HEALTHY AIR HUMIDITY

The importance of air humidification in hospitals and in outpatient settings

We Love Humidity
In order to keep this risk of infection low, the ambient air has to be treated. It has to be conditioned in such a way that, in practical terms, pathogens have no chance of survival. Achieving optimal indoor conditions requires the implementation of both the desired temperature along with a relative humidity level of between 40 and 60 percent. Therefore, external air which is sucked in must be humidified or dehumidified in a central air conditioning system regardless of the time of year. Particular attention must be paid to dry ambient air as it favors the survival of viruses and bacteria, and they weaken our immune systems, attack the mucous membranes and leave us with dry skin and eyes.

What is crucial for achieving optimally conditioned ambient conditions, what needs to be kept in mind and what solutions are available? This brochure provides information on these topics and on healthy air humidity and its significance in hospitals and medical facilities.
Hygiene

The aim of hygiene is to maintain or improve the operational capacity and wellbeing of individuals and of society. A main focus is on the prevention of infectious diseases. In this regard, hygiene is setting new challenges on a continuous basis as bacteria becomes more and more resistant.

Hospital hygiene is concerned with the research and prevention and defense against infectious diseases, which are acquired in hospitals, clinics or similar facilities. Thus, it equally serves for the protection of patients and staff and therefore overlaps with occupational health and safety.

The prevention of nosocomial infections in hospitals, is therefore a focal point in hospital hygiene.

In operating theaters and clean rooms in particular, isolation stations, intensive care and delivery rooms, a hygienically flawless ambient air supply is vital.

This is because, when the body’s defenses are weakened, the immune system is particularly susceptible to disease-causing agents. Through the skin and essential breathing, the patient comes in direct contact with the ambient air. Its hygiene is therefore of utmost importance for the maintenance, promotion and fortification of a patient’s health.

Therefore, a mechanical air supply must be provided at all times by means of a HVAC system, thus, external air must be heated, cooled, filtered and humidified or dehumidified and the supply air must be monitored at all times before entry to the room.
Danger of germs through aerosols

Water aerosols like droplets of mist or steam are tiny particles that are capable of floating, their size determines how many microorganisms they can carry. They get into our bodies via the airways, in this regard, we know the interrelationship of size and depth of penetration into our organism.

**Inhalable (0.5 — 18.5 µm)**
- None and throat area: 10 — 5 µm
- Trachea: 5 — 3 µm

**Thoracic aerosols that penetrate through the larynx right into the bronchi**
- Bronchii: 3 — 2 µm
- Bronchioles: 2 — 1 µm

**Alveolar duct aerosols that penetrate into the pulmonary alveoli**
- Alveoli: 1 — 0.1 µm

When coughing and sneezing, disease-causing agents such as flu viruses can be literally shot into a room through such droplets via saliva or mucous at speeds of up to 20 m/s and transferred to other people through inhalation. The ambient air humidity plays a decisive role in the capacity to survive and the floating behavior of the tiniest aerosol particles of these pathogens. But what exactly is the reason for this?

**Germs love dry air**
Dry ambient air with a relative humidity proportion of under 20% allows tiny droplets that are loaded with flu or cold viruses to dry up. They then shrink to sizes of up to 0.5 µm.

At the same time, their salt concentration increases so much that a veritable crust forms around them in the dry atmosphere. Thus, the capacity of the germs to survive indoors and the ability of the droplets to float are maximized. They can survive for up to 41 hours. So if anyone who has a cold coughs into a room which is too dry, this generates a contaminated atmosphere which can last for nearly 2 days.

The result is a high probability of other people present or people who enter the room breathing in these particles. Then it depends solely on their body’s own defenses and on the functioning of their immune system whether or not an infection occurs.

**Moist air kills viruses**
A constant relative air humidity between 40 and 60 percent, prevents droplets from drying out and forming a salt casing. Viruses and germs are thus deprived of the basis for their survival: in a highly-concentrated saline solution they become inactive within a few minutes.

