Condensation in loft spaces: Myths and realities

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ABSTRACT

Both European and national governments see the insulation of the existing housing stock as an effective method of reducing energy use across the UK and the EU. Although the proportion of insulated 'hard to treat' properties remains low, a variety of government initiatives has resulted in the insulation of a high proportion of accessible lofts and cavity walls. In relation to the insulation of lofts, anecdotal feedback from residential surveyors indicates an increase in condensation problems in loft spaces. Although this problem has been described and solutions proposed in a variety of publications, the defect is still misunderstood by many in the surveying and contracting sectors. In this paper the author draws on a range of published guidance and research and separates the myths from reality. The paper discusses the factors that cause condensation in loft spaces; describes how condensation can be distinguished from other forms of dampness and outlines how loft space condensation can be reduced to manageable levels.

Keywords: loft space condensation; loft insulation; loft ventilation

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INTRODUCTION

Increasing energy costs, concerns about climate change and threats to Europe's energy security are all factors that have pushed energy efficiency towards the top of the nation's agenda. European and national government responses range from energy labelling (energy performance certificates or EPCs) through to more focused initiatives such as the UK's Energy Company Obligation (ECO) and the 'Green deal', a financing scheme designed to encourage homeowners and landlords to improve the efficiency of their own buildings.

Policy-makers and commentators debate the effectiveness of these initiatives but homes in the UK are clearly beginning to change. According to government figures, increasing numbers of dwellings have been insulated in recent years, but many are still below building regulation standards.[1] For example, in 2013 it was estimated that:

- 16.2 million homes have loft insulation of at least 125mm (68 per cent of homes with lofts);
- 7.4 million homes with lofts have less than 125mm of insulation. Of these, around 1 per cent have no loft insulation at all;
- 13.4 million homes have cavity wall insulation (70 per cent of homes with cavity walls);

- 5.3 million homes with cavity walls are not insulated. Most of these are classified as 'hard to treat' and require further building work to make then suitable for insulation;
- there are 0.7 million homes with 'easy to treat' standard cavities that are not insulated;
- only 3 per cent of the 7.9 million homes with solid walls are fitted with solid wall insulation.

Statistics are always open to interpretation but in the author's opinion, the most straightforward insulation work has already been done. Insulating the remaining stock is likely to be technically challenging and costly.

IMPACT ON HOUSING CONDITIONS

Anecdotal feedback from residential surveyors confirms this changing picture. Double-glazing, draught stripping, thick layers of loft insulation and condensing boilers are commonly encountered. Although less numerous, most surveyors have inspected some properties with either external or internal wall insulation.

Where thermal improvements are part of a properly designed scheme, these changes can be beneficial, resulting in lower fuel bills, increased thermal comfort, and positive effects on occupant health. For example, Age UK estimates that 1.7 million older people in the UK cannot afford to heat their homes, and over a third (36 per cent) say they live mainly in one room to save money.[2]

Where insulation is piecemeal or poorly conceived, internal environmental conditions will become unbalanced and result in condensation and mould growth.[3] In the worst cases, it can result in deterioration of the building fabric, affect occupants' health and if the property is rented, expose the landlord to legal challenge.

This paper will focus on just one aspect of this complex and interrelated problem: loft insulation. Over the last year, the author has spoken at over 40 residential conferences, workshops and seminars attended by over 1,800 residential surveyors. The clear, albeit anecdotal, feedback is that condensation problems in roof spaces are on the increase. Water droplets on the underside of roofing felt, damp thermal insulation and, in the worst cases, stained ceiling finishes and wood rot have all been reported.

This paper considers loft spaces above habitable rooms where the ceilings are horizontal and fixed to the ceiling rafters. 'Room in the roof' arrangements are not considered.

CONDENSATION IN ROOF SPACES: MYTHS AND REALITIES

Condensation is a dynamic phenomenon and understanding how it occurs is an important part of the diagnostic process. Despite numerous publications clearly explaining the science behind this process, the causes of condensation are still widely misunderstood.

For example, the increase in condensation in roof spaces has caused a number of organisations to review their practices. The NHBC stated that increases in thermal insulation in roof spaces to modern standards greatly reduces the amount of heat passing through the ceiling and 'this can increase the risk of condensation because the surfaces in the roof remain cold'.[4] This view is partly shared by the Building Research Establishment (BRE) who state 'in a cold pitch roof . . . there is a risk of condensation on the underside of the roof; the thicker the insulation layer, the greater the risk of condensation'.[5] Although these publications set these statements in a broader context, they reinforce a common misconception across the sector — that increased levels of thermal insulation and a drop in loft space temperatures are the sole causes of condensation.

