

White paper

Humidity control in indoor environments:

Implications for health, comfort, and product integrity



Executive summary



Indoor air quality plays a pivotal role in shaping our health, comfort, and overall well-being. Among the various factors that contribute to a healthy indoor environment, relative humidity emerges as a critical parameter that often goes underestimated. The level of moisture in the air, commonly referred to as relative humidity (RH), has profound effects on human health, material performance and how electronics function.

Humidity control impacts diverse indoor environments. From residential spaces to industrial facilities, maintaining optimal humidity levels is essential

for fostering a healthy atmosphere. There are various methods employed to regulate humidity, from evaporative (adiabatic) to steam (isothermal) humidification. There are also specific applications of humidity control in different settings, such as homes, offices, industrial processes, and specialized environments like healthcare facilities, libraries, and museums.

Humidity control is not merely a luxury but a necessity for promoting health, preserving materials, and ensuring optimal functioning of equipment in indoor environments.

Relationship between temperature and humidity

For reference the following definitions have been adopted in this document:

- Absolute Humidity (AH) – Alternatively called the Humidity Ratio or Specific Humidity is the moisture content in gr/kg (dry air)
- Relative Humidity (RH) – The ratio (in %) between the actual quantity of water vapor in the air and the maximum quantity of water vapor that the air can contain at a certain temperature. At 100% RH, air is saturated and can hold no additional moisture. Condensation will then occur if the temperature is reduced

AH is a useful measure for converting RH levels between environments at different temperatures, such as indoor and outdoor conditions. If there are no additional sources of moisture or humidity in an indoor environment with outdoor ventilation, then changes in outdoor RH will influence indoor RH levels.

The relationship between temperature and humidity is demonstrated in the following illustration. In all three cases, the Absolute Humidity is constant, since the amount of water is six gr/kg (dry air) and air weight is one kg.

As temperature increases the air volume expands, and so the relationship between the Relative Humidity and the occupied space changes.

When calculating indoor humidity levels, we need to take into account the prevailing outdoor levels of RH and AH. If we assume that outdoor air is admitted into an empty indoor space and heated with no significant moisture loads present (e.g. no moisture is introduced from ingress, building materials, combustion or occupants), then we can establish a direct relationship between indoor and outdoor humidity levels at different temperatures.

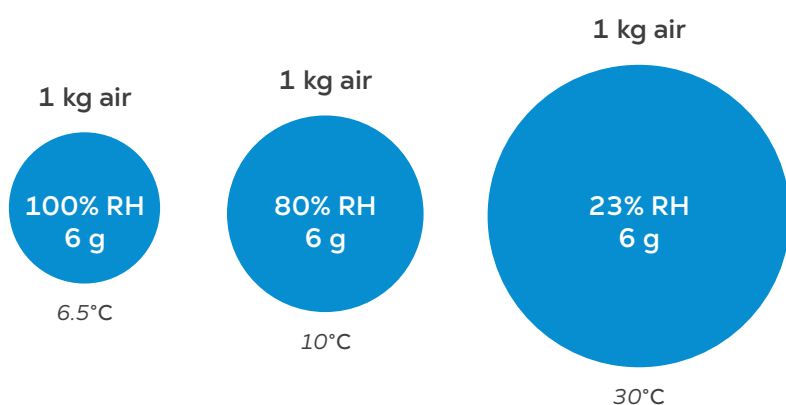


Figure 1: Visual representation of the relationship between air mass, temperature, AH and RH%

To demonstrate this, the table below shows indoor humidity levels that would occur in an indoor space described in the paragraph above, based on the outdoor levels reported in London on 12th–13th March 2020.

Based upon the outdoor conditions shown in Table 1, at an indoor temperature of 20°C the indoor RH% level varies between 24 to 31% RH. If the indoor temperature increases to 24°C, the indoor RH% level varies between 19 to 24% RH.

By using a psychrometric chart, we can easily visualise the effect on RH% levels when altering air temperature at specific AH levels. By using the measurement value in Table 1 for AH at 09:00 on March 12th (4 g/kg), the connection between RH levels at 4 and 20°C becomes apparent.

