THE ART, TO PROTECT

HUMIDITY IN THE MUSEUM
REQUIREMENTS AND SOLUTIONS

WD AUSTRIA

THE EXPERIENCE IN HUMIDITY

Introductory words about the publisher...

WD-AUSTRIA

- Established: 1994
- Multiple patent holders and repeated award winners
- Extensive range of products
- Author of technical publications on the topic of air humidity

WD-AUSTRIA works with associated companies in the following countries:

- Croatia
- Czech Republic
- Germany
- Romania
- Switzerland
- Israel
- Egypt
- Armenia
- Azerbaijan

In the international network of partners, there are over 200 employees in the expanded WD-Team.

Experts from the areas of mold remediation, construction and energy consultation, structure drying and air humidification guarantee an individual solution.

On the following pages, the impact of too high or too low air humidity on the exhibits will be explained in more detail.

WD-partner companies are pleased to assist you with individual solutions.

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Humidity in the museum

The most frequently asked questions from practical examples – answered by the WD-AUSTRIA team of experts

Temperature and humidity values
The humidity measurement

Recording temperature and humidity values over as long a period as possible provides information about how indoor climatic conditions behave during the course of the year. There are a number of measuring instruments are available, from a simple hygrometer / thermometer to thermo-hygrograph and data loggers with LCD displays.

Please remember that the measurement should be taken as close to the middle of the room as possible. In very large rooms, several measurements should be taken at different locations.

It would be considerably impractical to place the measuring device directly on the wall as the surface temperature of non-insulated walls could differ greatly from the actual room temperature. As a result the measurement would be inaccurate.

When exhibits are to be presented on the wall, it is recommended to conduct a dew point measurement, especially on the exterior walls. This will determine at which temperature and humidity constellation "condensation water" develops. If unfavourable humidity values are measured, there is a danger of mold growth and damage to the works of art.

Which temperatures should be taken into account?

Use of Space	Minimum	Maximum
Exhibition room	20	24
Depot and Archives	15	26
Restoration workshop	20	26
Library	17	25

Required from the persons responsible for the exhibition and exhibits: Temperatures between 20 and 23 °C and humidity values between 50 and 55 %.

However the conservationally optimal value varies from exhibit to exhibit.

In many applications, the guidelines cannot be strictly adhered to.

The exact adjustment of a specific temperature and humidity value, even with the most expensive technology, can only be achieved in exceptional cases.

In reality, the goal is to create a "climate of threshold values" with the funding available.

This is why upper and lower threshold values are determined by humidity and temperature values. These should be observed closely. Through the use of technical devices e.g. humidity levellers, the humidity values are monitored and automatically adjusted if deviations are found.

A lower threshold level of approximately 15 °C and an upper tolerance level of 26 °C can be used.
But the effect of humidity on the exhibits is even more important than the temperature! So from a conservational view, the focus of attention for threshold control will be in this area. For most exhibits, values between 50 and 55 % are optimal.

A compilation of the indoor climate recommendations can be found in the chapter "Which humidity values are suitable for which exhibits?"

Poorly insulated rooms and halls that have temperature and humidity fluctuations should not be utilised to store works of art. Temperature and humidity values (in the museum) should be oriented to the benefit of the objects and not the comfort of the people.....

Especially in exhibition rooms, the climatic conditions are greatly influenced by the stream of visitors. This is why corresponding compromises must be explored and found.

What influence does the temperature have on the relative humidity?

Warm air has a much larger humidity storage potential than cold air does. If warm air is e.g. used in cellar rooms, it will be cooled down.
However cooler air stores less humidity: Thus the relative humidity value automatically increases.

Explanation:

Assuming that 1 cubic metre of air contains 10 grams of water; then of course this quantity of water remains the same regardless of whether the room temperature is 5 or 30 degrees. This quantity of water is described as the **absolute humidity**.

