Dealing With Condensation, Dampness and Mould

1. Introduction

Condensation, dampness and mould growth are a major source of problems for housing management organisations, leading to complaints from tenants and absorbing a significant proportion of repair and maintenance resources.

This document will help you to identify different condensation and dampness problems and to develop and implement appropriate technical solutions.

The document deals with the two main types of dampness found in buildings: rising damp and penetrating damp. It also covers the two main types of condensation: interstitial (ie within the construction) and surface.

This document also deals with on surface condensation on walls and ceilings as this presents the most complex problems for housing managers.

Surface condensation in housing leads to:

- Mould growth.
- The deterioration of building finishes and fabric.
- Health problems for occupants.
- Increased complaints from tenants.
- Increased maintenance and management costs.
- An increased number of unfit and void properties.

Surface condensation can arise from thermal bridging of insulation or from the under-heating of poorly insulated and/or poorly ventilated properties. The under-heating of properties is closely linked with fuel poverty, and this document should be read in conjunction with the chapter of *Energy efficiency the guide*[1] on Delivering affordable warmth[2].

2. Rising damp

2.1 Occurrence

Rising damp is relatively rare in modern homes, but more common in older properties.

Moisture from the ground under and around a building rises up within external or internal walls made of permeable or absorbent building materials (eg brickwork, stone or plaster). Internal plaster finishes become saturated with moisture, leading to mould growth, the deterioration of the finish and eventually deterioration of the fabric of the wall itself.

The construction of most modern buildings includes a damp proof course– a layer of impermeable material (eg plastic) built into the external walls just above ground level. The damp proof course prevents moisture rising within the wall construction. It should be continuous and run beneath the cills of external doors.

There is also usually a damp proof membrane – a polythene sheet laid beneath ground-bearing floor slabs.

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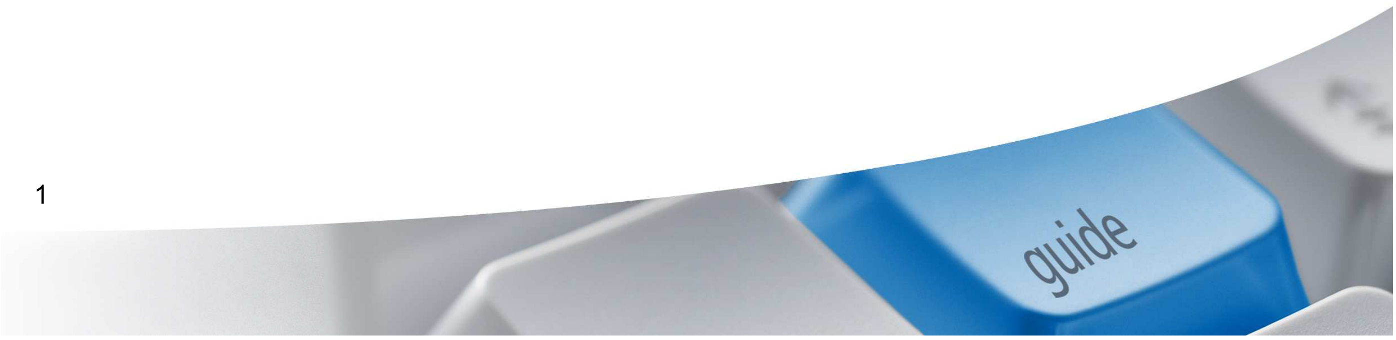
[1] All references to 'Energy efficiency the guide' refer to the Scotland version.
[2] www.est.org.uk/housingbuildings/localauthorities/theguide/



Older buildings, particularly those with solid stone or brick external walls, do not always have a damp proof course. Ground flows may be laid directly on to earth, meaning that there is no damp proof membrane. It is in these older buildings, usually those built before the 1930s, that rising damp is likely to be a problem. Rising damp may also be a problem in newer buildings where the damp proof course or damp proof membrane is defective in some way.

2.2 Identification

Rising damp is identified by the pattern of dampness, staining and mould growth along the lower areas of external masonry or internal walls. Typically, damp will be seen in the plaster finishes up to a metre above ground floor level. A moisture meter applied to internal wall finishes just above ground level will help you to identify rising damp in its early stages.

If the building already has a damp proof course, it should be visible in one of the horizontal mortar joints just above the external ground level. Rising damp all around the external perimeter of the building is evidence of a missing damp proof course.