Time	9:00	12:00	15:00	18:00	21:00	00:00	03:00	06:00	9:00
Outdoor temp (C)	8°	9°	9°	7°	7°	6°	7°	6°	8°
Outdoor RH%	60	49	52	67	68	77	70	73	62
Air pressure (hPa)	1,011	1,011	1,010	1,011	1,011	1,013	1,014	1,016	1,017
Outdoor AH (g/kg)	4.00	3.50	3.71	4.18	4.24	4.47	4.35	4.23	4.11
Indoor RH% @ 20°C	28	24	26	29	29	31	30	30	28
Indoor RH% @ 24°C	22	19	20	23	23	24	24	23	22

Table 1: Climate conditions for London, UK on 12th–13th March 2020. Source: Met Office, UK

Psychrometric chart

101.32 kPa

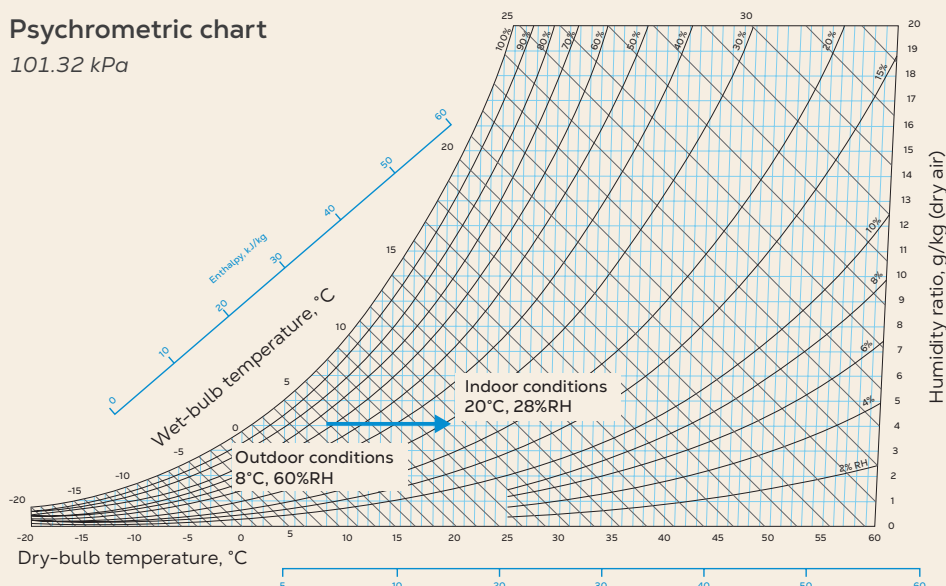


Figure 2: Psychrometric chart showing 8 and 20°C RH% conditions along the AH 4 g/kg line.



Importance of Relative Humidity:

- *Human comfort and health:* RH influences how the human body perceives temperature. At higher humidity levels, the body's ability to dissipate heat through perspiration is hindered, leading to a feeling of discomfort. Conversely, low humidity can result in dry skin, irritated eyes, and respiratory discomfort. Maintaining an optimal RH level contributes to a comfortable and healthy indoor environment.
- *Respiratory health:* Dry indoor air can exacerbate respiratory conditions, such as allergies, asthma, and cold symptoms. Inadequate humidity levels can dry out the mucous membranes in the respiratory tract, making individuals more susceptible to infections and allergies.
- *Viral transmission:* Research suggests that indoor environments with proper humidity levels may play a role in mitigating the spread of viruses. While humidity alone cannot prevent virus transmission, maintaining an appropriate range (around 40-60% RH) may help reduce the viability and transmission of certain viruses.

Effects of too high or too low humidity:

- *High humidity:* Excessive humidity can create a breeding ground for mold, mildew, and dust mites, triggering allergies and respiratory issues. It can also compromise building materials, leading to decay, peeling paint, and structural damage.
- *Low humidity:* In environments with low humidity, moisture is drawn from surfaces and living organisms, including the human body. This can lead to dry skin, irritated eyes, and increased susceptibility to infections. Low humidity can also cause materials like wood, textiles, and paper to become brittle and crack.

