

Air-humidifying control

Humidity control guidelines





Air humidity control

Foreword

This manual has been compiled to provide assistance when choosing the correct humidity control system. Individual descriptions are presented as examples and clarify basic principles. Schematic diagrams illustrate humidity control in context. Other control processes are not addressed. System designs used under practical conditions differ greatly, control diagrams therefore do not represent complete solutions

that can be realised in all cases in the manner described. It is imperative that a control specialist be consulted during planning.



Humidifying control guidelines for air-humidifying systems

Author: Christian Bremer (chartered engineer)
© Published by Axair AG, www.axair.ch

Contents

Foreword	2
Types of humidity control	6
Room and exhaust air humidity control	6
Supply air humidity control	6
Selection of most suitable control system	7
Isothermal air humidifiers	7
Steam air humidifiers with electrode heating	7
Steam air humidifiers with resistance heating	8
Steam air humidifiers with gas heating	8
Multiple steam distributor system for uniform humidity distribution	8
Pressurised steam air humidifiers for existing steam supply	8
<i>Diagram: Exhaust air humidifying control for steam air humidifying</i>	9
<i>Diagram: Exhaust air humidifying control with continuous supply air humidity limitation for steam air humidifying</i>	9
<i>Diagram: Supply air humidifying control with continuous output control for steam air humidifying</i>	10
Influence of humidifying distance on control accuracy	10
Shortening the humidifying distance	11
Important instructions on steam air humidifier control	11
Adiabatic air humidifiers	13
Circulating spray air humidifiers	13
Contact air humidifiers	13
High-pressure air humidifiers	13
Ultrasonic air humidifiers	14
Hybrid air humidifiers	14
<i>Diagram: Dew point control (exhaust air control with suction-side humidifier configuration) for adiabatic air humidifying</i>	14
<i>Diagram: Enthalpy control (exhaust air control with suction-side humidifier configuration) for adiabatic air humidifying</i>	15
<i>Diagram: Enthalpy control (supply air control with suction-side humidifier configuration) for adiabatic air humidifying</i>	16
Influence of humidifying distance on control accuracy	16
Important instructions on adiabatic air humidifier control	17
h,x diagram	19

Selection of most suitable control system

The selection of the most suitable control system for a particular application depends on the control distance, permissible control tolerance, humidity increase and air supply temperature. In addition to the problem level associated with the humidity control distance, control equipment chosen and control parameter settings, the control accuracy of a humidity control circuit is also greatly influenced by the humidifier itself. Overdimensioned humidifier capacities can be distinguished by unfavourable control behaviour in the lower partial load range. It is important in this case to ensure that continuous control is also possible in the lower partial load range. A differentiation is made between isothermal (steam) and adiabatic (atomising, evaporation) humidifying when it comes to air humidification. Although steam air humidifying is, technically speaking, not an exact isothermal process, the minimal heating of air that occurs is ignored when considering the control principles. Adiabatic air humidifying, on the other hand, is accompanied by a noticeable fall in temperature. This should be compensated for by employing a suitable register and, consequently, must be taken into consideration when choosing a control strategy.

Isothermal air humidifiers

Steam air humidifying is generally termed as isothermal. Reference has already been made to the fact that, in a thermodynamic sense, this form of humidifying is not an isothermal process. The addition of steam to system air causes a slight rise in temperature (0.12 K/g steam, as a rule of thumb). This low value is generally ignored. However, it should be noted that system air can also be heated by thermal radiation from the steam distributor. The volume of this heating depends on the steam distribution system selected and should be taken into consideration if necessary during system planning.

Steam air humidifiers with electrode heating

Electrode evaporators employ metallic elements (electrodes) in a steam cylinder immersed directly in the humidifying water. A current begins to flow between the electrodes when voltage is applied. This current is governed by the electrical conductivity of the water. The water acts as an electrical heating resistor and converts the electrical energy into heat. Electrical resistance diminishes relative to the increase of the immersion depth of the electrodes, with current consumption increasing. Steam capacity can therefore be continuously controlled from 20 to 100% by altering the water level.



