Photo: HCD

HUMIDITY AND HEALTH

Respiratory infections as a result of the “dry building syndrome”

condair

Respiratory infections – a problem of our own making

Infections of the respiratory tract are one of the most common reasons for employee sickness. Regular outbreaks of flu and other respiratory infections are particularly common in winter. Research has shown that humidity has a direct effect on virus survival and spread, and on the body's natural immune system. A problem of our own making – since many buildings and offices are far too dry during these critical winter months.

Over the last 20 years, strong demand for energy-efficient buildings has led to a sharp drop in the humidity of indoor climates. Airtight building envelopes, large glass facades and the absence of ventilation and air conditioning systems have all achieved huge gains in building energy performance. It is a problem for the occupants who are exposed to room air that is much too warm and dry: mucous membranes dry out, burning eyes, skin feels stiff and the voice scratchy – the symptoms of the "dry building syndrome", which more and more people are now suffering from.

Healthy air is essential

Food and water are important to life, but more essential is the air we breathe: every day, over 13,000 litres of air flows through our nose, mouth and lungs. We also spend over 90 % of our lives in enclosed spaces. The quality of indoor air and its ability to protect us from pollutants or pathogens are key factors that decisively affect our state of health. Findings from recent research have once again confirmed that relative humidity is of immense importance for the functional capability and immune performance of mucous membranes. The survival of viruses and bacteria is also closely related to humidity: an optimum relative humidity of 40 % and above is deadly within minutes to cold and flu virus particles coughed out into ambient air. When humidity drops under 40 %, viruses stay infectious for hours on end, and can be spread and breathed in throughout the building.

Dry buildings make you sick

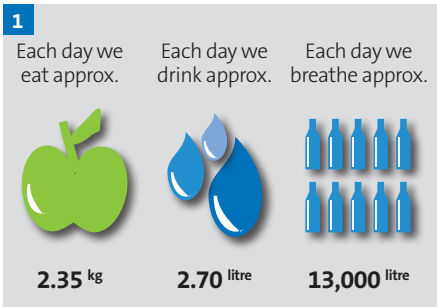
Experts all agree that efforts towards ensuring rapid improvements to office worker health are required in the next few years: almost three-quarters of specialists surveyed are confident that optimum air quality will be standard in almost every office by 2030 (Fraunhofer IAO, Stuttgart: Delphi Study Report, 2012). Planners, property owners, physicians and office personnel should therefore be considering ways to tackle the challenge of preventing the consequences of the dry building syndrome. The contents of this brochure can be used as the basis for a forward-looking dialogue between all stakeholders with responsibility for ensuring good health in the workplace.

Dr. med. Walter Hugentobler

MD, Internal and Family Medicine, Switzerland

"The latest scientific research findings confirm what's been suspected for decades: cold or flu viruses and many bacteria that are spread by coughing are stopped dead by the human comfort zone of 50 % relative humidity. If we maintain humidity at an optimum value, we can therefore now prevent most outbreaks of colds and influenza, while simultaneously improving the well-being and productivity of our staff."

1



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Better health and increased productivity

The German Fraunhofer Institute for Industrial Engineering (IAO) examined the importance and impact of air humidity in the office environment in a two-year study. The results show that problems and symptoms of dry air are experienced very differently by office workers in offices with and without humidification.