Health and well-being

General well-being:

Humidity levels significantly impact skin health and general well-being. Low humidity can cause skin dryness, itching, and discomfort. Adequate humidity helps maintain the skin's natural moisture balance, promoting overall comfort. Furthermore, properly humidified indoor spaces can alleviate symptoms related to dry eyes and nasal passages, enhancing the overall quality of life.

Respiratory health and humidity:

A well-maintained indoor humidity environment plays a vital role in supporting respiratory health. Dry air can irritate the respiratory tract, potentially worsening conditions like asthma and allergies. Mucous membranes in the respiratory system require a certain level of moisture to function optimally, ensuring that they effectively trap and expel airborne particles, allergens, and pathogens.

Occupational illnesses and humidity-related risks:

Occupational settings that expose workers to low humidity conditions can lead to a range of health issues. Dry air can cause dry eyes, throat irritation, and skin discomfort among workers. Additionally, workers in environments with inadequate humidity levels may experience a higher frequency of respiratory infections due to compromised mucous membranes.

Influence of humidity on viral transmission:

Viruses that cause respiratory illnesses, like the flu and coronaviruses, are mainly spread through tiny viral particles released when people cough, sneeze, talk, or even breathe. These particles come in various sizes: large droplets (>50 μm) fall quickly to the ground, particles in the 10–50 μm range settle in a few minutes, and small particles (<10 μm) can float in the air for hours and get deep into our lungs or land on surfaces.

The time these particles stay in the air depends on airflow and humidity. For instance, when indoor humidity is around 45–50%, the infectivity of flu particles drops significantly. Humidity also affects coronaviruses but studying them presents inherent risks and personnel must work under biosafety level 3 laboratory containment conditions. But the use of surrogate coronaviruses, such as TGEV and MHV, has the potential to overcome these challenges and expand the available data on coronavirus survival on surfaces.

At lower humidity (20%) and higher humidity (80%), these surrogate coronaviruses survived better than at moderate humidity (50%). Warmer temperatures also helped inactivate them faster than cooler ones.

It is possible to reduce the transmission and longevity of harmful viruses by controlling indoor RH levels. This can be done by using humidity control solutions which facilitate precise RH control for indoor environments. This humidity control is useful at all times, but particularly in typical 'flu season,' where outdoor temperatures and Absolute Humidity tend to be lower.

Research referenced in this document suggests that maintaining an indoor RH% between 40 to 50% yields the maximum protective effect from aerosolized and settled virus particles. By maintaining these levels, it is possible to contribute to a healthier, safer environment.

Energy and environmental considerations

Humidity plays a pivotal role in how we perceive temperature. Even though the dry-bulb temperature remains constant, higher humidity levels can make the air feel warmer due to reduced evaporation from the skin. Conversely, lower humidity levels can lead to the perception of cooler air. This phenomenon has significant implications for thermal comfort and can impact energy consumption in heating and cooling systems.

