

# Surecon Building Practice

## A guide for residential occupiers

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**SLIDE 1**

(Header) SURECON Sustainable Renovation and Construction - Compact Knowledge for the Construction Industry

In-Service SURECON Training - Building Counselling in the Field of Sustainable Construction and Renovation

SURECON Building Practice

Residents Guide

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(Footnote) Continuing education program of Dr. Ingo Dammer, Axel Leroy, Reimund Stewen  
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[www.surecon.eu](http://www.surecon.eu)

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**SLIDE 2**

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**SLIDE 3****1. Introduction**

“Learning correct living”: In earlier times it was fairly easy to live. There was no need for special attention to the humidity of rooms, as this at the time was not a problem. Windows, doors and fireplaces were quite leaky so that the moisture could easily escape from the house. However, heat was also lost.

Today, however, in times of steady increases in energy prices, structures must be planned and built quite differently. Moisture can escape less easily from the house of today, because it is much more insulated and sealed to prevent heat loss. This now leads to the fact that we need to change our behavior. We must learn to live properly. The planners and building contractors, of course, have to learn to plan and build with the current requirements of the Energy Saving Ordinance, which will be described only in passing. The construction physics may be mathematically “beautiful”, but in reality the small and smallest of errors can lead to large consequences for the house and the health of the residents.

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First, it is explained what water and water vapour are, and how much water vapour fits into a room. The differences between relative and absolute humidity are explained and also how water vapour is transported and distributed in the house.

The chapter on “correct living” gives important behavioral rules for daily living and the related management of water and water vapour.

The errors and their consequences are briefly explained with pictures, so that a visual impression of the consequences can be created and can be recognised quickly.

Finally, the effects of condensation are discussed, and information is given about mould (which should be considered as emergency measures by the residents). Measures regarding mould infestation are explained and instructions for proper renovation are given. Protection measures and risk assessment are also discussed.

The conclusion then constitutes of some tips and checklists.

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**SLIDE 4****2. Water Vapour**

Water suddenly “arises” in the house - to high humidity which condenses on cold spots.

Important terms are:

- Relative Humidity
- Vapour Diffusion
- Convection

**2.1 “Vapour Diffusion” - What is Water - What is Water Vapour?**

Water vapour is water in gaseous form: single H<sub>2</sub>O molecules. Each individual is a dipole = electrically charged. Should a second molecule arrive, they attract each other (like magnets) and stay together. Since they are very small, we cannot see them. Many H<sub>2</sub>O molecules unite to form water droplets. As soon as we can see them, we are talking about water or steam. Even in the ocean H<sub>2</sub>O molecules are only electrically interconnected.

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[DIAGRAM]

1. Water Vapour:

Water vapour consists of individual water molecules:  $2 \times H + 1 \times O = H_2O$

2. Water Droplets:

- Hydrogen bonding

- Water droplets are many water molecules that are electrically attracted to one another.

If much water vapour is there, then we can hardly see through:

- Clouds of steam while cooking
  - In the sauna after an infusion
  - In nature we speak of fog.
- The air is able to absorb water in gaseous form.
  - The warmer it is, the more water in gaseous form it can store.
  - Hence the term: relative humidity:
  - The higher the temperature, the more it can absorb.
  - The water vapour content of the air ( $g/m^3$ ) remains constant; if the air is warm, then it is relatively less than when the air is cold.
  - See the table below.
- 

#### **SLIDE 5**

[TABLE 1]

Air temperature - Water content of the air in  $g/m^3$

[TABLE 2]

Dew Point Curve

Liquid water

Water vapour content

Water vapour

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#### **SLIDE 6**

Source: J. Brandhorst

A few illustrative examples:

[TABLE 1]

Relative/absolute humidity

Air temperature in °C

50% relative humidity

100% relative humidity = water vapour saturation

Moisture content in grams per cubic meters of air

The thermometer is used as a representation of the temperature axis. The displayed temperature of 20°C is immaterial for the content of the slide.

Up to the maximum moisture content (= 100% relative humidity) the water is present in the air in gaseous form. At 20°C, 1m<sup>3</sup> of air can hold more than 17.3g of moisture, so the dew point is reached (= saturation vapour = 100% humidity). If the moisture content drops, the water precipitates.

50% relative humidity means that the air has absorbed only half the maximum possible amount of moisture ( $17.3 \times 0.5 = 8.65\text{g/m}^3$ ). If, for example, at 50% relative humidity the temperature of 20°C sinks to 9.3°C, the already set 8.65g moisture content of the steam saturation (= 100%) begins and water condenses out.

### **SLIDE 7**

A sample calculation:

An overcast November day has an air temperature of 10°C and a relative humidity of 100%. It is dissolved in an absolute humidity of 9.4g in a m<sup>3</sup> of air. At night, the air is cooled to 5°C. At 5°C, the air can hold only 6.8g/m<sup>3</sup> moisture. The remaining 2.6 g/m<sup>3</sup> occur in liquid form as fog in appearance. The next day, the sun is shining and the air is heated to 15°C. The absolute amount of moisture remains the same at 9.4 g/m<sup>3</sup>. Since the air at 15°C can hold up to 12.8g/m<sup>3</sup> humidity, relative humidity amounts now  $9.4/12.8 \text{ [g/m}^3\text{]} = 0.734 = 73.4\%$ .

How much water vapour fits into a room?

A room is 3 x 4m and 2.50m high = 30 m<sup>3</sup>

The air temperature is 20°C.

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Indoor air can absorb max.  $30\text{m}^3 \times 17.9\text{g}/\text{m}^3 = 537\text{g}$  of water  $\sim 0.6$  liters of water.

- If you want to dry your hair, then blow warm air over your head.
- $40^\circ\text{C}$  warm air can absorb about  $50\text{g}/\text{m}^3$  - more than  $30\text{g}$  of more than  $22^\circ\text{C}$  air - drying the hair.
- The very warm and moist air mixes with the rest of colder air. The precipitated moisture is absorbed by the remaining air.
- The room air heats up much faster than the objects, walls, ceilings and floors.
- Suddenly the mirror fogs:
- The surface temperature on the mirror is still so cold that the moisture can no longer be maintained.
- You pick up a bottle of water from the refrigerator ( $6^\circ\text{C}$ ). The layer of air around the bottle cools and the excess water vapour precipitates as water = condensed.
- If you have a cold spot on an outside wall, then water will precipitate there too.