Steam air humidifier
with electrode heating, CP2

Steam air humidifiers with resistance heating

Water is heated with electrical heating elements in the case of resistance-heating evaporators, similar to an immersion heater. Steam generation occurs independently of the electrical conductivity of the water. This means that fully demineralised water can also be used. Capacity control is achieved by controlling the flow over the heating elements. Steam output can therefore be continuously regulated between 0 and 100%. Steam air humidifiers with resistance heating are particularly suitable for applications where rapid and accurate control of steam output is necessary.



Steam air humidifier with resistance heating, Mk5

Steam air humidifiers with gas heating

Natural gas is used here instead of electrical current as a heating medium for generating steam. The hot combustion gases flow through a heat exchanger after the gas burner that heats and evaporates the humidifying water in a water tank. Modulated gas burners enable continuous evaporation control across a broad output range. Natural gas is a comparatively inexpensive energy source. Gas-heated steam air humidifiers are therefore particularly suitable where large steam capacities are involved.



Steam air humidifier with gas heating, GS

Multiple steam distributor system for uniform humidity distribution

Optimum control results depend on the uniform humidity distribution at the control sensor installation site. The sensors should therefore be installed at an adequate distance from the steam distributors. Multiple steam distributor systems facilitate rapid and uniform mixing of system air and shorten the required installation distances to the control sensors. They therefore contribute to optimum control behaviour where confined space conditions are involved. Multiple steam distributor systems are utilised for electrical steam air humidifiers with electrode or resistance heating and for gas-heated steam air humidifiers.



Multiple steam distributor system for uniform humidity distribution, OptiSorp

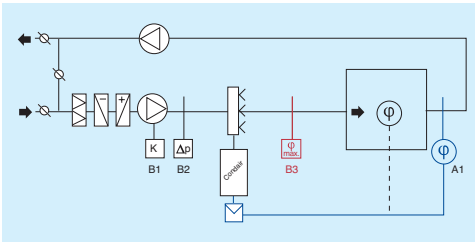
Pressurised steam air humidifiers for existing steam supply

In contrast to electrical steam air humidifiers that generate non-pressurised steam, pressurised steam air humidifiers utilise existing steam from a mains steam network. This steam is normally generated by a central steam boiler and introduced to the ventilation ducts via suitable valve technology and steam distribution systems. Pressurised steam air humidifiers can also produce large humidifying capacities with ease. The minimal delay period involved makes them excellent for high control requirements.



Pressurised steam air humidifier for existing steam supply, Esco

Exhaust air humidity control for steam air humidifying



A1: Humidifying - Control sensor
 B1: Fan monitor
 B2: Differential pressure switch/sensor
 B3: Humidifying - Maximum hygrosat

Function:

The control sensor (A1) is located in the room (or the exhaust air duct, to be more accurate). The safety hygrosat (B3) is located at an adequate distance in the supply air duct and deactivates the humidifier in the event of a malfunction.

Application range:

- Direct room humidifying
- Air-conditioning systems, primarily with circulation mode (lower Δx !)
- Consistent volume flow

Adjustment values:

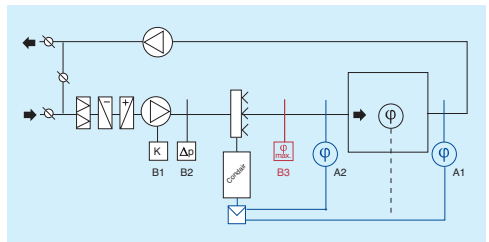
Controller:

Target humidifying value

Safety hygrosat:

Max. 80 % relative humidity (lower if possible)

Exhaust air humidifying control with continuous supply air humidity limitation for steam air humidifying



A1: Humidifying - Control sensor
 A2: Humidifying - Limit sensor
 B1: Fan monitor
 B2: Differential pressure switch/sensor
 B3: Humidifying - Maximum hygrosat

Function:

The control sensor (A1) is located in the room (or the exhaust air duct, to be more accurate). The limitation sensor (A2) and the safety hygrosat (B3) are located at an adequate distance in the supply air duct. The continuous limit sensor is activated with priority before the humidity control if the supply air humidity approaches the permissible value. The safety hygrosat deactivates the humidifier in the event of a malfunction.