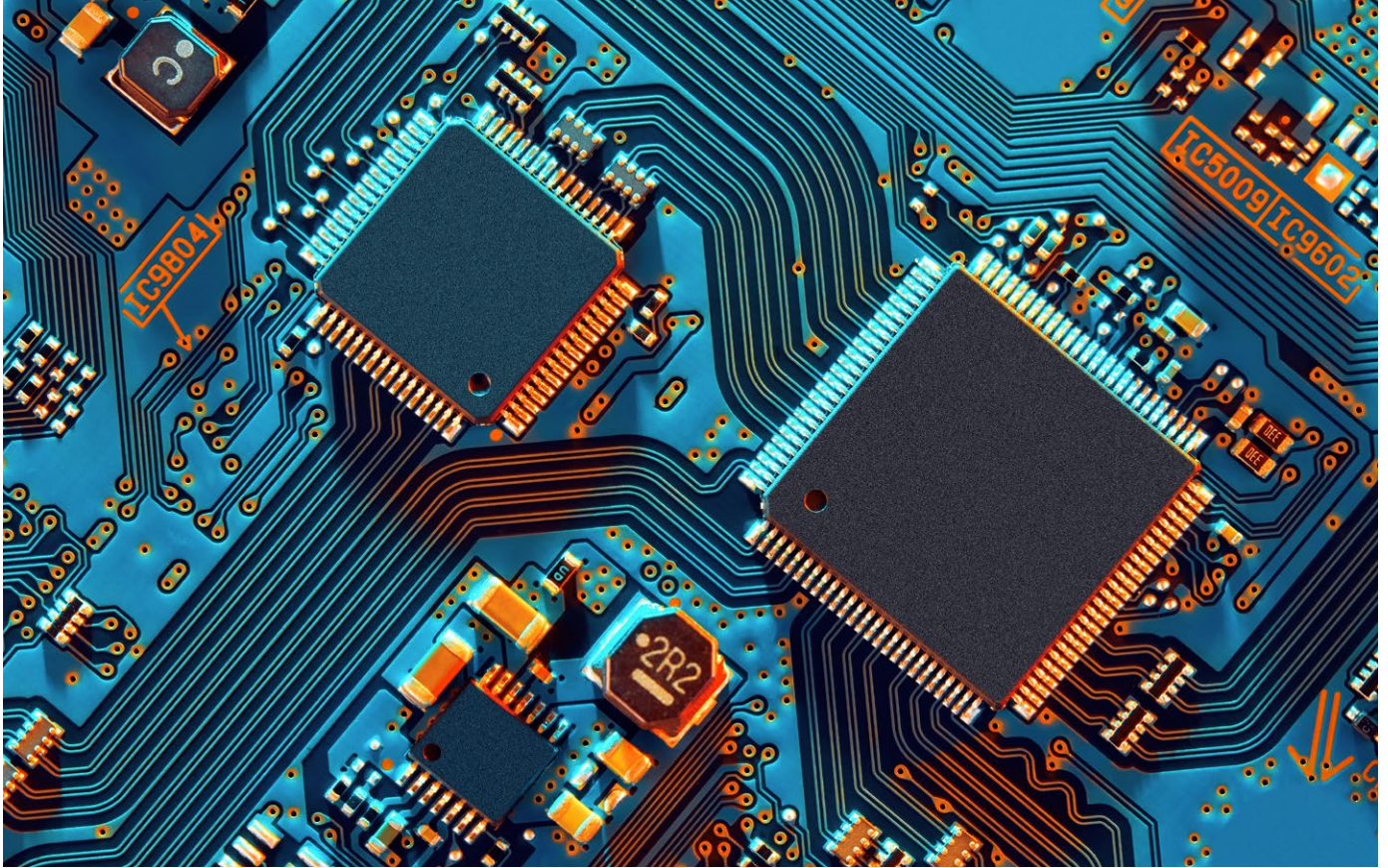
Efficient humidity control can contribute to energy savings. By optimizing humidity levels, HVAC systems can operate more effectively and consume less energy. In colder climates, maintaining proper

humidity levels can reduce the need for higher heating temperatures. While in warmer climates effective humidity control can help occupants feel comfortable at slightly higher temperatures, thereby reducing air conditioning demands.

Furthermore, proper humidity regulation can result in improved well-being and reduced sick leave. Maintaining optimal indoor humidity levels can prevent the proliferation of mold, bacteria, and viruses that thrive in excessively damp or dry environments. This can lead to a healthier indoor environment, reducing the risk of respiratory illnesses and allergies among occupants



Humidity's impact on materials



Humidity significantly influences various materials and electronic systems. Static electricity generation is a well-known consequence of dry conditions. When humidity is low, materials like plastics, paper, hair, and textiles tend to generate static electricity through friction. This can lead to uncomfortable shocks, but it also poses risks to electronic components and sensitive equipment.

Materials used in construction are also deeply affected by humidity levels. Wood, textiles, and building materials like concrete are all hygroscopic, meaning they can absorb, and release moisture based on the surrounding humidity.

Improper humidity levels can lead to warping, cracking, and even structural damage. Therefore, maintaining optimal humidity is critical to preserving material integrity and longevity.

