Condensation in Pitched Roofs

When you next go up into your loft to collect your Christmas decorations, if you were to find evidence of condensation, your first thought may be "I have a roof leak." The second may be "Is this condensation." The third will be "How do I stop it?"

Under the right conditions condensation will form wherever it is able. Once you understand the conditions under which it will form, you can begin to deal with the problem. This is a set of notes to help you understand why, when, where, and how, to control condensation in pitched roofs. Notice I say control it and not stop it.

First Principles

Warm air can contain a lot more water vapour than cold air. This is why we get frost when the air temperature is close to freezing (0 degrees Centigrade). You will notice that on the first night the frost is thick and stands up like spikes. This is because the air contains a lot of water vapour and the cold air can not hold the excess water vapour. When the water vapour comes into contact with a colder surface it turns from a gas to a liquid, and then to a solid in the form of frost. The second night the frost is less, and after a week of cold nights there is almost no frost. This is because on each occasion the amount of water vapour in the air gets less and less, until the amount of water vapour in the air is in balance with the air temperature. The opposite happens with warm air, it will absorb water vapour from wherever it can. An example of this is clouds that form, especially over the sea, or a lake, where the water is evaporating, or turning from a liquid into water vapour. It can be seen on very cold days when there is a mist over the surface of the lake in the early morning.

Warm air rises and cold air sinks. This is because when air heats up it expands, so it has a greater volume but the same weight. When air gets cold it contracts, this means it has a smaller volume for the same weight, so it will sink below the less dense warm air.

Now I know this all sounds a bit scientific but trust me it is relevant.

Condensation that has formed on the underside of VP underlay and about to drip off.

What happens in my house?

Now in a new house, builders use a lot of water to make concrete, lay bricks, and mix plaster. There is also a lot of water in emulsion paint, tile adhesive, wallpaper paste and other decorative finishes. There is also the rain that soaks the walls and floors before the roof goes on. All of the water that goes into making a building will eventually come to the surface and evaporate into the air. In the summer you can open your windows and allow the water vapour inside the building to mix with the hopefully dryer air outside (unless it is raining or foggy). But in the winter, because our heating fuel is expensive, we shut and seal the windows and doors to keep the heat in, which also prevents the water vapour from escaping into the outside air.

An unheated telephone box running with condensation

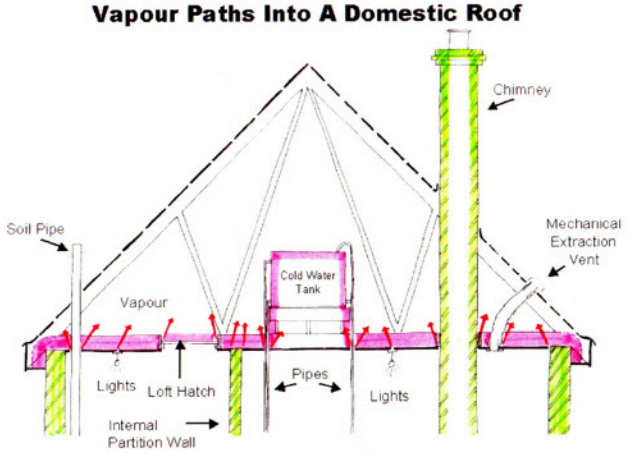
With better insulation our houses are also warmer, so the air inside the building will absorb more water vapour, making the risk of condensation forming ever greater. Whilst taking a hot shower in an unventilated bathroom, you should expect the room to fill with water vapour in the form of steam, and water in the form of condensation to form on the mirrors and walls. This shows that condensation can occur at any air temperature if the air has an excess of water vapour and there is a cooler surface that the water vapour can condense onto.

In older houses that have fully dried out, the problem is not one of drying out but having less insulation and more cracks and gaps through which air can pass; this is normally felt as a draught. Open fires are a big duct that allows cold air in when there is no fire burning in the fire place, air bricks in a larder keep the larder cold, but unless the larder door is well insulated and sealed the cold leaks into the kitchen. Older gas fired appliances require air bricks into the boiler cupboard or room, to provide sufficient oxygen for the gas to burn correctly. Old windows in brick walls can have small gaps around the frame and under the sill, and many opening frames do not fit properly, having been painted time and time again. Un-insulated boarded ground floors, where the timber has shrunk, often have gaps between the boards and between the floor and the skirting boards. All of these gaps allow cold air in and warm air out, helping to regulate the level of water vapour in the air, but can also produce localised cold spots where condensation will start. In very old houses damp wall and floors are also a source of water that vaporise off on the warm side (inside) increasing the amount of water vapour in the air.

