Condair: Adiabatic air humidification

Hygienic and efficient

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AxAir
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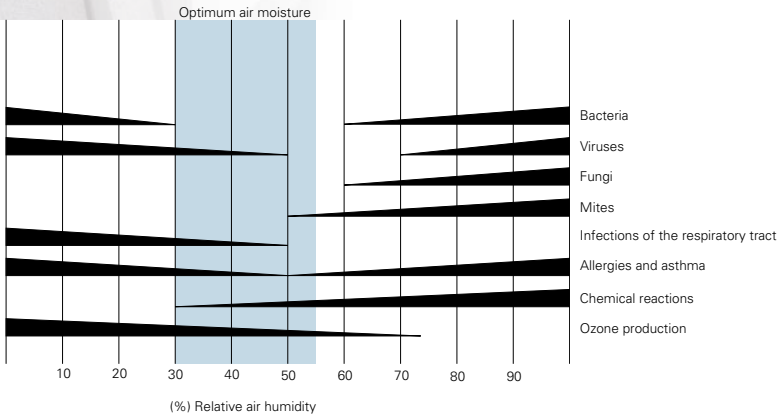
Adiabatic air humidification Hygienic and efficient

«Throughout the entire universe no matter is ever lost, it can only be converted!»

This physical principle is also true for air humidification and dehumidification in the course of which water (liquid) is converted into water vapour (gaseous). For this transition of the physical condition the impact of energy, which is also referred to as «transition energy», is required. In the course of air humidification this «transition energy» has to be added continuously, whereas it is released as so-called «latent energy» in the course of air dehumidification. Air humidification is based on three basic methods: evaporation, spraying and vaporization. The following article deals with a combination of the spraying and the evaporation technique with the help of the concrete example of Condair Dual, an adiabatic air humidifier by the Swiss manufacturer Axair.

Illustration of the distribution of microbial activity and chemical reactions depending on the air moisture



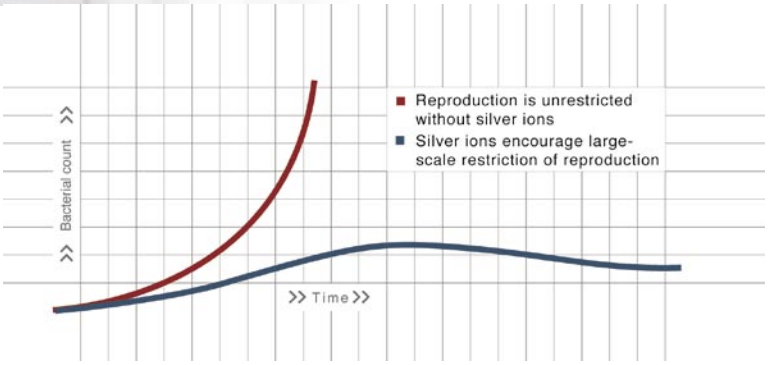
A controversial topic

It is actually inconceivable that air humidification is called into question again and again since for approx. two thirds of the year (in autumn, winter and spring) the water vapour content in the surrounding atmosphere is not sufficient to create a stable climate. But in many areas this is indispensable in order to ensure smooth work and production processes as well as the well-being of humans. For example air humidification is required in order to speed up certain industrial production processes, to prevent static charging, to protect valuable exhibits in museums or to create the framework conditions which are required from a medical as well as hygienic perspective in health technology. In refrigerated warehouses air humidification is used to reduce the shrinkage and weight reduction of fruits and vegetables and it is used in storing hygroscopic goods in order to prevent material losses through the release of water vapour to the ambient air. Nonetheless, the media frequently report on the alleged spread of pathogens, dusts, allergens, germs, spores, fungi, etc. through air humidification systems and «air-conditioning systems» in a manner which is emotional and partly not objective. This results in a feeling of uncertainty on the part of the users or operators of air-conditioning and ventilation systems, which frequently even leads to a rejection of these. For this reason the air-conditioning industry always needs to counter improper and negative statements with concrete arguments – in particular since air-conditioning and ventilation systems are indispensable in view of the current construction methods and occupancy in open-plan offices.

