DANTHERMGROUP

White paper
Industrial dehumidification

Dehumidification in practice:
understanding, comparing and specifying the right solution

Dantherm Group
Climate control specialists with over ***60 years*** of industrial expertise

Contents

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1. Why humidity matters

Managing humidity is one of the most important and most overlooked aspects of maintaining a healthy, functional building. Mould, corrosion, hygiene failures, equipment damage, and regulatory non-compliance are all direct consequences of uncontrolled moisture. Each one is measurable in operational cost and business continuity risk.

This document is intended for facility managers and decision-makers who need to understand how dehumidification works, what distinguishes the two principal technologies, and how to apply a structured methodology to select the right solution for their specific context. It also covers the European F-gas regulation — an increasingly important factor for anyone planning or replacing refrigerant-based equipment.

The consequences of excess humidity

An ideal indoor climate depends on two interdependent factors: temperature and relative humidity (RH). Beyond the accepted comfort range of 40–60% RH, the consequences extend well beyond discomfort:

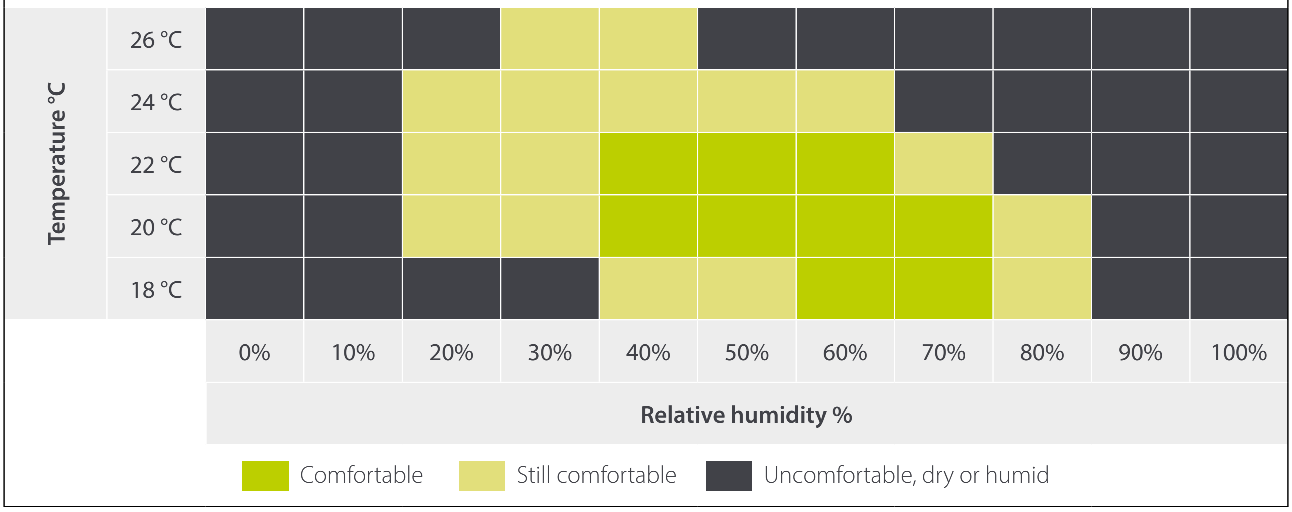
- Mould growth begins at RH levels above 70%
- Metal corrosion can begin at RH levels as low as 60% or even lower in special cases, such as gold-plated materials (45%) or in combination with sea salt
- In food and pharmaceutical environments, where chilled conditions are common, it is essential to monitor the dew point, as condensation poses both hygiene and compliance risks.
- Structural materials, like timber, plasterboard, and insulation, absorb moisture and degrade progressively

Health and safety for workers

There is no specific EU regulation on humidity levels for workplaces, but in many countries national standards exist, and employers are generally required to ensure minimum health and safety standards for workers according to the Directive 89/391/EEC, the so-called occupational safety and health (OSH) Framework Directive. This would naturally include safe humidity levels as mould growth in buildings can lead to health problems such as respiratory issues and allergies. Mould thrives in damp environments and spreads through spores.

Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor recommends humidity control in the range of 20%-60%.

