PREVENT ICE FORMATION

Air dehumidification to prevent condensate
and ice formation in cold stores

Air humidification, dehumidification
and evaporative cooling

condair

The problem with excessively humid air in cold stores

When storing food, such as meat and sausage meat and sausage products, dairy products, pasta and frozen foods, an optimal ratio between the appropriate room temperature and air humidity is top priority in ensuring lasting high product quality. Room conditions that deviate from the ideal conditions even just for a short period of time can often cause considerable damage.

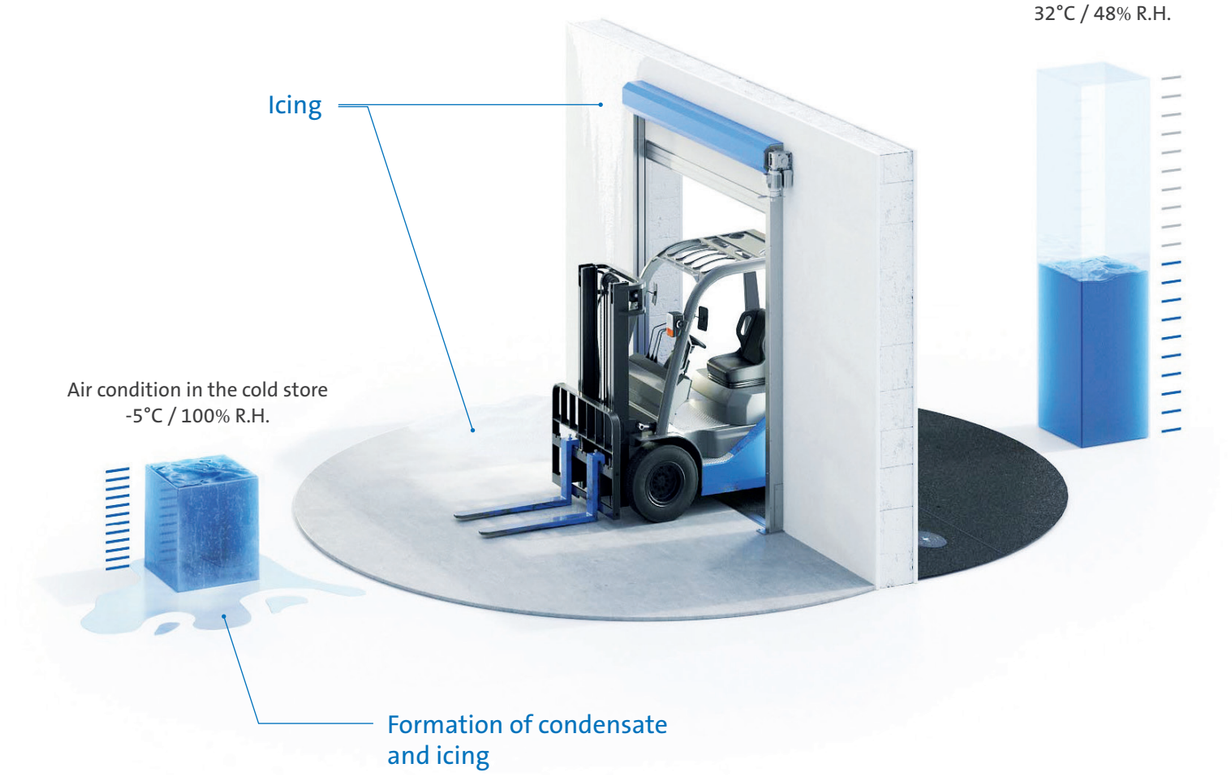
Regulating the air humidity poses a particular challenge here. It is unavoidable that warm and humid air flows into the warehouse, for example when goods are being brought in or taken out, or that products newly deposited in the warehouse release moisture into the air. For many operators, removing this moisture permanently and safely is a permanent problem, especially at storage temperatures of often far below 0°C. When water condenses out of the air, it precipitates as liquid or, in frozen storage, as ice on floors, walls and goods. This causes damage to the products and endangers operational safety, as people may slip and injure themselves or forklifts may slip on slippery ice.