Mitja Jurecic

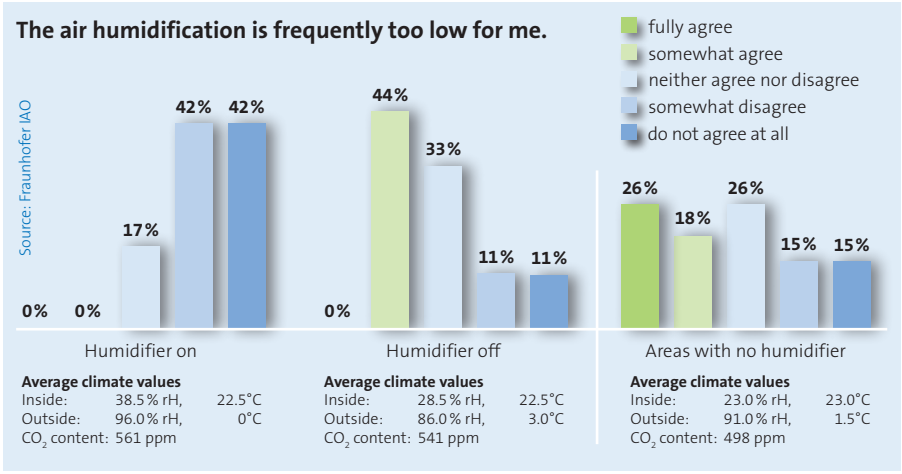
Project Manager, Fraunhofer "Office 21" Joint Research Project

"The use of specialised humidification systems has a positive effect on the evaluation of the workplace and can have an equally positive effect on the health and productivity of office workers."

The study, which was carried out in a department within the IAO, used three direct room humidification units to ensure a constant minimum humidity of around 40 % relative humidity. The survey of the office users took place over several months, during which the humidifiers were turned on and off periodically. The results of the survey were compared with other building areas where no additional humidification was used.

Low humidity is distressing

Analysis of data from the various scenarios revealed major differences in the personal perception of humidity (see diagram). With active air humidification, air humidity was never at any point felt to be too low. Where air humidification was inactive or not present, over 40 % of office users considered the air to be too dry and uncomfortable. Increasing air humidity affects office users in a positive way and gives a feeling of greater satisfaction in the work environment. In addition, over 50 % of respondents described the room climate as being very refreshing.



Dry mucous membranes

The results of the study also confirm the effect of dry air on the subjective perception of the respiratory mucous membranes: 54 % of employees in offices without air humidification agree with the statement that their airways are frequently felt to "dry out" at work. In workplaces provided with air humidification, such complaints about dry airways can be reduced by more than a third – to about 35 %.

4

5

1 Air is essential to life

2 Modern buildings are often too dry

3 Humidifiers protect our health

4 Fraunhofer Institute (Stuttgart, Germany)

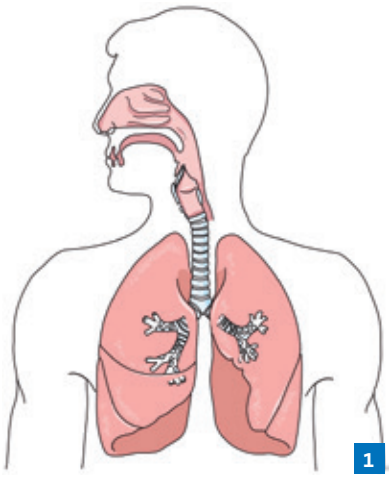
5 Direct room humidifiers at the Fraunhofer Institute

VIRUS SURVIVAL

DRY AND WET AEROSOLS

Viruses survive longer in dry air

In any enclosed space where numerous people spend a lot of their time, there's an increased risk that we will become infected with a cold or flu virus. If a sick person breathes, speaks, coughs or sneezes, thousands of infectious droplets spread through the air in a great many shapes and sizes. Research shows that virus survival rates rise sharply as indoor air starts to become increasingly dry.



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In room air, these exhaled droplets come together to form an aerosol – i.e. a mixture of solid and liquid airborne particles, gases and water vapour. Depending on their size and weight, these droplets can persist for hours in room air and spread throughout the building via the air-conditioning system.

Deactivated by optimal humidity

Aerosols expelled by sick individuals are loaded with viruses and bacteria, which are embedded in a watery "jacket" of bronchial mucus, saliva and dissolved salts. On leaving our airways, the aerosol droplets – with a moisture saturation of almost 100 % – enter the much drier room air. Here, the droplets shrink almost instantly to around half of their original diameter. Having lost almost 90 % of their weight due to water loss, their salt concentrations are now hugely increased. If the relative humidity in the office is within the optimum range for human wellbeing – namely 40–60 % – the salt concentration rises to a level where most of the viruses cannot survive and become deactivated.[1)] The risk of infection within this optimum range for air humidity is minimal.