Parallel to this is **relative humidity**, which is measured with hygrometers and which is generally referred to as humidity. These 10 grams of water, at an air temperature of 30 °C, result in a relative humidity of approximately 32 %. If the air is cooled down to e.g. 15 °C, then the effect occurs that was already mentioned: Cold air cannot "hold" as much water as warm air. So as described, the 10 grams of water remain in the air and the sinking temperature causes the humidity to rise to 78 %. This is why the temperature cannot be neglected when establishing roughly optimal humidity values!

Positioning of exhibits - Problem zones, wall and floor

The decisive factors with objects hanging on the walls are above all the temperature of the wall and the moisture content of the air in the room. It is based on this that the dew point is calculated.

With a room temperature of 20 °C and a humidity value of 80 %, this means that if the wall temperature drops below 16 °C the moisture in the cool component begins to condensate!

This danger is especially present in old buildings, which are usually not insulated – when the outside temperature is cold, the walls cool down!

Due to this problem, experts recommend installing a component heater: Thin heating pipes are laid at the base of or near the wall. By warming up the building, the formation of cold bridges can be effectively prevented. The transfer of heat ensures that the cool outer walls do not drop below the dew point: The danger of mold growth can be significantly reduced!

Nevertheless the component heater also poses the risk of producing an indoor humidity value that could damage the exhibits. Although the rear side of furniture, upholstery and paintings will in fact be protected against mold by controlling the temperature of the component: The existing indoor humidity causes damages to the works of art! This is why monitoring the humidity level with drying modules is highly advisable.

A largely neglected problem:

Floor-length curtains on cool outer walls

This prevents the warm, heated air from flowing through the wall surfaces behind the curtains.

The surface temperature of the outer wall remains cool. With an increased ambient humidity, there is a high potential for mold growth!

Practical example:

Insufficient air circulation in exposed sections and increased humidity lead to massive damages to exhibits again and again, as the following example illustrates:

Object:
Floor display cases for presenting a prehistoric skeleton

Resulting damage:
Due to rising ground moisture, the sand bed in the floor display case became contaminated. As a result of this permanent exposure to moisture, a large quantity of mold was able to spread over the bottom of the skeleton. By the time the extent of the damage had been discovered, penetrating damages to the exhibit had already developed.

Solution:
The skeleton was painstakingly restored by the Anthropological Department of the National History Museum. In order to prevent future damages, a WD dry air system has now been installed in the exhibition room. By adapting a special air nozzle, a "dry air cushion" between the floor and the display case developed. Thus a perfect climate is guaranteed inside the display case.

Humidity regulation through ventilation: What must be taken into account?

According to the latest insights, "shock ventilation" does not cause any damage to the exhibits. But only when the temperature differences between the indoor and outdoor areas is not too great!

During "shock ventilation", all the doors and windows are opened for a few minutes in order to achieve a full air exchange in as short a time as possible.

But the ventilating time must be meticulously limited to only a few minutes. If the exhibits are exposed to changed conditions over a few hours, this interaction will lead to cracking and swelling.

Caution: Only open the windows to ventilate the room during optimal weather conditions! Due to the short-term effect, it is necessary to repeat the procedure several times per day (even during the night).

This is of course not very practical in museums and the security requirements are clearly opposed to this procedure! In the winter, ventilating to remove increased humidity levels is in fact effective, but due to the resulting increase in heating costs, this measure is connected to strikingly high operating expenses!

Moreover, "shock ventilation" can lead to irrepairable damages to "fragile" objects. In particular, ivory carvings, papyrus, ancient scriptures and several minerals are extremely vulnerable to drafts.

Humidity situation in cool rooms:
High humidity values are almost unavoidable in cellar rooms, especially in the summer.

Due to the existing temperature differences between indoor and outdoor air, an improvement of the situation can seldomly be achieved.

Due to the penetrating warm air, condensation forms on the cool walls. Thus the moisture problem is increased!