The DIN 4108 specifies:

- At an outside temperature of  $-5^\circ\text{C}$
- an internal temperature of  $20^\circ\text{C}$
- and a humidity of 80%
- drops of condensed water arise when the surface temperature drops below  $12.6^\circ\text{C}$   
=> risk of mould

Nature may not imbalance. Therefore, water vapour goes on journey:

- By diffusion (independently)
  - Convection = wind (is carried along)
- 

### **SLIDE 8**

On one side of a wall there is more water in the air in  $\text{g}/\text{m}^3$  than on the other side.

Or in scientific terms: the vapour pressure is dependent on the absolute amount of water vapour in the air - different pressures balance each other out.

[DIAGRAM]

The Trail of the Water Vapour

High density water molecules

Diffusion resistance of the air -  $\mu = 1$

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Building material as a diffusion barrier

Diffusion resistance of the air -  $\mu = 30$

Low density water molecules

Diffusion resistance of the air -  $\mu = 1$

Source: EnergieAgentur.NRW

Diffusion is the migration of molecules, atoms and ions. Illustrated are water vapour molecules that move randomly and non-directionally in the room. If there is a difference in concentration between two spaces, the water molecules always move in the direction of lower water vapour concentration (pictured from left to right), even if there is a solid, impermeable barrier between the two areas. The building material in the middle (e.g. mineral structural substances) is airtight, but it is to some extent permeable because of its cavities, pores and capillaries. The migration of water vapour is dependent on the difference in water vapour concentration [ $\text{g}/\text{m}^3$ ] and the diffusion resistance of the building material. Air is the lowest barrier to water vapour and is represented by the  $\mu$ -value (water vapour diffusion resistance factor) of 1. A building material with the  $\mu$ -value 30 thus slows the concentration balance by a factor of 30. The diffusion of water molecules through building components is a very slow process. About 36 cm/h is assumed as the average speed. A small hole in the vapour barrier roof surface area has minimal impact on the  $\mu$ -value. The water vapour concentration is almost the same everywhere in a room with stationary conditions. Whether on the floor or the ceiling, everywhere it is the same amount of water vapour in the air [ $\text{g}/\text{m}^3$ ].

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**SLIDE 9****2.2 Convection**

Convection = air embarks on a journey

When air is heated, then it is less dense and rises up. Cold air is heavier and sinks to the bottom.

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When the sun shines on the desert, it warms the desert and dry air rises. If the sun is shining on the sea, the warm and humid air increases. When the air rises again it is cooled and can no longer keep the humidity, clouds form (less above the desert of course). When air rises, creating a vacuum at the bottom and sucking air from the environment - we have wind. In nature, the sun is thus the driving force.

In a building it is similar.

A radiator plays the part of the sun and heats the air around it, which is light and rises up. Colder air is sucked in at the bottom - creating air circulation.

Also, the air pressure in a building can result in wind. This is due to the temperature:

The warmer air is, the lighter it becomes. The higher a building, the faster the air rises. In a stairwell of a tall building, you can hear it whistling.

Wind meets a building. The wind enters the building and messes everything up. On the other side of the building, a vacuum it created and sucks the air flow out again - unfortunately including the heat generated.

If a building is constructed airtight, then the influence from outside is very small. However, two things cannot be prevented:

- The "lightness" of warm air
- The air pressure difference between the bottom and the top of a building.

However, if the air density level has a hole somewhere, then we have a big problem.

- This hole acts like a nozzle.
- Since the air here is very fast and transported with the water vapour, we have a lot of moisture.

Transport of moisture and condensation in winter: flow and diffusion through a component

[DIAGRAM]

Perfusion through the faulty building component

360g water/day m<sup>2</sup>

1mm construction joint over 1m long

Vapour diffusion through the intact building component

1g water/day m<sup>2</sup>

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### **SLIDE 10**

Source: EnergieAgentur.NRW

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### **SLIDE 11**

#### **2.3 Increasing Heat Loss**

... only by air flow across a roof (60 m<sup>2</sup>) with only one (!) transverse joint (10m) in width of 3mm, the heat loss of the entire surface (60m<sup>2</sup>) is increased at a pressure difference of 10 Pa to 95%

In other words:

Outside there is a wind force 2-3 (commonly: in a weather forecast, the wind force is always named), then the roof has a realistic insulating property of only 7cm and not of the built, calculated and found to be good 14cm.

[DIAGRAM]

Joint 1-10mm

Example: Roof area 6 x 10m

14cm fiber insulation

[TABLE]

Pressure Difference

Joint width

Weather-related pressure difference reference values

5 Pascal...wind strength 1-2 or moderate thermal

10 Pascal...wind strength 2-3 or strong thermal

20 Pascal...wind strength 3-4

**SLIDE 12****2.4 Transport of Water Vapour**

[PICTURE]

Source: Robert Borsch-Laaks, Expert in Building Physics, Aachen

[DIAGRAM]

Joint 1-10mm

Indoor climate: 20°C, 50% relative humidity

Transport of Water Vapour

- ...by diffusion: not very predictable
- ...by convection: very unpredictable

Since the air also contains H<sub>2</sub>O molecules, they are carried along.

Example:

- Outside: -10°C and 80% humidity
- Inside: 20°C and 50% humidity
- 3mm gap in the film - 5 Pa pressure difference

=> 400g of water migrates daily per meter gap in the insulation!

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**SLIDE 13**

The problems start at the very bottom

- At the lowest point in the house, the thermal vacuum is greatest
- Poor sealing on the soleplate leads to the "pool of cold air"

[DIAGRAM]

Neutral zone

Temperature difference

Source: Robert Borsch-Laaks, Expert in Building Physics, Aachen

Soleplate passage made of concrete - timber frame house wall: if the connection is not made air-tight, cold air is permanently pulled into the house.

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### ***SLIDE 14***

There are air tight sleeves in different dimensions which can react flexibly even during movements between the film and the cable/pipe.

It has long been known that by convection more moisture is transported as by diffusion.

The only solution is:

Build airtight!!!!

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### ***SLIDE 15***

## **3. Living Correctly**

### **3.1 Ventilation**

The moisture contained in the air and condensed on cold surfaces:

= Condensation.

**Condensed water must absolutely be avoided.**

Condensed water arises if:

- a lot of water in vaporous state
- is contained in warm air
- and this reaches cold surfaces,
- on which there is a layer of cold air
- that cannot hold water vapour.