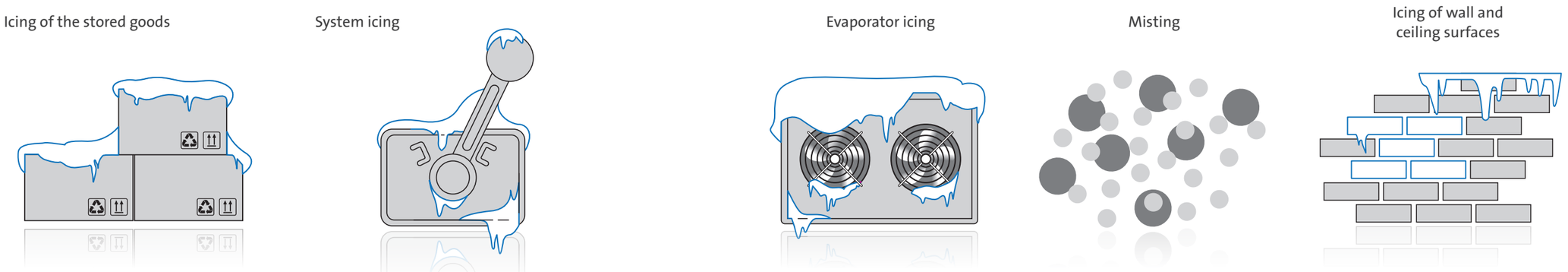
Recirculating air coolers which draw air from the warehouse and cool it in a heat exchanger before blowing it back into the storage area dehumidify the air only slightly.

With this dehumidification method, temperatures below freezing point quickly lead to icing of the cooler and to the necessity of a de-icing phase, during which neither cooling nor dehumidification are possible. In addition, the cooler must be set to very low operating temperatures (about 5 to 7 K below room temperature) to ensure any dehumidification at all at the very cold room temperatures. This is very energy-intensive and cost-intensive.

This brochure describes and recommends the use of an adsorption dryer in addition to conventional air cooling. An adsorption dryer dries the air permanently in a very efficient and economical manner.
It helps avoid the aforementioned problems from the outset.

One highlight is the **DA 500-4000 Freezer** adsorption dryer, which, thanks to its 100 mm thick, thermal bridge-free housing insulation, can also be installed outside and therefore does not take up valuable storage space.





Some thermodynamics: How dehumidification works

In thermodynamics, the enthalpy (h), temperature (t) and humidity (x) variables are inseparably interrelated. These variables are represented in a “h,x diagram”. Enthalpy h corresponds to the total heat content of the air, consisting of the air temperature and the water vapor present in the air. In the case of humidity, a distinction is made between absolute humidity x (g of water vapor in the air per kg of air) and relative humidity φ. The relative humidity indicates to what percentage the air is saturated. If the task now is to dehumidify the air for a process or to ensure specified target room air conditions, this results in challenges such as the following.

Cold storage A:
Room temperature -15°C, humidity x = 0.9 g/kg,
Density ρ = 1.37 kg/m³

Outdoor air in summer: +34°C, 42% R.H., x = 14 g/kg,
Density ρ = 1.15 kg/m³

Outside air in winter: 0°C, 80% R.H., x = 3 g/kg,
Density ρ = 1.29 kg/m³

Height x width of the opening: 2.5 m • 2 m

Opening time: 10 minutes per h

Assumption:
As a result of items being brought in and out (opening of doors and gates), outside air enters the cold storage and mixes with the room air. The amount of water that enters the cold storage depends on the air conditions and the resulting difference in density between the outside air and the cold store, the size of the opening, how long it is open, and the measures taken to protect against moisture ingress, such as an air curtain system.