Ventilation in cellar archives and cool rooms is only feasible if the outdoor temperature is at least 5°C below the indoor temperature.

Therefore, a tip for ventilation in cool rooms: When the outdoor temperature is warm, keep the windows closed and only open them when the temperature decreases. This is of course especially problematic in the summer since the outdoor temperature is seldom below the indoor temperature.

The general rule is:
The works of art can balance out slow changes in room temperature and humidity, without any resulting damages. However, maintaining the threshold levels of temperature and humidity is of utmost importance!

Basically any climate risk should be avoided, and when selecting exhibition or archive rooms, data on temperature and humidity levels must be taken into consideration. Installing drying units or humidifiers is advised in order to guarantee optimal spatial parameters.

Ventilating in the winter: Pros and cons
Ensure that "tilt ventilation" is avoided!

This form of ventilation (keeping the window open a crack) causes the wall surfaces near the windows to cool down. If the humidity values inside the room increase, then the water vapour in the air condensates onto the cool components, making mold growth unavoidable!

In the winter, however, another problem usually arises: The air is relatively dry in rooms with central heating! This could lead to massive crack formations in the works of art, parquet flooring and ceiling linings made of wood.

Installing air humidifiers is absolutely essential in order to balance out these climatically critical values; otherwise this could lead to irreparable damages.

When selecting a suitable humidifier, there are a few significant parameters to take into account, which we have summarised in "Measures against extremely dry air".

Forced air circulation: YES or NO?

"Stale" air in damp archives and art depots presents the problem that with unfavourably high humidity values, the danger of mold growth on cold structural elements increases disproportionately. Circulating the air with a drying unit is the most optimal measure to prevent mold growth even from starting. An application with special antibacterial filter materials eliminates mold spores and airborne germs present during the drying process!

Humidity adaptation of loan exhibits

If objects from climatically divergent areas are placed in other rooms (e.g. for exhibitions or restoration), it is necessary to slow adapt the object to the changed climatic conditions. That is why it is important to wait a few hours before opening the transport package. When there are much greater climatic differences, the object should be temporarily stored in a room with an average temperature level.

Pest infestations of exhibits

For long-term storage of exhibits, temperature and humidity levels that are as low as possible are recommended. In contrast to optimal humidity values in exhibition areas and archives, for long-term storage of exhibits a temperature from 10 to 13 degrees is considered to be optimal, since the multiplication of pests is reduced with decreasing temperatures.

Furthermore the configuration of the optimal humidity constitutes an even more important factor. In reality, the problem inevitably stems from the fact that with decreasing temperatures the relative humidity is negatively altered. For this reason, it is only advisable to reduce the temperature when the humidity can also be simultaneously reduced to harmless values!

For prophylactic reasons as well as to combat mold spores and decomposing bacteria, a specially developed spray system should be implemented.

Chemical preparations like hydrogen peroxide and chlorine can lead to massive damages!

This is why only agents that are biologically based e.g. Nano-Med-Steril® are recommended. These are perfectly harmless for people and can be implemented in work rooms (e.g. restoration workshops)! In addition to eliminating germ contamination, this application method also eliminates odour problems.

The implemented preparation splits the molecular structure of bacteria and mold cells, comprehensively and permanently eliminating the problem.

Which humidity values are suitable for which exhibits?

Wood

Wood can bear slightly elevated humidity values without major problems. When the air is too dry however, massive reactions take place, all the way to irreparable cracking: If e.g. wooden furniture is transferred from a relatively cool and slightly damp archive to a centrally-heated exhibition room. The wood humidity balance changes too quickly – the wood becomes brittle. The humidity range should not fall below or exceed 45 – 60 %.

Stoneware, clay and terracotta

Under unfavourable humidity conditions, stoneware, clay and terracotta react with the crystallisation of the salts present in the material. Glazes are especially prone to flake off.
Depending on the material, a relatively wide range of humidity can be used, namely 40 to 70 %.