Application range:

- Greater exterior air volume (higher Δx !)
- Lower supply air temperature (cooling state)
- Variable volume flow
- Post-humidifying of individual air-conditioning zones

Adjustment values:

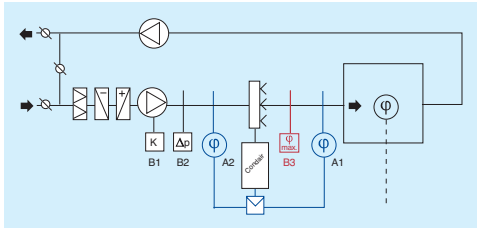
Controller:

Target humidifying value, target limitation value

Safety hygrosat:

Max. 80 % relative humidity (lower if possible), but greater than the target limitation value in any case!

Supply air humidifying control with continuous output control for steam air humidifying



- A1: Humidifying - Control sensor
 A2: Humidifying - Limit sensor
 B1: Fan monitor
 B2: Differential pressure switch/sensor
 B3: Humidifying - Maximum hygrostat

Function:

The control sensor (A1) is located in the supply air duct after the humidifier. The limit sensor (A2) is positioned in the supply air duct directly in front of the humidifier. The continuous output control is activated with priority before the humidity control if the existing humidity prior to the humidifier approaches the target humidity value. The continuous output control depends on the air humidity prior to humidifying and has a stabilising influence on the control circuit in the partial load range. The safety hygrostat deactivates the humidifier in the event of a malfunction.

Application range:

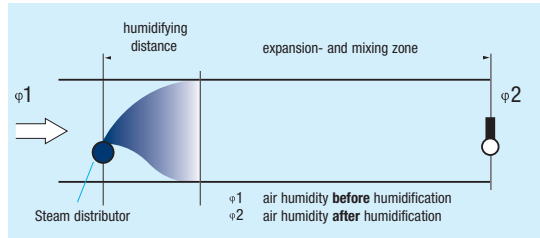
- Central air humidifying with several subsequent zone exits
Caution: A safety hygrostat should be provided for the central air humidifying and each air-conditioning zone!
- Very low space volumes and extremely high air exchange (e.g. fume cupboards, laboratories)

Adjustment values:

Controller: Target humidifying value, target value for output control (not less than target humidifying value!)

Safety hygrostat: Max. 80 % relative humidity (lower if possible), but greater than the target humidifying value in any case!

Influence of humidifying distance on control accuracy



The humidifying distance plays an important role during steam air humidifying. Steam emerging from the steam distribution pipes first condenses in the air flow and is visible as a mist within a certain distance (humidifying distance). The expansion and mixing zone then follows, in which uniform mixing of system air with the introduced steam occurs.

Achievement of hygienic operation when dimensioning humidifying distances alone make this circumstance important.

Optimum humidity distribution at the measuring sensor installation location is decisive if optimum control results are to be achieved. The humidifying distance depends on a number of factors and forms the basis for determining the required minimum distances to subsequent system parts and measuring sensors.

Reliable details on humidifying distance length and minimum necessary distances can be obtained from competent unit manufacturers.

Shortening the humidifying distance

This condensation is promoted to a certain extent through contact of the steam with the cooler system air. However, the main reason is the unfavourable distribution of the steam over the entire cross section of the duct along a steam distribution pipe.

The required humidifying distances are particularly absent in the case of retrofitting. Use of multiple steam distribution systems frequently leads to success in such cases. This enables the achievement of an almost completely homogenous distribution of steam over the entire air current with suitably short humidifying distances.

Important instructions on steam air humidifier control

Necessary safety element

- Safety hygrostat
- V-belt monitor
- Differential pressure sensor
- Flow monitor

Safety hygrostats:

Safety hygrostats deactivate the humidifier should the maximum permissible humidity level be exceeded (regardless of the reason). Safety hygrostats are not intended to perform any control function. They should therefore be provided in addition to the required control sensors and always installed as the first measuring element after the steam distributor.