Without an air curtain system, the above specifications result in a calculated infiltration of 1,251 m³/h of outside air into the cold storage in summer. By operating an air curtain system with 80% efficiency, this is reduced to 250 m³/h.

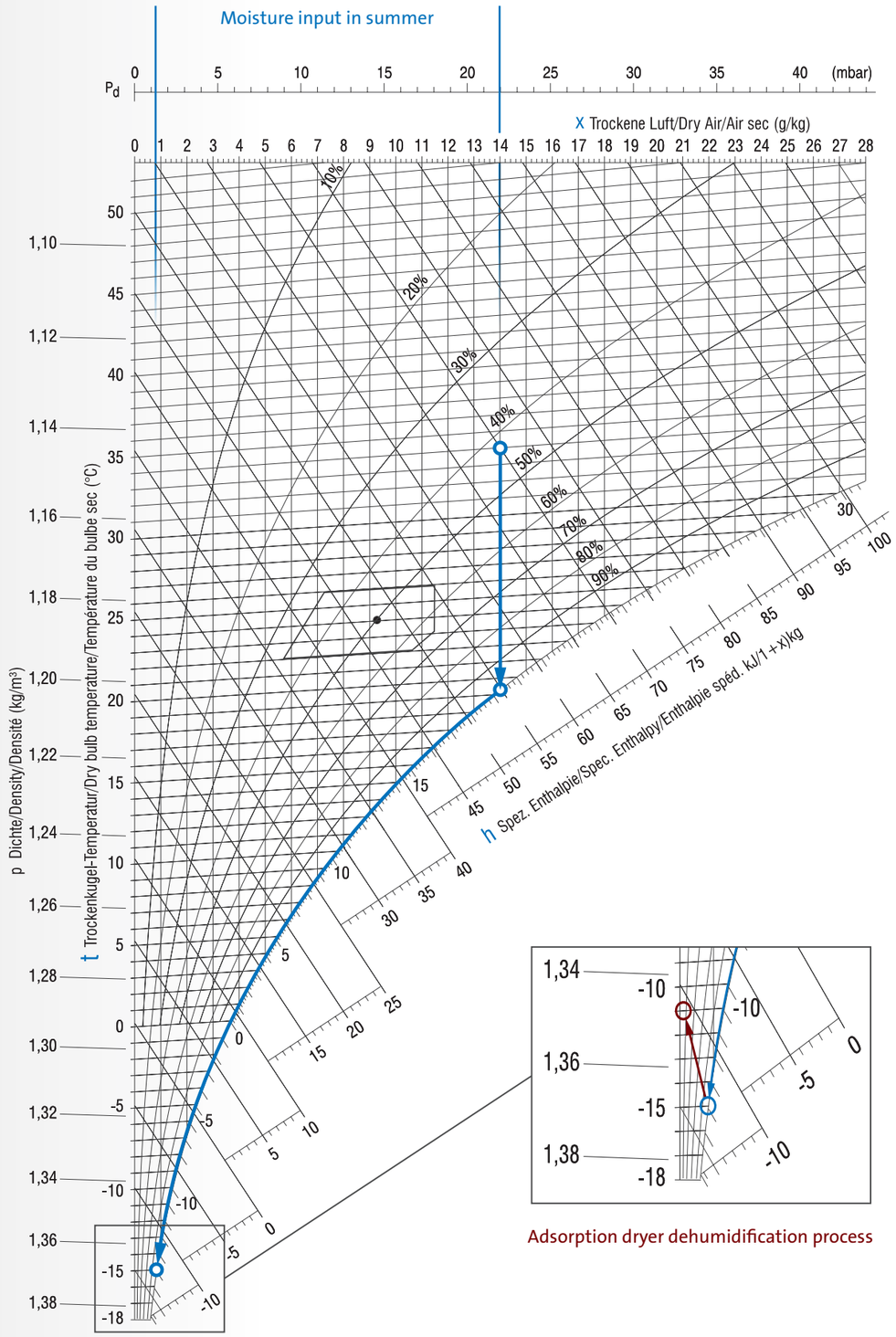
Summer operation:
250 m³/h • 1.15 kg/m³ • (14 – 0.9) g/kg = 3,766 g/h

In winter mode, the amount of infiltration air is reduced due to the lower outside air humidity. Moreover, the difference in the air density is also smaller. This reduces the calculated infiltration, taking account of the air curtain system also, to 150 m³/h.