Glass

The normal values for glass range from 45 to maximum 55 %. Should the glass however already be affected by "sick glass", then a conservational storage below approximately 40 % is recommended.

Paintings

Paintings often consist of several layers of colour, which vary in their reaction to changes in humidity. For this reason, paintings improperly stored are at risk of the colour cracking and becoming permanently damaged.
Paintings on wooden tablets and paper / papyrus react especially sensitive to changes in humidity conditions. Due to this sensitivity, it is therefore relatively difficult to establish a generally applicable humidity value.

In any case the dew point temperature plays a large role. This is a factor, which is unfortunately seldom considered in scientific publications and in the literature.

It can generally be said that an upper value of 70 % relative humidity should not be exceeded under any circumstances; otherwise there is a risk of condensation forming on the cool wall. Therefore values of 70 % relative humidity or above should only be considered harmless when the room temperature is very warm. Above all, the humidity level should be no higher than a maximum of 60 % in cool temperatures. A lower threshold of 40 % can be applied.

Hence the recommendation has to be: To strive for average values of 50 to 55 %. Dew point measurements are highly recommended in order to be able to determine the necessity of implementing an air dryer.

Tin

Temperatures under about 13 °C should be avoided as it increases the risk of tin pest. It should however be noted that in some depots, even at values of 10 °C, no damages were recorded. This confirms how difficult it is to set generally applicable "temperature and humidity rules" for exhibits. Therefore only a range with a recommended lower and upper value can be given.

Photo and Film Material

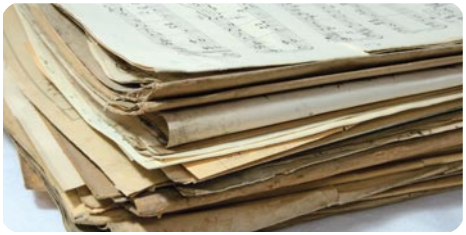
While grammophone records should retain a value of 40 – 55 %, for photographs and glass sheets, the ideal value should range between 20 – 40 %. Generally, photo archives should have temperatures of 21 °C and a humidity value under 50 %, if possible. Specific groups of materials, such as nitrate negatives, require especially well-controlled climatic conditions. This is why they are mainly kept in climate controlled display cases.

Metals

The same values apply for glass as for metals, although due to the lack of moisture storage capability at low temperatures, the danger of condensation forming is very great!

Paper and Leather

Paper and leather are especially susceptible to high humidity values – 50 to 55 % should not be exceeded.



Textiles (silk) and ivory

These objects react extremely sensitively to changes in humidity values. In connection with drafts, ivory carvings are especially at risk to cracking. Humidity range: 45 - 55 %.

Climate configuration in display cases

Due to the enclosed and limited volume of air, the climatic factors in special display cases can be regulated with considerably more precision than in large exhibition rooms.

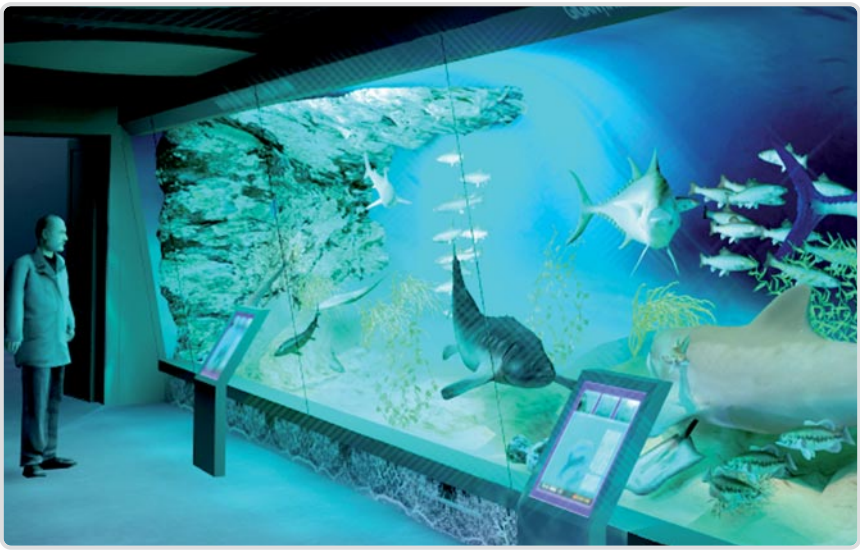
However the fact remains that in conventional display cases without climate configuration, there is the danger that unfavourable conditions promote mold and bacterial growth. The usually long unnoticed decay of the exhibits begins.