Dry air preserved

Things look very different if the relative humidity drops to below 40 %, however. This level of humidity causes the dissolved salts to spontaneously crystallise out, since the aerosols are forced to release even more water to the dry air. Once crystallised out, the salts are no longer harmful to viruses. In fact, the opposite occurs: the viruses are "preserved" and stay active and infectious for longer.[2)] The water-rich, "wet" aerosol now turns into a "dry" aerosol that contains more active viruses than the "wet" aerosol at a higher relative humidity. The risk of infection with cold or flu viruses is much higher in dry room air.[3)]

The time bomb of "dry aerosols"

If these "dry" aerosols are then breathed in, the abundance of moisture in the respiratory tract re-dissolves the crystalline salts by water absorption.[2)] The still-infectious viruses are released onto the mucous membranes of the airways, where they can penetrate into the membranes' cells and cause infection.

[1)], [2)], [3)] See bibliography on page 8

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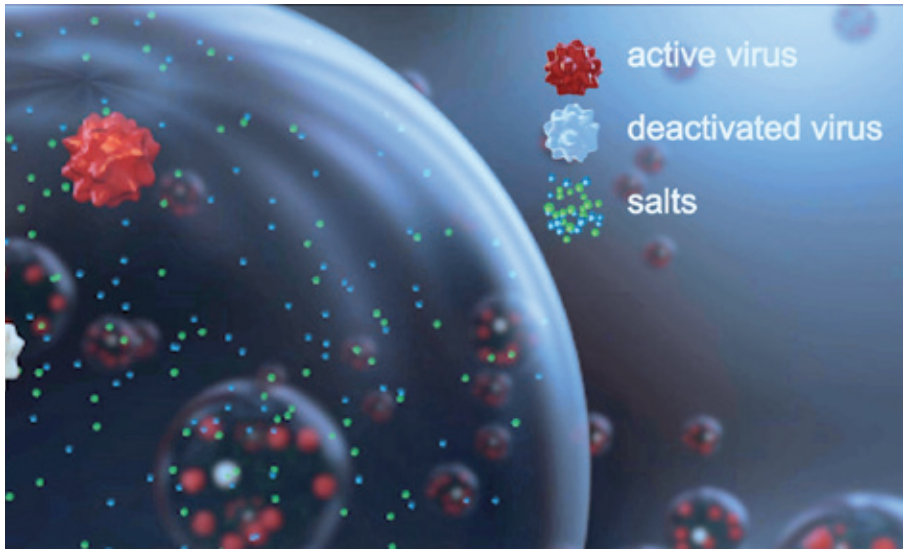
Humidity and health

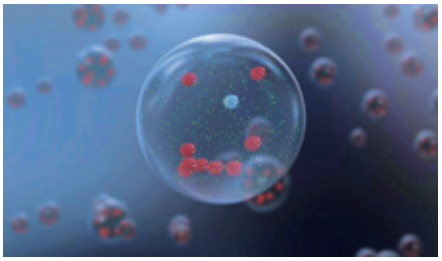
VIRUS SURVIVAL



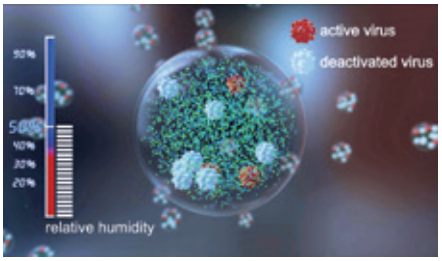
Videos
Air humidification

Check online here:
www.condair.com/
humidity-and-health/viruses

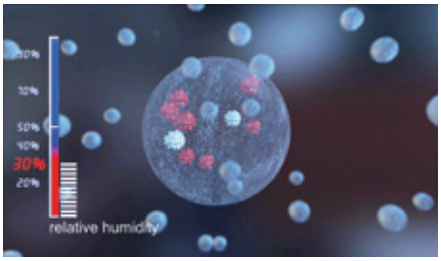
An aerosol
Aerosols expelled by infected individuals are loaded with viruses and bacteria, which are embedded in a watery "jacket" of bronchial mucus, saliva and dissolved salts.