The residents need to know:

- Proper ventilation
- Proper furnishing
- Fast action

and a possible mold infestation is uncritical.

[DIAGRAM]

Efficient Ventilation

[L] Transverse ventilation:

Windows/doors on opposite sides of the room completely open

[L] Rush airing:

Window fully open

Door closed

Window half open

Door closed

[R] Transverse ventilation:

Window tilted, opposite door fully open

Window tilted

Relative time for a complete air exchange

Source: EnergieAgentur.NRW

The bars indicate the “relative” time necessary for a complete air exchange. The exact duration of a complete air exchange is the temperature difference inside and outside as well as wind direction and air pressure. Of the various ways to ventilate through a window, transverse ventilation is the most effective. Often, however, transverse ventilation is not practicable, be it at night while sleeping or in the case of absence (unwanted visitors).

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### **SLIDE 16**

Only if it is aired carefully or if a mechanical ventilation system is in operation can the moisture be removed from the premises. To be sure to ventilate properly, a thermometer and hygrometer can give valuable information (more on that later).

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[GRAPH]

Rush Airing Instead of Tilt Ventilation

Proportion of Fresh Air to Room Air

--- Rush Airing

--- Continuous ventilation

t (in hours)

Source: Consumer Advice Centre NRW

- You see in a kitchen windowsill full of flower vases,
- in the living room family photos and
- in the bathroom cosmetics on the windowsills,
- then do not leave the window open -
- only tilted.

**Transverse ventilation impossible!!!**

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## **SLIDE 17**

### **3.2 Furnishing**

- Furniture against outside walls acts as an internal thermal insulation.
- Therefore: keep approximately 10cm from the outer wall.

[DIAGRAM]

Cold Walls behind Furniture

Closet with skirting board

20°C air

free wall

-5°C outside air

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Source: EnergieAgentur.NRW

[PICTURE 1]

Closet close to the floor

[PICTURE 2]

Closet is ventilated from below

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**SLIDE 18****3.3 Interiors**

- Curtains which are mounted on the ceiling do not allow for ventilation.
- Curtains on wall bars or suspended constructions allow ventilation.

[DIAGRAM]

Cold Walls behind Curtains

20°C air

free wall

-5°C outside air

Source: EnergieAgentur.NRW

Heavy curtains,

- that are pushed up into outer corners,
- that reach from floor to ceiling,
- are very susceptible to mould growth.

Light curtains are ventilated.

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**SLIDE 19****3.4 Dealing with Radiator Niches**

- Radiators produce hot air to be distributed as well as possible in the room.
- Warm air can re-absorb moisture which was reflected somewhere else.

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- Thus the warm air must also have space to spread out and to wander along the windows...

[DIAGRAM]

Radiator Niches

Insulation of Radiator Niches

Heat loss - Warm air

Heat radiation

- Aluminium foil reflects heat radiation
- Additional insulation reduces heat flow outside

[L] Covering the Radiator Niches

[R] Curtains in front of Radiators

- Prevents heat dissipation in the room
- Increases the heat loss to outside

Source: EnergieAgentur.NRW

An aluminum foil behind radiators reflected in the winter some of the heat radiation, but can allow heat diffusion.

In the summer, the penetrating water vapour from outside cannot go inside - there is a risk of mould growth when the aluminium foil plaster, plasterboard, wallpaper or old wall colours are left behind.

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**SLIDE 20****3.5 Measurement of Temperature and Humidity**

In each dwelling there is at least a room air-measuring device, which must show the following characteristics:

- Air temperature

- Humidity

[PICTURE]

Source: Klimatherm, residential air-monitoring device DTH-10

Meters show not only the permanent room temperature and the relative humidity, but they can also warn residents against excessive humidity if it exceeds 60% relative humidity by flashing a red LED. The resident is reminded of the air. If the room humidity below 60% relative humidity, the flashing light goes out again. In addition, some devices can be set to daylight savings time (e.g. by a slide switch on the back). Thus, the flasher can be switched on only during the critical times of the heating season. A flashing during the summer time, where moist air cannot condense on the warm walls (except if it enters a cold cellar) is thus avoided.

The use metering devices:

- serves the best use of heating energy (as little as possible, as much as necessary) and thus reduces high heating costs often unnecessarily incurred without climate control;
- protects against moisture damage due to condensation. No dew point underflow due to high humidity and thus no sporulation and mildew stains on the wall, and
- thus protects health against mildew! (Since this cannot develop).

Rule: Ventilation by numbers - valid during the heating season.

- The humidity in a room increases by 65% => transverse ventilation
  - The humidity decreases below 60% => close the window.
  - If the humidity is 85% sometimes for hours, no problem.
  - If the humidity is higher than 70% for days, a problem begins.
- 

## **SLIDE 21**

### **3.6 Heating and Ventilation**

[DIAGRAM]

Surface and Air Temperature

Outside air -10°C

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Inside air +20°C

Surface temperature [°C]

Air temperature [°C]

Source: EnergieAgentur.NRW

Thermal comfort is very strongly influenced by the temperature of the air and the temperature of the surrounding areas such as the inner wall, exterior wall and floor slab. The average value of room air temperature and average surface temperature of the enclosing surfaces is referred to in the literature as perceived, resulting, or room temperature.

Perceived temperature = (air temperature + average surface temperature) / 2

Three different spatial situations are presented. The area is heated to a temperature of 20°C and the outdoor air temperature is 10 ° C.

**Example 1:**

- Glazing (e.g. conservatory)
- Outside air temperature: -10°C
- Room air temperature: 20°C
- Perceived temperature: 15°C
- Evaluation of the indoor environment: not comfortable

**Example 2:**

- Room: Brick wall, not insulated
  - Outside air temperature: -10°C
  - Room air temperature: 20°C
  - Perceived temperature: 17°C
  - Evaluation of the indoor environment: not comfortable
- 

**SLIDE 22****Example 3:**

- Room: Brick wall, insulated
- Outside air temperature: -10°C

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- Room air temperature: 20°C
- Perceived temperature: 19.5°C
- Evaluation of the indoor environment: comfortable

The example shows that only in the room with the insulated exterior walls is there a comfortable indoor climate at an outside temperature of -10°C and at 20°C room air temperature. In the room with the uninsulated brick wall, a pleasant indoor climate is achieved only at an air temperature of 23 to 24°C. In the conservatory there will always be a cold outside air temperature at -10°C, regardless of the heating setting.