Jeff Howell, the *Sunday Telegraph*'s property advice columnist, further reinforced this misconception. In response to a reader's enquiry, Howell stated that the only solution to a post-insulation condensation problem in a loft was to 'let a bit of heat escape into the roof space, by reducing the thickness of insulation, or leaving the loft hatch ajar'.[6]

It is interesting to note that a year earlier David Snell, another *Telegraph* columnist, advised one of his readers that the best way to solve a roof-space condensation problem is to 'make sure there is no leakage of moist air from the house below'.[7] He went on to say 'Pay particular attention to the loft trap, making sure that the lid sits on a draught excluder or a rubber beading.' With this level of inconsistency, it is no wonder homeowners adopt a number of different solutions.

The reality is somewhat different. According to the BRE, condensation is caused where the amount of water vapour in the air (in the form of an invisible gas) exceeds the amount that air can hold at any given temperature.[3] When this limit is reached, the air is said to be saturated. This saturation point varies with temperature — the higher the temperature, the greater the amount of water vapour it can contain. When saturated, any extra water vapour will be deposited in the form of condensation. Consequently, condensation can be caused by an increase in the moisture content of the air, a fall in the temperature of the air, a fall in the temperature of adjacent surfaces or a combination of all three.

A psychrometric chart from BS 5250 shows the relationship between temperature, relative humidity and vapour pressure (the amount of water vapour in the air) graphically.[8] Using a theoretical case (see Figure 1), assume the temperature of the air in the loft space is 5°C with a relative humidity (RH) of 95 per cent (point one in Figure 1). The left-hand axis shows the vapour pressure to be approximately 0.85 kPa. Many commentators may consider 95 per cent RH in a roof space too high and condensation on colder adjacent surfaces could be expected (for example, on the underside of the roofing felt). Assuming the level of water vapour remains the same (at 0.85 kPa), to get the RH down to a 'safer' level (say 65 per cent RH — point 2 in Figure 1) the air temperature in the loft would have to be raised to around 10.5°C. In an uninsulated roof space, such a temperature rise would require a considerable input of energy — far more than the heat that a 'half-opened' access hatch could provide. A partially open access hatch would not only let heat into the loft but also water vapour. Vapour pressures in occupied habitable spaces can be as high as 1.6–2 kPa at peak times and this will result in a vapour drive from areas of high vapour pressure to low.[3] The amounts of water vapour in the loft would quickly rise unbalancing the conditions and resulting in more condensation not less.

The moisture content of roof timbers in a ventilated roof space was measured in one study.[5] This found during the colder, wetter winter months (September to March) that

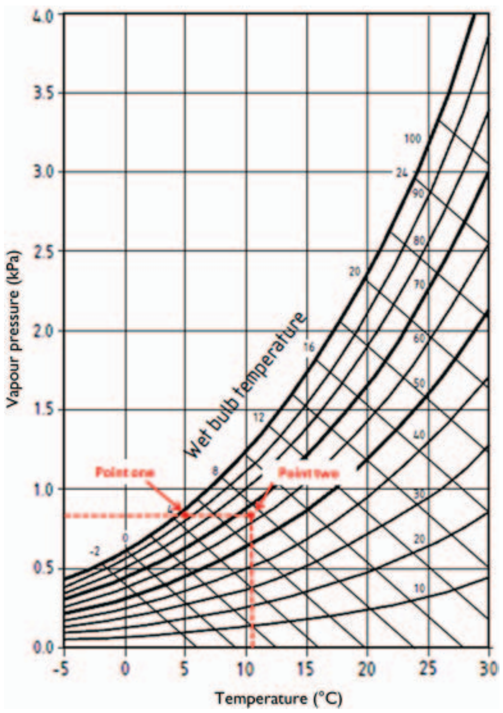

Figure 1: Psychometric chart from BS5250

the moisture content of roof timbers is likely to rise as they absorb moisture from the high humidities from the roof. However, this moisture will quickly re-evaporate 'and safely escape outside during the warmer months'. This same report goes on to say that during winter months, the conditions within a cold pitched roof insulated at ceiling level closely reflect the temperatures, vapour pressures and relative humidities of the external environment, and where the moisture content of roof timbers attains a level of 24 per cent for a period of three months or more, 'the retrofitting of ventilators should be considered'.