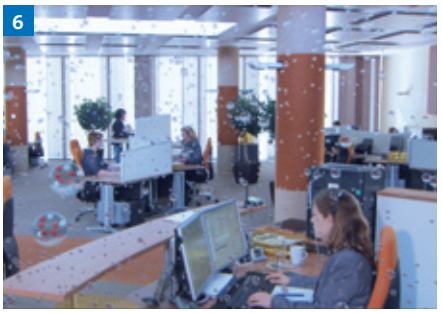
Exhaled aerosols
As they exit the airways, aerosol droplets exhibit water saturation levels of almost one hundred percent and contain many active, infectious viruses.



Wet aerosol (at 50 % relative humidity)
After being exhaled, the aerosols shrink almost instantly, losing around 90 % of their weight due to water loss in the process. Salt concentrations rise sharply, deactivating most of the viruses.



Dry aerosol (at 30 % relative humidity)
At a relative humidity of under 40 %, the dissolved salts rapidly start crystallising out. The viruses are not damaged but are in fact "preserved" by this process of crystallising-out – and they stay active and infectious for longer.



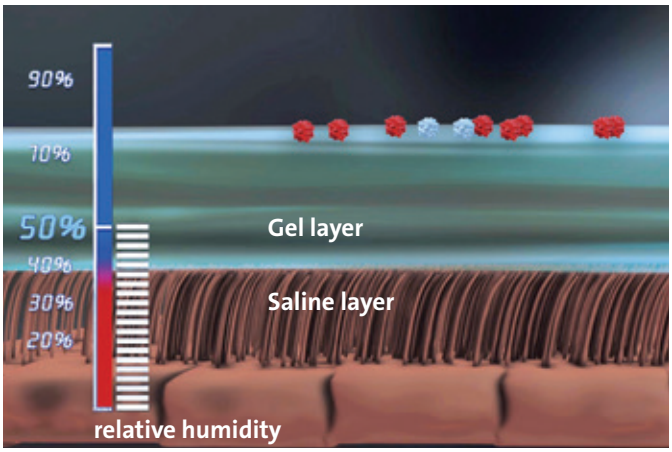
THE MUCOUS MEMBRANE IMMUNE RESPONSE

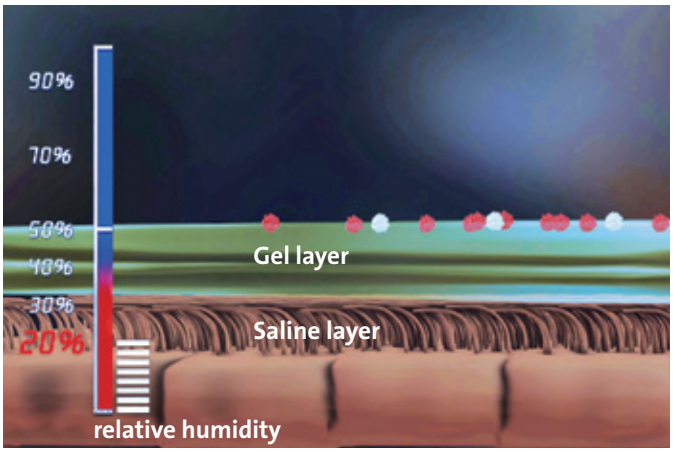
SELF-CLEANING PROCESSES STOP IN DRY AIR

Mucous membranes need humidity

Humans are not entirely defenceless in the face of attacks from viruses and bacteria in the environment. The mucous membranes in our airways protect us from infection by their self-cleaning mechanisms and their immune response. Recent research findings show how the effectiveness of this immune defence system depends on relative humidity.