COMFORT CHART (according to Leusden and Freymark)



Key principle

Warm air can hold more moisture than cold air. As temperature drops, the same absolute quantity of water vapour represents a higher relative humidity, and the risk of condensation increases accordingly. An unheated storage building in winter may show dangerously high RH even if it feels dry. Effective dehumidification means controlling relative humidity, not simply removing a fixed quantity of water.

The physics of humidity: absolute vs. relative

Air has a finite capacity to hold water vapour. The maximum amount it can hold at any given temperature is known as the saturation point, or dew point. The actual water vapour content expressed as a proportion of that maximum is the relative humidity (RH). Consider this practical example:

Given that the humidity ratio (g/kg of dry air) stays constant as air is heated (with no moisture added or removed), the air expands and the absolute humidity (g/m^3) decreases slightly. Air containing 5.4 g/m^3 of water at 5 °C has a relative humidity of approximately 80%, which is sufficient to promote mould growth and corrosion under suitable conditions. After heating the same air to 25 °C, its absolute humidity decreases to about 5.0 g/m^3 because the same amount of water vapour occupies a larger volume. The relative humidity falls to approximately 22–23%, which is generally too low to support mould growth. The amount of water vapour per kilogram of dry air is unchanged; only the air temperature and volume have changed.

This distinction is fundamental. Damage from moisture — mould, rot, rust — is driven exclusively by relative humidity, not by the absolute quantity of water in the air. It should also be noted that heating a space will lower its relative humidity; however, the water vapour present may still condense on cold surfaces such as pipework or uninsulated areas. It is therefore essential to understand the dew-point temperature in relation to surface temperatures. Dehumidification tackles the root cause directly.

2. Condensation vs. desiccant dehumidification

There are two principal technologies used in professional dehumidification: condensation (refrigerant-based) dehumidifiers and desiccant (adsorption-based) dehumidifiers. Each operates on different physical principles, and each is better suited to particular applications and environments. Choosing the wrong technology, even though the unit is correctly sized, can result in inadequate performance, excessive operating costs, or repeated failures.

2.1 Condensation dehumidifiers

Condensation dehumidifiers — also called refrigerant or compressor dehumidifiers — operate on the same thermodynamic principle as a domestic refrigerator. It draws moist room air across a cold evaporator coil, chilling the air below its dew point. The moisture condenses into liquid droplets, which drain into a collection container or via a continuous drain connection. The now-dry air is then passed across the warm condenser coil, re-heated slightly, and returned to the room.

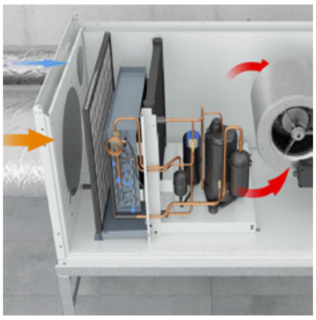
This technology offers excellent energy efficiency and dehumidification performance at moderate temperatures (roughly 15–35 °C), making it the dominant choice for commercial and light industrial environments that are heated or semi-heated.

Defrost systems

At low ambient temperatures, the evaporator coil can reach sub-zero temperatures, causing ice to form and progressively restricting airflow across the coil. Left unmanaged, this ice build-up would eventually stop the dehumidifier working altogether. All commercial condensation dehumidifiers therefore include a defrost mechanism. But defrosting itself is a trade-off, not a free fix.

During any defrost cycle, airflow is temporarily reduced and active dehumidification pauses. As the accumulated ice melts, the moisture it contains is released back into the airstream, meaning a dehumidifier briefly returns some humidity to the room before resuming normal operation. This is a normal and unavoidable part of the defrost process, but it means that overall dehumidification capacity degrades as ambient temperatures fall — the colder the environment, the more frequently and for longer the unit must defrost, and the greater the impact on net performance. The type of defrost mechanism fitted determines how significant this impact is, and therefore how suitable a unit is for colder environments.