Positioning of humidity sensors and hygrostats:

Ensure that system air is mixed uniformly.

Humidity sensors and hygrostats should therefore

be positioned at an adequate distance from the steam distributor (preferably as far away as possible). Recommended minimum distances should in any case be adhered to as reference values. Multiple steam distribution systems should be employed if necessary in conditions where confined space and short distances prevail!

Rules of thumb:

- Always provide safety hygrostats.
- Individual safety hygrostats should be provided for central air humidifying and post-humidifying in each air-conditioning zone.
- Safety hygrostats should not be set higher than 80 % relative humidity.
- Safety hygrostats should always be set higher than the target control value (min. 10 % relative humidity.)
(*Caution:* Note the measuring accuracy and switching hysteresis!)
- The safety hygrostat should always be installed as the first measuring element after the steam distributor.
- Recommended minimum distances for humidity sensors and hygrostats should be adhered to. Multiple steam distribution systems should be employed if necessary in conditions where confined space and short distances prevail.
- Additional safety equipment should be used for air flow monitoring (V-belt monitoring, differential pressure sensors, flow monitors).
- Overdimensioned steam air humidifiers (electrode heating) display poor control characteristics in the lower partial load range.
Solution: resistance heating.
- Use steam humidifiers with resistance heating for greater control requirements or supply air humidity control.

Adiabatic air humidifiers

Adiabatic humidifying provides room, exhaust air and supply air humidity control options. Humidity control can only be achieved in conjunction with temperature control, due to the drop in temperature caused by removal of evaporation heat from the system air. The commonest control processes are dew point or enthalpy control. Choice of the best process to achieve optimum results depends mainly on the controllability of the humidifying system employed.

Circulating spray air humidifiers (air washers)

Humidifying water is contained in an open water tank in the case of circulating spray humidifiers. It is extracted from the tank with a circulation pump and sprayed via nozzle pipes in the humidifier housing. Part of the sprayed water evaporates during this process, and this must be recirculated to the water tank via a float control. Additionally, part of the concentrated humidifying water from the water tank is drained and also recirculated via the float control. In addition to the actual application purpose (i.e. washing harmful substances out of the air), the primary role previously fulfilled by air washers was also air humidifying. These types of units are seldom employed for air humidifying today, due to current hygiene requirements. Continuous humidifying capacity control is either impossible with such systems, or can only be achieved to a very limited degree.

Surface air humidifiers (trickle-type humidifiers)

Humidifying water is in this case trickled over a contact medium (aluminium, glass fibre material or similar). The damp contact medium is then permeated by system air, with some of the humidifying water evaporating on the surface of the contact medium. Hygienic humidifying is possible if water is treated suitably and maintenance performed at regular intervals. Continuous humidifying capacity control is either impossible with such systems, or can only be achieved to a very limited degree.

High-pressure air humidifiers

Humidifying water is atomised to form a fine water aerosol by compressing it by up to 100 bar in a nozzle chamber using a high-pressure pump. Air humidifying occurs as a result of partial evaporation of this water mist in the air flow. Non-evaporated humidifying water is conveyed away via water separators. It is important in the case of high-pressure air humidifiers to ensure that perfectly hygienic humidifying water is sprayed into the respiratory air. Bacteria formation in nozzle chambers must be prevented. The level of continuous humidifying capacity control attainable depends on the pump technology and atomising nozzles employed. A minimum water volume that limits continuous operation in the lower range is necessary in all cases if perfect functionality is to be ensured.



High-pressure air humidifier, Fast Fog

Ultrasonic air humidifiers

Ultrasonic air humidifiers have special ceramic vibration elements on the bottom of an open water tank. These are agitated electrically to produce high-frequency vibrations. This in turn causes extremely fine droplets to rise to the surface of the water, and these are captured by the passing air flow and introduced into the system air to be humidified. These droplets evaporate in the air flow within a certain distance.

Ultrasonic air humidifiers have extremely sensitive hygienic characteristics. Continuous humidifying capacity control is possible.



