Climate management in waterworks

Air always contains a specific amount of water vapour. There is therefore a latent risk of dew water forming on cold surfaces of water-bearing system components in elevated tanks, waterworks, wells and pumping stations, etc. Moisture can also build up in walls as a result of water vapour diffusion, causing significant structural damage.

This technical information explains the basic principles of climate control and air dehumidification, and provides instructions for selecting the correct dehumidification equipment.

The problem

Dew water **(Fig.1)** causes in particular
- Corrosion and damage (rust) on mechanical and electrical equipment **(Fig. 2)**
- Electrical faults due to short circuits and leakage currents up to and including system failure
- Moisture penetration damage and corrosion on the building structure **(Fig. 3)**
- Mold formation on surfaces and walls **(Fig. 4)**
- Unhygienic conditions in high-level tanks, pumping stations, shafts, waterworks.

Examples

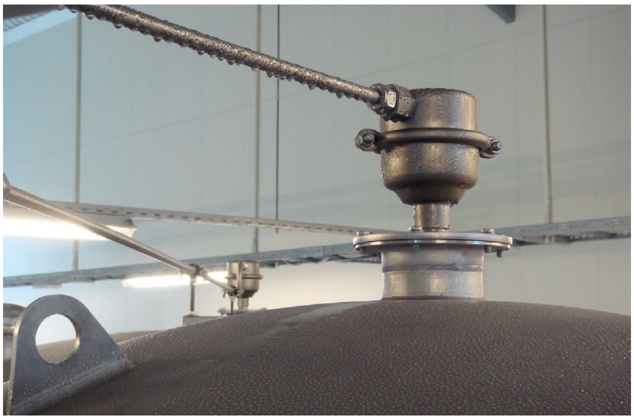


Fig. 1: Dew water formation


Fig. 2: Corrosion and rust

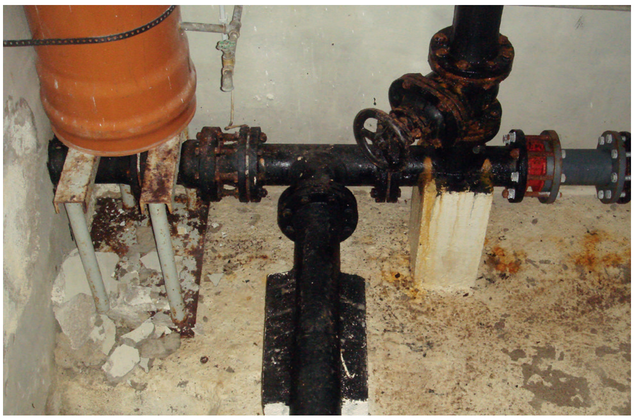


Fig. 3 : Moisture penetration damage

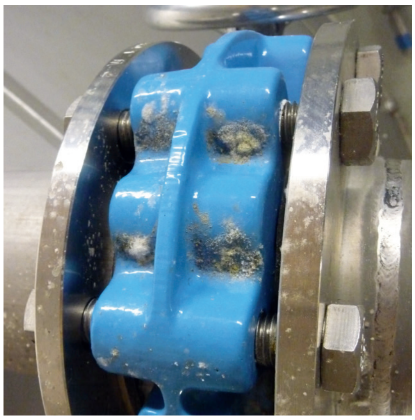


Fig. 4: Mold formation

Air dehumidification

Dew water formation can be continuously prevented by means of controlled dehumidification. Consequently, air dehumidification also helps to preserve the long-term value of the often high-value systems and building structures.