In the case of vegetables as in the case of many other products the air moisture has a direct impact on the weight and, hence, also on the sales price.

In order to counteract the hygienic risks, which are cited so often, in particular the regular and thorough inspection and maintenance of air-conditioning systems are important. If required and possible, this can include cleaning of the air-conditioning ducts. Very often disinfection of entire system modules is also required. In particular older systems, which are equipped with so-called «scrubbers», require a high maintenance expenditure. Moreover, the addition of biocides for the destruction of germs in the humidifier water entails high costs – not to mention the appropriate warnings which have to be complied with in any case. UV irradiation of the water used for humidification, which is employed frequently, also entails disadvantages, because it can only have an effect in those areas in which it has a direct impact. Edges, corners and floating particles in the water create shadows which considerably restrict the effect of UV radiation. Moreover, UV radiation can only inactivate germs which already exist but it cannot prevent the growth of germs in places which are not reached by the radiation. A so-called biofilm then forms as of a protective cover which at the same time also constitutes a breeding ground for further growth of germs. Since the human immune system cannot differentiate between living and dead germs, allergic reactions in connection with this type of destruction of germs can never be entirely excluded.

The addition of silver ions to the humidified water introduced is much more effective than the treatment of micro-organisms with chemicals in the humidifier water or UV irradiation. This is primarily reasonable in combination with fully desalinated water. The technology of water treatment which is used most frequently in actual practice today is a combination of ion exchange for dissolving the hardness constituents from the potable water with downstream reverse osmosis for «filtering» of all residual minerals, suspended matter and a large part of the micro-organisms carried by the water. Further factors guaranteeing hygiene and safety are the current strict guidelines in the field of air-conditioning and ventilation technology with regard to the operation, maintenance and servicing of existing plants as laid down in DIN 1946 (as a draft) and in the new VDI 6022-1 (currently in the version of a green print) as well as in VDI 3808.

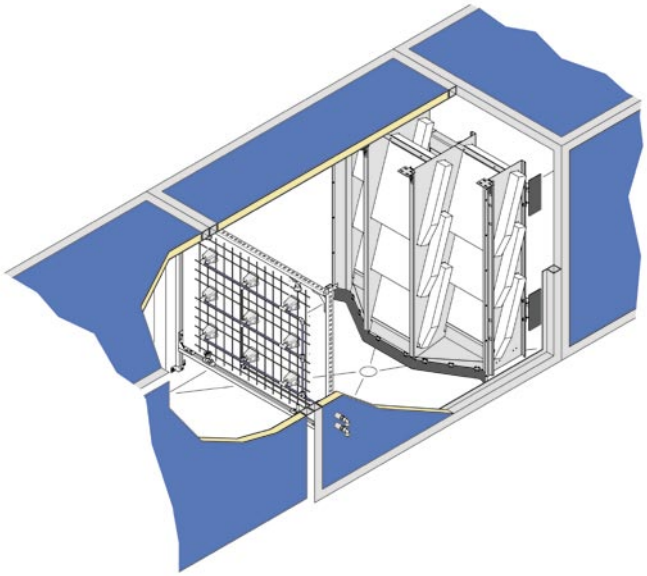


Technologies

As has been mentioned at the beginning various technologies and systems are available for air humidification which are based on three essential methods:

- **Evaporation**
  mats sprayed with water, filters, contact bodies or ceramic plates
- **Spraying**
  with the help of mechanical disc atomizers, one-fluid and two-fluid nozzles, so-called impact nozzles and ultrasonic atomizers
- **Vaporization**
  by means of electric steam generation or pressure steam humidifiers in combination with an existing steam system, e.g. in industries or hospitals, which form a functional unit together with a control valve, distribution system and condensate discharge

Apart from the evaporation technique the actual «scrubber» forms the oldest humidification method. Since, as the name suggests, the main task of this device was washing out of dusts, fibres and gasses from the air taken in. During the early days of industrialization spinning and weaving mills paved the way for this technology. Over the past years, the adiabatic technology – a combination of spraying and evaporation – has been rediscovered and has seen a rapid development because of increasing energy costs. This results in a situation in which new technologies appear on the market again and again. These for instance comprise various combinations of spraying nozzles which work at operating pressures of up to 140 bar overpressure in the humidifying water system, and downstream evaporation elements of various materials and types of design. However, the humidification efficiency and evaporation output of these systems are somewhat restricted in most cases. Moreover, the laws for the smallest water drops and aerosols have to be taken into account. Because of their size (partly <1µm) these are very floatable, carried by the air and move within the atmosphere in accordance with the laws of the Brownian molecular movement. Without suitable construction measures they can penetrate even the smallest gaps (also those of separator elements).