Electronics are highly sensitive to humidity as well. High humidity can lead to condensation on electronic components, potentially causing short circuits and corrosion. Conversely, very low humidity can result in the buildup of static electricity, which poses a risk of damaging sensitive electronic circuits. Controlling humidity in data centers and electronics manufacturing facilities is essential to ensure reliable performance and prevent costly failures.



Humidification methods

Several methods are employed to control humidity levels in various settings:

→ Evaporative (adiabatic) humidification and cooling systems use a process that adds water molecules to the air to increase relative humidity and lower the temperature. Depending on your application, increased humidity or a lower temperature are the desired outcomes. Evaporative humidifiers are commonly used in air handling units, data centers, and larger facilities with cooling needs.

→ Steam (isothermal) humidification systems raise humidity levels to restore optimal indoor climate. Using boiling water to produce the steam, these ultra-hygienic systems are free from harmful substances. This method is versatile and suitable for various scales and control systems, commonly used in industries and commercial premises.

These humidification methods find applications in various contexts, from household humidification and office spaces to industrial processes, plantations, and greenhouses. Selecting the appropriate method depends on factors such as the size of the area, required humidity levels, energy efficiency considerations, and specific environmental conditions.

Humidity control in indoor environments

Humidity control varies across different indoor environments, each with its unique considerations and requirements:

- Office spaces and commercial premises: Humidification in office environments is typically not standardized. Some landlords incorporate humidity control into climate systems, while others leave it up to employees to arrange for standalone humidifiers. As we spend considerable time in these spaces, ensuring optimal humidity can enhance comfort, productivity, and overall well-being.
- Industrial applications and manufacturing processes: Industries often have specific humidity requirements to ensure product quality, equipment performance, and safety. From preventing wood warping in the construction sector to maintaining the freshness of food in storage facilities, humidity control is integral to many manufacturing processes.
- Server rooms and data centers: Data centers house vast quantities of electronics and require precise humidity control. Maintaining humidity levels between 40% and 65% RH is crucial to prevent static discharges and ensure the reliability of sensitive components. Evaporative humidification can be particularly valuable in these environments, even during colder seasons.
- Household humidification: In households, humidification is often managed through standalone devices like electric steam humidifiers or open water containers. Many individuals use these methods to alleviate discomfort caused by dry air, but there's room for awareness and improvement. Integrating humidification systems into HVAC setups could ensure consistent and optimal humidity levels throughout homes.