In addition, droplets with diameters of up to 100 µm remain comparatively large. Their ability to float is thus severely limited. They slowly sink to the floor and can then no longer be inhaled. The size also prevents them from penetrating our organism.

**Float duration in the air**
- 0.5 µm: 41 hours
- 1 µm: 11 hours
- 3 µm: 11 hours
- 10 µm: 6 seconds
- 100 µm: 6 seconds

**Aerosolize**
There might be a Serial-Killer in our Hospitals!

Scientific literature and patient experiences are making it clear that despite current infection control practices, at least 5 out of every 100 in-patients will contract a new infection or healthcare associated infection (HAI).

These serious and largely preventable HAIs which threaten patient healing and their very survival, globally kill more people than AIDS, breast cancer and auto accidents combined.

This is a horrible situation! The surgeon and patient safety champion, Dr. Atul Gawande, describes victims of HAIs as, “the easiest 100,000 lives we can save”, because no new cure is needed. Instead, hospitals need systems in place that will help to solve this costly and preventable problem.

As healthcare leaders struggle to balance hospital budgets and patients stagger under the burden of HAIs, we need to ask if there are facility management strategies which we are missing, ones that would alleviate both of these healthcare crises. A better understanding of how indoor conditions influence both the infectivity of microbes and the ability of patients to fight infections will help identify best practices to decrease HAIs.

Hospitalized patients are exposed to infectious HAI microbes from two main sources: people and building reservoirs. A wide array of pathogens carried into the hospital by sick patients, visitors and staff are expelled into the building through common activities such as talking, coughing, vomiting, skin shedding and toilet-flushing. A single sneeze injects approximately 40,000 infectious aerosols into the room air, so clearly the indoor microbial load can become huge. Vulnerable patients are exposed to virulent microbes that have survived the powerful selection pressures from antimicrobial medications, housekeeping disinfectants and indoor building climates. These infectious microbes, often resistant to antibiotics and other antimicrobial medications, rapidly reproduce and spread through the building via transmission modes keenly adapted to the indoor environment, populating the hospital with microbial communities of pathogens. Not surprisingly, hospitals have unwittingly become reservoirs and vectors for ubiquitous HAI pathogens.

Today’s hospital infection control protocols focus largely on hand, instrument and surface hygiene, as well as on cough etiquette and facial masks. While these strategies target the interruption of transmission through contact and short-distance, large-droplet spray, they do not immobilize the tiny, aerosolized droplets which can spread infectious microorganisms over significant distances and for extended periods through the air.

While the magnitude of airborne droplet transmission continues to generate disagreement, epidemiologists do concur that despite robust surface hygiene interventions to control HAIs, the number of recorded cases has increased by 36% in the last 20 years and continues to grow every year.

Until recently, environmental monitoring for infection control has relied on cell-culture tests which only detect microbes which appear to be alive at the time of collection. This is deceiving!
Indoor Environmental Measurements of 10 Patient-Rooms

Room air changes
Temperature
Visitor and Staff traffic (beam breaks)
Absolute and relative humidity
Lighting levels (lux)
Carbon dioxide Levels
Room pressurization
Outdoor air fractions

While suspended in tiny airborne aerosols, infectious microbes are often temporarily in ‘travel mode’, appearing dead and non-infectious when collected during air sampling. But, when re-exposed to hydrated air, people are much healthier! What are the reasons for this?

Human lung physiology demands provision of 100 percent saturated air heated to 98.6 degrees Fahrenheit for their essential function: gas exchange. In the lungs, inhaled oxygen is exchanged for the metabolic waste product carbon dioxide across delicate, one cell membranes of the alveoli. Deep in the lung tissue, fragile alveoli sacs are in close proximity to blood vessels. To prevent infectious particles from settling into the alveoli where pneumonia or systemic blood infections could easily result, physiological barriers trap particulate matter in the upper regions of the respiratory system.