Hybrid humidification technique

The Condair Dual by the Swiss manufacturer Axair is based on the principle of adiabatic humidification; however, it uses a combined spraying and evaporation technique which prevents disadvantages like the ones outlined herein above. In the development of the system compliance with all known regulations and engineering standards as well as the preservation of a high standard of hygiene were the main focuses. The following conditions were used as the basis during the three-year development stage:

- *Modular structure and possibility of retrofitting of existing air-conditioning and ventilation systems and/or exchange of technologies which are already available*
- *Short fitting lengths*
- *Compliance with all current hygiene regulations*
- *Lower consumption of energy and water, lower maintenance expenditure and, hence, lower operating costs*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Hygiene certificate regarding air humidification granted by Institut Fresenius on account of the excellent test results of Dual 2

During the final stage of the development process the project was accompanied scientifically by Hygieneinstitut Fresenius for one year. Various air-conditioning and ventilation systems were tested continuously with regard to hygienic aspects both in the lab and during ongoing plant operation in practice. On account of the excellent test results the «Fresenius Hygiene Certificate» for air humidification – which is a novelty in humidification technology in this form – was granted which is not only valid for the plants tested but also for the Dual system as such regardless of the place of installation. This is also the reason why the diverse systems are serviced and hygiene examinations are carried out regularly for the purpose of confirmation of the certificate. Moreover, a professional assembly is indispensable in order to preserve the high hygienic standards.

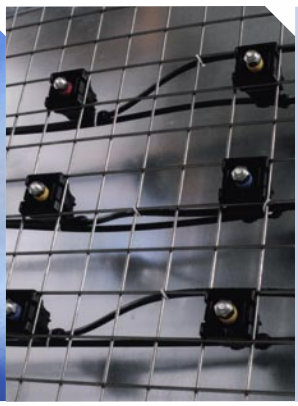
Sophisticated hygiene and design concept

These high hygiene requirements are based on a sophisticated concept the core of which is silver ionization. Shortly before the entry into the molecular nozzles silver ions, which deposit on the ceramic plates via the mist of drops, are added to the humidification water. Here, they also have an effect on the stream of air mass flowing through as a form of prevention. In case of a shutdown of the plant of more than 12 hours a water jet pump ensures complete emptying of all water-carrying plant components within the humidifier unit. [Picture 9]

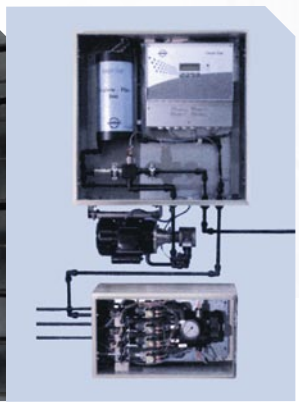
Apart from silver ionization the Condair Dual is characterized by its special design. Highly porous and resistant ceramic plates with a thickness of 50 mm are arranged like roof tiles in a humidifier chamber [Picture 6] and offer a large specific surface for post-evaporation of the humidifier water. The resistance against a stream of air mass flowing through is low and amounts to approx. 70 Pa at an air velocity of 2.0 m/s with reference to the free cross-section. The rectifier and mist collectors which are required for the scrubber and similar humidification methods as a matter of necessity are not required in this case. With the help of a molecular nozzle with an inserted ceramic mouth piece, which was developed specifically for this purpose, a finely sprayed mist of drops which can float in the air is generated at a water pressure of 4 to 8 bars [Picture 7] and already evaporates in part on the path towards the ceramic plates before it deposits there as a thin film of water. Through the withdrawal of the evaporation energy (= transition energy) from the air flowing past, the transition of the physical condition from water to water vapour can take place with a high efficiency. All molecular nozzles are distributed evenly throughout the cross-section of the housing with the help of a computer program so that a uniform coverage of the ceramic plates throughout the entire cross-section is ensured at all times and also during operation under partial load. [Picture 8]

