



HOW TO PREVENT HUMIDITY ISSUES IN DISPLAY AND STORAGE CASES

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1.0 Introduction

The largest factors with display cases are the protection of contents and the overhead cost. These include the cost of keeping humidity inside the enclosure at an optimal level to allow the contents to be displayed at their prime condition. Costs such as energy and the environmental impact of the chosen solution should now more than ever be considered, when looking at humidity control solutions for display and storage cases.

This whitepaper will explain what humidity is, why it is important to understand humidity in the preservation of materials to be displayed and stored, including items such as books, musical instruments,

plant matter etc. and compares different ways and technologies to control enclosure humidity using the latest in dehumidification techniques.





2.0 Background information

Before reading this whitepaper, it is advisable that you understand the following basic terminologies to understand the whole processes involved:

2.1 Humidity

Humidity is the ratio of water vapor in the air to the maximum amount of water vapor in the air that could be present if the air were completely saturated at a given temperature. Humidity therefore is dependent on the air's temperature. A crucial point that is often forgotten or misunderstood about relative humidity (RH) is that the "relative" part is referring to that "given temperature" from the definition. Therefore, humidity is relative to temperature. Meaning that the warmer the air mass, the more water vapor the air can hold.

Humidity is expressed as a percentage where 100% relative humidity using the symbol "RH" would represent the maximum amount of water that is able to be held in the air at a given temperature.

2.2 Dew point

The dew point is where moisture in the air becomes water droplets. The Dew point of a given body of air is expressed as the temperature to which air must be cooled to become saturated with water vapor. This temperature depends on the air pressure and water content of the air.



A Dew point temperature is never greater than the air temperature. This means if the air cools, moisture must be removed from the air and this occurs through condensation. This process results in the formation of tiny water droplets. These tend to form on the coldest part of a container, window in a room etc.

The higher the relative humidity, the closer the dew point is to the current air temperature, with 100% relative humidity meaning that dew point is equivalent to the current temperature. In cases where the dew point is below freezing (0°C or 32°F), the water vapor turns directly into frost rather than dew. Where the



condensation is ice, this is known as the frost point. Therefore, air with a lower dew point is drier than air with a higher dew point.

2.3 What is a Dehumidifier?

A dehumidifier removes moisture from the air. A major reason dehumidifiers are used is if the moisture in the air meets dew point, then water globules will start to form. For things like electronic devices or metal items stored in a display cabinet this can be catastrophic as the water droplets act as conductors and can create short circuits causing least case data miscalculations, worst case component failures. Dehumidifiers are used in lots of different applications such as matter preservation. In food if the moisture content is high, it will perish faster and will allow bacteria and moulds to grow. With bacteria the majority require a relative humidity (RH) of 60% or more to grow, though some can survive and multiply in less than 20 percent RH. Even domestic items such as cameras should be stored in a dehumidified display case to ensure the camera lens is not fogged internally by moisture ingress. Therefore, the job of a dehumidifier is to remove moisture from the air when the humidity is too high.

2.4 What is a Humidifier?

A humidifier does the opposite to a dehumidifier. Its job is to add moisture to the air. If you have too low a moisture content items can also start to perish. An example of this is paper. If paper is kept in too low a moisture content it will start to break down the fibres holding it together. Paper needs to maintain a humidity level of between 30 – 50 percent. Too dry it will fall apart, too moist then it will start to bubble up and also attract moulds.

3.0 Why do we need to use dehumidifiers in display cases?

The reason for keeping items in a display case at controlled humidity levels is to ensure when they are viewed, or used, they are in perfect condition or sensitive devices such as cameras and instruments, i.e. lasers, can be used immediately. Even in airtight cabinets moisture levels can have long and also

short term effects on the items displayed inside. For example, anything steel housed will start to rust at humidity levels over 50%, so keeping metal items in a humidity-controlled environment is a prerequisite, even electronic devices will change their characteristics due to humidity levels.

	Recommended Relative Humidity Level	Recommended Temperature
Paper and Books	40% - 55%	+18°C - +22°C
Steel Items	35% - 40%	+5°C - +25°C
Cigars and Tobacco	70% - 75%	+20°C - +23°C
Taxidermy Animals	45% - 55%	+15°C - 27°C
Musical Instruments	40% - 60%	+21°C
Vegetable Matter	80% - 95%	+0°C - 35°C
Paintings	45% - 55%	+15°C - +25°C
Clothing	50% - 55%	+24%
Sterile Instruments	<60%	+21%
Cameras	35% - 45%	-10°C - +50°C
Pottery and Ceramics	40% - 60%	+15°C - +25°C
Lasers	15% - 25%	+15°C - +25°C
3D Printer Filaments PLA	30% - 50%	-20°C - +30°C
3D Printer Filaments Nylon	<50%	-20°C - +30°C
3D Printer Filaments PVA	<50%	+10°C - 30°C
3D Printer Filaments ABS	30% - 50%	+15°C - +25°C

Example of recommended storage temperatures and humidity levels for display cabinets



4.0 Different types of dehumidifiers

There are 3 main types of dehumidifiers.