- **Air circulation defrost:** the compressor switches off and warm room air is used to melt the ice naturally. This is simple and effective where ambient temperatures remain consistently above approximately 15 °C. Below this threshold, defrost periods become disproportionately long relative to running time, and dehumidification capacity will be reduced to the point where the unit can no longer keep pace with moisture loads.
- **Hot gas defrost:** hot refrigerant gas is redirected directly to the evaporator via an internal valve, clearing ice in minutes rather than via passive air warming. Because defrost cycles are short, airflow disruption and moisture release back into the room are minimised, and overall capacity is much better preserved. This enables the dehumidifier to operate in temperatures below 15 °C.



The inside of a condensation dehumidifier showing from left to right: Inlet air, including optional fresh-air inlet, via ducts, filter, evaporator coil (cold coil), expansion valve, condenser, compressor, and supply fan.

Selection guideline

If the space will consistently remain above 15–18 °C, an air circulation defrost model is cost-effective and efficient. For environments below 15 °C, or those subject to seasonal cold, specify a hot-gas defrost unit. At temperatures above approximately 18 °C, both systems deliver comparable performance. For ambient temperatures below 10 °C, you should in any case specify a desiccant dehumidifier.

2.2 Desiccant dehumidifiers

Desiccant dehumidifiers use a different mechanism entirely. Rather than chilling air to condense moisture, they pass it through a slowly rotating wheel impregnated with a hygroscopic material (typically silica gel) that adsorbs water vapour from the process airstream. A separate regeneration airstream, heated to high temperature, then drives the captured moisture out of the desiccant wheel and exhausts it via a duct to the outside.

This approach delivers several distinct advantages over refrigerant technology:

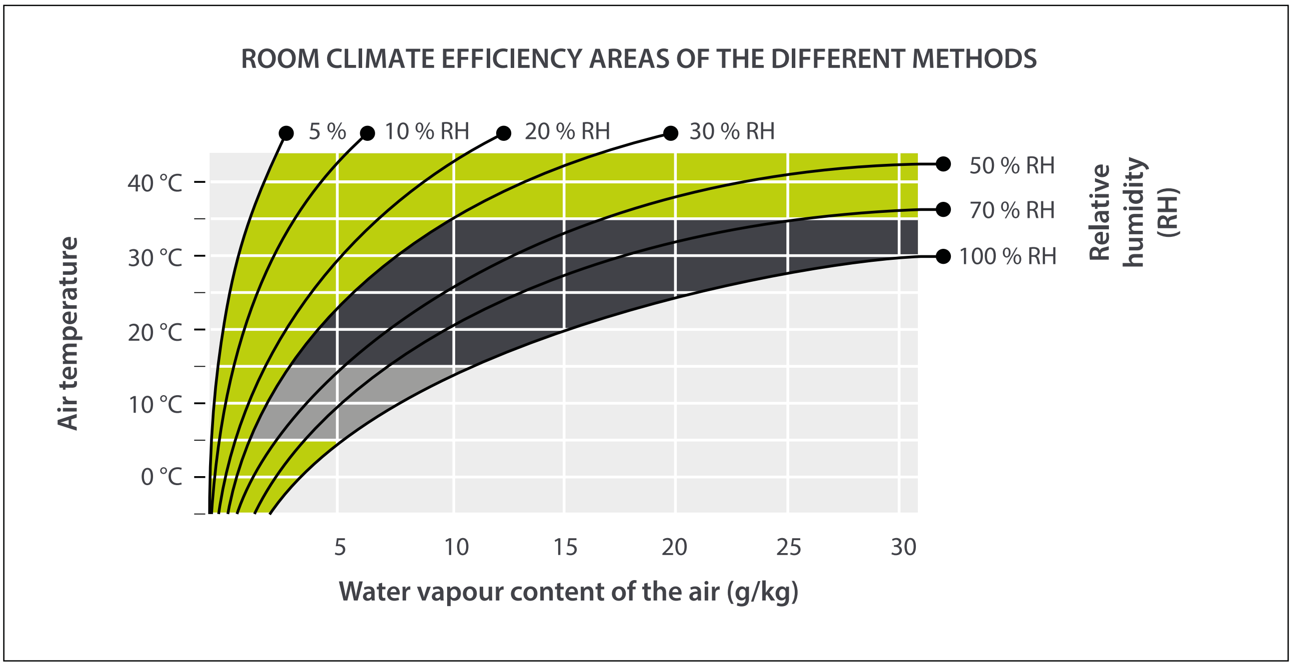
- Effective operation at sub-zero temperatures – performance is not adversely affected by cold ambient conditions
- Ability to achieve extremely low dew points, well below those achievable by refrigerant systems
- No condensate collection – moisture is expelled as warm vapour via a ducted exhaust (Some desiccant dehumidifiers use air-cooled condensers to liquefy the water vapour, allowing the resulting water to be drained away)
- Consistent output because the desiccant technology is much less dependent on the air temperature than condensing dehumidifiers