Rising damp in isolated places is usually evidence of a defective or bridged damp proof course. Bridging of the damp proof course occurs where abutting features (steps, ramps, walls) or simply high external ground levels allow moisture to pass into the external wall of the building above the damp proof course.

2.3 Rectification

If the damp proof course is defective, it is usually necessary to cut out and replace the defective portion.

Where a damp proof course is absent, the usual solution is to inject a new damp proof course into the existing wall. Holes are drilled at regular intervals around the perimeter of the building, just above external ground level, and a chemical is injected under pressure. The chemical is absorbed into the masonry and forms an effective barrier to the passage of moisture.

Injected damp proof courses must be installed by specialist contractors, who usually supply a guarantee. Prior to installation, it is necessary to remove any internal plaster finishes from all affected walls up to one metre above the internal ground floor level. Once the damp proof course has been injected, you can replace the plaster with new, waterproof plaster and replace or make good any skirtings, etc.

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A brick wall that has had an injected damp proof course installed

Where a damp proof membrane is missing, it is sometimes possible to apply a sealing compound or fix a polythene damp proof membrane on top of a concrete ground floor slab. However, it is usually necessary to replace the entire floor construction, taking the opportunity to install insulation as well as the new damp proof membrane.

If the property is a listed building, it may not be possible to inject a damp proof course or replace a floor. Instead, it may be necessary to manage and live with the problem. One approach is to paint the walls externally with lime wash (which 'breathes' but has to be replaced every couple of years) and to keep the rooms warm and well ventilated. Guidance on the control of damp in old buildings is available from the Society for the Protection of Ancient Buildings (SPAB)[1].

3. Penetrating Damp

3.1 Occurrence

Penetrating damp is the term applied to the penetration of moisture through the fabric of a building, from the outside to the inside, over a period of time. It usually occurs at a relatively high level through external walls or roofs and is almost always the result of defective construction.

The most common defects that will lead to penetrating damp are:

- Blocked rainwater gutters, hoppers or down-pipes. These overflow causing the adjacent wall to become saturated.
- Defective concrete 'haunching' around disused chimney pots that have been capped or sealed. This allows water to enter the unused chimney and then penetrate into the building.
- Defective flashings around chimneys, flues, soil-and-vent pipes and ventilation terminals, and at abutments of roofs to vertical walls. These defects usually cause leaks rather than damp, but sometimes water finds its way into the roof construction and emerges elsewhere as penetrating damp.

[1] www.spab.org.uk/html/publications/the-bookshop/.

- Defective or inadequate valley gutter linings. Valley gutters should be lined with lead or with proprietary liners that are carried 200 millimetres up the roof pitch on either side of the valley, under the slates or tiles. If this is not done, snow or ice that accumulates in the valley can get under the roof finish and penetrate into the building.
- External wall cavities that have been bridged by rubbish left in the cavity or by mortar droppings left on wall ties or insulation batts during construction. If the wall is subsequently exposed to driving rain, water penetrating the brick outer leaf may be led across the cavity, locally saturating the inner masonry leaf and subsequently internal plaster or plasterboard finishes.

3.2 Identification and rectification

Penetrating damp is readily identified by a localised area of damp or saturated wall/ceiling finishes. The same symptoms can, however, be caused by leaks in plumbing or drainage pipes. You should therefore employ a surveyor or skilled builder to determine the cause of the problem and prescribe an appropriate solution.

Rectification usually involves repairs carried out by a builder or roofing contractor.

4. Interstitial condensation

4.1 Occurrence

Interstitial condensation occurs when warm, moist air from inside a building penetrates into a wall, roof or floor construction and meets a cold surface. This causes the air to cool, lowering its capacity to carry moisture, and resulting in condensation on the cold surface.

In time, the condensation can cause rotting of timber or corrosion of metal components. Structural damage may occur and it is likely to be invisible to the occupants of the building.

