band above the pattern is also noted and indicates that a gap in the mineral fibre above the ceiling joist exists at this location.

3.5.3 The reason for the missing insulation was poor workmanship and supervision by the loft installation contractors.

3.5.4 Further details of this survey are given in “Mineral Fibre Loft Insulation, Compaction, Settlement, Missing Mineral Fibre and Heat Loss – A White Paper”.

To obtain a copy, contact the Kingspan Insulation Marketing Department (see rear cover)

3.6 Dust, Dirt and Insects

3.6.1 The free movement of air in a loft-space, as a result of designed ventilation, not only carries moisture out of a loft, but may also carry dirt and dust in. This dirt and dust can sit on and in the quilt insulation. The result is that the mineral fibre quilt could have its thickness reduced and therefore a degradation of its thermal performance may occur.

3.6.2 The provision of ventilation gaps in a loft space can also create potential access for birds, bats and insects, which can have a negative effect on loft insulation performance.

3.7 Health and Safety

3.7.1 In order to achieve the elemental U–value requirements of current Building Regulations/Standards (0.16 $W/m^2.K$) a total depth of 270 mm of man made mineral fibre could be required (assuming joists at 600 mm centres), 100 mm would normally be installed between ceiling joists and 170 mm running at 90 degrees across the tops of the joists.

3.7.2 The 170 mm thick second layer of insulation is used to eliminate heat escaping through the less thermally efficient timber ceiling joists. If the tops of the ceiling joists are covered with insulation, moving around in the loft for maintenance purposes can become hazardous. It may be difficult, if not impossible, to locate the tops of the joists.

Figure 5 This photograph from the local authority study shows the additional layer of mineral fibre insulation missing from a substantial portion of the loft.

4 Unventilated Lofts

4.1 Much research has been done into the performance of unventilated lofts that incorporate vapour permeable sarking membranes to control condensation formation.

4.2 An unventilated loft uses the same basic construction as a ventilated loft. The exceptions being that a vapour permeable sarking membrane is used in place of the normal bituminous felt underlay and that the eaves are sealed.

4.3 The Building Research Establishment prepared a report for DuPont that compared the performance of two identical houses, one with a ventilated loft space and one with a unventilated loft space.

4.4 They concluded that the 'unvented' roof reduced the ventilation by **74%**. This translated into a daily energy consumption saving of **9.5%**[3].

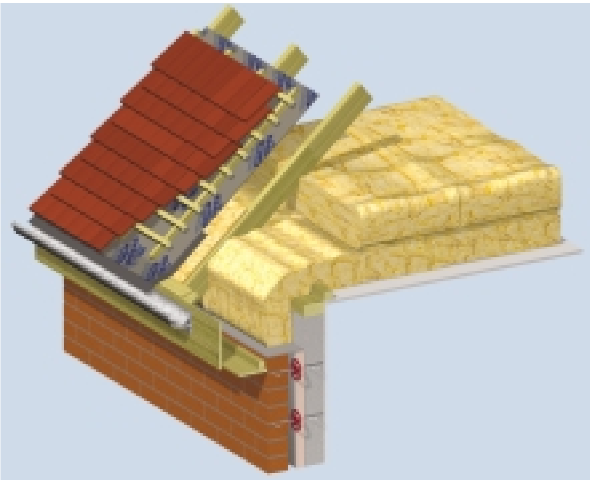


Figure 6 Breathable sarking membrane (e.g. *Kingspan* **nil*vent***®) installed over rafters to create a sealed unventilated loft space.

3 BRE Client report number 204741 – Additional airtightness and vapour pressure of Tyvek roof tile underlay: Prepared for Mr Arturo Horta, DuPont Nonwovens.

5 Unventilated Lofts – The Problems

5.1 Compressed Insulation in the Eaves

5.1.1 When the over-joist layer of insulation is pushed tight up against the roof membrane it will be compressed at the eaves, but only very locally, and a cold bridge can be created. However because of the geometry of the roof, achieving this extent of coverage can be extremely difficult.

5.2 Missing in the Insulation at the Eaves

5.2.1 The majority of new-build lofts are created using a trussed rafter system. A trussed rafter is a triangulated plane roof frame that does not require ridge boards or purlins for structural support.

5.2.2 The combination of the triangular construction of a trussed rafter and the relatively low pitch of the roof (e.g. 30° degrees) can result in significant areas of the loft being difficult, if not impossible, to insulate effectively.