In the author's opinion, this highlights the dynamic nature of environmental conditions in roof spaces and for relatively long periods, the moisture levels of roof timbers will be above those considered acceptable in habitable areas. As many residential practitioners use conductivity moisture meters to assess timber components in roof spaces, relatively high moisture meter readings may result in unnecessary recommendations for further investigations.

Another BRE report considered condensation and airflow in pitched roofs and found that moisture produced by the normal activities of a household raises temperatures and water vapour pressures in the habitable parts of the dwelling above those of the outside air.[9] Some of this heat and moisture (20 per cent of the total) leaves the house by way of the loft and passes through the ceiling by a combination of conduction, diffusion and air leakage. These studies further revealed that 80 per cent of the water vapour that does get into lofts gets there by air leakage through gaps around the loft access hatch, light fittings, service pipes and so on.

To summarise this brief review of some of the myths and realities associated with condensation in loft spaces:

- increased levels of thermal insulation in lofts does not by itself cause condensation;
- moisture levels in roof timbers will be higher during the winter months;
- warm and moist air that leaks into the loft will have a much bigger impact on condensation levels than any reduction in roof space temperatures.

REDUCING THE CONDENSATION PROBLEM

Before specific advice is given, a review of some of the broader issues is necessary. The following matters may assist in this understanding.

Well-sealed ceilings

Research into roof space condensation led to an amendment of the British Standard 5250 (2002) 'Control of condensation in buildings'.[8] This document accepted that a completely air and vapour-tight ceiling will be difficult to achieve and introduced the concept of a 'well sealed' ceiling as part of a strategy of reducing condensation problems in lofts.

The Standard describes the function and purpose of vapour control layers (VCL) and identifies three main types used in ceilings:

- a separate membrane within the structure (for example, a plastic sheet between the plasterboard and ceiling joists);
- a lining board with an integral membrane (foil backed plasterboard);
- a suitable coating applied to internal surface of the element (vapour control paint).

Whatever the choice, it is important that the VCL is placed on the warm side of the insulation.

The Standard also reminds the reader that more moisture gets into lofts by air leakage than diffusion through the ceiling and recommends that more attention be paid to reducing air leakage paths. Some of the more important characteristics of a well-sealed ceiling include:

- all gaps and cracks are sealed wherever possible;
- no access hatch or door should be positioned in bathrooms or kitchens because of high water vapour pressures in these spaces;
- a well-sealed, purpose-provided access hatch with third party evidence of low levels of air leakage should be used;
- penetrations for services and other fittings (especially downlighters) are sealed with proprietary products;
- any wall cavities or spaces behind dry linings are sealed to prevent air movement into the loft.

Sealing the ceiling is not the only action required. The British Standard also recommends:

- overall moisture levels in the dwelling should be controlled through appropriate ventilation strategies and techniques;
- the roof space is ventilated to ensure any water vapour that does get through is dispersed.

This advice is not unique and is reflected in current guidance for contractors who insulate cold lofts as part of projects carried out under the various government schemes.[10]

Cold bridging and loft insulation

High levels of water vapour is not the only cause of problems in loft spaces as discontinuities in thermal insulation can also cause localised condensation. Often called 'cold bridging' or 'thermal bridging' it occurs where part of a structure has lower thermal resistance components. This can result in cold surfaces on which condensation, mould growth and/or pattern staining can occur.[8] Figures 2 and 3 show a typical example.

Figure 2: Above this ceiling, the loft insulation has not been pushed up to the back of the wall plate and taken over the head of the wall. Condensation and mould growth has formed on the resulting cold areas. This is still visible despite being cleaned with diluted bleach

Fitting 250–70mm thickness of thermal insulation at the junction of the rafters and ceiling is difficult especially between trussed rafters with a lower pitch. Kingspan Insulation solutions investigated this problem and found that:[11]

- omitting the second layer of insulation from the eaves so that the ventilation is not blocked could double the U value of the ceiling and significantly affect thermal performance;
- butting the insulation up to the underside of the eaves ventilation tray could degrade the U-value by 500 per cent because of compression of the material;
- even at low wind speeds, air movement through ventilated eaves could further reduce the thermal performance of the eaves insulation.