Important note for planners: industrial desiccant dehumidifiers discharge moisture as warm water vapour. They require ducted connections to atmosphere and do not incorporate internal condensate tanks. Installation plans must account for the regeneration air exhaust path.

A TTR 13500 desiccant dehumidifier with a view to the rotating desiccant wheel.

2.3 Comparison table

Factor	Condensation	Desiccant
Operating temperature	15-35 °C	-20-40 °C
Low-temperature performance	Reduced below 15 °C; icing risk	Excellent; no icing
Minimum achievable RH	40% RH	<10% RH possible
Energy efficiency	High at moderate temperatures	Lower; regeneration heating required
Condensate handling	Internal tank or gravity drain	Ducted vapour exhaust required
Typical applications	Warehouses, pools, commercial buildings, construction	Cold stores, pharma, food processing, chemical industry, unheated storage



Desiccant technology works in a wide temperature area, especially when the target condition has a lower dew-point temperature (10-15 °C or lower)

Condensation dehumidifiers with air circulation/hot gas defrosting

Condensation dehumidifiers with hot gas defrosting theoretically work below 15 °C, although at low capacity. Desiccant dehumidifiers would in this temperature area be a better choice.

3. EU F-gas regulation: implications for condensation dehumidifiers

The landscape for condensation dehumidifier technology is being fundamentally reshaped by European environmental legislation. Understanding this regulatory change is important for anyone planning a new installation, specifying replacement equipment, or managing the long-term lifecycle of an existing dehumidification system.

3.1 The regulatory framework

Regulation (EU) 2024/573, which entered into force in March 2024, replaces the previous F-gas Regulation (EU) No 517/2014. Its overarching objective is to reduce fluorinated greenhouse gas (F-gas) emissions by approximately 98% compared to 2015 levels by 2050. It operates through two mechanisms: a progressive phase-down of total HFC volumes available on the EU market, and sector-specific placement bans on equipment using refrigerants with high global warming potential (GWP).

3.2 Key milestones

Date	Regulatory measure
March 2024	Regulation (EU) 2024/573 enters into force, replacing Regulation 517/2014.
2025	Restrictions on refrigerants with GWP > 750 apply to new equipment categories.
2027–2030	Progressive and significant reduction in HFC quotas available on the EU market.
2050	Target horizon for near-total elimination of synthetic HFCs. Natural refrigerants become the norm.

3.3 Why R407C is affected

R407C is the most widely used refrigerant in commercial dehumidifiers today. Its global warming potential (GWP) is 1,774, which means one kilogram released into the atmosphere has the same warming impact as 1,774 kilograms of CO_2. The F-gas regulation is designed to eliminate precisely this class of emission.

Natural refrigerants — propane (R290), ammonia (R717), and carbon dioxide (R744) — carry negligible or zero GWP, but each has practical constraints that limit their universal adoption: propane is highly flammable, ammonia is toxic at concentrations above a few hundred parts per million, and carbon dioxide requires operating pressures up to 150 bar, far above the 15–25 bar typical of HFC systems.

3.4 The transition to R454C

Given these practical constraints, a transition from R407C to the also synthetic refrigerant R454C is underway.

R454C has, though, a modest reduction in thermodynamic efficiency at elevated temperatures and is also mildly flammable, without material impact for the majority of applications. R454C has a GWP of 148, more than 90% lower than R407C, and is therefore fully compliant with Regulation (EU) 2024/573 and viable for the foreseeable future.

