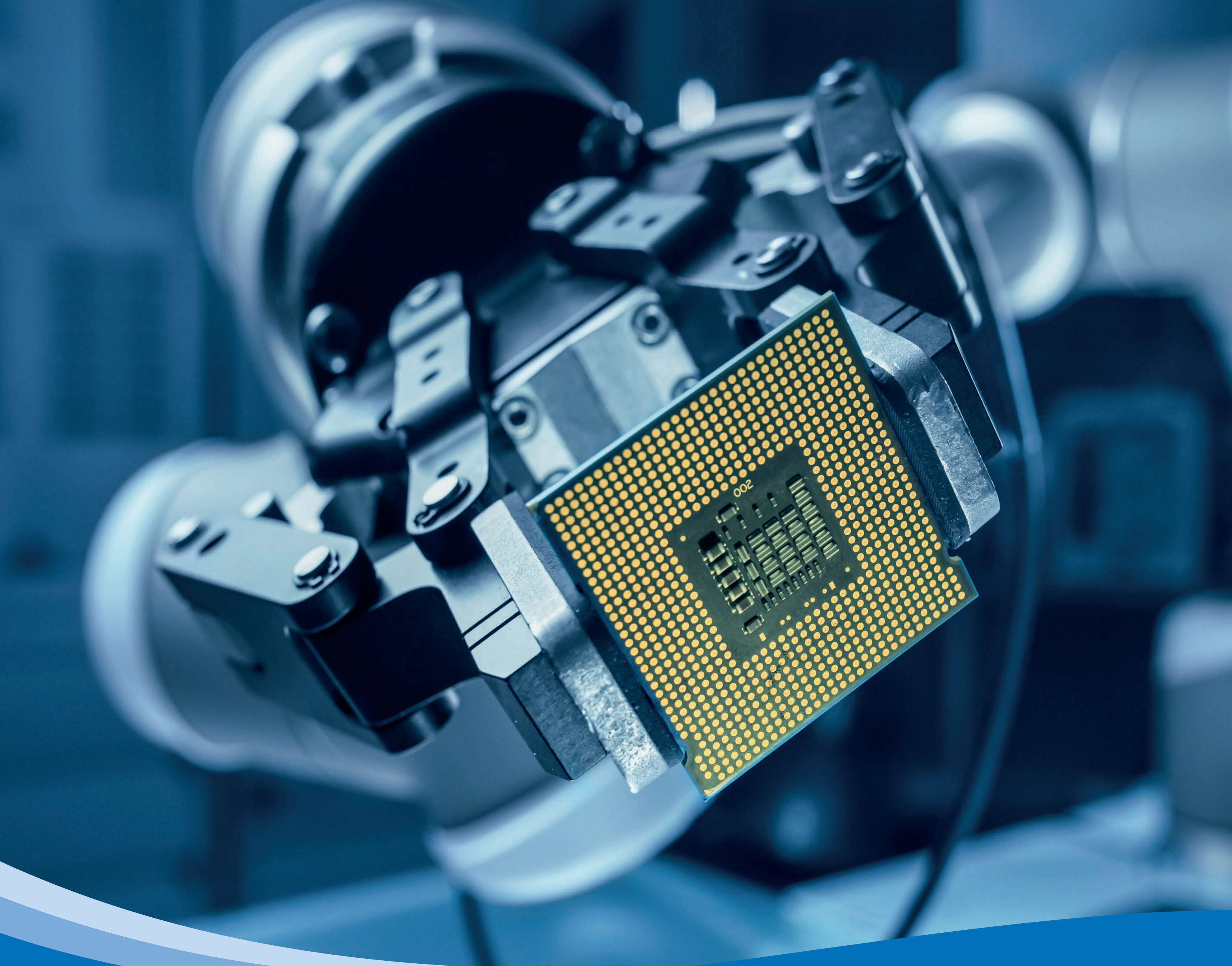


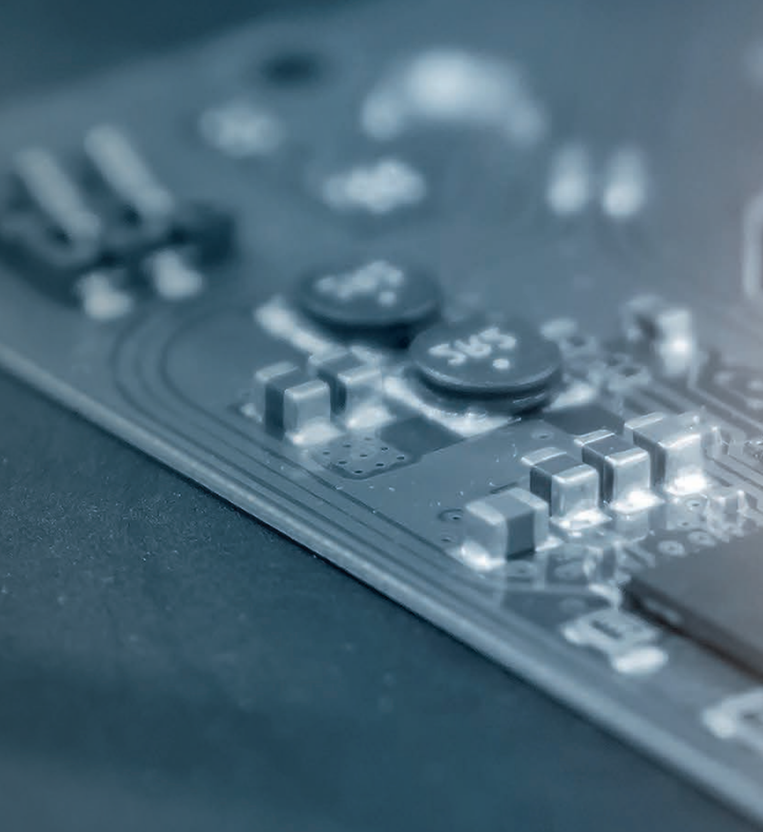
ELECTRONICS INDUSTRY

The importance of air humidity in production and storage

Humidification, dehumidification and evaporative cooling

condair

The need for dehumidification in the electronics industry



The storage of electronic components and finished products presents many challenges due