Ultrasonic air humidifier, NKDB

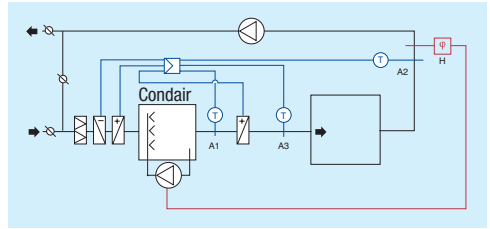
Hybrid air humidifiers

These humidifiers employ a combination of atomising and evaporation. The humidifying water is first sprayed under low pressure in fine water droplets into a humidifying chamber and partially evaporates in the air flow. The remaining water droplets are intercepted by ceramic elements and subject to post-evaporation. The humidifying water introduced is thus utilised to an extremely efficient degree. This unique technology is distinguished by a high degree of hygienic safety. The combination of atomising and evaporation enables continuous humidifying operation across the entire output range.



Hybrid air humidifier, Condair Dual

Dew point control (exhaust air control with suction-side humidifier configuration) for adiabatic air humidifying



A1: Dew point sensor
A2: Temperature sensor
A3: Minimum temperature sensor
H: Hygrostat

This control variant is mainly employed for circulating spray air humidifiers (air washers) and contact humidifiers. The humidifying system is installed between the preheaters and post-heaters. The following is a description of a room or exhaust air control with suction-side humidifier configuration. The sensor configuration should be adapted accordingly in deviating system designs or supply air humidifying control systems.

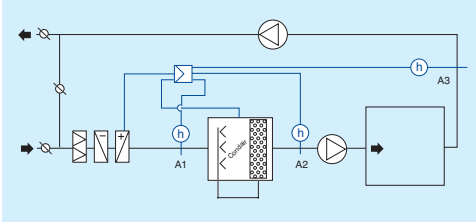
Function:

The dew point sensor A1 activates the preheater and cooler, maintaining a consistent dew point. The room or exhaust air temperature sensor A2 activates the post-heater (the sensor A2 is located in the supply air duct in the case of supply air humidifying control). The minimum temperature sensor A3 also actuates the post-heater and prevents a drop below a minimum permissible supply air temperature. The hygrostat H deactivates the humidifier (e.g. washer pump) when the target humidity is reached. A safety hygrostat is normally not required, as the evaporation principle prevents oversaturation of the air.

Application range:

- Circulating spray air humidifiers (air washers)
- Surface air humidifiers (trickle-type humidifiers)

Enthalpy control (exhaust air control with suction-side humidifier configuration) for adiabatic air humidifying



A1: enthalpy sensor
A2: enthalpy sensor
A3: enthalpy sensor

Enthalpy control enables the achievement of optimum results in adiabatic humidifying systems where continuous capacity control is permitted. Enthalpy control is distinguished by the fact that only a preheat register is installed in front of the humidifying system which heats the system air until the target enthalpy is realised. Controlled air humidifying then occurs until the desired air condition is achieved. An additional post-heater is not required during humidifying. This control process offers the enormous advantage of enabling extremely efficient humidifying with low purging water consumption. In addition, hygienic safety is increased through relatively low supply air humidity.

Function:

The enthalpy sensor A3 measures the exhaust air enthalpy, comparing it with the specified target value. The enthalpy sensor A1 activates the preheater until the target enthalpy is reached. The adiabatic air humidifier is also actuated via the enthalpy sensor A3. The enthalpy sensor A2 fulfils a safety function and limits humidifying capacity where air temperatures are too low (provided the controller exhibits suitable functionality!). It may be necessary to utilise an additional safety hygrostat in the supply air duct in the case of air humidifiers that atomise water

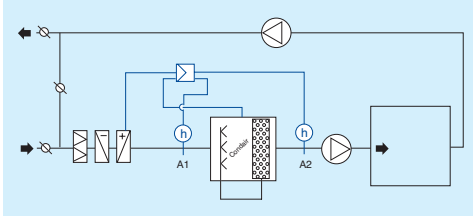
directly in the air ducts (high-pressure and ultra-sonic atomisers).