There is an increased risk of interstitial condensation occurring in certain types of construction, including:

- 'Cold roof' construction, that is, flat or pitched roofs constructed with insulation placed in the voids between timber joists or rafters, above a plasterboard ceiling and beneath a plywood roof deck or sarking felt and external finish. Warm moist air that penetrates between the insulation and the joints/rafters will meet the cold underside of the roof deck/sarking. This causes condensation and could lead to the rotting of the deck and the tops of the joints/rafters.
- Timber-or steel-framed walls with insulation between the framing members and sandwiched between plasterboard internal linings and external sheathing board. Warm moist air that penetrates between the framing members and the insulation will meet the cold inner surface of the sheathing. This again causes condensation and can lead to rotting or corrosion of the framing.
- Insulated internal 'dry-lining' of solid walls. This consists of insulation between battens fixed to the walls and lined internally with plasterboard, or thermal board fixed directly to the walls on battens or plaster 'dabs'. Warm moist air that penetrates behind the lining board will meet the cold inner surface of the external wall, resulting in condensation and potentially rotting or corroding the battens.

In all of these cases, the insulation could become saturated and therefore ineffective.

4.2 Identification and Rectification

Interstitial condensation is difficult to identify. It is often only discovered when some other problem becomes apparent (eg failure of timber of metal framing).

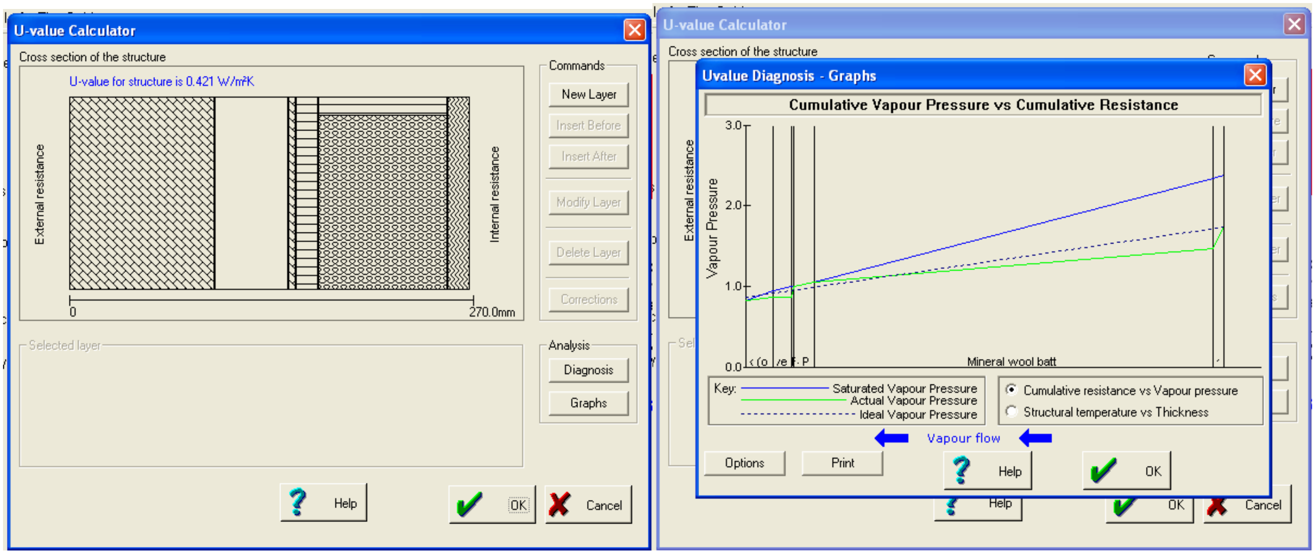
You should employ a surveyor or skilled builder to determine the cause of the problem and prescribe an appropriate solution. In many cases, extensive building work will be required to correct the defect and repair the damage.

There are several ways of avoiding interstitial condensation:

- ‘Warm roof’ construction, that is, placing the insulation on top of the roof deck but beneath the waterproof finish. This ensures that the underside of the roof deck is around the same temperature as the heated space underneath.
- Incorporate polythene vapour barriers or damp proof membranes into framed wall and roof constructions, on the inside of the insulating layer and framing, before the wall or ceiling linings are fixed. Alternatively, proprietary lining board (plasterboard backed with aluminium foil or impermeable paper) may be used.
- Use a vapour-based ‘breathing’ construction that is airtight but vapour permeable. In this type of construction, the vapour resistance of the inner layer must be at least five times the vapour resistance of the outer layer, so that any water vapour that condenses within the construction will find its way to the outside. Vapour balanced construction is becoming more common, especially for insulated roofs and framed walls.