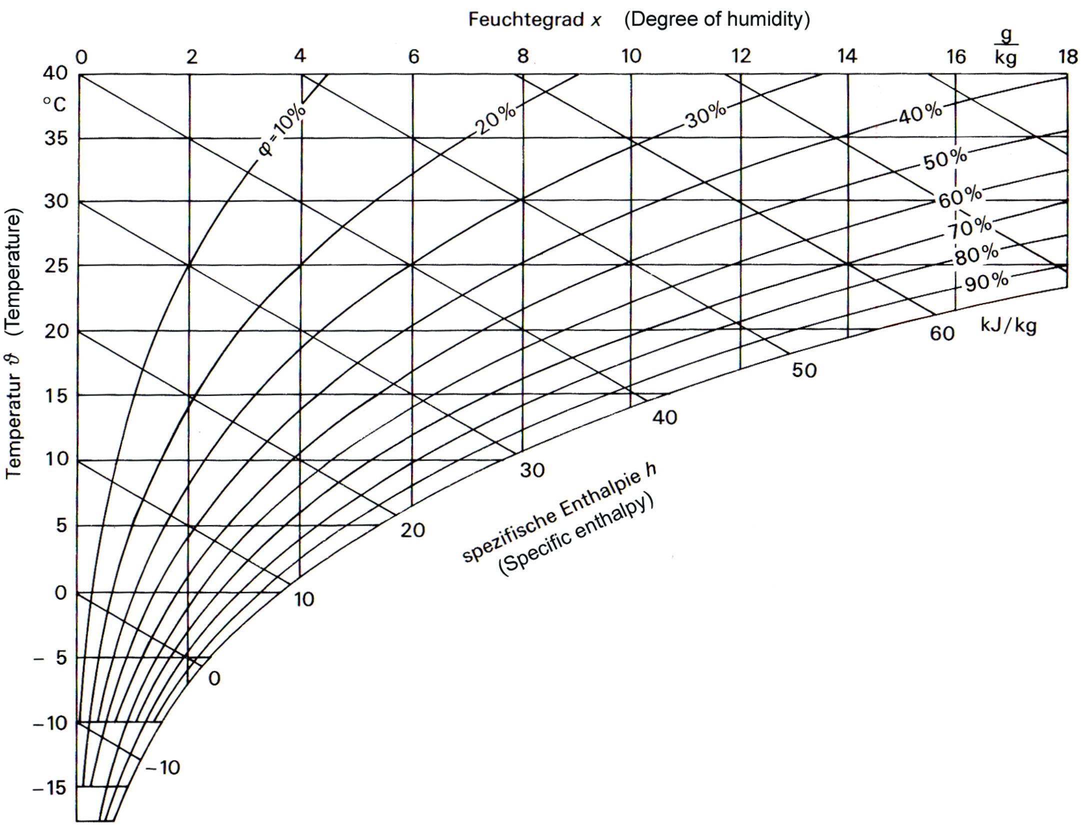
Humidity

Degree of humidity

Normal ambient and room air always contains water vapour due to natural evaporation processes. The maximum amount of water vapour (saturation) in the air depends on the temperature and is expressed in g/kg as absolute humidity. However, air is normally not saturated. The ratio of the current absolute humidity to the maximum possible humidity is expressed as a percentage as the relative humidity. The relative humidity also changes with the temperature due to the temperature dependence of the water vapour content. When warm, moist air is cooled, the relative humidity increases up to 100%. When more cooling occurs, dew or condensation is formed. This point is referred to as the dew point, and the corresponding associated temperature is referred to as the dew point temperature.

If the dew point of the air is below the water temperature, the water evaporates and drying occurs.

Mollier h/x diagram



The relationship between the temperature, humidity and specific enthalpy of the moist air is summarised in the Mollier h/x diagram.

Table 1 shows important points with the respective state variables. It can be clearly seen that the condensation point depends on the air temperature and the relative humidity.

Table 1 Water content [g/kg], specific enthalpy [kJ/kg] and condensation point temperature [°C] as a function of the air temperature [°C] and rel. humidity [%] (Abbreviation in Table 1 r.h.).