#### Recommended Actions

The higher the surface temperature of the space-enclosing surfaces, the lower the air temperature can be (and therefore heating costs), so that people feel comfortable in a room. This can only be achieved with building insulation.

#### [DIAGRAM]

Heating and Ventilation - typical cold zones

Kitchen, bathroom, bedroom, hallway, living area, balcony/portico

Heating and Ventilation - avoiding cold zones

Source: EnergieNatur NRW

Pictured on the left is a layout with different temperature distribution in the dwelling.

Bathroom approximately 24°C, kitchen and living are about 20°C, bedroom and hallway about 15°C.

#### **What happens when the bedroom door is open?**

Moist, warm air flows out of the bathroom into the bedroom. Due to the cold wall surface in the bedroom, condensation arises. The moisture is transported by air from the home. If the window or mirror fogs up in the bathroom, it is high time for airing.

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**SLIDE 23**

If room temperatures for each room are identical or similar (right picture), the doors can be kept open. Correct and timely ventilation is important nonetheless. The references to furniture, curtains and radiator niches must be observed.

**Recommended Actions**

Basic summary: To avoid condensation in the living room,

1. the air must continuously be exchanged,
2. it must be heated properly,
3. it should be properly furnished, and
4. structural weaknesses must be eliminated.

**4. Mistakes and the Consequences**

The errors are divided into structural defects, behavioral errors, combinations and specific weather events

**4.1 Constructional Errors****Thermal Bridges**

Here, thermal bridges and thermal bridge effects are visualised:

In the first picture the insulation is in many areas damaged: either it is missing, or the airtightness level (slide under the rafters) is faulty and the insulation becomes wet. Another way of checking or diagnosing thermal bridges is thermography.

In the second picture, the insulation on the facade does not meet the insulation in the roof - the insulation mantle is open. The heat is then “going”, warming the tiles from the bottom so the frost has no chance. The energy losses are negligible, the possibility of mould growth in the transition wall-interior roof grows.

[PICTURE]

Constructional errors - visible from the outside

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**SLIDE 24**

[DIAGRAM]

Thermal Bridges on the Gable End

Outer Wall

Outside air, outer wall, heated living room

Source: EnergieAgentur.NRW

If walls (gable and interior walls) of a heated space are not insulated below the roof, this creates a thermal bridge. If between the wall and the edge rafters there remains an uninsulated gap that has been flushed out by air, the thermal bridge is particularly effective. The answer is a top-side insulation of the wall crown of min. 8cm strength. Moreover, if there is enough space between the wall and rafters, this area can also be insulated.

For internal walls, there are no special requirements for insulation, but there are requirements for upper sidewall insulation for home partitions, providing soundproofing and fire protection.

Suitable materials are e.g. rockwool slabs. It is also possible, however, to perform this on the top row of bricks with foam or aerated glass with  $\lambda = 0.12 \text{ W/mK}$ .

### **Recommended Actions**

Thermal bridges should be avoided by thermal separation of building components.

[DIAGRAM]

Thermal Bridges on the Gable End

Optimisation of the Detailed Design

Insulation: 0, 120, 40, 160 mm

Source: EnergieAgentur.NRW

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**SLIDE 25**

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This picture represents the thermal bridge effect of the verge with different insulation thicknesses. This is the graphical representation of the results of a simulation calculation at strengths of 0mm/40mm/120mm/160mm embankment material along the top of the verge. The internal temperature at the exit wall/roof must not fall below 12.6°C, otherwise the risk of interstitial condensation and mold is formed (see DIN 4108-2). This detail is similar to a partition between terraced houses. It must be ensured in addition to fire and noise protection requirements into the design.

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**SLIDE 26****Structural errors - visible from the inside**

[PICTURE 1]

If pipes are insulated, then complete.

[PICTURE 2]

The insulation mantle should be closed.

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**SLIDE 27****Structural errors - visible after dismantling****SLIDE 28**

Structural defects - visible during construction

All stone rows must be covered during the construction phase, in the window openings a mortar layer should be applied.

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**SLIDE 29**

Structural errors - visible after dismantling

Martens have to live somewhere too...

## **4.2 Behavioural Errors**

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### ***SLIDE 30***

## **4.3 Combinations of Constructional and Behavioural Errors**

Mould: a little damage

Mould: a medium damage

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### ***SLIDE 31***

Mould: a great damage

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### ***SLIDE 32***

(same as above)

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### ***SLIDE 33***

**In almost all cases, water is the problem.**

- Water comes - unintentionally - from outside in - building envelope is defective.
- Water in/on the house cannot be restrained - piping is defective.
- Water "produced" suddenly in the house - high humidity condenses on cold spots.

[DIAGRAM]

A building consists of roofs - diagonal or horizontal

Walls - perpendicular

Floors - horizontal

These areas can have holes through which the rain pours in.

Problems:

- Roof tiles defective or “crazy”
- Gutter overflowing or downpipe connected incorrectly
- Facade defective

[DIAGRAM]

### **Causes for Possible Moisture Damage**

Soil moisture:

1. Horizontal sealing defective
2. Vertical sealing defective

Rainfall:

3. Defective cleaning jobs
4. Rain pipe leaking/clogged
5. Leak in the roof covering
6. Bad connections
7. Leaking water pipe

Source: EnergieAgentur.NRW

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### **SLIDE 34**

Disconnected downspout

Facade drops:

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### **SLIDE 35**

Water finds its way

Disconnected downspout

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### **SLIDE 36**

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Special case: Heavy rain event

Special case: faeces backflow

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**SLIDE 37**

Special case: utility room

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**SLIDE 38**

At the lowest point, a little water is always collected.

Pipes defective in the house. Which supply lines are there:

- Cold/hot water
  - Sewage
  - Rainwater - internal downpipes
  - Heating water
- 

**SLIDE 39****5. The Potential Implications of Condensation**

If one sees mould in a corner of the dwelling, then immediately give notification to the landlord.

Now an inspection of the mould is still very simple and inexpensive, and the cause can be easily eliminated.

If a roommate or a visitor smells a typical musty smell, then immediately report it to the caretaker.