Figure 3: This is the view of the same ceiling shown in Figure 2 but from within the loft space. The insulation is approximately 75mm thick and upgrading this to 250–70mm while maintaining roof space ventilation would be a challenge

Kingspan's solution was to use a sealed, breathable sarking membrane with insulated dry lining plasterboard on the underside of the ceiling joists. Kingspan claims this solution can reduce the need for loft insulation to 150mm between the joists.

A similar issue is highlighted by the Energy Saving Trust.[12] Although cavity wall insulation is the focus of this guide, it identifies a number of cold bridges including at the top of older walls where a course of bricks closes the cavity. The guide points out that getting the loft insulation over the wall head to resolve this problem is likely to be difficult and suggests a deep insulated coving internally.

The BRE also acknowledges this problem and has suggested that in order to provide sufficient ventilation and to accommodate insulation, it may be more appropriate to use a pre-formed, insulated section rather than 'simply relying on placing quilt insulation into this area'.[5]

In the author's opinion, these publications highlight the difficulty of avoiding cold bridging when lofts are insulated to current standards. The more sophisticated solutions outlined above are clearly described in several standard setting publications but, in the author's opinion, it is rare to find this attention to detail in practice

The influence of roof covering underlays

As the thermal regulations have brought in higher standards, manufacturers have responded with a number of innovative products. Microporous or 'breathable' roofing felts have become a common sight in loft spaces to both newly constructed and existing homes. Manufacturers of these products claim up to 25 per cent of the heat lost through a conventional roof system is by air leakage through the ceiling and from the loft space to the outside air. They claim that because these 'breathable' felts allow water vapour to permeate through, purpose provided ventilation to the outside air is not required.

British Standard 5250 provides detailed guidance about the use of different underlays and identifies two types for pitched roofs:[8]

- Those with high water vapour resistance (Type HR). These include traditional bitumen-based sarking felt or the newer meshed reinforced plastic underlays. To reduce the condensation potential with this type of underlay, cross-ventilation is vital.
- Those with low water vapour resistance (Type LR). These include the fleece-type underlays. Where the ceiling is 'well sealed', some Type LR roofs may not require roof space ventilation but this has to be confirmed by third party certification (for example, a BBA certificate).

These breathable roofing felts present a number of advantages especially to designers aiming to create highly insulated and low energy buildings. However, increasing numbers of breathable felts have been affected by condensation and many authorities have reviewed their guidance. For example, a building control department issued new guidance for breathable felts and pointed out that they are not simply a replacement for conventional overlays, they must be considered holistically from ceiling to roof tiles.[13] Following recommendations in BS 5250, many building control departments will now only allow unventilated roof spaces if the following conditions are met:

- all penetrations into the roof space are properly sealed;
- loft hatches must incorporate effective compressible draught seals;
- the rooms below the ceiling must include provision for the dispersal and rapid dilution of water vapour, including extractor fans in kitchen and bathrooms;
- all water tanks must be covered with a tight fitting cover;
- any vent pipes should be arranged so that they do not discharge water vapour into the loft space;
- cavities are closed at plate level to stop vapour transfer to roof space;
- recessed spotlights and down lighters must be sealed in accordance with the appropriate BBA/BRE certificate.

Even where this standard is achieved, some manufacturers still require ventilation at high level so it is important to check the BBA certificate for the particular product.

Building control authorities will often require ventilation with breathable felts in a number of other situations:

- If the roof fitted with the breathable membrane is linked to an existing roof fitted with traditional felt or a roof space that is already vented.
- If the breathable membrane is fitted tight across the rafters with no counter battens. This reduces the ventilation above the underlay and so could affect performance. Normally a ventilated gap of 25–50mm between the surface of the LR underlays and the underside of the roof tiles is required.

It is clear to the author that breathable felts do not provide a 'quick fix' to the condensation problem but have to be part of a moisture management system that encompasses the whole property.

Lofts and storage

Traditionally, ceiling joists are designed to support the weight of the ceiling construction with an allowance for access for essential maintenance. In reality, homeowners often see the loft space as useful storage area. When thermal regulations were less stringent, it was possible to fit boarding over 75–100mm thick insulation without too much compression and loss of thermal value (although overloading of the ceiling often resulted).