Ambient air moisture is necessary for optimal functioning of this defensive mechanism. Respiratory mucosa from the nose to the small bronchial tubes moistens and heats inhaled air before it reaches the alveoli. When ambient air is dried to RH of 20%, patients lose 60 to 80 grams/hour (1/3 to 2 liters/day) of water. The water loss by airways alone is 300 to 500 milliliters per day.

In addition to drying the upper respiratory tract mucosa and reducing clearance of infectious droplets, the patient struggles to maintain adequate hydration needed for immune cell functioning and wound healing. This needs to be reworded - is not a complete sentence.

Conclusions

The hospital’s physical environment has a significant impact on the health of patients. Unfortunately, too many patients are harmed and hospitals waste money on avoidable HAIs.

The dry air in most hospitals create habitats for microorganisms that are unprecedented in the natural world, and have untold consequences for the selection and transmission of pathogens. By maintaining RH in patient care spaces between 40 to 60%, the transmission and infectivity of airborne pathogens will be reduced, and surface cleaning will be more effective due to less resuspension and redeposition of pathogens. In addition to creating a less infectious environment, indoor air hydration will support patients’ physiologic skin and respiratory tract defenses, immune cell functioning, wound healing and total body fluid balance - all natural defenses against HAIs. Current indoor air guidelines for hospitals do not specify a lower limit RH in patient care areas and are even promoting lowering the minimum acceptable RH level operating rooms from the current 35% down to 20%. This is a mistake! Management of healthcare facilities must focus on the number one priority: patient healing.

To best protect patient health, optimize clinical outcomes and decrease excess healthcare costs, we must maintain the indoor RH between 40 to 60%. This exciting new data on the influence of hospital indoor air on healthcare-associated infections, and consequently, on patient outcomes, gives hospital engineers and building managers new tools to ensure the best possible outcomes for patient healing.

Projected financial impact of room air humidification for a 250-bed hospital. Cost-reduction analysis if healthcare-associated infections were decreased by 20%
Unlike camels in the desert, we are unable to store water for long periods. Therefore, each loss of water must be balanced out on a daily basis through nutrition and the intake of liquids, in illness this can occur by means of infusions if necessary. Otherwise our bodies react with sensitive disruptions. We feel thirsty even at liquid losses of 0.5 percent. At 2 percent, the physical and mental operational capacity is reduced. From 5 percent, our body temperatures increase, and in the event of a loss of water of 10 percent of our body weight, severe symptoms such as blood thickening, confusion or circulatory failure may occur. Through failures of the nervous and circulatory systems, a deficit of over 20 percent leads to death.

Note: We can survive without food for about four weeks depending on fat reserves, but we can only survive without water for a few days. A desert climate significantly accelerates this process. Excessively dry atmospheric air for prolonged periods is similar!

The human body consists of 75% water
Contamination - A dangerous dissemination threat (Photo © Philippe Lejeune)
Hygiene is a top priority in hospitals. Electric steam humidifiers generate an absolutely germ-free atmospheric air humidity, as the water used is heated to temperatures of 100°C, which no germ or disease-causing agent can withstand. For this reason, mineral-free or regular tap water can be used, no special processing is required.

Steam air humidifiers can be integrated into any existing central air conditioning system or, in most cases, retrofitted. They are easy to clean and maintain. For the even injection and distribution of the steam in the air flow, it is especially important to implement the humidification distance correctly.

It is made up of the mist zone and the subsequent expansion and mixing zone. When this is measured properly, the occurrence of condensation inside the air pipes is prevented.

In addition, this prevents water aerosols from reaching the filter. The humidification distance is also important for correct humidity control, since control sensors should only be installed where there are balanced humidity values. Due to the quick and homogeneous mixing with the system supply air, in the case of extensive steam injection, significant reductions of the humidification distance are also achieved.