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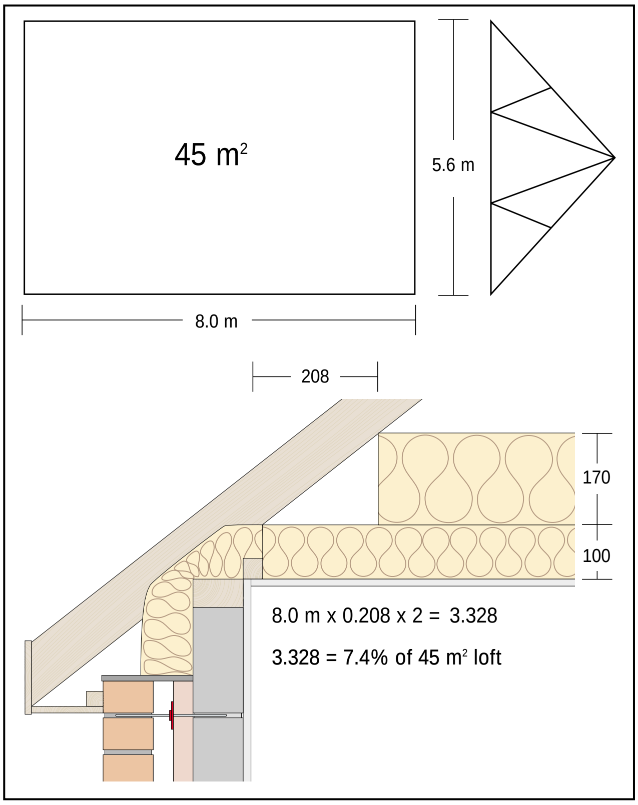

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5.3.4 The reason for the missing insulation is poor workmanship and supervision by the loft installation contractors.

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5.4 Health and Safety

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5.4.2 The 170 mm thick second layer of insulation is used to eliminate heat escaping through the less thermally efficient timber ceiling joists. If the tops of the ceiling joists are covered with insulation, moving around in the loft for maintenance purposes can become hazardous. It may be difficult, if not impossible, to locate the tops of the joists.

6 The Kingspan Insulation Solution

6.1 There is a solution to all the problems detailed in this White Paper. A sealed, unventilated loft using a breathable sarking membrane (e.g. *Kingspan* **nil*vent*®**) and an insulated dry-lining plasterboard (e.g. *Kingspan* **Kool**therm K18 Insulated Dry-lining Board) on the underside of the loft floor joists.

6.2 *Kingspan* **Kool**therm K18 Insulated Dry-lining Board comprises 12.5 mm tapered edged plasterboard bonded to premium performance CFC/HCFC-free rigid phenolic insulation.

6.3 *Kingspan* **nil*vent*®** is the next generation of breathable sarking membranes. It is effectively 100% airtight, completely waterproof and has excellent water vapour permeability.

6.4 The use of *Kingspan* **Kool**therm K18 Insulated Dry-lining Board with integral 50 mm insulation on the underside of the loft floor joists results in the requirement for loft insulation (thermal conductivity 0.040 W/m^2.K) being reduced to just 150 mm between joists.

6.5 No layer of quilt above joist can significantly lower the risk of compressed and missing insulation at the hard to reach eaves area.

6.6 No eaves ventilation tray means the layer of quilt insulation over the wall plate should not suffer from compression.

6.7 Health and safety risks, when carrying out essential maintenance, can be lessened as the tops of the joists can be seen.

6.8 If a loft is to be used for storage the provision of a storage platform is easy. Assuming a 100 mm deep joist, 50 x 50 mm battens can be fitted on top of the joists and a suitable platform fixed on top.

6.9 With less insulation in the loft, it should be easier to inspect the quality of workmanship.

6.10 The use of *Kingspan* **nil*vent*®** to create a sealed unventilated loft means that dust, dirt and insects are restricted from entering the loft space. As there is no ventilation, there is no bulk air movement to reduce the thermal performance of the man made mineral fibre by air infiltration.

6.11 Most importantly, if there are no ventilated eaves, there are no ventilation paths that can become blocked.

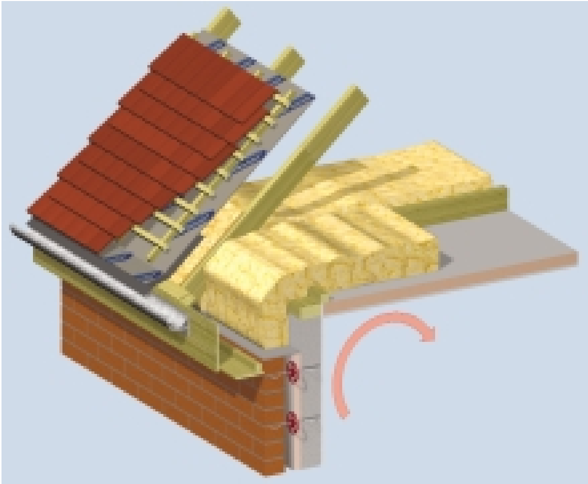

Figure 7 *Kingspan* **nil*vent*®** breathable membrane installed over rafters to create a sealed unventilated loft space. The use of *Kingspan* **Kool**therm K18 Insulated Dry-lining Board below the ceiling floor joists results in the depth of loft insulation being reduced to more manageable levels.

NB: The requirement for under tile/slate ventilation should be assessed to BS5250: 1989 (1995) (code of practice for control of condensation in buildings), as should the requirement for a vapour controlled layer.

Contact Details

Customer Service

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

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General application advice and advice on design detailing and fixing etc... can also be provided. Site surveys are also undertaken as appropriate.

Please contact the Kingspan Insulation Building Fabric Insulation Technical Services Department on the TECHLINE numbers below:

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