Now that the typical thickness of insulation is 250–300mm, using the loft for storage purposes becomes impractical. Where homeowners lay boarding over the top of such deep insulation, the thermal insulation value will be decreased and the additional pressure on the ceiling below could result in damage or even collapse. Under these circumstances, occupiers need to accept that loft spaces are no longer places for informal storage and surveyor's advice should reflect this.

The exception is for access walkways for maintenance purposes. Lofts can contain water tanks, boilers and control gear associated with photovoltaic panels to which operatives will need access. Where these fittings are further than 1m from the hatch, an access walkway will be required. Although specifications for these walkways vary, most standards require a minimum board width of 300mm fixed directly to the joists. The walkway should be fully insulated beneath and the thicker insulation stopped at the edge of the boards.[10]

ASSESSING LOFT SPACES FOR CONDENSATION PROBLEMS

Where loft space condensation is found, it is important for surveyors to identify the problem, highlight the most likely causes, and put forward effective but practical solutions. Care should be taken when interpreting readings from conductivity moisture meters especially during the colder months. Judgments should not be based solely on moisture meter readings but placed in context with the signs listed below. In most cases, condensation problems are straightforward to spot. The main visual characteristics include:

Water droplets on the underside of the roofing felt

This could range from a general misting to heavy water droplet deposits that fall away when touched. These surface deposits will be more common during the late autumn through to early spring. Even within this 'condensation period', the amount of condensate can vary even within a 24-hour period because of changing external and internal conditions. The level of deposit is likely to be highest in the early morning.

Damp or wet insulation and stains to the ceiling finishes

In thickly insulated lofts, the condensate may be held within the insulation without affecting the ceiling below especially if the upper and lower rolls of insulation are laid perpendicular to each other. Where the condensate does affect the ceiling, the stains can be diffuse and spread over a broad area. The staining and damage is usually less intense than that caused by roof or plumbing leaks. Where foil-back plasterboard is used, the staining may follow plasterboard joints.

Wet and/or rotten timbers

Features on the underside of the roof can concentrate the flow of the condensate and a typical example is the underside of valley gutters. The saturation of timber components can cause wood rot.

Mould growth

Mould can grow on the underside of the roofing felt, roof timbers and on stored possessions. Although this will be more obvious during the colder months, the mould growth will still be evident during the summer period allowing a diagnosis outside of the condensation season.

IDENTIFYING THE CAUSE

Although the visual evidence may strongly suggest the cause, it is important to eliminate other possible causes. For example:

Built-in moisture

This is water enclosed within the structure during the building process and is often a problem during the first few months after the construction has finished (both new build and larger refurbishment schemes). This may result in more generalised condensation in the roof space during the first heating season but it should disappear as the building dries out. If the problem returns, look for another cause.

Roof leaks

Faults in the roof covering are usually more localised and related to a physical problem that can be seen from the outside or inside of the roof.

Plumbing leaks

Leaking water and overflow pipework can result in similar signs but like roof leaks, they are usually more concentrated and associated with a particular source of water. The underside of cold water tanks can be affected by condensation causing similar damage to the ceilings below but more restricted in extent.

Specific water vapour sources

Specific faults in and around the roof space can result in high levels of water vapour. Typical examples include:

- Water tanks without lids: Most common with feed and expansion pipes from hot water tanks and/or heating systems. Warm and sometimes steamy water from expansion pipes can produce large amounts of water vapour and be the cause of the problems. This is usually indicative of a fault with the heating system requiring an urgent repair.
- Ducts from extract fans and other ventilation systems: A variety of flexible ducts are becoming a common sight in many lofts. These can be from extract fans to a bathroom or more sophisticated whole house systems. If these are poorly fitted and the flexible ducts fall away from the ventilators, the appliance can deliver large amounts of warm and moist air into the loft (see Figure 4).
- Flues from boilers and other heating appliances: Fanned balanced flues allow boilers to be located centrally within a dwelling with the flue taken up through the loft to terminate above the roof covering. Faults in the flue can result in warm moist combustion gases affecting the loft space and create dangerous conditions.

Blocked ventilation to the roof space

This is particularly common where the property has been recently insulated with the insulation taken over the ventilation route. Replacement PVC fascias and soffits can have a similar effect.

GENERALISED LOFT SPACE CONDENSATION PROBLEMS

Once the other possible causes have been eliminated, condensation caused by a general movement of water vapour from the dwelling below may become the primary suspect. For descriptive purposes, the author refers to this type of deficiency as 'generalised loft space condensation' to distinguish it from the other causes described above.