Always have the following brochure ready for issue to tenants:

Publisher: Federal Environment Agency;

Help! Mould in the Home: causes - effects - remedy

Attack of the black dust (double brochure)

Download free as a PDF at:

<http://www.umweltdaten.de/publikationen/fpdf-l/2227.pdf>

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## **SLIDE 40**

### **5.1 How does mould grow?**

Mould infestation for many people is only a problem when the mould is visible. In reality, the problem already started earlier: mould may thus be an indicator of vulnerability of a constructive nature and/or error.

There are over 80 different mould species infesting components known in residential buildings. Each of these types of mould and its constituents can present a health hazard, 10% of which are considered to be of particular concern to health.

#### **Hazard Classes according to Sedlbauer**

- A. Fungus is toxic and should not occur in a living room.  
Immediate need for action.  
The whereabouts of the source is not to be tolerated.
- B. Fungus is harmful the longer the exposure time, i.e. allergenic or pathogenic.  
Medium-term need for action.
- C. Fungus is not harmful, but leads to economic damage.  
Long-term need for action.

Mould spores can cause, inter alia, allergies, infections, asthma, bronchitis and pneumonia. Mycotoxins (fungal toxins) and MVOC's can induce poisoning. MVOC's is the English abbreviation for Microbial Volatile Organic Compounds, i.e. microbial volatile organic compounds (metabolites/excretions).

In particular, the mycelium can cause allergies when touched. Some species of mould are shown to be carcinogenic in animal experiments.

After its settlement, mould's metabolites and the number of growing spores increases the health risk.

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## **SLIDE 41**

### The life cycle of moulds

[DIAGRAM - im uhrzeigersinn]

The spread of spores by air movement

Deposition of spores on surfaces

Release of cell contents

Formation of mycelium

Formation of spores, followed by replacement of the spores

Source: EnergieAgentur.NRW

Mould is a living being. It needs food (organic substances) and water in the form of moisture, reproduces by spores and has exudates/metabolic products (MVOC's). The spores are like the seedlings, the seeds of the moulds. Like dust or pollen, they are always detectable in the air. One can only poorly protect oneself from spores. Since they are microscopic, they are not visible to the naked eye. A normal spore concentration in an unencumbered dwelling is about 500 to 1,000 spores/m<sup>3</sup> of air. 1,300 spores/m<sup>3</sup>, at which the limit of the normal spores load is reached, presents a health hazard for a normal person. This is an empirical value in practice, without consideration of the metabolites. Surfaces with organic ingredients provide a food source for spores. With enough moisture/water/steam, the second basis for life, the mould begins to grow and form a mycelium. During growth, metabolic products form (Source: Energy Agency NRW).

In advanced stages of mould growth, mould can develop self-sufficient moisture from their excretions to live off. This creates a moist environment and the mould does not need any more moisture supply from the outside (Source: Energy Agency NRW).

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[TABLE]

Class - Characteristics - Pictogram

0 - no growth identifiable

1 - growth only visible under a microscope

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- 2 - growth visible to the naked eye
- 3 - clear growth
- 4 - heavy growth
- 5 - complete overgrowth

Source: Dissertation by Sedlbauer, University of Stuttgart, Building Physics

In living spaces, moulds can find a good food source especially in and on organic materials. These are mainly paper, wood products, and textiles. For this reason, mould is often found on and under wallpaper, wood beams, curtains and mattresses.

Mineral materials are generally unsuitable for moulds because they do not provide a food source. However, many mineral materials containing organic additives can easily feed the mould. It so happens that mould likes to settle on silicon joints in the bathroom or in mineral wool. Even if no nutrients are present in the material, the surface contamination (for example dust) may be sufficient for a mould (Source: Energy Agency NRW).

A few materials have the property of keeping mould away due to their pH (acid value). These include lime, lime, lime paint, plaster silicate and silicate paint. Other materials may lead into deeper layers of the material due to its structure, absorbing water and moisture from the surface - they are hygroscopic. Thus, the moisture on the surface is lower and the moulds have less opportunities to develop. This applies to renewable and organic materials such as wood, but also on clay, brick and silicate fiberboard.

Once mould has settled, it grows and multiplies. If it is disturbed, it tries to ensure its survival by the excessive production of spores. This survival response of the mould should definitely be considered. If an attempt is made to distribute mould to dry out, it discontinues its growth and produces an excessive number of spores, so as to guarantee its survival. This leads to an increased health hazard.

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**SLIDE 43**

In the case of mould infestation, the cause should always be investigated and corrected. Room users can eliminate smaller mould infestation by themselves, if they do not have an allergy to moulds, chronic respiratory diseases or a weakened immune system.

For larger mould infestation, it is also often a good idea to take immediate action before the actual renovation begins. Again, the resident can do some things themselves. The emergency measures should not become "permanent measures" if the causes are not identified and eliminated. The actual restoration should be carried out by specialist companies.

[PICTURE]

Mould spores are everywhere, and they need nutrients and moisture to grow. It is virtually impossible to create a living space that offers no nourishment for spores. To avoid mould spores, so you have to focus on the prevention of moisture itself.

Source: Federal Environment Agency, mould remediation guide

## **5.2 Eliminating the Infestation of Small Areas**

According to the Federal Environment Agency's 'Measures for the Removal of Small-Scale Mould' (e.g. <math>0.5\text{m}^2</math>, only superficial infestation) can be carried out without the involvement of qualified personnel. However, the cause must be identified and removed. It is important to work in as little dust as possible. Basically, surfaces that are infested with mould should never be rubbed dry, so that the spores are not swirled around in the air. Mould infested materials must be thoroughly cleaned. If this is not possible, e.g. when mould or mildew has penetrated into the upholstery or furniture, they should be removed completely. A mere killing of moulds is not enough, as allergic and irritant effects may also arise out of killed moulds.

In order to limit the distribution of the spores in the air as much as possible, the affected area should first be wet wiped or vacuumed with particulate filters (e.g. HEP filter). The vacuum cleaner should be considered in addition to housing sealing according to EN 1822. Recognised vacuum cleaners such as the DMT symbol (German Montan Technologie Ltd.) or the TÜV mark "suitable for allergy sufferers".

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### **SLIDE 44**

## **5.3 Substances and their Dangers**

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Several products for mold removal are on the market. These include so-called biocidal active substances. The warning of many products goes from health hazards to environmental impacts. Please refer to the labeling on the products.