In museums, humidity regulators such as Silikagel or salt solutions are fully insufficient solutions. This is not an effective way to control humidity values.

For standard display cases, a special display case conditioner is used to configure an optimal climatic value.

In Dioramas however, which can sometimes be from 10 to 30 m², individual solutions are necessary, as the following example clearly shows:

During the new conception of the Museum of Natural History in Bucarest, the planning team was faced with the challenge of installing air conditioning units in over 40 large display cases, the largest of which had an air volume of 80 m³.



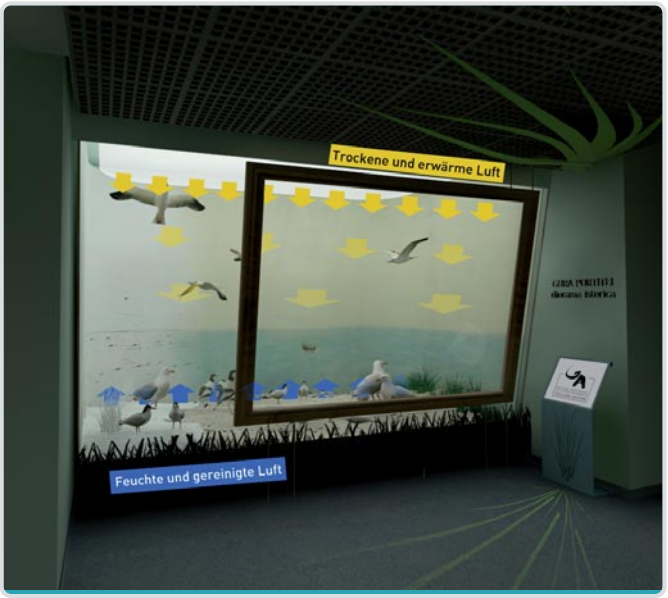
A temperature control was in fact possible with a flat profile air-conditioning unit. But this still could not solve the humidity problem.

A further demand was presented by the shallow installation depth. The humidity configurators could only be installed into the ceiling above and in the floor below the Dioramas.

This demand led to the development of a special product line. Through the use of physical thermal, a floor installation system configures the air to the optimal values.

Thus the humidity distribution is absolutely the same in all areas of the display cases. The virtually silent operation of the unit enables visitors to observe the exhibits undisturbed. By using energy-efficient systems, the unit can be operated with a minimum of energy costs.

In order to avoid condensation formation in the large display case windows, a dry air stream is directed directly towards the glass fronts, thus creating a natural "dry air curtain".



Humidity configuration in the museum

The most frequently asked questions from practical examples, answered by the WD-AUSTRIA team of experts.

Problem: "Humid air"
How can excessively high humidity values be reduced?

For air drying, the following procedures are available:

- Drying by heating up the air
- Absorption drying
- Condensation dehumidification

Drying by heating up the air

A problematic method: The room temperature is heated up to several degrees above the necessary values. The humidity is thereby subjectively reduced; but this is deceptive!

The quantity of water vapour can not "vanish into thin air" and either remains in the room or is forced into the walls.
High heating costs are the result – without having solved the problem!