	40% r.h.		50% r.h.		60% r.h.		70% r.h.		80% r.h.		90% r.h.		100% r.h.	
30 °C	10,61 g/kg	57,3 kJ/kg	13,32 g/kg	64,2 kJ/kg	16,05 g/kg	71,2 kJ/kg	18,8 g/kg	78,2 kJ/kg	21,58 g/kg	85,3 kJ/kg	24,38 g/kg	92,5 kJ/kg	27,21 g/kg	99,7 kJ/kg
	14,9 °C		18,4 °C		21,4 °C		23,9 °C		26,2 °C		28,2 °C		30 °C	
25 °C	7,89 g/kg	45,2 kJ/kg	9,89 g/kg	50,3 kJ/kg	11,9 g/kg	55,4 kJ/kg	13,93 g/kg	60,6 kJ/kg	15,97 g/kg	65,8 kJ/kg	18,03 g/kg	71 kJ/kg	20,1 g/kg	76,3 kJ/kg
	10,5 °C		13,8 °C		16,7 °C		19,1 °C		21,3 °C		23,2 °C		25 °C	
20 °C	5,8 g/kg	34,8 kJ/kg	7,27 g/kg	38,5 kJ/kg	8,75 g/kg	42,3 kJ/kg	10,23 g/kg	46 kJ/kg	11,72 g/kg	49,8 kJ/kg	13,21 g/kg	53,6 kJ/kg	14,71 g/kg	57,4 kJ/kg
	6,0 °C		9,3 °C		12 °C		14,4 °C		16,4 °C		18,3 °C		20 °C	
15 °C	4,22 g/kg	25,8 kJ/kg	5,29 g/kg	28,4 kJ/kg	6,36 g/kg	31,1 kJ/kg	7,43 g/kg	33,9 kJ/kg	8,5 g/kg	36,6 kJ/kg	9,58 g/kg	39,3 kJ/kg	10,67 g/kg	42 kJ/kg
	1,5 °C		4,7 °C		7,3 °C		9,6 °C		11,6 °C		13,4 °C		15 °C	
10 °C	3,04 g/kg	17,7 kJ/kg	3,8 g/kg	19,6 kJ/kg	4,56 g/kg	21,5 kJ/kg	5,33 g/kg	23,5 kJ/kg	6,1 g/kg	25,4 kJ/kg	6,87 g/kg	27,4 kJ/kg	7,64 g/kg	29,3 kJ/kg
	< 0 °C		0,1 °C		2,6 °C		4,8 °C		6,7 °C		8,4 °C		10 °C	
8 °C	2,65 g/kg	14,7 kJ/kg	3,32 g/kg	16,4 kJ/kg	3,98 g/kg	18,1 kJ/kg	4,65 g/kg	19,7 kJ/kg	5,32 g/kg	21,4 kJ/kg	5,99 g/kg	23,1 kJ/kg	6,67 g/kg	24,8 kJ/kg
	< 0 °C		< 0°C		0,7 °C		2,9 °C		4,8 °C		6,5 °C		8 °C	
6 °C	2,31 g/kg	11,8kJ/kg	2,89 g/kg	13,3 kJ/kg	3,47 g/kg	14,7 kJ/kg	4,05 g/kg	16,2 kJ/kg	4,63 g/kg	17,7 kJ/kg	5,22 g/kg	19,1 kJ/kg	5,8 g/kg	20,6 kJ/kg
	< 0 °C		< 0 °C		< 0 °C		1 °C		2,8 °C		4,5 °C		6 °C	

Example The water temperature in a waterworks is 10 °C, the room temperature in winter is approx. 12 to 15 °C at a relative humidity of 60%. According to Table 1, the condensation point is 7.3 °C, which means that no condensation is formed. In summer, the air temperature rises to 20 °C with the same relative humidity. However, the associated condensation point is now at 12 °C, with the result that condensation occurs. In this case, the relative humidity of the air must be reduced to below 50% in order to prevent dew point formation.

Air dehumidification and condensation point in the waterworks

In waterworks, the surface temperatures of the water-carrying pipelines, valves and tanks are mostly in the 8 to 12 °C range, or between 1 and 20 °C in extreme cases. As already explained, condensation can form particularly in the warmer times of the year when warm, moist air comes into contact with cold surfaces. In order to prevent condensation and mould formation, the humidity in waterworks should not be permanently higher than 65-70% r.h.
The greater the difference between the air temperature and the surface temperature, the lower the relative humidity needs to be in order to prevent the condensation point not being reached. This also applies the other way round: The smaller the temperature difference, the greater the humidity can be.