Typical moisture generation rates for household activities

Activity	Moisture generation rate
People asleep	40 g/hour /person
People being active	55 g/hour/person
Cooking with electric	2000 g/day
Cooking with gas	3000 g/day
Washing dishes	400 g/day
Washing clothes	500 g/day
Bathing and washing	200 g/person/day
Drying clothes indoors (including using an unvented tumble dryer)	1500 g/person/day

Vapour Paths Into A Domestic Roof



All houses, both new and old, will have occupants who breathe out water vapour. They make hot drinks, cook food using hot water. They wash dishes and clothes in hot water and often wash the floors. A lot of cleaning products in sprays contain some water. We all take showers and baths in hot water and wash our hands and clean our teeth in warm water. House plants and cut flowers are watered with cold water that vapourises. Water is involved with a lot of what we eat , drink and use for cleaning. Water consumption can not be avoided in our daily life, so what can we do? We can be aware of the water vapour in the form of steam and other warm liquids, and give them a path to escape to minimise the amount that is absorbed into the air. Mechanical fan extraction in bathrooms and kitchens are a good example of removing water vapour before it becomes a problem. The problem activities are things like drying damp clothes on radiators, where the water vapourises off into the air, tumble dryers that vent into the room, big tropical fish tanks and decorative water fountains that allow water to vapourise into the warm internal air. Lowering the amount of water vapour in a building can be achieved by full ventilation, such as an air conditioning system, full ventilation using a heat recovery system, or lots of de-humidifiers to remove the water vapour within the heated rooms. The natural solution is to ventilate rooms carefully so that levels of water vapour are kept low, but not compromising the loss of heat out of the building.

Transmission.

Once the water vapour has been absorbed into the warm air that is rising to the top of the building, it will try and keep rising, through any gaps, holes and cracks that are in the structure. Even if there are no holes or gaps, water vapour can pass more slowly through materials like emulsion paint, plasterboard, timber and insulation, into the cold loft space above. Every penetration through the ceiling, be it a cable, pipe, duct, or hatch, all provide

a potential leak path that need to be closed off.

Some modern houses have a vapour check between the plaster board ceiling and the roof insulation, to stop the water vapour passing through the ceiling. This can take the form of a thick polythene sheet, or Aluminium foil. In all cases the joints must be sealed to make a continuous membrane. Holes should be kept to a minimum, or sealed with an appropriate mastic compound. Loft hatches can have a sturdy seal around both the frame and the lid and be well insulated. Flimsy plastic hatches look acceptable on day one, but tend to deform after a few years and allow air to bypass the seals. Every time the loft hatch is opened it allows a rush of warm moist air to rise up into the loft, and cold air to sink into the building, so the fewer times the hatch is opened in cold weather the better. It is also not a good idea to locate the loft hatch in the bathroom or just outside the bathroom door, as this is where the greatest concentration of water vapour is found in most houses. If the warm air can be contained within the warm habitable rooms of the house, the less that can get into the loft and set off the condensing cycle during cold spells of weather.

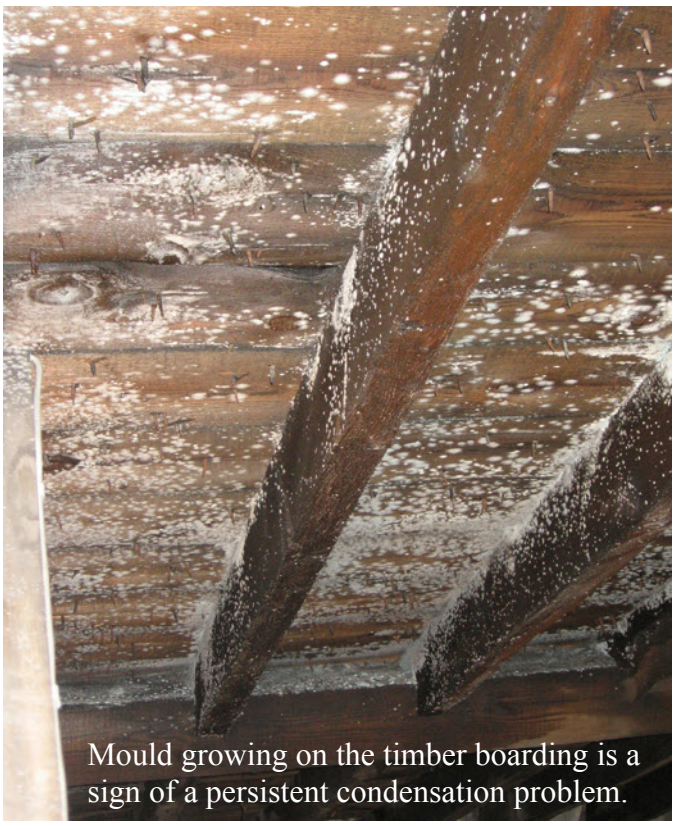
In the Loft

Once air from inside the building gets into the loft it may immediately meet the colder air and warm it up, and at the same time cool it self down. Being colder the new rising air will not be able to hold as much water vapour and will need to deposit it as soon as possible, normally onto the coldest surface in the loft. Where the air passes up through the insulation material the air will loose its heat but keep the quantity of water vapour. The more insulation the less heat will get into the loft. The colder the air on the cold side of the insulation and the more water vapour in the rising air, the greater the risk of condensation forming.