to the high sensitivity of the various operating processes.

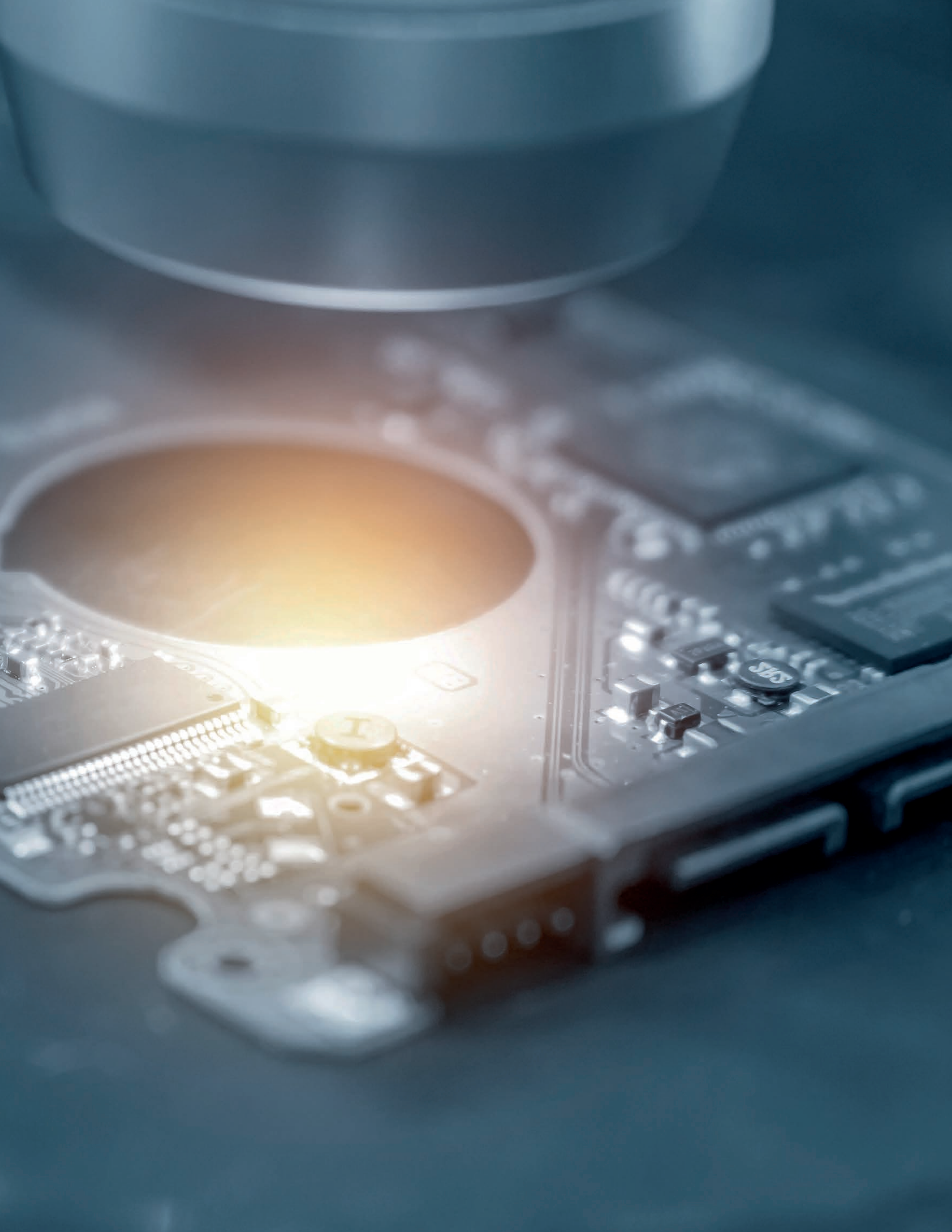
This sensitivity increases especially when large quantities of electronic components are stored, often for long periods of time.
The longer they are stored, the greater the risk that even minor adverse storage conditions will damage them and make them unusable for further use.