Check online here:
www.condair.com/humidity-and-health/viruses





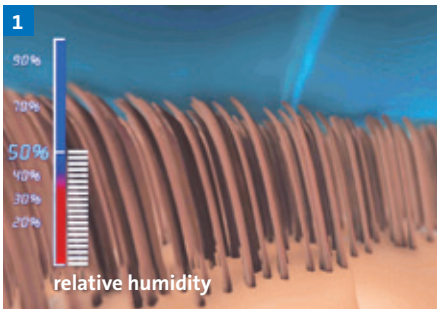
The mucous membranes in the nose and the lower respiratory system feature innumerable tiny hairs (cilia) on their surfaces, which swing in a mobile saline layer like wind-blown grasses. Covering this is a sticky, gel-like mucous layer that can trap viruses, bacteria and airborne pollutants. The rhythmic movement of the tiny cilia continuously transports the mucous to the voice box, where – together with its cargo of pathogens – it can be swallowed or coughed up and thus rendered harmless.[4] This self-cleaning mechanism keeps the person healthy.

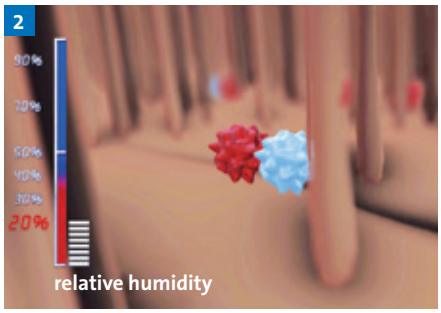
Stops immune defence

As relative humidity drops, however, the saline layer starts to dry out. The volume and thickness of the saline layer is reduced and the cilia become progressively flattened until, ultimately, they can no longer move at all. As a result, the pathogen removal process comes to a stop. Accordingly, viruses now find it easier to penetrate into mucous membrane cells and cause infection.

Maximum self-cleaning

Experiments have shown that the fastest pathogen transportation rate – and thus the lowest risk of infection – is achieved at levels above 45 % relative humidity. As humidity sinks below this value, the cilia find it increasingly harder to move and the risk of infection increases.[4]



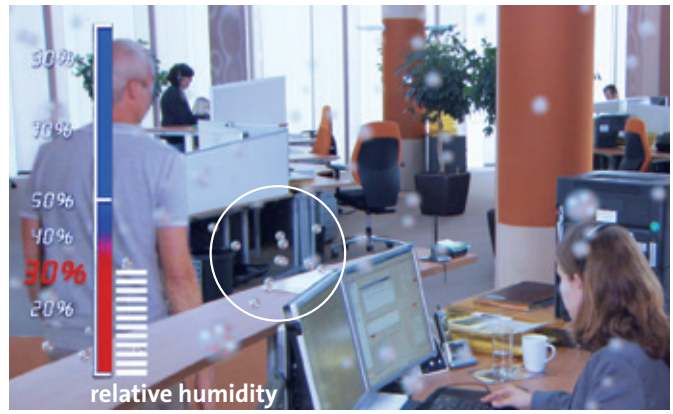


A higher risk of infection

Depending on their size and weight, aerosols carrying a cargo of viruses and bacteria can persist for hours in room air and spread throughout the building via the ventilation system. The risk of infection rises proportionally to the time spent in this environment. Relative humidity directly affects whether aerosols stick strongly to surfaces or are swept up to become resuspended in room air.

Low rate of resuspension with optimal humidity

High rate of resuspension in dry air

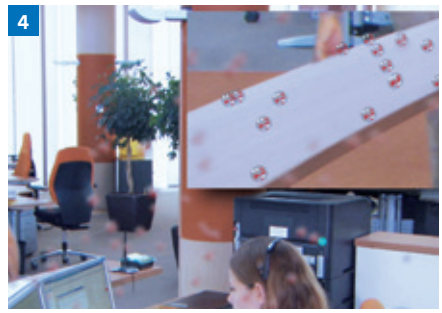


Above a figure of 45 % for relative ambient humidity, infectious aerosols from our airways still contain a lot of water and are thus heavy and "sticky". The time they spend in the air is therefore much shorter, since they become deposited on floors or surfaces. In addition, the bonding forces between their water content and the surfaces mean that "wet" aerosols adhere more strongly, making it harder for them to be swept back into the air.[5] If air humidity is sufficiently high, there is therefore a lower risk of breathing in infectious aerosols.