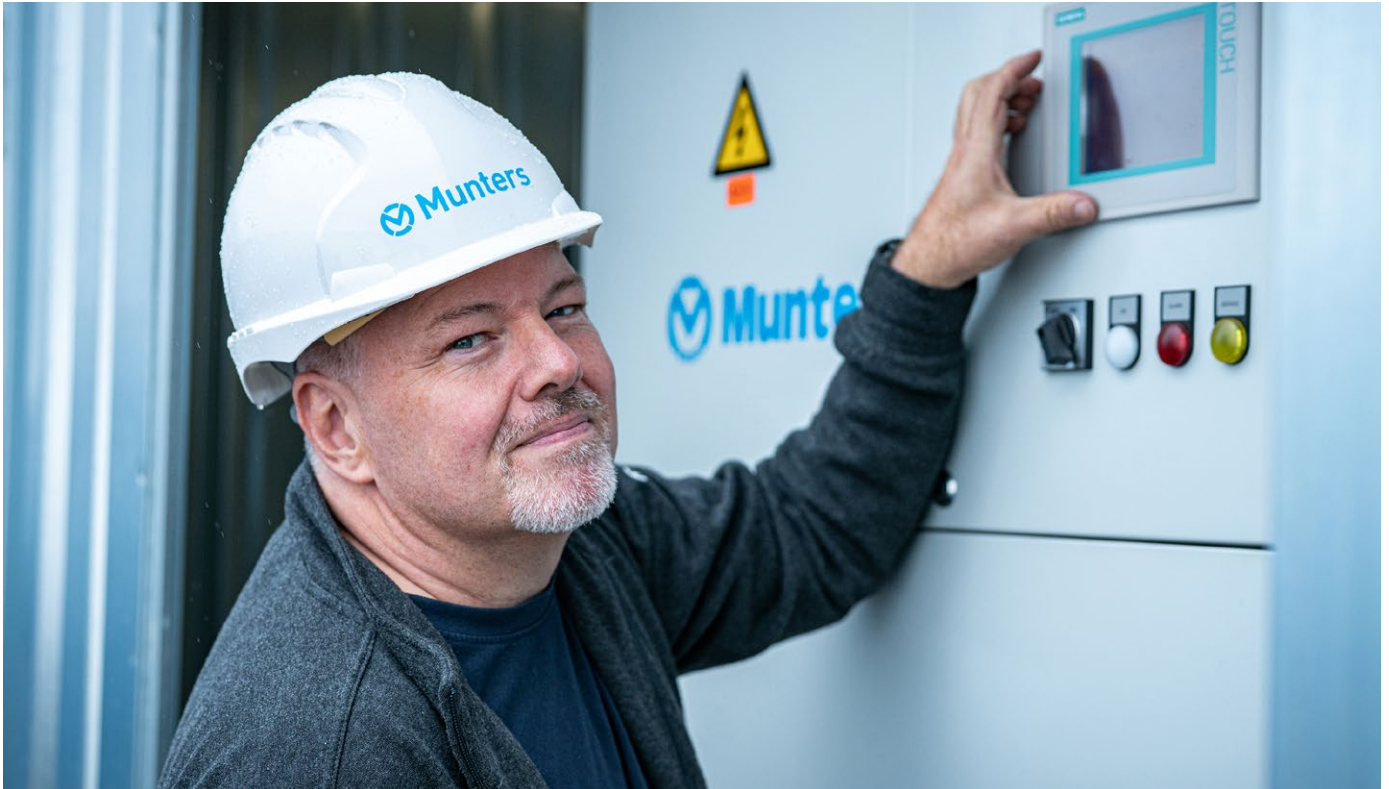




Humidity control in specialized environments

Humidity control takes on a new dimension in specialized environments with distinct needs:

- Health care facilities: Hospitals and healthcare centers prioritize air quality due to sensitive patients and surgical procedures. Optimal humidity levels (25-50% RH) contribute to patient well-being and infection prevention. Maintaining these levels requires specialized systems to ensure optimal care and recovery environments.
- Libraries and archives: Libraries and archives house valuable materials vulnerable to humidity fluctuations. Precise control (12-18°C and 30-40% RH) preserves the integrity of books, documents, and other artifacts. Proper climate control prevents mold, degradation, and other forms of damage that can compromise the longevity of historical collections.
- Museums and artifact preservation: Museums play a critical role in safeguarding cultural heritage. Humidity control (20-22°C and 40-60% RH) is vital for protecting paintings, sculptures, textiles, and other artifacts. This practice prevents degradation, cracking, and fading, ensuring the preservation of art for generations to come.
- Food production and storage: The food industry relies on optimal humidity levels to maintain product quality and safety. From preventing spoilage in cold storage to ensuring consistent production conditions, controlling humidity (40-95% RH) is essential to preserve food quality and extend shelf life.



Conclusion

Humidity control plays a multifaceted role across diverse environments, impacting everything from comfort and health to product quality and historical preservation. The significance of maintaining optimal humidity levels cannot be overstated. By raising awareness and implementing effective humidity control strategies, we can create more comfortable, productive, and sustainable environments for individuals and industries alike.