To prevent such damage to PCBs and sensitive components, they can be stored in moisture-proof bags. Using conventional baking is also a proven method, but it can be very time consuming and costly. Precisely controlled and optimized dehumidification is therefore paramount for the safe and successful storage of components and can save companies from costly damage.

For example, if the room humidity is not low enough or cannot be constantly controlled, the following problems will occur:

The risk of damage and oxidation of stored materials increases when the relative humidity (RH) exceeds 50%: at this value, the probability that oxygen and condensate in the air react with the materials increases, and with it the risk that the quality of the components and their functionality is affected.The increased humidity in the storage room also leads to an increased risk of water diffusion: the hygroscopic material of the electronic components attracts condensation and combines with it. This can also lead to significant damage to the components in terms to material and functionality.

Humidity control and management are therefore critical to the success of electronic component storage, making it all the more crucial that operators have access to solutions they can rely on one hundred percent!


SBS

Practical example: Dry storage for electronic components

In order to increase the storage capacity and to combine decentralized drying cabinets, a manufacturing industrial enterprise decided to create a new multi-level storage system. The surface-mounted components (SMDs) stored inside are subject to a moisture sensitivity level (MSL) and must therefore be stored at all times in an environment with a relative humidity of ≤ 5% at a temperature of approximately 59°F.