External hygrostat In waterworks in particular, which often have larger rooms, the switching devices (hygrostat or condensation point sensor) should be installed externally if possible. Locations at a height of about 1.5 m that are not interfered with by the equipment or by other air flows (heating, dissipated motor heat etc.) are ideal for hygrostats.
Hygrostats should be set so that the condensation point is 4-5 K below the surface temperature of the condensation surfaces or to max 70%. In drinking water reservoirs with stainless steel tanks, the room air temperature is close to the water temperature and is constant. In this case the dehumidification can be operated with a fixed hygrostat setting.

Condensation point sensor

Via external condensation point sensors installed directly on the pipe surface, it is possible to operate air dehumidifiers in line with specific requirements and therefore optimised in terms of energy costs. Irrespective of the air temperature, condensation point sensors detect the risk of the condensation point not being reached even before dew water formation occurs.

Dimensioning and equipment selection

Condensation air dehumidifiers or adsorption air dehumidifiers can be used for air dehumidification in waterworks. Dehumidifiers based on the condensation principle generally work very economically. A cooling unit creates a cool plate on which the air flowing past can be cooled down and the moisture condensed and removed.

The dehumidification capacity and therefore the economy of these units are reduced as the temperature decreases (risk of ice formation / automatic defrosting required). Adsorption dryers are therefore preferred for use in the low temperature range (< 3 °C).

Dimensioning of dehumidification units

Ideally, air dehumidification units work with circulating air, i.e. only the air **in** the room is dehumidified **and** the ingress of air from the outside is prevented. In operational waterworks, there is normally some limited air exchange (outside air entering) even in closed rooms. Depending on the degree to which the shell of the building is sealed, we can assume an hourly air exchange $\mathbf{L_W}$ of between 25 to 40% of the room volume $\mathbf{V_R}$.

The required dehumidification capacity $\mathbf{L_E}$ is thereby roughly determined as follows:

Formula

$$L_E = V_R \bullet \text{Density} \bullet L_W \bullet \text{Water vapour content difference} \bullet 1/1000 \text{ [kg Water /h]}$$

Example

Room volume V_R = 2800 m³, air density approx. 1.25 kg/m³, air change L_W = 0.4, outside air temperature 25 °C at 50% rel. humidity, target condensation point 8 °C.
The required hourly dehumidification capacity is therefore:

$$L_E = 2800 \text{ m}^3 \bullet 1.25 \text{ kg/m}^3 \bullet 0.4 \bullet (9.89\text{-}6.67 \text{ g/kg}) = 4508 \text{ g or } 4.5 \text{ kg/h}$$

The heat quantity $\mathbf{Q_{ENT}}$ to be removed by the cooling unit at this operating point is determined from the difference of the associated enthalpies multiplied by the removed water volume.
In the example (in accordance with Table 1) it is:
$$Q_{ENT} = (50.3 - 24.8 \text{ kJ/kg}) \bullet 4.5 \text{ kg/h} = 114.75 \text{ kJ/h}$$

Power consumption of dehumidifiers

The maximum power consumption of an air dehumidifier unit is comprised of the cooling unit's ventilator power and motor power combined, plus any heating registers for defrosting. The required cooling capacity is directly related to the temperature and the specific enthalpy of the air being dehumidified (see the table, the Mollier h/x diagram and the above example).

A much greater heat quantity must be removed at a high temperature than at a low temperature. Focussing solely on dehumidification capacity or power consumption is therefore unsuitable when comparing air dehumidification units. Ultimately, all condensation dryers work on the same principle and are subject to the same laws of physics. The fact is that irrespective of the given motor power or the maximum power consumption, besides the ventilation power a condensation dryer basically uses in energy only the respective cooling power required for removing the heat quantity.