The risk of interstitial condensation should be checked when new build or refurbishment projects are specified. Many software products for calculating the U-values of buildings can also check the risk of interstitial condensation.

The illustrations below, from the NHER evaluator programme, show analysis of a poorly insulated, brick-clad, timber framed wall construction in which there is a risk of interstitial condensation on the inner surface of the plywood sheathing.



Cross-sectional graph through a timber-framed wall construction showing actual and saturated vapour pressures within the wall, in order to indicate the risk of interstitial condensation (condensation is likely where Saturated Vapour Pressure $\geq$ Actual Vapour Pressure, ie where the green line meets the blue line).[1]

[1] Taken from the *NHER Evaluator* software, courtesy of National Energy Services Ltd.

5. Surface Condensation

There are two main causes of surface condensation:

- ‘Thermal bridging’ of insulation with a wall or roof construction.
- Under-heating of poorly insulated and/or poorly ventilated homes.

5.1 Thermal Bridging

Thermal bridging is sometimes known as “cold bridging”. It occurs when the insulation layer within a wall or roof is interrupted by another material or is reduced in thickness (usually at corners or junctions).

The thinner area of insulation leads to greater heat loss through that part of the wall or roof and thus a locally reduced internal surface temperature. When the warm, moist air inside the property comes into contact with the cooler surface, it is chilled and less able to carry moisture. This results in surface condensation.

Surface condensation leads to the saturation of wall finishes, which provides an ideal environment for mould growth. Mould is unsightly and can cause health problems for occupants. If the problem is not dealt with, the finishes and even the fabric of the building will deteriorate.

5.2 Identification

You will recognise surface condensation due to thermal bridging because the pattern of staining or mould growth reveals the underlying thermal bridge. Typically, the condensation and mould growth are confined to corners. However, if the staining and mould growth are not dealt with, they will spread, making the thermal bridge more difficult to locate.

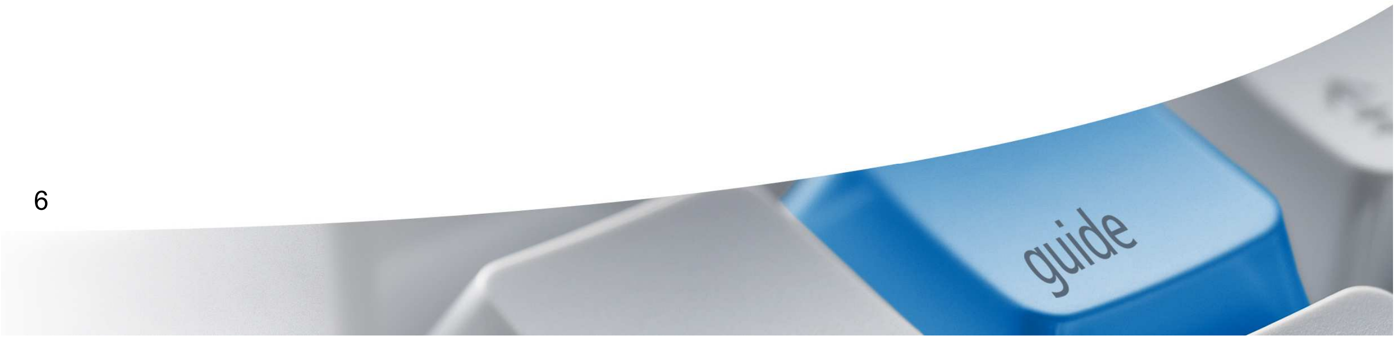
5.3 Rectification

Eliminating this type of surface condensation involves eliminating the thermal bridge. You can achieve this most easily be installing insulated dry-lining within the home. This raises the internal surface temperature adjacent to the thermal bridge and prevents condensation occurring.

For walls, insulated dry-lining may consist of insulation between battens fixed to the wall and lined internally with plasterboard. Alternatively, you can use thermal board fixed directly to a wall on battens or plaster ‘dabs’.

For ceilings, you would normally use thermal board nailed to the joists or rafters, replacing the original lining.

In either case, care must be taken to reduce the risk of interstitial condensation occurring behind the lining (see section four).