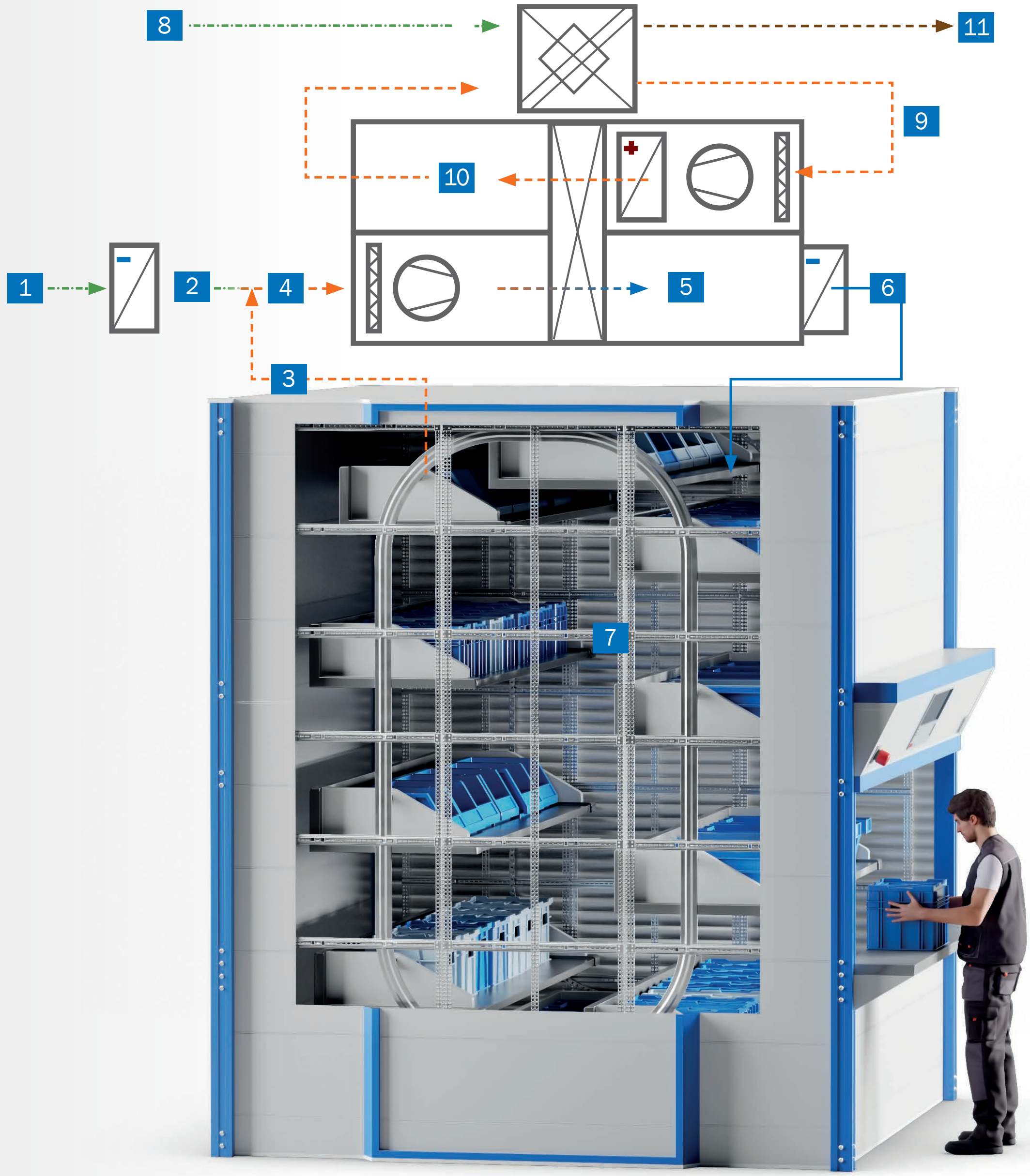
Due to the very low level of relative humidity which is required, the moisture load to be removed from the store room environment is very high, especially during summer months. During this period, the warm air has the highest humidity. The highest humidity loads during storage result from the process of accessing the storage room up to 250 times a day and the constant supply of outside air that is used to create a slight vacuum in the room to counteract airbourne moisture (humidity).

In the 2,472 ft³ storage room, the desiccant dryer used for air drying has a total air capacity of 824 CFM. 10% outdoor air is constantly added to the recirculating air (storage room exhaust air) with a flow rate of 741.6 CFM. During this process, the portion of outside air is pre-cooled from 95°F and 45% RH to 53.6°F and almost 100% RH. This pre-treatment of the outside air removes the peak humidity spikes and provides a very stable inlet condition to the Condair DA unit guaranteeing stable dry air outlet.

Mixing of recirculation air and outside air results in a temperature of 58.5°F and 16% RH. As the air passes through the dryer, latent heat of vapourisation is released and this causes the outlet air temperature to rise to approximately 78.8°F. The drying process reduces the absolute humidity to 1.785Gr/lb upon exiting the dryer. This corresponds to a negative dry dew point of -20.2°F. The now dried air can be cooled by the addition of an aftercooler to reduce the air temperature to the target temperature of 122°F.

The desiccant dryer is continuously controlled as the moisture content of the air stream can vary dependent on the number of times the area is accessed, as well as variations in outside ambient air conditions. There are several sensors in the storage system, which determine and adjust the capacity of the dryer depending on the maximum value to be maintained. A separate airflow is brought into the unit for the regeneration of the drying rotor. This passes through a cross flow heat exchanger and then PTC heaters which raise the air temperature to around 220°F. The inlet condition of this air has a direct effect on the energy usage and the overall drying capacity of the system.