Caution: Fan and room heat loads should be taken into consideration during planning, as they influence humidifier enthalpy. The evaporation output is reduced if enthalpy is too low.

Application range:

- Hybrid air humidifiers
- Adiabatic humidifier systems that enable continuous control

Enthalpy control (supply air control with suction-side humidifier configuration) for adiabatic air humidifying



A1: enthalpy sensor

A2: enthalpy sensor

Supply air control is also possible in the case of adiabatic humidifying systems if system technical requirements make this necessary. However, the low storage capacity between the steam distributor and humidity sensor means that problem levels associated with the control distance are higher. This control variant is particularly suitable for a combination of central adiabatic humidifying with a higher humidifying capacity and subsequent zone post-humidifying using electrical steam generators. Post-humidifying, in turn, can then be realised with an exhaust air humidifying control. Moreover, these versions offer the previously described advantages associated with enthalpy control in the case of continuous controllable adiabatic humidifying systems.

Function:

The enthalpy sensor A2 measures the supply air enthalpy to compare it with the specified target value. The enthalpy sensor A1 activates the preheater until the target enthalpy is reached. The adiabatic air humidifier is also actuated via the enthalpy sensor A2. It may be necessary to utilise an additional safety hygrostat in the supply air duct in the case of air humidifiers that atomise water directly in the air ducts (high-pressure and ultrasonic atomisers).

Caution: If the enthalpy sensor A2 is positioned after the supply air fan, fan heat should be taken into consideration during planning, as it influences humidifier enthalpy. The evaporation output is reduced if enthalpy is too low.

Application range:

- Hybrid air humidifiers
- Adiabatic humidifier systems that enable continuous humidifying capacity control

Influence of humidifying distance on control accuracy

Due to design conditions, the humidifying distance is often governed by the constructional length of the air humidifier in the case of adiabatic humidifying systems. However, the humidifying distance should also be taken into consideration if devices are used that spray aerosols into the air flow that are not completely removed (high-pressure or ultrasonic air humidifiers). Aside from problems associated with hygiene, the same principles as those described on page 10 apply in this case. However, longer humidifying distances are involved than is the case in steam air humidifying, due to the low energy content of the atomised water.

Important instructions on adiabatic air humidifier control

Necessary safety elements:

- Safety hygrostat (high-pressure and ultrasonic atomisers)
- V-belt monitor
- Differential pressure sensor
- Flow monitor

Safety hygrostats:

Safety hygrostats deactivate the humidifier should the maximum permissible humidity level be exceeded (regardless of the reason). Safety hygrostats are not intended to perform any control function. They should therefore be provided in addition to the required control sensors and always installed as the first measuring element after the humidifying system.