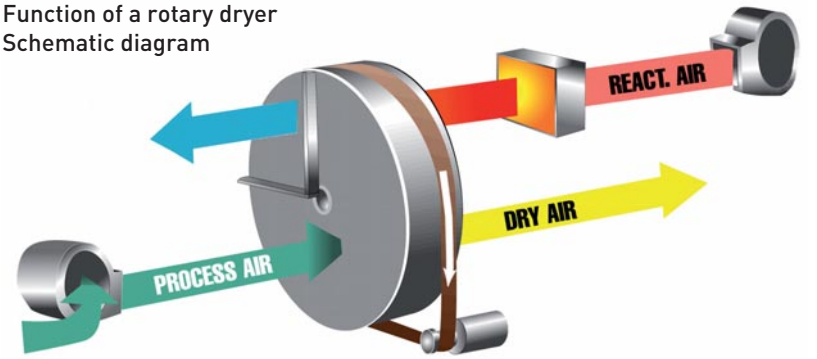
Rotary drying:

In this system, the air in the room is guided into a drying module. The moisture is absorbed by a hygroscopic element inside the dehumidifier. Through the use of an air hose, the humid air is diverted outside. The dry air remains in the room.

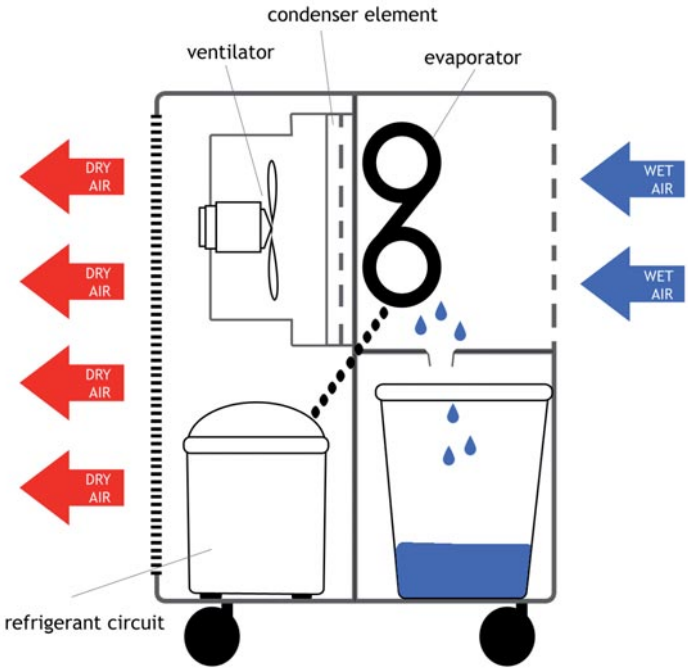
An outer wall breakthrough is necessary in order to dissipate the humid and warm air. If this is not possible, a capacitor can be temporarily used, which removes the accumulating humidity.

Due to the comparatively very high investment costs and the high energy consumption, rotary drying is only used in exceptional cases, e.g. if very low humidity values must be achieved, or if room temperatures are around the freezing point.

Function of a rotary dryer
Schematic diagram



Function of a condenser dryer
Schematic diagram



Condensation dehumidification

The gentle and energy-saving drying system.

Humid air in the room is sucked up by a ventilator and guided into the drying unit via a condenser element. This element is continuously cooled with a refrigerant circuit to below the dew point. Since the incoming air is warmer as the air in the condenser unit, the air is promptly cooled and thus "loses" water vapour, which condenses into water droplets and is guided into a container (or condensate hose).

Using the same principle as in heat pumps, the dried air in the condenser dryer is heated up again in an energy-saving way and is redistributed into the room.

Which criterias are decisive for a condenser dryer?

- Easy operation (e.g. mechanical humidity controller)
- Automatic restart after power failure
- To not use sensitive electronics
- Axial fan to reduce the noise level
- Fan performance of at least 300 m^3/h
- Large exhaust opening to avoid dust turbulence
- Easy to clean (open water container, drip cup)
- Suitable for non-monitored operation
- Easy maintenance and simple part replacement during repairs.