- 1) Ventilator/Heat pump types commonly known as refrigerant dehumidifiers.
- 2) Desiccant
- 3) Solid state.

Each has a different method of collecting moisture and knowing the difference between each variant will help you decide which one would best suit your needs to help protect your displayed or stored items.

4.1 Ventilator/Heat pump/Refrigerant Dehumidifiers

A heat-pump or refrigerant dehumidifier, as they are also known, uses the same process as a domestic refrigerator. The refrigeration process cools a metal plate on which moisture from the air condenses. A fan constantly draws the room air through the dehumidifier and over the cool metal plate(s) and all the time more of the moisture condenses onto the plate and drips into the dehumidifier's water tank. Eventually the relative humidity in the room/home is reduced to a normal level and the unit will then switch itself into standby until such a time as it is required again.

Refrigerant dehumidifiers are most effective at typical room temperatures and their performance declines dramatically in cooler conditions. The common reason for this is the formation of ice on the metal cooling plates (coils). This freezing can occur at any temperature from about 65°F/18°C downward. A refrigerant dehumidifier can operate effectively at lower temperatures but requires higher performing components and additional features to achieve this, making it more expensive. So, if you think your dehumidifier may often be used in a room which often has a fairly low temperature then this may not be the best option.



4.2 Desiccants bags dehumidifiers

Desiccant dehumidifiers absorb water from the air using a desiccant. A desiccant is a material that absorbs water and will be familiar to anyone who has ever found a small pack of crystals, labelled "silica gel", packaged with a camera, computer, or some other product when you purchase these types of electronic products. Also known as desiccant dehumidifiers, they consist of hydrophilic materials, such as silica gel. Many desiccant dehumidifier units contain single-use desiccant-type cartridges, gel, and powders, which when laden with moisture need to be thrown away and replaced with a new desiccant.

4.3 Desiccant Dehumidifiers

A desiccant humidifier uses the hygroscopic materials used in desiccant bag dehumidifiers but uses electromechanical parts to reuse the desiccant. In a desiccant dehumidifier, a wheel consisting largely of the desiccant turns slowly through the incoming air stream and absorbs moisture. During the rotation cycle a proportion of the wheel is passing through a stream of warm air which "reactivates" the desiccant by driving off the moisture. This condensed water is then collected in the dehumidifiers collection tank or automatically drained out via a tube from the back of the unit to the outside or via a plug hole etc. This type of dehumidifier tends to be smaller and lighter than the refrigerant type. Desiccant dehumidifiers can operate at much lower temperatures than a refrigerant type.