Winter operation:
150 m³/h • 1.29 kg/m³ • (3 – 0.9) g/kg = 406 g/h

Due to the room temperature of -15°C, the water condensing from the air will now form ice on the surfaces and goods in the room enclosure.

The formation of both condensate and dangerous ice formations can be avoided by operating adsorption dryers.



Adsorption dryer dehumidification process

Fully insulated adsorption dryer enables outdoor installation

Adsorption dryers are used if low air humidity below about 10% R.H. is desired, as well as at very low temperatures. Under these conditions, the technical and energetic outlay required to dehumidify air because of the dew point being undercut, i.e. the operating principle of a condensation dehumidifier, is enormous and accordingly difficult or impossible to realize. In contrast, adsorption dryers harness the properties of silica gels, which enable effective drying of the air even at low temperatures.

The air to be dried is conveyed into the unit by the process air fan. After passing through an air filter, the air reaches the slowly rotating sorption rotor. This consists of over 82% silica gel on an air-permeable glass fiber honeycomb structure. The silica gel is very hygroscopic due to its extremely large inner surface area of up to 800 m² per gram. Therefore, it can absorb large amounts of water from the process air on the surface and store it in its inner structure. As the air flows through the sorption rotor, two processes take place simultaneously: The process air can be thoroughly dehumidified. However, depending on the dehumidification intensity, the air temperature may rise sharply in the process. Therefore, in many cases, the air which is now dehumidified but warm has to be cooled before it is returned to the room.

For this dehumidification process to work, the sorption rotor must be continuously regenerated. This means that the moisture stored in the silica gel must be constantly removed from the rotor. This is done using regeneration air, which comes from the other side and flows through the sorption rotor in countercurrent. The regeneration air is heated and the relative humidity is thus reduced to such an extent that water can be expelled from the silica gel and bound in the air as vapor (desorption).

The regeneration air, which is now moist, leaves the adsorption dryer and is discharged to the outside after supplementary heat recovery as necessary. The media used to heat the regeneration air are hot water, steam, gas burners or electrical energy.

DA-series Condair adsorption dryers are used wherever very low humidity levels are required at very low temperatures. The sorption rotor retains its capacity almost permanently under optimum operating conditions, enabling safe operation down to temperatures of -30°C and the achievement of the lowest humidity levels. In addition to 30 standard models with dehumidification capacities from 0.6 to 182 kg/h for process air flows from 120 to 27,000 m³/h, the DA dryers are also available in a wide range of special designs. For example, pre-cooling and/or post-cooling coils and heat exchanger or condensation modules can already be installed in the units at the factory. All processes operating in the adsorption dryer in line with the supply air target conditions are controlled depending on the current operating conditions via either the on-site ICE or optionally the PLC integrated in the unit.

A special version of the adsorption dryer is the **DA 500-4000 Freezer**. In addition to the previously described components of a standard adsorption dryer, this unit series is equipped with 100 mm thick AISI 304 stainless steel insulated housing. This technology has been developed and optimized over many years and critical thermal bridges have been eliminated. The individual components (fans/rotor/heating elements) are also optimally matched in order to plan the best, most efficient and most economical solution for the particular application.