Condenser dryer

Due to repeated successes, museum experts recommend using the following product series: **Convenience drying modules**

Tip

An extensive topic development and detailed explanation of each dryer can be found in "Guide to selecting an air dryer". Published by WD publishing company. ISBN 978-3-200-009677.

Problem: "Dry air"
Measures to reduce high humidity values

There are basically three ways to increase the moisture content in the air:

- Atomization
  e.g. ultrasonic atomizer
- Water evaporation using rotation systems
- Water vapour
  e.g. high temperature evaporation

Over the last decades moisture enrichment through water evaporation or atomization has widely spread.

However, over the last few years the rotary humidification system has proven itself. And not only because of the energy optimised working method and the high efficiency!

During water evaporation, there is also the risk similar to atomization, in that the lime present in the tap water will evaporate and form a lime stain on exhibits and wooden flooring. In addition, atomizers and evaporators are very clean-intensive and come with high maintenance costs for replacing spray nozzles and filter cartridges. Since the water in evaporation systems must constantly be heated to high temperatures, the energy costs involved are incredibly high.

The problem with the "atomization system" was demonstrated in a study conducted by renowned doctors. The fine spray is absorbable by the lungs. Dust particles and bacilli attach themselves to the mist particles – and can directly enter the human body!

This is why for museums and restoration workshops, but also for apartments and offices, only rotary humidification systems are recommended. With integrated UVC water disinfection, next to an optimal humidity configuration, the air will be both washed and rid of dust! A significant factor of all humidification systems is the adjustable controlling of the humidity value, which prevents over-humidifying.

Which criterias are decisive for an air humidifier?

- Rotation humidifier motor to avoid lime deposits
- Filter cleaning to remove bacteria must be possible at 60 – 90 °C!
- Automatic restart after power failure
- UVC water disinfection for the prevention of pathogenic bacteria
- Non-monitoring operation and automatic control
- Easy maintenance and simple part replacement during

Rotation humidifier

Hence the unit recommendations by museum experts:
Rotorary humidifiers with UVC disinfection unit

Tip

For further information see "Guide to selecting an air humidifier", ISBN 978-3-950-243307 – published in the WD Publishing Company.

Conclusion

An air dryer isn't simply an air dryer and an air humidifier isn't simply an air humidifier!

If an equipment acquisition is planned, the following selection criteria must be considered:

- Performance capacity of the device
- Room size and air temperature Use of space
- Hygiene and disinfection problems
- Power requirements and long-term operation
- Components must be designed for long-term operation
- Easy operation and cleaning of the devices
- Lowest possible maintenance costs
- Replacement of spare parts must be possible without special tools

To avoid mispurchases, an individual consultation and performance determination should be carried out by a specialised supplier.

Some final information:

For short-term requirements (e.g. special exhibitions), renting a unit can be more cost-effective than purchasing one.

Air-conditioning units, air humidifiers and drying units should be periodically cleaned.

Especially with older models, there is a danger that they will become breeding grounds for germs and mold spores. Here, decontamination using the Nano-Med-Steril method for mold removal is recommended.

Anti-mold filters and dust collecting systems improve the air climate in restoration workshops and reduce health risks!

Any questions can be addressed to:
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- **Leitfaden zur Auswahl eines Luftbefeuchters ISBN 978-3-950-243307 - erschienen im WD-Verlag**

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- **Pathogen propagator air humidifier?**
  Criteria when choosing a humidifier
- **Risk factor: Dry air?**
  Dry air promotes influenza viruses
- **Influence of moisture on exhibits**
  Indoor climate situation in museums, exhibition rooms and archives
- **Specialized information: Air dehumidifier**
  Criteria when choosing an air dryer
- **Mold-free structure drying**
  The most important questions from practice on the topic
  Structure drying and water damage refurbishment
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  How do I ventilate correctly?

Questions about the subject of humidity?
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