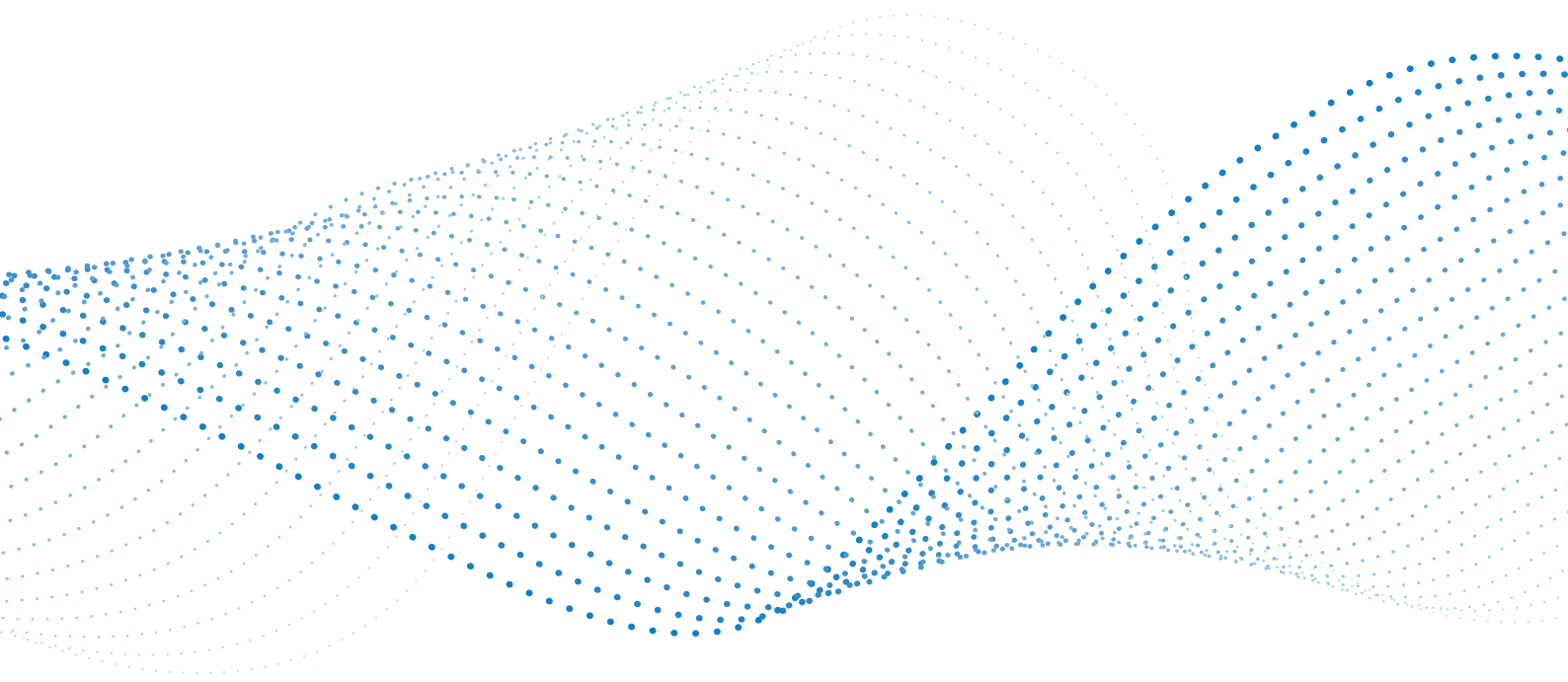
As we move forward, future trends and innovations in humidity control will likely focus on enhanced energy efficiency, integration with smart building technologies, and the development of eco-friendly solutions. By embracing these advancements, we can continue to improve indoor environments, bolstering well-being and efficiency for generations to come.

About Munters

Munters has more than 60 years of experience in humidity control, with scalable solutions for all types of industrial, commercial and public service environments. We offer consultation, engineering support, installation and life cycle management for our flexible range of products, with a global presence that keeps us close to our customers.

The right climate to change the future

Munters is a global leader in energy-efficient and sustainable air treatment solutions. Using innovative technologies, Munters creates the perfect climate for demanding industrial applications and agriculture sectors. Munters has been defining the future of air treatment since its founding in 1955, and has been listed on Nasdaq Stockholm since 2017.



Munters is a global leader in energy-efficient air treatment and climate solutions. Using innovative technologies, Munters creates the perfect climate for customers in a wide range of industries.

Munters has been defining the future of air treatment since 1955. Today, around 4,000 employees carry out manufacturing and sales in more than 30 countries.

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