The attached diagram illustrates the principle of the system in the practical example above: the air quantities and corresponding conditions are summarized in the table.

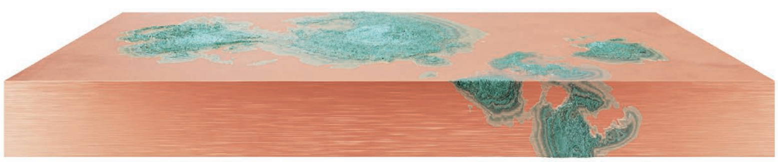


	Data point	Airflow volume [CFM]	Temperature [°F]	Relative humidity [% RH]	Absolute humidity [grains/lb]
1	Outside air ratio OA	82.4	95	45	112
2	Pre-cooled OA	82.4	53.6	95	60.9
3	Storage room recirculating air RCA	741.6	59	8.6	6.3
4	Mixed RCA & OA	82.4 + 741.6	58.5	15.7	11.83
5	Dry air	824	78.8	1	1.785
6	After-cooled supply air SUP	824	59	2	1.785
7	Indoor air IA	824	59	≤ 5	≤ 3.5
8	OA for regeneration	235.4	95	45	112
9	Regeneration air In heat recovery HR	235.4	140	13	112
10	Humid air out after HR	235.4	194	4	147.7
11	Humid air exhaust	235.4	136.4	18	147.7

Where moisture is undesirable

Oxidation of iron

Oxidation of copper



Corrosion/oxidation of copper can increase when it comes into contact with water or at high humidity levels.

A closed oxide layer is formed — the green-black patina, which protects the underlying copper from further corrosion. However, this prevents or severely hinders the further use and processing of copper into high-quality electronic components.
On the other hand, other materials such as plastics, adhesives, soldering materials and insulators used in the manufacture of electrical and electronic components are in some cases much more sensitive to excessive moisture and can cause irreparable damage to the finished components through oxidation and diffusion.

These negative effects are less likely to occur during the actual production process, but can occur during the often lengthy storage of raw materials and finished products.

Impact of air humidity on soldering results

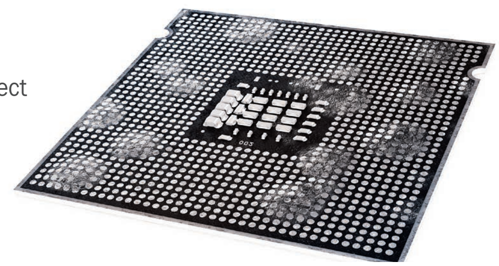
Reflow soldering of SMD semiconductor components that have absorbed an (excessively) high level of moisture can lead to defects and cracks as well as debonding of the soldered materials.

The higher the temperature demand during the soldering process, the higher the risk of delamination. This risk was further increased by the ban on lead soldering and the resulting need to work at temperatures above 482 °F. The increase in volume due to the sudden evaporation of the moisture stored on the surface and in the substrate can cause a popcorn effect.

Even seemingly minor deviations in the solder profile can lead to significant deviations from the desired result.

Appropriate preventive drying before the soldering process is therefore essential to ensure product quality; it also avoids further drying processes that are otherwise necessary. These additional processes are often time-consuming, costly and damaging to the components!

Popcorn effect



Moisture barrier bags — or storage in a dried environment?

The moisture sensitivity level (MSL) defines the moisture sensitivity threshold of electrical components. The classification of MSLs, how to handle and use them are defined in the IPC/JEDEC J-STD-020 and IPC/JEDEC J-STD-033 industry standards. The latter opens the possibility that storing SMD semiconductor components of MSL classes up to 5a at an ambient humidity ≤ 5 % RH is considered equivalent to storage in airtight, diffusion-resistant bags (MBBs), allows for unlimited shelf life, and storage of the components for an unlimited period of time.

Similarly, the lifespan of moisture-sensitive parts can be reset when exposed to humid ambient air.

For Class 4, 5, and 5a MSL components with exposure times of 8 hours or less, subsequent storage in a dry environment of ≤ 5% relative humidity and a storage period equal to 10 times the exposure time can reset lifespan.