However, existing equipment charged with R407C may continue operating as long as it remains functional. But because R407C has a GWP above 750, virgin R407C would no longer be permitted for servicing after 2032. Only reclaimed or recycled R407C can still be used. In effect, an R407C unit purchased in 2026 can likely operate for decades.

4. Case studies

The following case studies illustrate the breadth of environments in which professional dehumidification plays a critical operational role. Each presents a distinct challenge and demonstrates how the choice of technology was driven by the specific demands of the application.

Wine production and cellar storage

Valpolicella, Italy

Challenge	Solution and results
The Valpolicella region is one of the world's most celebrated wine-producing areas, where a centuries-old tradition involves part-drying harvested grapes on ventilated wooden grids before pressing. During this multi-month drying process, controlled humidity is critical: too much moisture causes rot; too little desiccates the grapes prematurely. Underground cellars and stone-walled caves, with limited ventilation and fluctuating temperatures, made stable humidity control through heating alone impossible.	Condensation dehumidifiers were selected for their ability to maintain continuous, automated airflow control in sealed environments with limited ventilation. The technology provided consistent, precise moisture management across both production and storage stages, preserving the quality characteristics of the wine. *Read the full case study >*

Pharmaceutical cleanroom

Insud Pharma, Spain

Challenge	Solution and results
Insud Pharma, a global pharmaceutical manufacturer, requires stringent environmental control in its Spanish production facilities. Clean rooms with HEPA H14 filtration must maintain 18 °C at just 3% RH to meet FDA and EMA standards — an absolute humidity of 0.38 g/kg. The challenge was compounded by high airflow volumes of 11,000 m^3/h and significant pressure drops across laminar airflow filtration systems.	Desiccant adsorption technology was the only viable choice: refrigerant systems cannot reach dew points this low. High-efficiency EC fans with automatic pressure compensation maintained constant airflow despite increasing filter resistance. Steam reactivation reduced electrical consumption. The pharmaceutical regulatory environment demands continuous, auditable control. Desiccant technology delivered it. *Read the full case study >*

Water damage restoration

Devon Hills Holiday Park, UK

Challenge

A major fire in September 2022 destroyed approximately 50% of the roof of an 800-square-metre, two-storey leisure complex. Firefighting operations caused extensive water ingress throughout both floors. Restoration commenced in winter conditions, with cold ambient temperatures slowing moisture evaporation and the substantial scale of the site compounding the challenge.

Solution and results

High-capacity industrial desiccant dehumidifiers were deployed, which was the only appropriate choice given winter operating temperatures where condensation technology would have been unable to perform effectively. The desiccant units extracted moisture continuously through the colder months, preventing mould growth and structural deterioration.

Read the full case study >

Food production hygiene control

MareDeus Food Solutions, Spain

Challenge

MareDeus is a leading packaged fish producer whose facilities are cleaned after each shift using high-pressure steam, saturating the environment with moisture. HACCP regulations require the prevention of condensation on surfaces in food production areas. Standard condensation equipment proved insufficient, resulting in dense fog and condensation throughout the production chain.

Solution and results

Desiccant adsorption technology delivered 492 kg of moisture removal per 24 hours with an airflow of 4,300 m^3/h, operating to −20 °C. Following installation, MareDeus recorded: complete elimination of fog and surface condensation; reduced defrost cycles on refrigeration equipment; improved hygiene scores; and measurable productivity gains.

Read the full case study >

5. Other use cases and applications

Due to the exceptional capabilities of desiccant technology, it is employed across a range of specialised industries, including food production, pharmaceuticals, electronics, defence, utilities, chemicals, automotive manufacturing, and preservation.