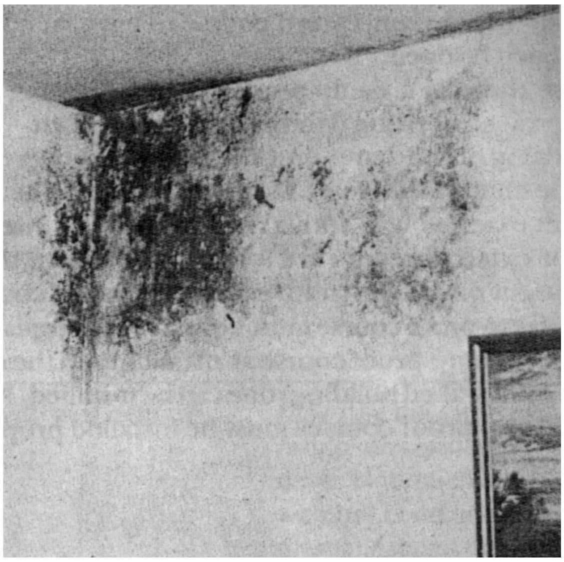


Dampness and mould staining due to condensation arising from thermal bridging in a building where the structural concrete frame bridges the wall insulation

5.4 Under-heating

When a home is not properly heated, the internal surface temperatures of the external walls and roof can be very low, particularly if the building is not adequately insulated. When the warm moist air circulating within the property comes into contacts with the cold surfaces, it is chilled and less able to carry moisture. This results in surface condensation.

The problem of under-heating is often exacerbated by poor ventilation. Moisture is put into the air inside the home by the residents' cooking and bathing, drying clothes and simply just breathing. This moisture can be readily removed from the air (ie by extractor fans in kitchens and bathrooms or flues on heating appliances); if it is not, then the risk of surface condensation is increased.



Dampness and mould staining due to surface condensation in an under-heated dwelling.
(Picture courtesy of Energy Inform)

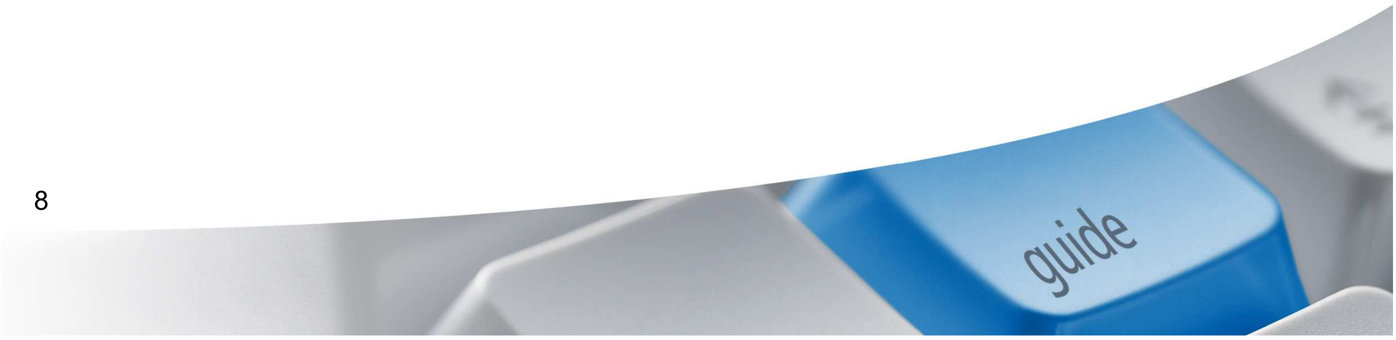
Tenants on low incomes often cannot afford to heat their homes properly. This often arises when a home has inadequate insulation or an inefficient heating system or uses an expensive fuel for heating. Where a tenant spends more than 10 per cent of their income on energy costs, they are described as being in fuel poverty. Householders in fuel poverty are likely to:

- Heat less of their home (ie fewer rooms).
- Heat their home for less time (even when it is occupied).
- Heat their home to a lower temperature.

In addition, householders sometimes believe that trickle ventilators and extractor ventilation fans are allowing expensive warmth to escape from their homes, so they close the ventilators and switch off or disable the fans. All of these circumstances result in a cold dwelling with a high moisture content – a guaranteed recipe for surface condensation.

5.5 Identification

Condensation from under-heating will always occur first on the coldest surfaces (such as single glazed windows) and in poorly ventilated places (eg behind wardrobes). In severe cases, whole walls and ceilings can be affected. This condensation leads to the saturation of wall and ceiling finishes, which can in turn lead to mould growth.