Moisture barrier bags

The right dehumidification technology

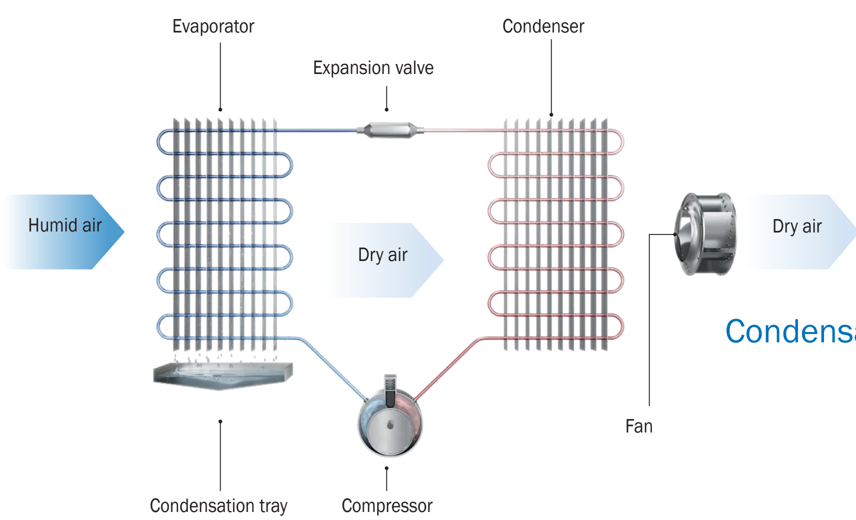
As demonstrated earlier in the brochure, there is a variety of challenges to overcome in dehumidification. Depending on the type of production, further processing and the storage of active ingredients and raw materials, the spectrum ranges from “high temperature with low humidity” to “low temperature with low humidity”.

One way to dehumidify air is to operate ventilation units with integrated water coolers. In this case, the outside air drawn into the ventilation unit is cooled down significantly in the cooler, thus dehumidified and then introduced into the room. This type of dehumidification, however, is often only suitable to remove excess humidity in warm and humid weather. In addition, the humidity values that can be achieved from an economic point of view often do not meet the required target conditions and the air must be dehumidified further.
To significantly reduce the operating costs for air dehumidification, secondary dehumidification units are typically used. They either dehumidify a required partial air volume or are installed directly in the room. There, they constantly draw in room air, which is filtered, dehumidified and then supplied back into the space as dry supply air. Both methods of dehumidification have advantages and drawbacks and must be tested and evaluated for each application. For direct in-space installation, not only the internal moisture load but also the external moisture load, e.g. from mechanical ventilation in summer, must be taken into account.
The dehumidifiers used for this purpose are available as condensing dehumidifiers and desiccant dryers.

Condensing dehumidifiers

These dehumidifiers are ready-to-use units for standard dehumidification processes in which a relative air humidity of up to 40% is to be maintained at a room temperature of about 41 to 95 °F. The units contain a refrigerating machine with compressor, evaporator and condenser. As shown in the figure below, the fan draws humid room air into the unit, filters it and then passes it through the evaporator. Liquid refrigerant flows in this evaporator, removes heat from the air and evaporates it. This cools the air to the point where its temperature drops below its dew point and a condensate forms. The lower the temperature in the evaporator, the more water is removed from the air as condensate and the drier the air becomes. The water is collected in a condensate tray and discharged into the drain.

The now dehumidified but cool air then flows through the condenser of the refrigerating machine. There, it is heated by the condensation heat and flows back into the room as dehumidified supply air. The continuity of this process allows to constantly dehumidify the room air is to the desired setpoint value.



Condensation dehumidification — operation principle

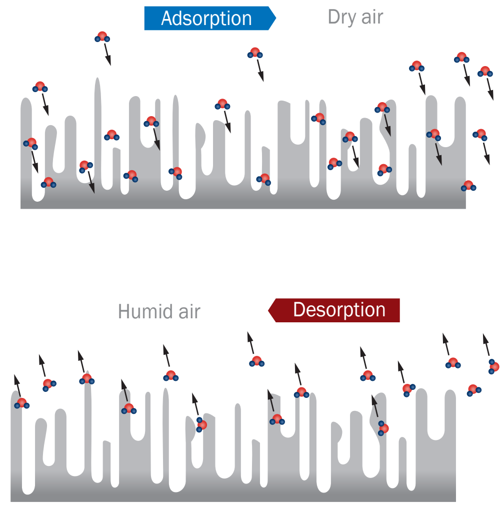
Desiccant dryers

These dehumidifiers are used when low humidity below about 40% RH is to be achieved at often very low temperatures. It would be too costly and energy-intensive to use a condensing dehumidifier for this purpose. Desiccant drying uses the properties of silica gels to dehumidify the air by lowering its temperature significantly below the dew point.