[Picture 6]

[Picture 7]



[Picture 8]



[Picture 9]

Fully desalinated water and filtered air

Further advantages of this technology comprise the fast drying effect of the ceramic plates after switching-off of spraying by the air volume stream as well as the proportionate triggering through an external signal. In this way a moisture tolerance of +/–4 % r. h. with reference to the moisture target value is achieved with little expenditure.
All in all, this innovative combination of a homogeneous mist of the finest possible drops of water with subsequent evaporation via ceramic plates ensures a high efficiency of humidification and, hence, the best possible utilization of the humidifier water at the smallest possible share of drip water. With reference to the efficiency of humidification the quantity of waste water amounts to approx. 10 to 15 % of the maximum humidification output possible.

In order to safeguard hygiene and safety in the humidification chambers, only fully desalinated water (permeate) is used. The humidification chambers are lined accordingly for this reason. A water-processing system with «softening» in connection with a downstream «reverse osmosis» and a closed pressurized storage container is recommended; in this context care has to be taken to make sure that a connection between the point of extraction and the molecular nozzle with the surrounding atmosphere is excluded. Fully desalinated water (permeate) which is available in industries in sufficient quantities can also be used provided flawless hygiene is ensured. For the purpose of protection against contamination the air taken in should be filtered with a filter of the F7 quality before the humidifier chamber (according to the current state of the art) In case of an excessive contamination by very fine dust particles which cannot be filtered out by the F7 filters (e.g. on industrial estates and in similar conurbation areas), special measures have to be taken. In any case care has to be taken to make sure that detergents, provided such are used, are removed without leaving any residues by means of sufficient rinsing.

Versatile applications

On account of the modular design of the Dual technology, this technology is not only suitable for new plants but also for retrofitting of air-conditioning and ventilation systems which already exist without any major expenditure. To that end, old glass-fibre-reinforced plastic housings have to be cleaned and any possible leadthroughs have to be closed with glass-fibre mats and epoxy resin. After a more detailed examination the previous control system can perhaps be reused.
In case of a corresponding design of the system the adiabatic cooling effect can also be used for cooling during the summer. For example in a foil-processing company six new facilities in rooftop infrastructure centres with an air volume flow of 60,000 m^3/h were equipped with an adiabatic Condair Dual system. During the winter the ambient air humidity for the production is kept at approx. 60 % r.h. During the summer the room temperature is maintained at approx. 24 to 26 °C with the help of adiabatic cooling. This means the humidification technology operates continuously throughout the entire year. On account of the high operating time thorough hygienic service is carried out every six months.
One further example of industrial applications is cooling of the intake air of gas turbines. In this case the technological system is located in a housing which is galvanized on the outside and lined with stainless steel on the inside. A bird screen and filter of the F7 type were installed upstream. The entire unit was connected to a gas turbine subsequently. During the summer the intake air for the turbine is cooled with the help of the Dual technology and the efficiency of the gas turbine is, hence, increased considerably. Since the electric energy generated is fed into the public power grid in part, the investment for the Condair Dual pays off within only a short period of time through reimbursements which are paid for this.