[DIAGRAM]

#### Frequently used biocidal substances and their hazard symbols \*

Alcohols

Aldehydes

Quads

Halogens

Chlorine products

High alcohol peroxides

\* Hazard pictograms on the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) of the UN Commission

#### SLIDE 45

#### Overview of Hazard Symbols \*

[DIAGRAM]

Hazard symbol Hazard description	Meaning (hazard and user instructions)
<b>Explosion Hazard</b>	<b>Danger:</b> Substances that can explode under certain conditions. <b>Management:</b> shock, impact, avoid friction, sparks and heat.
<b>Extremely Flammable</b>	<b>Danger:</b> Spontaneous combustion, flammable gaseous materials, moisture-sensitive materials or flammable liquids. <b>Management:</b> Avoid contact with ignition sources/hazards (air, water).
<b>Highly Flammable</b>	<b>Danger:</b> Spontaneous combustion, flammable gaseous materials, moisture-sensitive materials or flammable liquids. <b>Management:</b> Avoid contact with ignition sources/hazards (air, water).

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<b>Oxidising</b>	<p><b>Danger:</b> Substances that may ignite flammable materials or promote fire, and can make it difficult to fight the fire.</p> <p><b>Management:</b> Avoid all contact with combustible materials.</p>
<b>Highly Toxic</b>	<p><b>Danger:</b> If inhaled, swallowed or absorbed through the skin to a considerable extent, it can lead to damage to health or even death. Even less than 25mg/kg of body weight can lead to death.</p> <p><b>Management:</b> Avoid contact with the human body and immediately contact a doctor if feeling unwell.</p>
<b>Hazardous to Health</b>	<p><b>Danger:</b> When absorbed into the body, these substances can cause a health hazard.</p> <p><b>Management:</b> Avoid contact with the human body, and inhalation of vapours and contact your doctor if feeling unwell.</p>
<b>Corrosive</b>	<p><b>Danger:</b> Living tissue, but also many materials are destroyed on contact with this chemical.</p> <p><b>Management:</b> Do not breathe vapours and avoid contact with skin, eyes and clothing.</p>
<b>Irritant</b>	<p><b>Danger:</b> Substances that are irritant to skin, eyes and the respiratory system can cause inflammation.</p> <p><b>Management:</b> Do not breathe vapours and avoid contact with skin and eyes.</p>
<b>Dangerous for the Environment</b>	<p><b>Danger:</b> When released into the environment, damage to the ecosystem can be brought about immediately or later.</p> <p><b>Management:</b> Do not discharge into drains, soil or environment, depending on the hazard potential. Observe special disposal instructions!</p>

\* Hazard pictograms according to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) of the UN Commission

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However, there are also products that are not dangerous and harmful to the environment in their application. These include the products of the company Jatiproducts. More information is available at [www.jatiproducts.de](http://www.jatiproducts.de).

**Jati Products**

- Fruit acids + hydrogen peroxide <5%
- Safe for skin

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- Not a hazardous substance
- Not a dangerous good
- Mould retardant

When tenants/room users use products for mould removal, it is important to note that these products should be applied only to small areas and that these products act only on the surface and do not penetrate deeply into the material. For larger areas, remediation should be carried out by a specialist company.

[PICTURES]

Top left: For surfaces

Top right: For indoor air

Bottom left: For attic insulation

Bottom right: For cavities

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**SLIDE 47****5.4 Measures to be Taken by the Inhabitants in the Case of Mould Infestation (according to EnergieAgentur.NRW)**

Mould infestation in the home, when you proceed correctly, is basically a manageable and solvable problem.

Belonging to this correct procedure is the understanding that the mould is a serious problem. Without an analysis, you cannot tell what health risks emanate from a particular instance. Due to all the moulds that settle in buildings, from which you can expect health threats to arise and some types can cause serious health problems, you should not take any chances, but rigorously follow the following principles.

- **Calling in the Landlord**

As a tenant, you are obliged to inform the landlord of the mould. Unfortunately, mould infestation often has the ability to cause a conflict between tenant and landlord. So that the situation does not escalate, both parties should talk to each other to find the cause of the mould and initiate appropriate remediation. The cause of the mould must be found in any case. This role falls to appraisers or experts. These professionals can also contribute to

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conflict resolution. The tenants' association members provide legal and technical information for mould growth.

- **Calling in the Experts**

Unfortunately, no one can with certainty determine moulds on building components only by visual inspection. Therefore, it is essential to bring in a specialist. A diagnosis about the origin of the moisture, which brought the mold to grow, is generally not easy. The cause of the moisture leading to mould growth can rarely be found properly. It is usually a combination of structural problems and patterns of use.

An expert determines the cause of mould infestation and develops further action, including restoration. A rule of thumb: the longer the mould could grow (i.e. the older it is) the greater the chance that it poses a high risk to health. If wide infestation or mould growth is present in construction cavities before the start of a mould remediation analysis, in every case you should give priority to your own safety and the safety of the professionals who remove the mould and infested materials.

- **Conducting Analysis**

The actions of mould removal must always be tailored to the specific mould. Only by laboratory analysis can the nature of the mould be clearly established. If the filamentous fungus is known, the health risk can be estimated. From health hazard, the protective measures to clean up and disposal are derived.

- **If necessary, consult a Doctor**

If health problems exist, you may need to contact a medical professional with knowledge of moulds with the results of the analysis. Not every family doctor can help here. Health departments, medical practitioners, employee hygiene institutes and environmental ambulances are appropriate contact persons. A collection of addresses can be found in the appendix.

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**SLIDE 49**

- **Carrying out Restoration**

Mould infestation generally requires remediation, which involves the removal of all infected materials. The sole use of mould-killing products brings about only a very brief success. Most of these products contain substances that are harmful for humans. Some species of mould have been specialised and can process these fungicides as food. Even the old home remedy of vinegar promotes mould growth more than it inhibits it. A simple sweep is only a cosmetic measure. Without proper rehabilitation eliminating the causes, spores repeatedly use the existing moisture in order to develop into moulds.

For health prevention and to minimise the risk of a new mould growth, the success of mould removal should be checked by a second laboratory analysis. With a high number of spores in a space, the mould removal must be repeated. Eliminating the cause of moisture, remediation should only be done after the removal of the mould, as the mold on removal of moisture and drainage reacts with increased spore production.

After removal of the mould, the moisture restoration is initiated. A permanent mould remediation can only succeed if all causes of mould infestation are permanently removed.