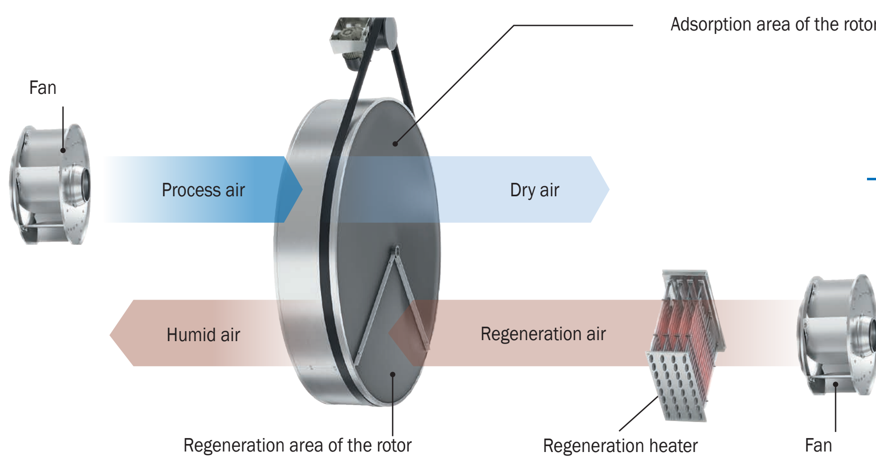
A desiccant dryer consists of a rotary heat exchanger, air filters, two fans for conveying the process air and the regeneration air, a heater for heating the regeneration air and the associated control (see figure below).

The process air fan conveys the air to be dried into the unit. After passing through an air filter, the air reaches the slowly rotating sorption rotor. This consists of more than 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 244,121 ft^2/ounce. Therefore, it can absorb large amounts of water from the process air at the surface and store it in its inner structure.

Two processes occur simultaneously as the air flows through the sorption rotor.
The effective dehumidification of the process air can lead to a significant increase in temperature depending on the intensity of the dehumidification. Therefore, it is often necessary to cool the now dehumidified but warm air 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. This is done with regeneration air coming from the other side and flowing through the sorption rotor in the opposite direction to the process air. The regeneration air is heated and thus dried to such a low relative humidity that water can be expelled from the silica gel and bound in the air as vapor (desorption). The now humid regeneration air leaves the desiccant dryer and is blown out to the outside air, if necessary after an additional heat recovery. Hot water, steam, gas burners or electrical energy are used as media for heating the regeneration air.



Desiccant drying
— operation principle

Desiccant dryers
Condair DA series

Wherever very low humidity levels are required, for example in industrial drying processes or in processes with very low temperatures, Condair DA series desiccant dryers are used. The silica gel-coated sorption rotor works virtually doesn't wear out under optimal operating conditions and enables safe operation down to temperatures of -22 °F, achieving even the lowest humidity levels. The silica gel used as a drying medium is non-respirable and non-flammable.

In addition to 6 models in 208V and the 7 models in 480V with dehumidification capacities from 1.32 to 44lbs/hr for process air flows from 300 to 2400 CFM, the DA dryers are also available as a range of special models.

In addition to the selection of different regeneration processes, there is also the option of using existing media such as steam or gas fired. Combining them with the electrical regeneration heater integrated in the unit allows for considerable savings in operating costs, particularly with larger systems.

Depending on the current operating conditions, all processes running in the desiccant dryer are controlled either via the on-site ICA or via the PLC installed in the unit to achieve the target conditions of the supply air.

Condair DA 300N - 2400N
Dryers that can be configured in different ways to meet the individual needs of our customers especially for use in production areas and large rooms.

Nominal drying capacity**
7-44 lb/h.

**at 68 °F– 60% RH

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