Efficient and reliable

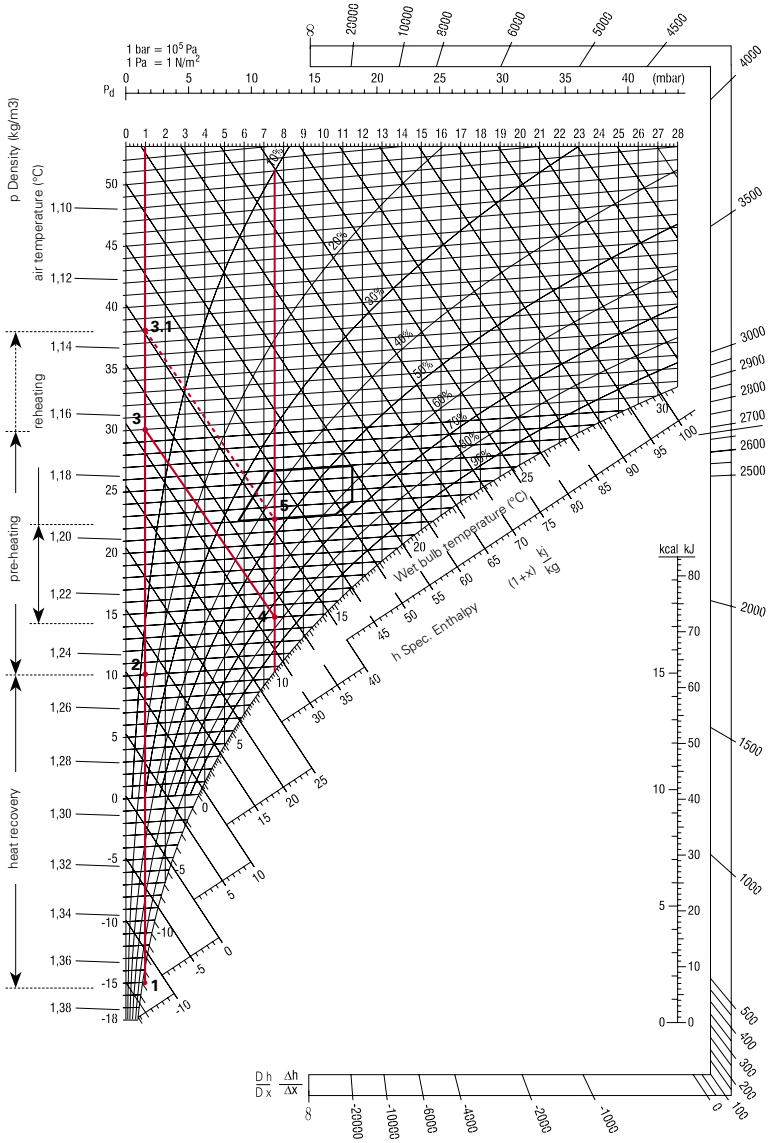
The hybrid humidification technology described has now been in operation successfully in many air-conditioning and ventilation systems for approx. ten years. It can be used in various applications, it is easy to assemble and logical in terms of its structure and mode of operation and is easy to understand for everyone. In addition to this, there is a low maintenance expenditure connected with a high hygiene standard and reliability.

Technical data of Condair Dual

Humidification output	2,000 l/h (delivered and in operation so far)
Air velocity in device/conduit	0.5 to 4.0 m/s
Humidification efficiency	max. 91 % r.h.
Control accuracy	+/- 4 % r.h.
Operating pressure on molecular nozzle	4.0 to 10.0 bar
Water inlet pressure	at least 2.0 to 10.0 bar
Overall length of the entire unit	1,200 mm
Quality of humidifier water	fully desalinated water 0.5 to 15 µS
Water-air ratio	< 0.01
Pressure drop	approx. 70 Pa at V = 2.0 m/s
Required filter quality before humidifier	F6 or better F7
Waste water quantity	<10 % depending on humidification efficiency
Test certificates	Hygiene certificate by Institut Fresenius. Design examination by the Institute for Air Hygiene, Berlin

Illustration of adiabatic air humidification in the h,*x* diagram

In connection with adiabatic systems the transition energy (= thermal energy) which is available plays a considerable role for the transition of the physical condition. For this reason the air has to be heated before the adiabatic air humidifier in order to achieve a given humidification output. This is effected by means of a heat exchanger installed before the humidification system with the help of existing oil or gas heating systems (e.g. water vapour, hot water from pump). The evaporation procedure is then effected exclusively by means of the extraction of thermal energy from the air flowing past. (This is shown on the «h» line in the diagram).
Cooling of the air flowing past with simultaneous absorption of water vapour (absorption of moisture) is shown in the h,x diagrams [Illustrations 10 and 11]. The thermal behaviour of an air-conditioning and ventilation system for exclusive operation with outside air is shown in Illustration 10. The outside air (1) is preheated by means of a heat recovery system (2), heated to the operating temperature by means of the so-called preheater (3) and afterwards it can take up moisture