Food industry

The food industry faces numerous humidity-related challenges that require careful management, such as:

- Hygiene safeguards to minimise microbiological contamination and ensure compliance with food safety regulations:
  - Preventing condensation and ice formation below freezing point
  - Inhibiting mould and mildew growth
- Climate and weather independence to guarantee:
  - Consistent product quality
  - Optimal production output
  - Efficient drying times
  - Extended shelf life
- Minimising downtime, for example after cleaning or during defrosting

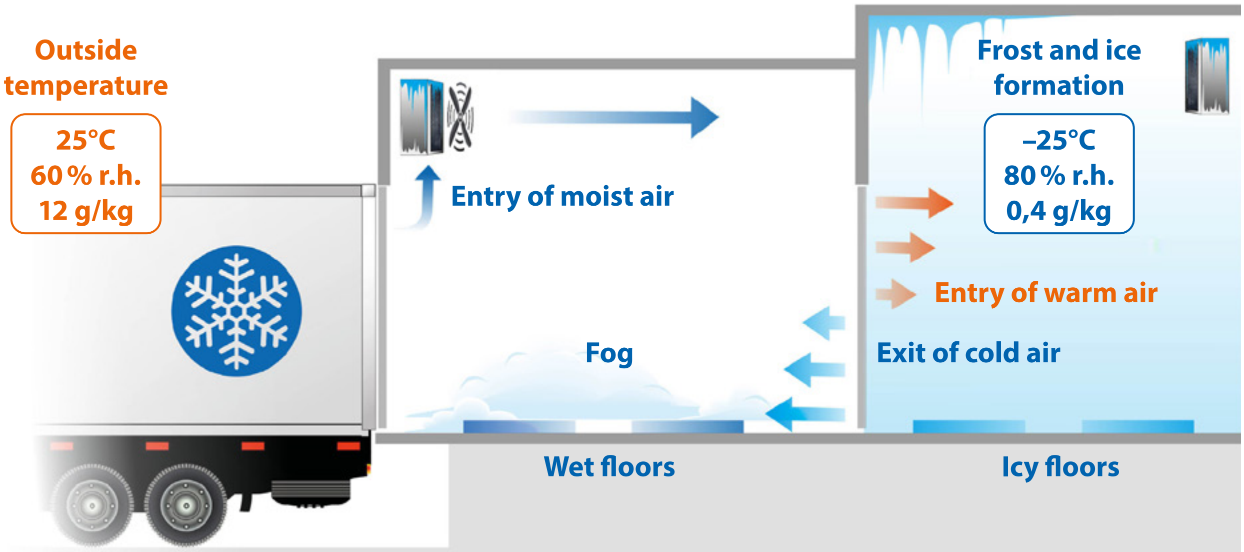
Coating

A relevant example for both the food and pharmaceutical sectors is the coating of chocolates or tablets with sugar or artificial sweeteners. This is a layer-by-layer drying process where dehumidification accelerates water evaporation after each coat, allowing the next liquid sugar layer to be applied more quickly. This not only increases production capacity but also ensures uniformity and hardness in the final product, reducing incidents of sticky coatings. The desiccant method enables this drying process to occur at the lowest possible temperature.

Cold storage

At the loading bays of cold storage facilities, warm, moist air can enter the warehouse, causing frost and ice formation, while cold air escaping can create mist and wet floors outside. In the loading bay, condensation may drip onto the products. Inside the cold store, accumulated ice may fall onto the products and the floor, and frost may build up on the evaporator. A dehumidifier in the loading bay can effectively:

- Prevent fog and condensation
- Avoid wet and slippery floors
- Reduce moisture inflow into the freezing area, thereby preventing ice build-up



Pharmaceutical industry

In the pharmaceutical sector, dehumidification also supports:

- GMP compliance
- Maintaining consistent conditions year-round
- Ensuring precise dosing
- Optimising granulation
- Facilitating smooth powder flow
- Preventing machine clogging, reducing the need for cleaning and shutdowns
- Increasing productivity
- Minimising waste
- Maintaining hygienic conditions with reduced micro-organism growth

Precise humidity control is particularly critical during the production of gelatine capsules and the packaging of tablets. Controlled humidity helps maintain sterile air and extends product shelf life.

Other industries

In defence facilities, humidity control is essential to prevent the degradation of materials and ammunition.

In wind turbines and bridge elements, desiccant dehumidification ensures a protected internal climate, independent of external temperatures, to prevent corrosion.

For laminated glass production, the hygroscopic Polyvinyl Butyral (PVB) film between the panes must not absorb moisture. During PVB processing, the temperature must be maintained between 18°C and 23°C, with relative humidity at 23–28% and PVB water content at 0.4–0.6%.