Air circulation

In addition to optimum dehumidification, air circulation also plays an important role - particularly in large-volume and high buildings. Otherwise, temperature stratification and poor airflow in areas can still lead to partial condensation.

In the case of units with greater pressing (> 300 Pa) and with air discharge pipes for targeted flow guidance, one unit set up centrally is sufficient in most applications.

Deeper shafts and areas covered with gratings must be checked separately. Gratings form a barrier to air circulation. Here, continuous air exchange may have to be ensured by means of directed air flows via pipe systems or with air recirculation systems.

In the case of high buildings and stainless steel high-level tanks, units with air discharge upwards via adjustable pipes or bends are the preferred method for adjusting a directed flow. These dehumidifiers can be set up centrally and are ideally operated with a hygrostat.

Determining the circulation volume

To ensure good air dehumidification, the room volume of the closed building or the room being dehumidified should be circulated approximately every hour. Complete air circulation is important, since only this allows good moisture transport via natural convection processes.

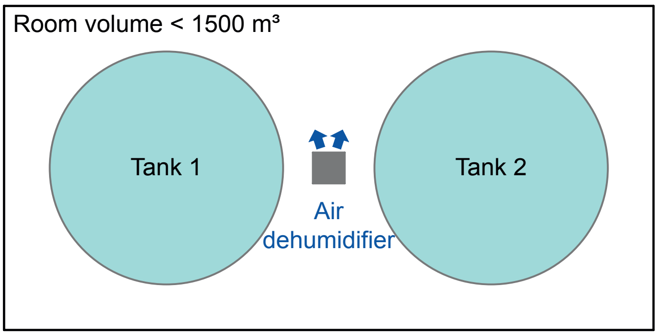
Ancillary rooms or room areas with poor air flow must be served by separate dehumidifiers if necessary. The air circulation provided by these units must be tailored to the respective room sizes. Air dehumidifiers must be placed so that short circuit flows are avoided and good circulation is achieved. Where there are large surface areas (large volume in low rooms), pipelines for targeted flow guidance are advantageous.

Sufficiently dimensioned discharge lines for removing the condensation (risk of blockage) should be provided when there is a stationary set-up.

The room volume $\mathbf{V_R}$ is obtained from the gross volume minus the volume of the fittings such as tanks etc.

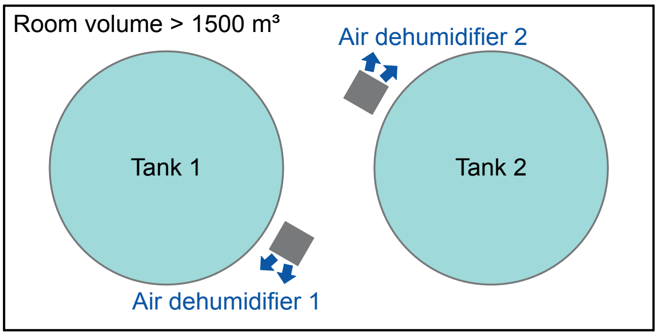
Number of units

With a room volume of up to approximately 1500 m³, it is possible to guarantee sufficient air dehumidification with one dehumidifier set up centrally. At the same time, the circulation capacity must be equal to or greater than the room volume (see the air dehumidifier data sheet).



Set-up with one air dehumidifier

More than one dehumidifier should be used in the case of room volumes greater than 1500 m³. If necessary, ceiling fans can also be used to ensure good air circulation. Only the units with greater pressing should be used in the case of larger room volumes.



Set-up with two air dehumidifiers

Ventilation and heating

In waterworks operation, a change of air can become necessary under certain conditions (infeed and removal of cooling air, removal of gases and vapours, air compensation in the event of water level fluctuations in tanks etc.).