- **Tips for the Transition until the Result of the Analysis of the Mould is present**

Depending on the case, it is recommended to use mould-free spaces in the home and, if necessary, to close the door to the mould-infested areas with masking tape. Avoid masking small areas, as the mould would grow even faster.

Do not tamper with the fungus with a brush, sandpaper, hair dryer or vacuum cleaner. This will distribute the spores on a large scale around the whole house.

Mould infestation in the home is basically a manageable and solvable problem. In the event of damage, you should consult experts.

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**SLIDE 50****5.5 Measures in the Case of Larger Mould Infestation**

The next chapter deals with the remediation measures for a larger infestation, these should be carried out not by the resident/room user themselves, but by a specialist company. These

notes are taken from the "Mould Remediation Guide" 2005 of the Federal Environment Agency, unless otherwise indicated.

Publisher and Editor:

Federal Environment Agency - Indoor Air Hygiene Commission of the Federal Environment Agency, Dessau 2005

This booklet is available free of charge via [uba@broschuerenversand.de](mailto:uba@broschuerenversand.de) and as a PDF at <http://www.umweltdaten.de/publikationen/fpdf-l/2951.pdf>

Before proceeding with the renovation work, a risk assessment must be carried out by an expert, which involves the determination of the necessary safety measures for the restoration staff as well as for residents/room users.

#### **5.5.1 Risk Assessment and Protective Measures**

- Assessment from a hygienic standpoint
- The urgency of the implementation of remedial measures
- Assessment of the risk involved in the implementation of remedial measures
  - Exposure of workers to
    - biological substances
    - chemicals used
  - Hazards to the residents/room users

From the individual hazards mentioned above results in a total risk, from which in turn the necessary protective measures and, where appropriate, transitional measures for the cleaning are derived.

For the protection measures following distinction is made:

- Health and safety measures with a view to
    - Exposure to microbiological pollutants
      - technical and structural measures
      - organisational measures
      - personal protective equipment
      - occupational health screening
    - Exposure to chemical pollutants
  - User and object protection measures
-

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Listing all protective measures is beyond the scope of this position. They can be found in the mould remediation guide. As an example, the following table shows evidence of the gradation of personal protective measures and measures to prevent the spread of moulds.

Criterion	Intensity Level	Suggested Protective Measure in the Area of Occupational Safety
Not to worry about the dust-free removal of small areas of mould-infested, weak spore loads regardless of the duration of action	0	Gloves (1)
Short tasks (<2 h) at medium spore load, especially the development of grit	1	If necessary, black/white separation, Disposable protective clothing Cat. III, Type 5 (2), Gloves (1), Safety Glasses, Respirator with P2 filter (3)
Longer-term jobs (> 2 h) at medium spore load	2	Black/white separation Disposable protective clothing Cat. III, Type 5 (2), Gloves (1), Respirator protection at level TM2P recommended, Fan-assisted respirator hoods with particle filter (TH2P) (3)
High spore load, independent of time at work, e.g. strong development of fine dust or aerosols, no effective local ventilation	3	Black/white separation, Lock, possibly with ventilation, Disposable protective clothing Cat. III, Type 5 (2), Gloves (1), Respirator Class 3 TM3P (3)

(1) = Instructions for selecting suitable gloves are the BGR 195, "Rules for the use of protective gloves."

(2) = In the case of contact with a large amount of sewage, waterproof protective or disposable clothing that is impermeable to microorganisms.

(3) = The filters of disposable respirators are at least switched during the working day and disposed of.

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Pay attention to protective measures!

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- Cover or remove items that are difficult to clean, e.g. textiles, from the restoration area.
- Remove food and other items such as children's toys and clothes before the renovation of the room.
- Work if possible in low dust, e.g. vacuum or moisten surfaces beforehand.
- Prevent the spread of mold spores.
- Do not touch mould with your bare hands - wear protective gloves made of plastic (available at hardware stores).
- Do not breathe in mould spores - wear an appropriate respirator (available at hardware stores) and discard after use.
- Avoid getting mould spores into the eyes - wear special dust goggles (available at hardware stores).
- Wash contaminated clothing thoroughly after use, or use disposable protective clothing and dispose of it afterwards.

#### **SLIDE 53**

Another example from the mould remediation guidelines are in the following table, which gives a comparison of techniques in terms of the expected dust and aerosols.

Object of Renovation	High Dust or Aerosol Pollution	Low Dust or Aerosol Pollution
Cleaning	Wipe dry or sweep	Damp cloth or vacuum
Cleaning	Dry blasting	Spray extraction
Remove wallpaper	Remove drying	Remove moistened or crosslinked
Removing material	Only mechanical	Mechanically via local ventilation
Artificial drying	Printing method	Suction air outlet to outside

Due to the complexity of the causes, nature and the severity of the hazard and the technical possibilities of restoration, it is not possible in every event for exact specifications to be followed with respect to the labour, consumer and environmental protection. Therefore, it is imperative that in each case a risk assessment is carried out and respected, and protection measures to be undertaken must be defined.

**When moulds grow, then you should work according to the renovation guidelines in 13 steps.**

If we do not avoid build failures, we must rehabilitate them:

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- the house
- the inhabitant

**What happens if we do not take the building physics into account?**

**Mold infestation.**

**An example of the consequences from Bocholt:**

- Needed house bought, seller had repainted the inside
- After a year of significant mould growth - loss in the amount of €40,000
- Entire family ill - moved out - sued seller
- Redemption is not possible because seller is insolvent
- Bank calls for debt from buyers
- Ruined young family and sellers
- Bank possesses unsellable ruins

**Where does mould grow?**

**(Almost) everywhere!**

**It eats almost anything!**

**It needs no light!**

**“No mould visible” does not mean “no mould there”!**

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**SLIDE 54**

According to the mould guide of the Federal Environmental Agency, restoration must aim to completely remove the mould-damaged materials.

To kill moulds is not enough, because even killed moulds can have allergic and irritant effects.