Dampness and mould staining due to a combination of surface condensation and thermal bridging in an under-heated dwelling. (Picture courtesy of Energy Inform)

5.6 Rectification

Eliminating surface condensation due to under-heating is a complex process. The problem often arises from a combination of the income and actions of the household and the technical characteristics of the home itself.

You can find out more about assessing and increasing householder incomes from the chapter of *Energy efficiency the guide* on Delivering affordable warmth[1]. You may wish to combine measures to increase householder incomes with the delivery of advice about reducing fuel costs, keeping warm at lower cost and the importance of adequate ventilation. The delivery of advice is described in more detail in the chapter on Energy advice for tenants[2].

This document considers ways of eliminating surface condensation by measures applied to the property itself.

The usual first response to surface condensation caused by under-heating is to improve the ventilation of the home. Typically, extractor ventilation fans are installed in kitchens and bathrooms and trickle ventilators are installed in window heads to provide a balancing supply of fresh air. However, there are two disadvantages to this approach:

- If your tenants still cannot afford to heat their home adequately, they may see the ventilation measures as an additional expense and circumvent them. They may close trickle ventilators, switch off or remove the fuses from extract ventilation fans or disable humidistat controls.
- The ventilation measures will remove some of the moisture from the air. However, if the property is inadequately insulated and remains under-heated, surfaces may still remain cold enough for condensation to form.

[1] www.est.org.uk/housingbuildings/localauthorities/theguide/.
[2] www.est.org.uk/housingbuildings/localauthorities/theguide/.

Another approach is to install a new efficient and controllable central heating system, usually with the aim of providing whole-house heating at a lower cost to the tenant. Again, this measure in isolation may fail because inadequate insulation could prevent the tenant from being able to afford to heat their home properly.

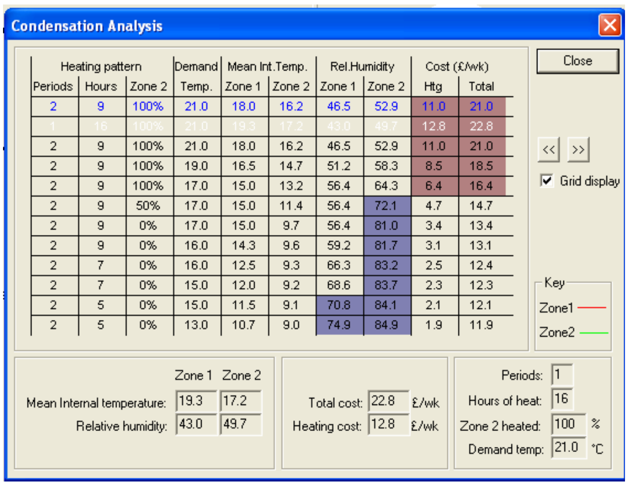
An effective response to surface condensation should involve a combination of four measures:

- Insulation to raise the temperature of the internal air and internal surface temperatures of walls and ceilings.
- Improved heating efficiency to enable tenants to heat their homes properly at a lower cost.
- Controlled ventilation to remove moisture from the internal air.
- Advice to help the occupants understand how to use their heating and ventilation systems.

It can be difficult to establish the most appropriate combination of these measures. You should find the package that delivers affordable warmth, reduces the risk of surface condensation and is at minimum cost.

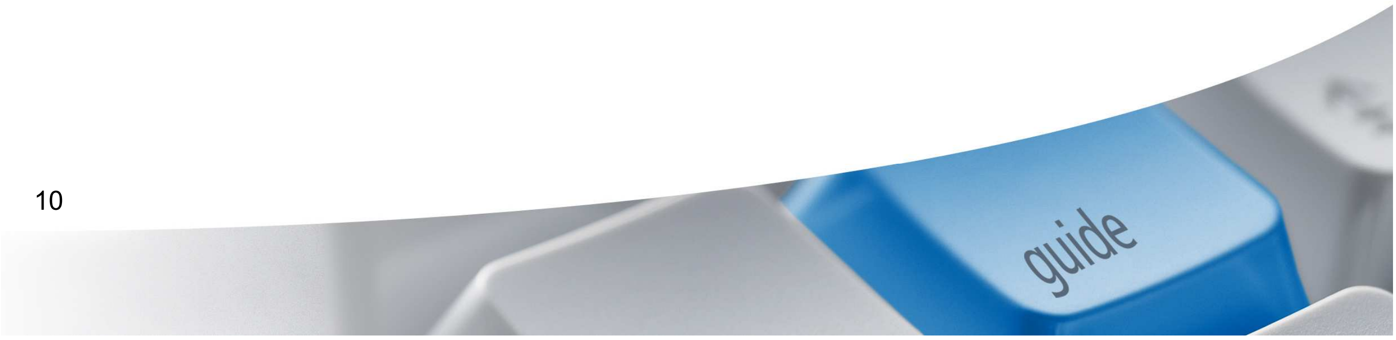
You can use BREDEM-based software (eg NHER evaluator) to identify appropriate measures. The software produces an analysis of the risk of surface condensation forming. The software simulates the performance of the home using data on its current insulation, ventilation and heating patterns and can then confirm the cause of a problem.