Dwellings affected by generalised loft space condensation are likely to have the following characteristics:

- HR underlays (bitumen or plastic) beneath the roof covering. Original slate and tiled roofs without the benefit of an underlay are not usually affected by this problem;
- breathable underlays (type LR) that are tautly fixed across the rafters with no space between the underlay and the underside of the roof covering;

Figure 4: This flexible duct should connect the extract fan from the bathroom to the ventilating tile in the eaves of the roof. Because the wrong ducts have been used, it is impossible to join these effectively allowing warm moist air to get into the roof space

- original lath and plaster ceilings — especially those that are cracked and in poor condition;
- plasterboards that are not foil backed;
- a high number of ceiling penetrations for services (especially downlighters) that are not properly sealed;
- the dwelling does not have extract fans in the bathroom and or kitchen and/or a lack of background ventilation to other rooms (for example, trickle vents in the windows or air bricks through the wall);
- poorly sealed loft hatches and/or the loft hatches in the ceilings over bathrooms and kitchens. Larger access hatches with 'pull down' ladders are particularly difficult to seal especially if they are used regularly;
- lack of sufficient loft space ventilation. Although it will be impossible to assess this accurately, a robust rule of thumb can provide a good starting point:
  - the equivalent of a continuous 25mm strip to each 'long' side of the roof to provide cross ventilation;
  - the equivalent of 5mm continuous strip at the ridge to provide high level ventilation especially if the roof pitch is greater than 35°.

The construction of many existing roofs may prevent the installation of a continuous ventilation strip and in these cases individual roof tile ventilators may be used. These should give the same equivalent ventilation area, be equally spaced and located as close to the eaves and ridge as possible.

SOLVING THE PROBLEM

If any single cause has been eliminated and the dwelling presents many of the above characteristics, it is reasonable to assume that the problem is due to 'generalised loft space condensation'. As previously discussed, this type of problem is likely to be caused by a number of interrelated deficiencies and so the solution is likely to be complex requiring a number of actions.[14] These include:

Seal all service penetrations

This typically includes using suitable collars around larger pipes and ducts, purpose made non-combustible hoods or boxes over down-lighters (proprietary hoods are available) and expanding foam around smaller cables and pipes. Please note: the foam should be compatible with the cables.[10]

Seal or replace loft access hatches

Where these are in bathrooms or kitchens, they should be removed and resited. Where the existing hatches are in low humidity areas, they should be sealed by filling gaps around the frame and the ceiling with expanding foams, insulating the back of the hatch lid to the same standard as the rest of the roof space, fitting good quality, compressible draught stripping between the lid and the frame and making sure that the lid is kept in place with an appropriate fastener (lightweight lids can lift during windy weather).

Provide loft space ventilation

Where missing or inadequate, provide loft space ventilation to the outside air.

Install extract and background ventilation to the dwelling

This should meet the requirements of the current building regulations and the occupants advised how to use the system.

Enhance the vapour resistance of the ceiling

Older ceilings are unlikely to have an effective vapour barrier. It is the author's experience that property owners are unwilling to replace the existing ceiling to allow a conventional VCL to be fitted. A reasonable compromise could include the filling of all cracks and holes in the existing ceiling with flexible filler; the ceilings lined with a thick lining paper and painted with a vinyl-based paint suitable for kitchen and bathrooms. Although this will not stop all diffusion through the ceiling construction, it is likely to reduce it to manageable levels.

Insulate cold bridges

Where the loft insulation cannot be laid over the cold bridge, provide alternative solutions. This could typically include deep insulated covings; use of insulation with higher thermal resistivity where conventional loft insulation cannot be accommodated; or the dismantling of the eaves/soffit construction to allow insulation over the wall head.

CONCLUSION

Avoiding dampness in buildings in all its forms is about attention to detail and resolving condensation problems in lofts is no different. Loft insulation is no longer a desirable, unskilled building operation carried out by well meaning DIY enthusiasts. Instead, it is one part of an integrated strategy designed to improve the energy efficiency of a dwelling. This approach should look at the property as a whole so a balance between ventilation, heating and thermal insulation is maintained and condensation problems are avoided. To achieve this balance, the level of design and specification will exceed the conventional expectation of many advisers and owners. It is also likely to result in more extensive and costly building work.

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