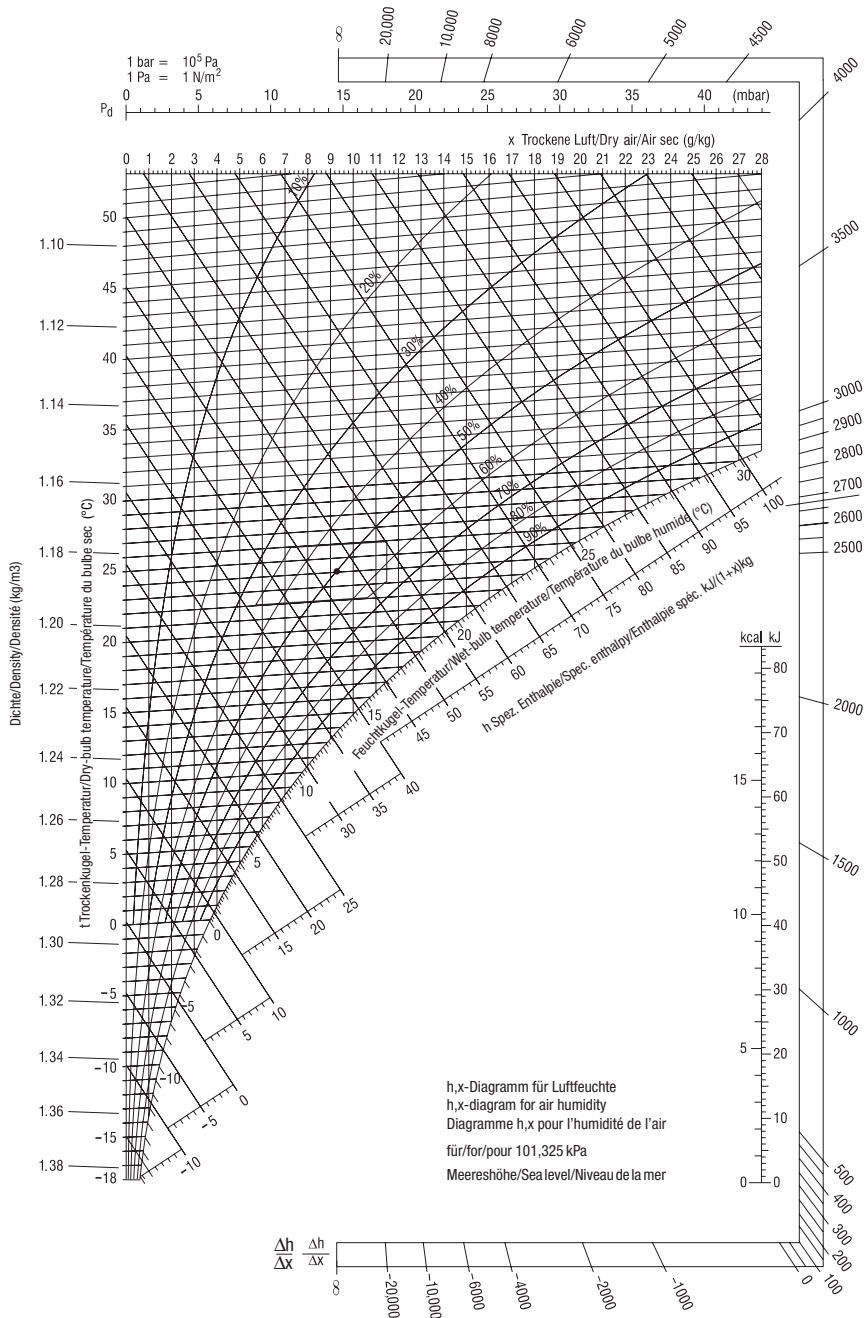
Positioning of humidity sensors and hygrostats:
Ensure that system air is mixed uniformly. Humidity sensors and hygrostats should be positioned at an adequate distance from the humidifying system (preferably as far away as possible).

Rules of thumb:

- Dew point control for adiabatic humidifiers without continuous capacity control (circulating spray humidifiers, contact humidifiers).
- Enthalpy control for adiabatic humidifiers with continuous capacity control.
- Always take fan and room heat loads into consideration during humidifier design.
- Ensure that the air flow is uniform.
Install a perforated plate or flow rectifier in front of humidifying systems if necessary.
- Provide safety hygrostats for high-pressure and ultrasonic humidifiers.
- Individual safety hygrostats should be provided for central air humidifying and post-humidifying in each air-conditioning zone.

- Safety hygrostats should not be set higher than 80 % relative humidity.
- Safety hygrostats should always be set higher than the target control value (min. 10% relative humidity.)
(Caution: Note the measuring accuracy and switching hysteresis!)
- The safety hygrostat should always be installed as the first measuring element after the humidifier.
- Provide adequate minimum distances for humidity sensors and hygrostats.
- Additional safety equipment should be used for air flow monitoring (V-belt monitoring, differential pressure sensors, flow monitors).

h, x diagram





Manufacturer:

Axair AG, a WMH Company

CH-8808 Pfäffikon SZ, Talstrasse 35 – 37, P.O. Box

Tel. +41 55 416 61 11, fax +41 55 416 62 62

Internet <http://www.axair.ch>, e-mail info@axair.ch

2519221 06603.2

AxAir
a WMH Company