The excess water vapour in the air will turn to water on the coldest surface and may freeze if it is below freezing point. The vulnerable surfaces are metal components, or the underside of the underlay between the loft and the roof tiles; this will gradually build up until water droplets form. It will then either drip off, or run down the surface. Quite often a small amount of vibration can cause the water droplets to shake loose forming rain inside the roof. In very big cold roof spaces, like aircraft hangers, it is possible for a cloud of excess water vapour to form, and then rain inside the roof when enough water vapour has built up, or the temperature drops. If there is a Vapour Permeable underlay and it is very very cold, as the excess water vapour passes through the underlay it can freeze and form an ice sheet within the material, which when it melts can fall as rain inside the loft.

Another cause of condensation in a loft can be water storage tanks with no lids, especially feed and expansion tanks where the water coming into the tank can be very hot. Filling a tank with hot water will generate a lot of steam in a cold roof and add to your fuel bills. Setting up the heating system correctly and covering and insulating the tanks in a roof properly, are good practices.

Ducts that pass through a loft space can develop splits, or joints can come apart over the years, resulting in steamy air being blown into the loft from a bathroom. In some instances the duct work may not have been installed at all Having been missed by the builder, the electricians, and the roofer. Remember, to allow air to be taken out, fresh air needs to be let in to replace it. Without a flow of air the ventilation system may not be doing anything.



Mould growing on the timber boarding is a sign of a persistent condensation problem.

The most common place that condensation is found in roofs is on the underside of the underlay both close to the eaves and the ridge, but mostly evenly over the total surface. There are several types of underlay; some are more prone to condensation forming on them than others. The type of underlay that is a reinforced sheet of plastic is the first that will show condensation on the surface, as it has no absorbency and no ability for the water vapour to pass through it. Bitumen reinforced underlay has a small amount of absorbency before it will show condensation on the surface and little ability of allowing water vapour to pass through it. Finally there is Vapour Permeable membrane underlay that will allow a large amount of water vapour to pass through the material so will be the last to show condensation on the surface. Once it reaches its water vapour transmission limit, or the water vapour freezes as it passes through the membrane, then the performance of this type of underlay is drastically affected. VP underlay works well under normal ambient temperatures, but appears to be little better than other underlay at the extremes of our climate.

The practice of ventilating the roof space above the insulation and below the underlay is not a means of preventing condensation forming, but one of controlling the condensation once it has formed. Provided there is a flow of outside air able to flow into the loft at low level on the windward side of the building, and out of either the leeward side of the building, or at the ridge, then as the moisture laden air that rises into the loft is quickly diluted with fresh air, with a lower water vapour content, and allowed to escape outside of the roof. Also if the condensation does form in the loft, the ventilation will slowly absorb the water as it re-evaporates, as the air temperature rises by day, and once the cold spell passes.

The best option is to undertake all of the options, but in many properties this may not be possible, so undertake what you can.

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Summary

1 Reduce the amount of water vapour that can be absorbed into the air.

2 Extract excess water vapour at source, such as bathrooms, utility rooms, kitchens gymnasiums and indoor swimming pools.

3 The ceilings between the warm habitable rooms and the cold loft space should contain a vapour check layer, and as few penetrations as possible, and all cracks and penetrations should be sealed to stop air rising through the gaps.

4 The colder the roof, and the warmer the habitable rooms, the greater the risk of condensation forming. This means the more roof insulation used, the greater the need to stop air and water vapour leaking from the habitable rooms into the loft.

5 If there is an outbreak of condensation in the roof, do not keep going and looking to monitor the problem, every time the loft hatch is opened it will make the problem worse.

6 If your roof does not have any ventilation passing through it from one side to the other, and all of the other measures have been tried to reduce the problem, then install ventilation to take the water vapour in the air away as quickly as possible.

7 Under the right conditions condensation will form, and can do so at any air temperature, if the amount of water vapour in the air is high enough. Condensation is more likely to occur during cold weather than during warm conditions.

8 Vapour Permeable underlay, or roof space ventilation, will not stop condensation forming, but will help, along with other measures, to control the condensation once it has formed.

9 For further advice regarding room extract fans, vapour check layers, insulation, roof underlay and roof space ventilation, go to the web site of one of the product manufacturers or speak to their technical or sales departments for more specific advice on the installation of their products, or obtain a copy of British Standard 5250: The code of practice for the control of condensation in buildings.