Air humidification with steam
Reduction of operating costs with indirect evaporative cooling

Indirect evaporative cooling, also known as adiabatic cooling, is a process in which latent and sensible evaporative heat from water can be used to cool supply air in a hospital’s HVAC system. To do this, the water is firstly evaporated on the exhaust air side of a HVAC system using an evaporative cooler. Heat energy is removed from exhaust air in the process, thus, it cools down. Then the exhaust air is conducted close to the warm external air in the crossflow, without coming in contact with it. From a hygiene point of view, this solution is absolutely harmless, which is very important for hospitals or other medical areas. Through heat recovery from the external air, the added moisture in the exhaust air condenses once again, therefore heating the exhaust air and cooling the supply air at the same time.

Apart from the speed at which air passes through the evaporative cooler, the evaporated water quantity and hence the attained cooling depend on the condition of the output air which enters the evaporative cooler. The theoretical limit of evaporative cooling is reached upon complete saturation of the exhaust air with water, i.e. at a relative humidity of 100 percent. Humidity increases up to values between 92 and 95 percent are realistic in air conditioning systems at economically viable cost, depending on the design of the evaporative cooler used. As mentioned previously, indirect evaporative cooling is suitable for the sensitive cooling of the supply air. Depending on the location, on especially hot days or for redundancy reasons, if additional cooling energy is required, a mechanical cooling system can also be used – but this can be a much smaller size. In a suitable system design, much more electrical driving energy for a cooling system is saved by indirect evaporative cooling than is needed to overcome the additional air-side pressure loss through the extractor fan.

The question of cost-effectiveness

In practical terms, the greatest hurdle when using renewable energy is cost-effectiveness. Efficiency measures such as indirect evaporative cooling have to “pay”, additional costs incurred during the investments must be absorbed again through the savings achieved during operation.

A reliable system simulation therefore makes the relationships transparent and allows a realistic comparison with conventional measures for cooling buildings. Since HVAC systems in hospitals work to condition the air all year round and have to meet the highest possible standards for hygiene reasons and for the preservation of health, it has to be taken into account that in many cases a depreciation will set in within an acceptable time frame. From the operating cost viewpoint, the system thus proves economical right from the first day.
Air humidification technologies

**GS Steam Humidifier**
Condair GS units enable high-efficiency humidification with gas. The exhaust gas can be discharged directly through HVAC exhaust air. Exhaust gas heat is mostly recovered through heat recovery in the HVAC unit. And it’s easy to add these units to existing systems.

**EL Steam Humidifier**
These products are the first choice whenever simple but reliable steam/air humidification is required. Users of such installations look for simple and easy operation, and demand healthy, hygienically humidified breathing air.

**RS Steam Humidifier**
Similar to the Condair EL, the Condair RS also features a variety of unique design features that enable operational safety with the highest precision and control accuracy. The RS also boasts patented lime scale management which prevents permanent deposition of lime scale on heater rods. A long useful life and extremely short maintenance times are thus guaranteed.

**ME Evaporative Cooler**
Evaporative cooling enables a significant reduction of the operational costs for building cooling, because energy-efficient evaporative cooling allows for smaller cooling batteries to be used or for them to be dispensed with altogether.

**OptiSorp Steam Distributor**
The OptiSorp multiple steam distribution system ensures a homogeneous, even distribution of steam and thus optimal, hygienic sorption of the steam in the air.

**ESCO Pressurized Steam Distributor**
Hospitals often require a pressurized steam network for various applications in the lab or the sterilized area and in many cases this is already present. An ESCO Pressurized Steam Distributor means this steam can be made available for air humidification, making a separate steam generator on the HVAC system unnecessary.

**RAV Pressurized Steam Generators**
The Condair RAV series conforms to Pressure Equipment Directive (PED) 97/23/EC of 05/29/2002 and is therefore not subject to monitoring or approval. Whenever steam is needed quickly in exactly the right quality, Condair RAV steam generators are always the right choice.