Application example:
Frozen storage

If humidity problems occur in cold stores with internal temperatures often well below 0°C, they quickly become apparent. When warmer, more humid air flows into the cold room, water condenses out of the air and then precipitates as ice on floors, ceilings and walls. Large ice formations are quickly formed, especially on the evaporators of the refrigeration system and in the dock area, which then require time-consuming manual removal. And when evaporators ice over, this increases the pressure loss compared to the air, which must be constantly cooled using the recirculation method. This results in lower air and cooling capacities, frequent defrost cycles and higher operating costs. At the same time, especially with ice forming on the floor, there is an increased risk of people slipping and injuring themselves or that forklifts cannot be driven safely.

These problems are prevented by consistently dehumidifying the air in the frozen storage using an adsorption dryer. Such an adsorption dryer constantly draws in room air from the cold storage and dehumidifies it below the dew point, then blows the dehumidified, dry air back into the room or, ideally, directly back to the recirculating air coolers.

This reliably and permanently prevents the unwanted condensation of water from the air and the formation of ice in the store. As the temperature difference between the outside air and the cold storage is usually very high, in most cases, it makes sense to install the adsorption dryer directly in the cold store. This helps avoid power losses due to the transfer of heat from the cold inside of the dryer to the warm outside air. However, since problems with condensing moisture in the cold storage often only occur later in operation and then have to be remedied quickly, there is often no space left in the store for the subsequent installation of an adsorption dryer.

For such cases, Condair's range also includes a DA adsorption dryer with 100 mm insulation, which also allows installation outside the cold store. The enormous insulation prevents heat from entering the drying process taking place in the adsorption dryer, ensuring safe and efficient operation. However, this type of application requires a lot of experience and must be planned and executed precisely.

Application example:
Test bench

Test benches frequently have to maintain temperatures from +35°C down to -20°C for specified measurements. Irrespective of the temperature, however, the humidity must also be adapted to these extreme conditions.

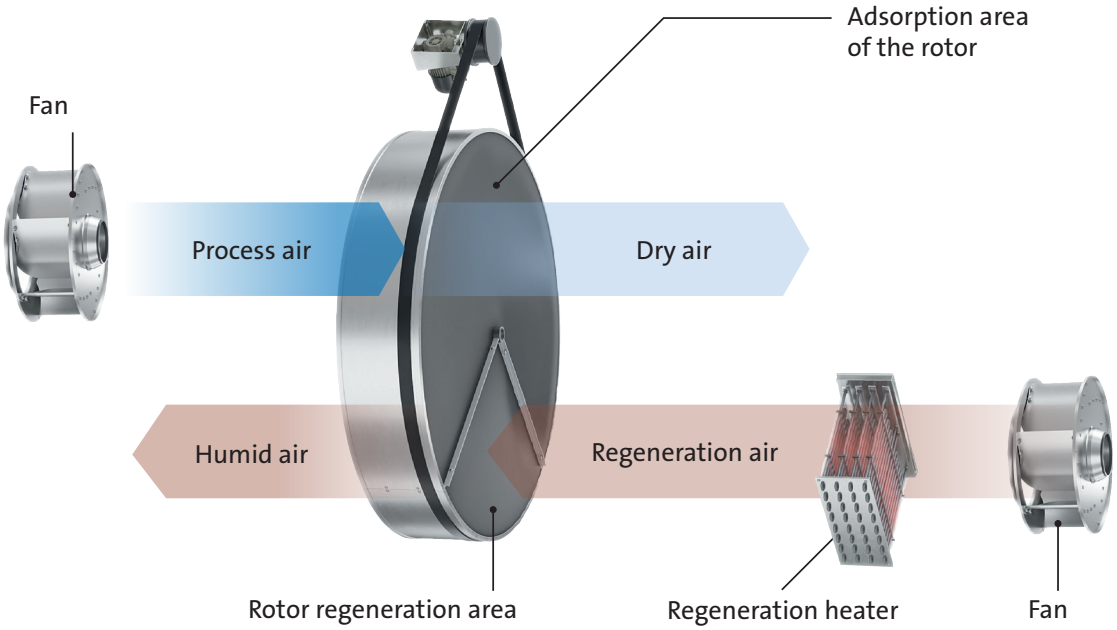
Adsorption dryers are particularly suitable for this purpose, because they can dehumidify the air reliably and efficiently over the entire temperature range by means of the sorption principle.