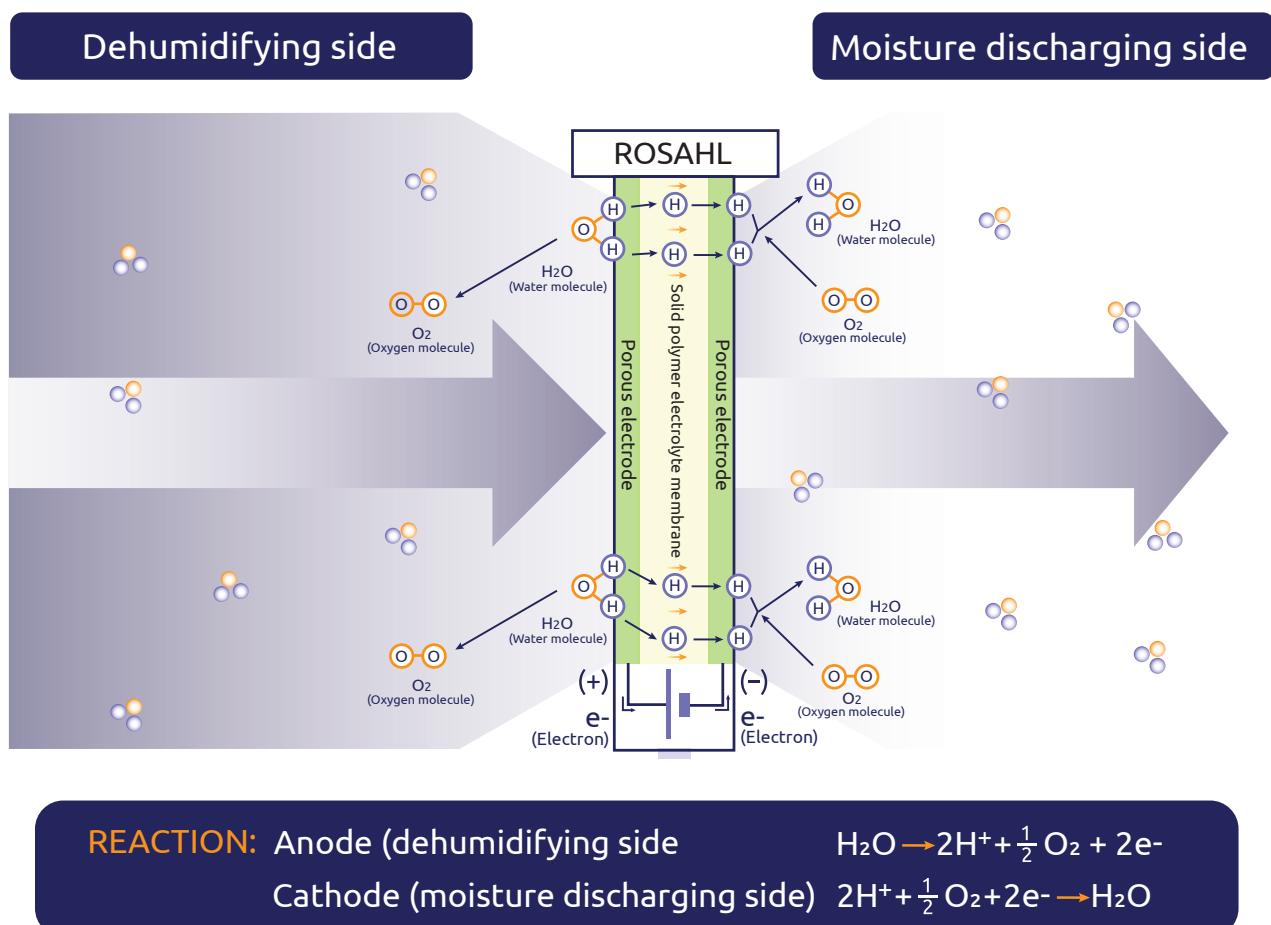


4.4 Solid State Dehumidifiers

A solid-state dehumidifier removes moisture from the air by the use of electrolysis when a small voltage is applied to a solid polymer electrolyte (SPE) membrane. The membrane attracts moisture to an absorbent side, where it dissociates into hydrogen ions (H^+) and oxygen. The hydrogen ions (not hydrogen gas) migrate through the membrane for discharging on the cathode (moisture discharging) side where they react with oxygen in the air, to form water vapour. Solid state dehumidifiers provide clean moisture extraction and low cost, maintenance free performance. One major advantage of solid-state dehumidifiers is that they are extremely compact and small, with the smallest devices being the size of a hazelnut.

4.4.1 How does a solid-state dehumidifier work?

PRINCIPLE OF DEHUMIDIFICATION



(Picture kindly supplied by and rights to
Rosahl Technology owned by Mitsubishi Electric)

5.0 What to consider in choosing the way to control humidity in your display cabinets

When deciding which type of humidifier you need for your 3D filament storage case(s) you will need to consider the following questions:

- 1) How often will you open the storage case? If regularly, then every time you open the case, you will basically reset the RH level in the case to the RH level of the room you are in. If you open the case regularly then desiccant bag humidifiers will fill and become useless very quickly.
- 2) How often are you able to empty water collected? If you are leaving the filament storage cases for periods on their own, please remember that refrigerant and desiccant dehumidifiers collect all the moisture they expel from the air in collection tanks. These will need to be monitored and emptied when required.
- 3) Does the environment where you are storing the 3D filament cases need to be quiet? If you do not want to hear electro-mechanical noises, then you will only be able to use desiccant bags or Solid-state dehumidifiers as they make zero noise. Refrigerant and desiccant dehumidifiers do make noise which will increase as the machines get old and start to mechanically wear. Solid state dehumidifiers and desiccant bags do not wear out.
- 4) Do you want/need to be energy efficient? If being energy efficient is necessary due to government regulation or personal financial position, then solid-state dehumidifiers and desiccant bags are the best way forward. Solid-state dehumidifiers like Rosahl's dehumidifiers use only 3 VDC and for smaller membranes use only 0.06 watts of energy. Disposable single-use desiccants are energy efficient, but if you have the type that can regenerate it takes a lot of energy to periodically dry out the crystals.
- 5) Do you have environmental or recycling requirements? For companies and individuals that have environmental and recycling requirements then refrigerant, most desiccant dehumidifiers and solid-state dehumidifiers will meet your needs. Due to the one-time use of desiccant bags the desiccants cannot be reused or recycled, and these compounds such as silica gels will just be put into landfill sites.