Dry aerosols stay in the air for longer

If office air humidity is below 40 %, however, "dry" aerosols are created with crystalline salts, which are smaller and lighter than "wet" aerosols. They stay airborne much longer, are less sticky and therefore do not clump together so easily. Air-conditioning units and office activities mean that dry aerosols are rapidly swept off surfaces (e.g. desks, cabinets) back into the air, where they continue to spread.[5] When humidity is low, the risk of becoming infected by viruses – which also stay infectious longer in dry air – is therefore much higher.

[4], [5] See bibliography on page 8



1 Tiny hairs (cilia) on mucous membranes

2 Viruses penetrate the mucous membranes

3 Aerosols can stay in the air for hours

4 Wet aerosols become stuck to surfaces

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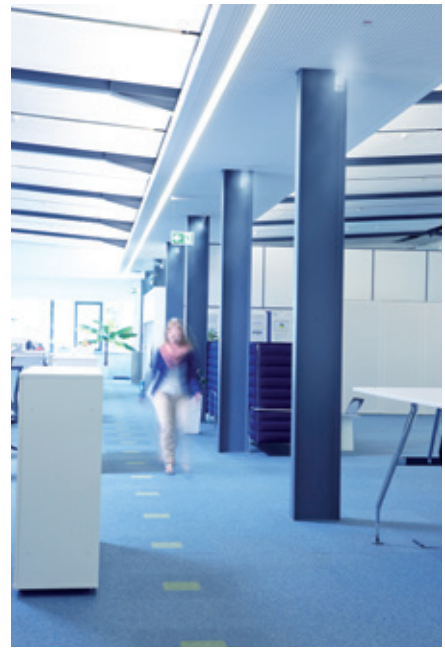
A checklist for companies

Companies can use this checklist as a starting-point to find out whether humidity is adequate in the workplace and whether they need to carry out additional audits or obtain professional advice. **If more than five answers are red/yellow,** then companies should seek independent, non-binding advice on the topic of "humidity and health". This checklist also promotes a useful dialogue between the managing director, the company doctor, the works council, safety specialists, facility management, management staff and employees.

Workplace/department: _____

	Urgent need action	Check regularly	No need for action at this time
1. Are there symptoms due to the indoor climate?	☐ **Yes** • Stinging eyes • Difficulty swallowing • Dry mucous membranes • Hoarseness • Problems with the voice • Skin irritation • Headaches • Other: _____		☐ **No**
2. Are employees often absent due to respiratory infections?	☐ **Yes**	☐ **Unknown**	☐ **No**
3. Does work in company departments involve a lot of spoken communication?	☐ **Yes**	☐ **Unknown**	☐ **No**
4. Have room temperature measurements been conducted over a prolonged period of time?	The resulting average values are … ☐ > 24 °C ☐ 23 °C ☐ 22 °C ☐ 21 °C ☐ 20 °C		
5. Have relative humidity measurements been conducted over a prolonged period of time?	The resulting average values are … ☐ < 30 % RH ☐ 35 % RH ☐ 40 % RH ☐ 45 % RH ☐ 50 % RH		
6. Does the indoor climate form part of the workplace hazard assessment?	☐ **No**	☐ **Unknown**	☐ **Yes**
7. Have you installed a specialised humidification system?	☐ **No**	☐ **Unknown**	☐ **Yes**
8. What method is used for additional room humidification?		☐ Portable, free-standing units ☐ Plants ☐ Indoor fountains ☐ Humidification system (air-conditioning unit) ☐ In-room humidification system	
9. Does the humidification method used achieve the recommended optimal value? (40–50 % RH)?	☐ **No**	☐ **Unknown**	☐ **Yes**
10. Have you already consulted professional advice on humidification systems?	☐ **No**	☐ **Unknown**	☐ **Yes**

HUMIDITY AND HEALTH



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