**5.5.2 How does a Renovation work?**

1. Determine the cause
2. Risk assessment, determine the protective measures
3. If necessary, transitional measures for delays
4. Planning the renovation

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5. Carrying out the restoration
6. Removing mould-infested material
7. Cause elimination
8. If necessary, disinfectant cleaning building components freed of mould
9. If necessary, technical drying
10. Reconstruction
11. Fine cleaning
12. Restoration control measurement under conditions of use
13. Removal of the property, if necessary, with notes on the change of user behavior

Can one person deal with these tasks alone? **No.**

#### Who do we need this?

- **The building biologists**
- **A biologically trained architect**
- **Craftsmen of various trades**
- **Distributors that have protective equipment and materials in stock**
- **Environmental doctor**
  
- All the players come from a region
- They are commonly trained in:
  - Building Physics (causes)
  - Mould (safeguards)
  - Building materials (skills)
  - Legal position (safety)
 in theory and practice (construction media centre and construction site)
- Marketing measures

Better than refurbishment is to help to avoid the formation of mould:

- Carefully observe the building inside and out
- The tenant must:
  - Provide tips for ventilating and for furnishing
  - Provide contingent meter
  - Ask for help:

**Report quickly - act quickly**

**Possible sources of error and their consequences**

**SLIDE 55****6. Tips and Checklists****6.1 Notification by the Tenant**

Tenants should immediately make a report if:

1. Rainwater pipes are broken:
    - Downpipe
    - Gutter
  2. The building shell has a hole
    - Roof
    - Facade
    - Window
    - Doors
    - Basement
  3. The heating system has a hole:
    - Heating pipes
    - Valves
    - Radiator
  4. Water pipes have a hole
    - Cold water
    - Hot water
    - Valves, fittings
    - Bath, shower basin, sink, toilet
    - Sewers
  5. Water enters from the outside:
    - Backwater
    - Rainwater
  6. Moisture condensation on walls, ceilings, windows.
- 

**SLIDE 56****6.2 Basement Checklist**

[DIAGRAM]

**Humidity**

1. On the wall => (a) damp walls
2. On the floor => (b) moisture partially above the water line  
=> (c) extensive humidity

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3. Under the ceiling => (d) condensation of water pipes  
=> (e) wet ceilings

=> Check ventilation in the basement. In the winter, in the transitional period only at night. In the summer ventilate nothing if possible.

- If correct,
- (a) Basement sealing probably damaged or rising damp in the dado (lower part of interior wall) => contact a construction expert.
- (b) Possible leaking water pipe => contact a pipe fitter.
- (c) Possible rising damp => contact a construction expert.
- (d) Possible leaking water pipe => contact a pipe fitter.
- (e) Possible leaking water pipe => contact a pipe fitter.

Source: EnergieAgentur.NRW

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## **SLIDE 57**

### **6.3 Checklist for Proper Ventilation**

Am I ventilating correctly?

To reduce the humidity in the room, a brief airing should preferably take place several times daily (5-10 minutes of a wide open window):

#### Bathroom

Ventilate right after showering or bathing, before the steam penetrates the surface materials. After about an hour, ventilate once again. If necessary, repeat the ventilation process.

In the bathroom, the water should be removed from the walls and floor after showering.

Wet towels and walls in the bathroom can - despite brief ventilation - still contain a lot of water; Hand towels are therefore best dried on the radiator, leaving the window open until the towels feel quite dry ((he heating in the bathroom should not be turned off in the winter,

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which considerably accelerates the drying of towels; after a few minutes they are often done).

In the case of inner (en suite) bathrooms:

Without a Fan:

Check if there is draft coming from outside. Hold a sheet of paper in front of the grille; it must remain independent from the suction of the grid. A test with a lighter or candle is possible.

What's better is the use of a ventilation expert in consultation with the owner.

With a Fan:

- Does the fan run for an appropriate amount of time?  
At least 1 hour.
- Is the fan efficient (it blows out a lighted candle)?
- If the fan is correctly positioned? Does it make a burning candle flicker even in the corners?

If not, contact a ventilation specialist in consultation with the landlord.

Kitchen

In the kitchen, much moisture can be removed from the room by a cooker hood with discharge of exhaust air to the outside. Such an outlet is also sensible from the viewpoint of the discharge of cooking fumes and - in the sense of combustion gases - cooking with gas.

Hoods with air recirculation systems are not suitable for reducing the humidity in the kitchen.

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**SLIDE 58**

Little or not heated Rooms

Less heated rooms (e.g. bedrooms) should not be heated by means of warm air from other rooms (in the evening). In colder room, this may result in condensation on walls or windows.

When using the - little heated - bedroom, the removal of moisture should be provided by good ventilation in the morning after rising (each sleeper creates water vapour).

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Rooms that are not used for a long time, and heated, should be ventilated frequently.

### Absence

If the window of a dwelling cannot be opened several times a day because of the absence of the inhabitants, the interior doors should at least be kept open so that any remaining moisture from the bathroom and kitchen can be distributed evenly across all rooms.

Source: Federal Environmental Agency (ed.), Help! Mould in the Home: causes - effects - remedy; 2009.

### **Alternatively: Air by Numbers!**

#### **6.4 Tips for Interior Design**

Furniture and pictures if possible should not be placed against an outside wall. However, if necessary, a ventilation of these areas must be ensured.

If possible,

- Furniture should be at least 5cm, better at 10cm, or at best 20cm moved away from the outer wall.
- There should be at least one air gap of 5cm between the floor and furniture, or between the ceiling and fitted cupboard.
- Where appropriate, air holes should be drilled into the cabinet base and in the upper end strip. A small distance between the outer wall and cabinet (possibly the baseboards) should be removed from the cabinet.
- To prevent mouldy mattresses, a slatted frame should at least be used. An underlying bed box should be removed if present.
- Thick curtains should be removed from the outer wall. They prevent the removal of moisture as well as the heating of the outer wall and optionally the room corner.

Source: EnergieAgentur.NRW

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### **SLIDE 59**

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### **SLIDE 60**

### 6.5 Tips for Drying Clothes

- Washing should be dried as far away as possible outdoors or in a well ventilated basement or attic.
- Never dry laundry in humid areas.
- In dryers with air extraction devices, direct the waste air to the outside (preferably with a special exhaust duct).
- If the laundry is dried in a drying room, ventilate every 2 hours and reheat in between (see bathroom checklist). A hygrometer will help in the assessment and monitoring of indoor air humidity.

Source: EnergieAgentur.NRW

### **IMPORTANT!**

**The information contained in this guide does not constitute legal advice. Where questions arise in relation to the building owner's or tenant's legal position and existing rights and obligations, the opinion of an appropriately qualified professional should be sought in a timely manner. Law firms and organizations such as tenants' associations or house and property owners associations can assist in this respect.**