5.1 Dehumidifier type comparison chart

Below is a simple comparison chart of dehumidifier types. Some dehumidifiers only reduce moisture but some like Rosahl's Solid-State dehumidifiers will humidify and dehumidify.

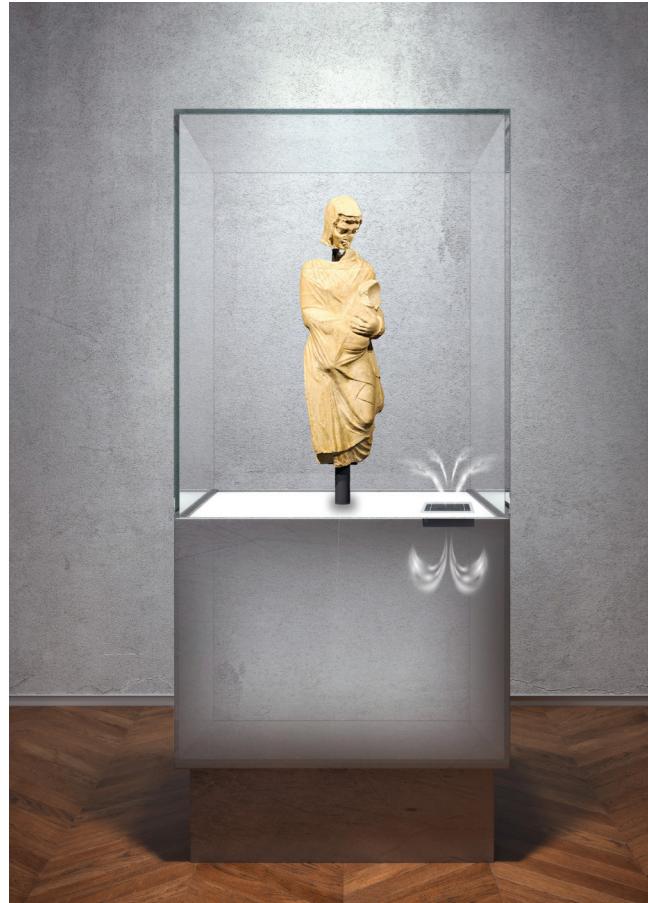
	Refrigerant Dehumidifiers	Desiccants Bags Dehumidifiers	Desiccant Dehumidifiers	Solid State Dehumidifiers
Initial Cost	High	Low	High	Medium
Energy Use	High	None	High	Low
Life Expectancy	Medium	Very low	Medium	High
Environmentally friendly	Medium	No	Medium	High
Filament container size	Large	Small	Large	Medium
Operating Temperature	Better in higher temperatures	Good at most temperatures	Good at low temperatures	Good at most temperatures
Waste	Water is collected in a drip tray	Water is absorbed into the material	Water is collected in a drip tray	None
Negatives	Needs tray emptying of water	Needs replacing often. No accurate indication of when full	Needs tray emptying of water	None
Dehumidify	Yes	Yes	Yes	Yes
Humidify	No	No	No	Yes
Size	Large	Small	Large	Small - micro small



6.0 Conclusion

In conclusion, one of the main factors in display and storage cases is to reduce the overall cost of having a humidity control solution. An easy way to decrease maintenance and reduce actual running costs is probably by using solid-state dehumidifiers, which offer a compelling solution for effectively controlling moisture and humidity in display and storage cabinets and enclosures. This white paper has highlighted the numerous advantages of using solid-state membranes, including their compact size and low energy consumption.

By using solid-state polymer electrolyte (SPE) membranes, dehumidifiers such as Rosahl's micro-dehumidifiers provide a waterless and maintenance-free option for enclosures. The absence of moving parts ensures silent and vibration-free operation, combined with their small energy and physical footprint, makes using them for display and storage cases humidification solutions a simple choice.



Example of a simple dehumidification solution using a solid-state humidifier
and powered by a USB-C PSU, produced by <http://chip45.com>

Footnote

Rosahl dehumidifiers are manufactured by Mitsubishi Electric. For more information on Rosahl micro-dehumidifiers please contact enquires@westside-int.com or visit micro-humidifiers.com



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