The chart below shows an initial surface condensation risk analysis for a poorly insulated, inadequately ventilated property with inefficient heating. Each row represents a different heating pattern, with poorer heating at the bottom of the table. The darker blue highlights identify a risk of condensation, mostly in zone two (ie all of the dwelling except the living room). The lighter red highlights show heating patterns which are unaffordable (ie they are not appropriately energy efficient or are too expensive for the tenant). The near overlap of the red and blue highlights indicates that there is no affordable heating pattern that does not carry a risk of surface condensation.



Condensation Analysis

Heating pattern			Demand	Mean Int.Temp.		Rel.Humidity		Cost (£/wk)	
Periods	Hours	Zone 2	Temp.	Zone 1	Zone 2	Zone 1	Zone 2	Htg	Total
2	9	100%	21.0	18.0	16.2	46.5	52.9	11.0	21.0
1	16	100%	21.0	19.3	17.2	43.0	49.7	12.8	22.8
2	9	100%	21.0	18.0	16.2	46.5	52.9	11.0	21.0
2	9	100%	19.0	16.5	14.7	51.2	58.3	8.5	18.5
2	9	100%	17.0	15.0	13.2	56.4	64.3	6.4	16.4
2	9	50%	17.0	15.0	11.4	56.4	72.1	4.7	14.7
2	9	0%	17.0	15.0	9.7	56.4	81.0	3.4	13.4
2	9	0%	16.0	14.3	9.6	59.2	81.7	3.1	13.1
2	7	0%	16.0	12.5	9.3	66.3	83.2	2.5	12.4
2	7	0%	15.0	12.0	9.2	68.6	83.7	2.3	12.3
2	5	0%	15.0	11.5	9.1	70.8	84.1	2.1	12.1
2	5	0%	13.0	10.7	9.0	74.9	84.9	1.9	11.9



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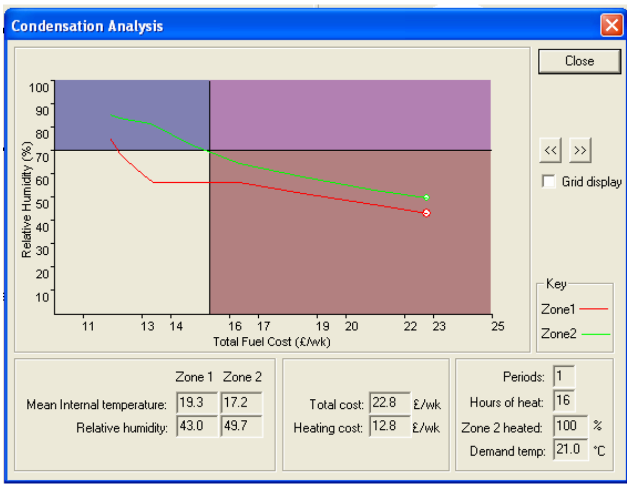
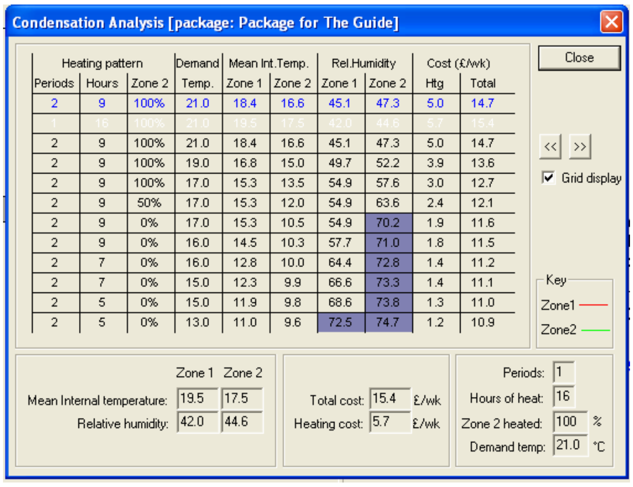