Archiving paper documents, photographs, cellulose films, microfilms, and ancient parchment requires absolutely stable temperature and humidity levels.

Water utilities require humidity control to manage condensation issues when warm outside air meets cold pipes. Left unmanaged, this can lead to corrosion and eventually pipe bursts. The dew-point temperature on the surface is therefore essential.

The Trotec pyrometer dew-point scanner, BP25, measures air temperature, humidity, surface temperature (range: -50 °C to +260 °C) and dew-point temperature (range: -30 °C to +100 °C).

Across these applications, the common requirement is precise, stable control of humidity, often within narrow tolerances and independent of temperature swings. By decoupling latent load (moisture) from sensible load (temperature), desiccant dehumidification delivers the required stability: consistent relative humidity regardless of external conditions, protecting sensitive materials, structures, and processes where even small fluctuations risk degradation, corrosion, or product failure.

6. Guide to assessing a dehumidifier solution

Selecting the appropriate dehumidification technology and unit capacity requires a structured assessment of the application environment. The following four steps summarise the key considerations and map them to the principal product categories available.

Step 1 — Define the operating environment and the operational challenge

Before selecting a dehumidification technology, it is essential to understand not only the environmental conditions of the site, but also the underlying operational challenge driving the need for humidity control.

In many projects, excessive humidity is the root cause of wider operational, quality, compliance or productivity issues. A clear understanding of these issues is critical to selecting the right technology, sizing the equipment correctly and defining realistic humidity targets.

Making a sustainable assessment typically includes the following questions:

- What products, materials or processes must be protected?
- Is humidity causing mould growth, corrosion or condensation?
- Are there hygiene, HACCP, FDA or GMP compliance requirements?
- Is moisture affecting product quality, shelf life or packaging integrity?
- Are there operational issues such as equipment downtime, maintenance costs (e.g., malfunctions), frost, slippery floors or employee discomfort?
- Is the objective to preserve assets, improve production stability or accelerate drying after water damage?
- Is the environment continuously occupied, temperature-controlled or exposed to outdoor air infiltration?

Only once the operational challenge has been clearly identified should the environmental conditions be evaluated.

The single most important environmental variable is the ambient temperature range in which the dehumidifier will operate. This determines which technology is appropriate before any other consideration.

Step 2 — Assess humidity requirements

Not all applications require the same target humidity level:

- 40–60% RH: standard comfort and material protection (commercial buildings, warehouses, leisure facilities)
- 30–40% RH: enhanced conservation (archives, museums, electronics manufacturing)
- < 20% RH or very low dew point: pharmaceutical, chemical, cold storage — desiccant technology only

Sometimes air humidity is not the only data point you need. Surface temperature and dew-point temperature can be just as critical.

Step 3 — Consider moisture load and airflow

Dehumidification capacity must be matched to the moisture load in the space. Undersizing a unit results in persistent high humidity; oversizing increases capital and running costs unnecessarily. Key factors include:

- The volume of the space (m^3)
- The number of occupants or processes generating moisture
- The frequency and intensity of moisture-generating activities (steam cleaning, wet processes, product storage)
- The rate of air exchange with the outside, for example due to door openings

Step 4 — Pay attention to condensate management

This consideration is often overlooked in specification and creates installation constraints later:

- Condensation dehumidifiers produce liquid condensate. Allow for a gravity drain to a suitable drain point, or plan for manual emptying of a collection tank.
- Desiccant dehumidifiers exhaust moisture as warm vapour via a duct connection. The regeneration air exhaust path must be incorporated in the installation design from the outset.
- Some desiccant dehumidifiers are equipped with an air-cooled condenser, which creates water instead of exhausting humid air. A practical solution if you want the desiccant capacity but not the ductwork.

Dantherm Group has over 60 years of experience designing and manufacturing climate solutions for residential, industrial and commercial applications. Our portfolio includes condensation and adsorption-based systems used in construction, water damage restoration, swimming pools, and large-scale industrial environments worldwide.

Contact Dantherm Group if you need assistance with assessing and sizing drying solutions.

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05-2026

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