So that the dehumidification is not influenced by the ventilation, the corresponding system parts must be set up in separate rooms or must be closed off with direct ventilation to the outside. Natural ventilation is in some cases only still usual in shafts, whereby here too air dehumidification - combined with forced ventilation via ventilators - is more advantageous when necessary. For energy-related reasons, heating must be limited to operational and chemicals rooms (e.g. sodium hydroxide storage etc.) and control rooms. Also for energy-related reasons, heating is not suitable for air dehumidification.

Summary

The benefits of dehumidification units outweigh their cost. They are largely maintenance-free in operation. The unit, filter and discharge lines must be cleaned or replaced regularly. The units should be fitted with hourmeters so that any performance reduction or excessive running times due to incorrect settings can be detected.
Temporarily switching off air dehumidifiers must definitely be avoided so as to maintain a constant room climate.

Dehumidifiers for waterworks

The series HDE air dehumidifiers were developed for both commercial use and for use in waterworks. For this reason, these dehumidifiers have a corrosion-resistant stainless steel housing (Protection Class IP54) and especially large and sturdy transport wheels. The generously dimensioned ventilators provide high-volume air circulation and therefore excellent dehumidification performance even in large and high rooms. Full electronic control guarantees an efficient dehumidification process even at low operating temperatures.

External hygrostats or condensation point sensors can be connected. The condensation is permanently removed via a hose. All connections and switches are installed protected on the rear of the housing.

Areas of use Operation under normal atmospheric conditions and at ambient temperatures of between 1 °C and 35 °C, at a relative humidity of 40% to 99%.

Design

- Stainless steel housing
- Hot gas defrosting
- Protection Class IP54
- Fully electronic controller
- Cleanable air filter
- Operating hours displayed in the controller
- Impact-protected filter/evaporator
- Coolant R410A
- Optional condensation pump possible
- External hygrostat, condensation point sensor optional

HDE 150 / HDE 210

HDE 370

Technical data - dehumidifier

Dehumidifier	HDE150	HDE210	HDE370
HE article number	**151614**	**151615**	**151616**
Dehumidification performance at 8 °C / 70% r.h. [l/d]	11.9	26.2	30.9
Dehumidification performance at 12 °C / 70% r.h. [l/d]	15.9	32.1	38.8
Dehumidification performance at 20 °C / 60% r.h. [l/d]	21.5	39.4	48.0
Dehumidification performance at 27 °C / 60% r.h. [l/d]	29.6	53.0	65.3
Dehumidification performance max. 30 °C / 80% r.h. [l/d]	40.8	71.7	93.2
Power consumption at 10 °C / 70% r.h. approx. [W]	200	770	920
Power consumption max. [W]	330	1010	1510
Voltage [V / Hz]	230 / 50	230 / 50	230 / 50
Air circulation max. [m³/h]	600	800	1000
Increased pressing ext. [Pa]	-	-	300
Sound pressure level [dB(A)]	47	48	57
Weight, net [kg]	50	56	82
Dimensions incl. wheels and handle (height x width x depth) [mm]	915 x 545 x 490	965 x 545 x 490	1100 x 610 x 635

Scope of delivery: Room air dehumidifier with plug-in external hygrostat

Important

It is essential to fit the flow guides (2 x stainless steel curves with sleeves and deflectors) supplied with the HDE370. Operation without the flow guides would result in an excessive flow speed at the evaporator with the consequence that performance may be reduced.

Condensation point monitor TW Ö/S

Condensation point monitors enable the air dehumidifiers to be operated efficiently and economically at higher temperatures. The condensation point monitor is installed on cold surfaces or directly on pipelines. It can be used as a moisture sensor, a condensation point sensor or a limit value switch and the dehumidifier can be operated in such a way that it is activated by the switching output of the condensation point monitor even before condensation forms on the pipe surface. A 24 V AC power supply from the dehumidifier is required in order to operate the condensation point monitor.

Technical Data - condensation point monitor

Condensation point monitor	TW Ö/S
HE article number	**151617**
Capacitive sensor	for operating range 75-100% r.h.
Temperature range	0-50 °C
Output signal	Floating changeover contact 24 V AC
Protection Class	IP65

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