Surface condensation risk analysis for a poorly insulated dwelling with inefficient heating and no ventilation.[1]

The software can then be used to investigate the effects of improvements. Each measure or package of measures can be evaluated in terms of its capital cost, savings in fuel bills and the effect on the risk of condensation.

The following chart shows another analysis for the same property after a package of improvements (wall insulation, a more efficient heating boiler and controlled ventilation) has been installed. There are now several affordable heating patterns, which do not carry a risk of surface condensation.



Heating pattern			Demand	Mean Int.Temp.		Rel.Humidity		Cost (£/wk)	
Periods	Hours	Zone 2	Temp.	Zone 1	Zone 2	Zone 1	Zone 2	Htg	Total
2	9	100%	21.0	18.4	16.6	45.1	47.3	5.0	14.7
1	16	100%	21.0	19.5	17.5	42.0	44.6	5.7	15.4
2	9	100%	21.0	18.4	16.6	45.1	47.3	5.0	14.7
2	9	100%	19.0	16.8	15.0	49.7	52.2	3.9	13.6
2	9	100%	17.0	15.3	13.5	54.9	57.6	3.0	12.7
2	9	50%	17.0	15.3	12.0	54.9	63.6	2.4	12.1
2	9	0%	17.0	15.3	10.5	54.9	70.2	1.9	11.6
2	9	0%	16.0	14.5	10.3	57.7	71.0	1.8	11.5
2	7	0%	16.0	12.8	10.0	64.4	72.8	1.4	11.2
2	7	0%	15.0	12.3	9.9	66.6	73.3	1.4	11.1
2	5	0%	15.0	11.9	9.8	68.6	73.8	1.3	11.0
2	5	0%	13.0	11.0	9.6	72.5	74.7	1.2	10.9

[1] Charts taken from the NHER Evaluator software, courtesy of National Energy Services Ltd.

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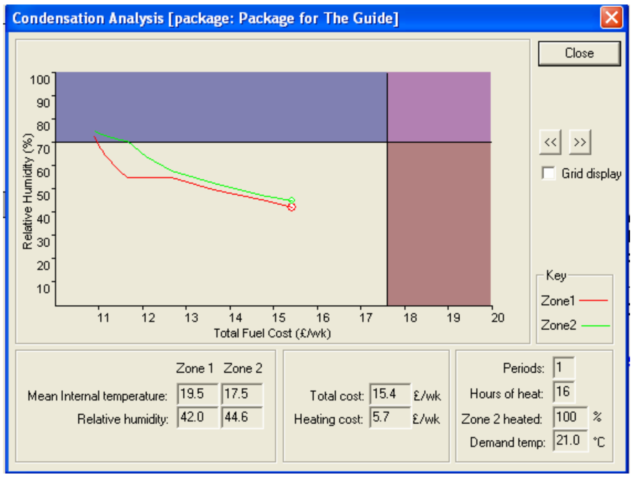

Surface condensation risk analysis for the same dwelling, after a package of improvements has been implemented

Software can help you identify the most cost-effective package of improvements to address a surface condensation problem. In many cases, technical measures alone are not enough – energy advice is an essential component of the package.

6. Further Information

BS 5250:2002 'Code of Practice for the Control of Condensation in Dwellings' – available from British Standards Online[1].

Energy Advice Handbook, available from Energy Inform[2]

The following publications are available from Energy efficiency best practice in housing[3]

- 'Energy efficient ventilation in housing: a guide for specifiers on the requirements and options for ventilation'.
- 'Minimising thermal bridging when upgrading existing housing: a detailed guide for architects and building designers'.
- 'Energy efficient refurbishment of existing housing'.

[1] www.bsonline.bsi-global.com/server/index.jsp.
[2] www.energyinform.co.uk.
[3] www.est.org.uk/housingbuildings/publications/.