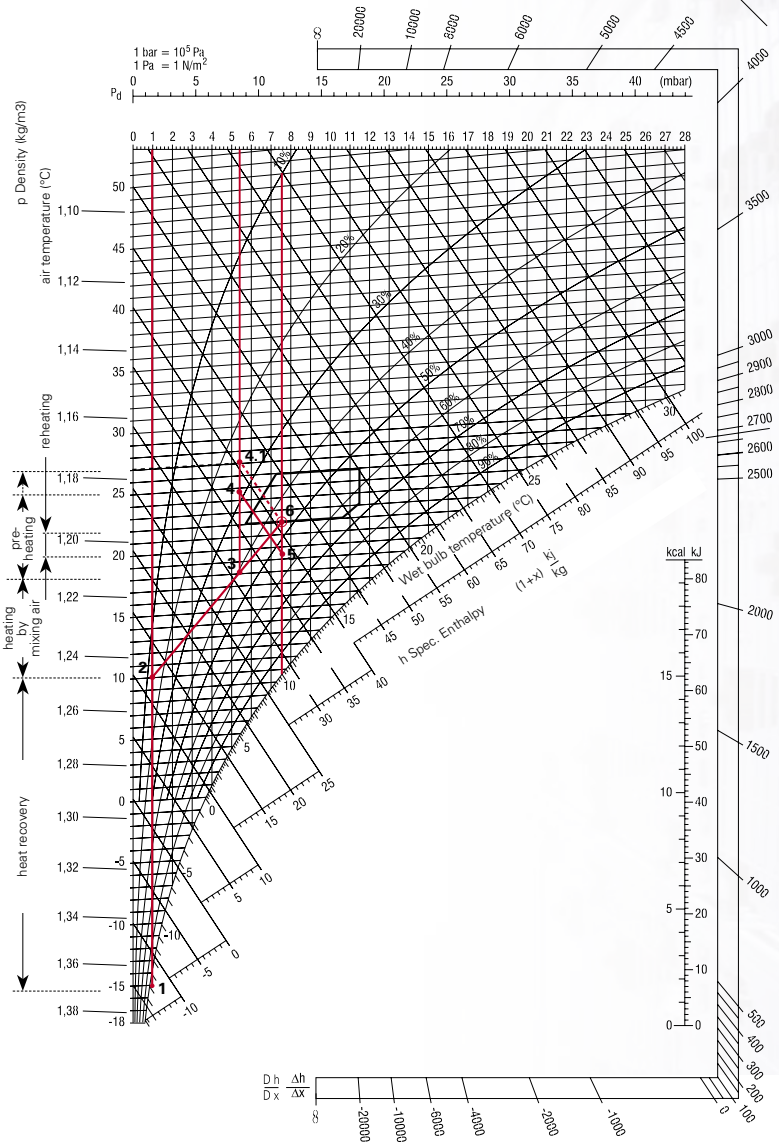


[Illustration 10]

Illustration of an adiabatic system for operation exclusively with outside air

by releasing the evaporation energy in the downstream air humidification system (4). With the help of the internal thermal loads – if required also with the help of a post-heater – the humidified air is heated to the desired room temperature. With regard to temperature and moisture this technological solution can be controlled best with the help of an enthalpy control system dimensioned accordingly. In order to reach the operating point directly adiabatically the transition energy has to be provided exclusively in the preheater (3.1 = dashed section).

For reasons of energy saving and also on account of the system so-called mixed-air systems (Illustration 11) are used today in which the outside air taken in is first heated by means of a heat recovery system (2) and then mixed with the return air from the ventilation system by means of air valves controlled accordingly (3). This mixed air is heated to the required operating temperature by the preheater (4) and humidified (5). The desired operating temperature is achieved by means of the post-heater or by means of existing internal thermal loads (6). Very stable moisture and temperature values can be achieved with a well-dimensioned control system.



[Illustration 11]

Illustration of an adiabatic mixed-air system

Consulting, Sales and Service

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