Due to the very wide temperature range on test benches, the following problem arises: At cool process air temperatures, the adsorption dryer housing also cools down considerably and condensate from the room air forms on the housing at first, eventually even leading to hoarfrost. This may also spread to the electrical compartment and the regeneration section. Accepting icing as a given and, in the best case, equipping the units with a condensate tray is certainly not a permanently acceptable solution here from a professional viewpoint.

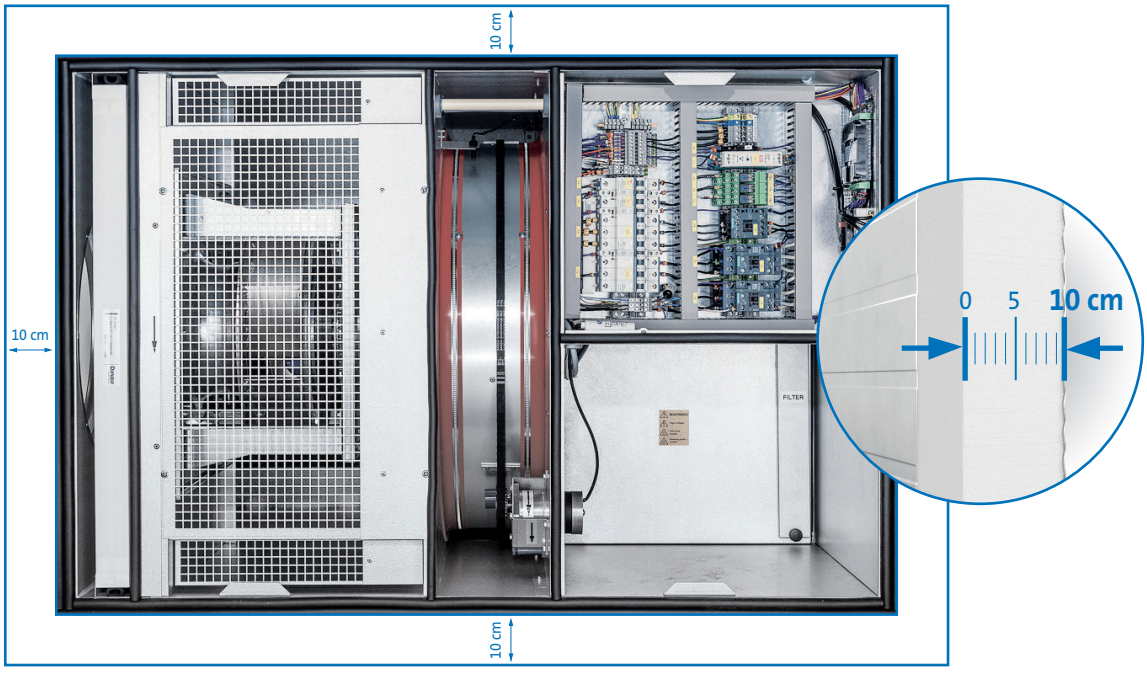
An alternative is to preheat the cold air before it enters the adsorption dryer, then to dehumidify it, and finally to cool it back down to the target temperature. This is an extremely high energy outlay, since not only does the air have to be constantly heated to an additional perceptible degree and then cooled, but heating the air also leads to a drop in the relative humidity and consequently the dehumidification process also becomes more inefficient.

This is because a lower relative humidity [% R.H.] with a constant absolute humidity [g/kg] requires a higher energy input in the regeneration process and results in very high humid air temperatures.

Functional principle of **adsorption dryer**



Comprehensive insulation **Condair DA Freezer**



Condair GmbH
Parkring 3, 85748 Garching
Phone +49 (0) 89 20 70 08-0, Fax +49 (0) 89 20 70 08-140, www.condair.de