Winery Humidification Backgrounder

Or, how to utilize humidity to improve winemaking.

A White Paper presented by

Fogmaster®

Humidification Backgrounder

A low humidity can have serious negative consequences…

- It is uncomfortable for people. Problems can include dry eyes and mucous passages, not to mention respiratory distress.
- It promotes the build-up of static electricity, causing unwelcome sparks and discharges, static cling of textiles and, in some environments, a risk of fire or explosion.
- It causes textiles, paper and wood products to dry out, leading to shrinking, cracking, splitting and loss of strength.
- In the wine industry, it accounts for significant product losses during barrel aging. It also allows empty barrels to shrink and perhaps to leak.

This Backgrounder offers general information on ways to boost and control humidity. It is relevant for many humidification projects, but concentrates on the wine industry — warehouses that store new barrels before delivery and those aging wine in barrels.

THE Fogmaster® CORPORATION

Humidity Management in Wineries

For centuries, wine has been stored in cellars (or caves) to take advantage of their cool temperatures and relatively high humidity. Today, wine production is growing in regions that lack these advantages.

As the industry expands, barrel storage and aging will increasingly take place in above-ground warehouses that benefit from humidification.

And even a newly constructed cave may suffer from low humidity if the surrounding soil is dry. (It does, however, benefit from the cave's uniform cool temperature.)

Benefits Of Humidification For Wineries

A humidification system can add water vapor to the air when the natural humidity level is low. This brings several benefits:

1. Topping Losses Are Reduced.

The wall of an oak barrel is semi-permeable. As much as 10% of the wine may be lost to evaporation during barrel aging. Raising the humidity in the barrel room slows evaporation, leaving more product to be bottled.

2. Barrels Stay In Better Condition.

Raising the humidity retards empty barrel shrinking and leaking. And barrel washing, sterilizing and steaming go faster when the wood does not need rehydration.

3. Wine Quality Is Improved.

A high humidity in the surrounding air reduces water evaporation from the barrel, slowing the natural increase in alcohol level.

4. An Investment in Humidification has a Quick Payoff.

Slashing topping losses from 8% to 4% per year can pay for a humidification system in less than 12 months. (Of course, potential savings estimates should take account of the winery's barrel inventory and loss history.)

A humidification system can add water vapor to the air when the natural humidity level is low, which brings several benefits such as reduced topping losses, barrels in better condition and improved wine quality.

Types of Humidification Systems

Wineries and barrel manufacturers use many techniques to raise humidity—from wetting floors with hoses, to bedroom humidifiers; from swamp coolers, to fully automated systems.

Types of Automated Systems include...

Passive Systems

These move air over—or through—a wetted surface or membrane. (They include wicking systems, "swamp coolers" and pad coolers.) As air moves over the wetted surface, it picks up water vapor.

The major use for a passive system is cooling, however; humidification depends on uncontrollable factors (inside/outside air temperature, water temperature, outside humidity). Passive systems cannot regulate humidity independently.

Hot Water / Steam Generators

These heat water to increase available water vapor. They range in size from a pan of boiling water on a stove to an industrial boiler. A large steam generator may require additional investment for electrical gear and water pretreatment.

These systems have high electrical operating costs and usually add heat to the room.

Droplet Systems

These eject water droplets to evaporate into vapor. Results depend on many factors including droplet size (small is better); how quickly the added water vapor is mixed with room air; the potential for dripping or wetting; and maintenance requirements.

Droplet generators are available for small or large rooms and have relatively low operating costs.

Since droplet systems are often the choice for wineries, let's look a bit more closely at them. There are three general ways of producing water droplets for humidification:

- "Slingers" dribble water onto the hub of a rapidly spinning disk or fan blade. The water film spreads towards the edge of the blade and is flung off as droplets.
  If backed by a large fan, a slinger moves lots of air and distributes droplets widely. Slingers tend to be noisy, and they don't produce the very small droplets preferred for quick evaporation.
- Pressurized nozzles force water through a small orifice to form a mist. Some operate at modest pressure (150-250 psi), others at high pressure (1000-1500 psi). High pressure systems produce smaller droplets that evaporate faster and are less likely to cause wetting. However, they may need sophisticated filtration to prevent solids plugging small nozzle openings.
- The Sentinel® "cold" fogging nozzle uses the turbulence of a low pressure air stream to atomize water into small droplets. Droplet size is user adjustable. The nozzle has no small orifices and is not susceptible to plugging or dripping.

System Control

When the humidification system operates, it raises the relative humidity. Once the RH reaches the target setpoint, it should turn on only as needed to replace water vapor losses.

An automated humidification system demands a humidity sensor and controller. Systems running under the control of a timer, or those with only manual control, produce wide humidity fluctuations.

Planning: Issues & Concerns

This section highlights a number of issues that should be considered when planning for humidification.

In new construction, a good design will avoid many of the problems covered below. A barrel room with compatible refrigeration, minimal ventilation and little traffic won't lose much water vapor. What little make-up water is needed can be delivered as small droplets.

In the real world, however, humidification projects tend to be add-ons to existing facilities. This necessitates trade-offs and compromises.

This section covers the principal factors that should be considered.

Water Vapor Losses

Humidification is most successful in rooms that have good control of vapor losses. The higher the loss rate, the higher the demand for make-up water vapor. The humidification system must run longer. If losses are excessive, it might be unable to maintain the desired humidity target.

The main pathways of vapor loss are migration, condensation, and absorption.

MIGRATION LOSSES can be accidental — say, air exchange through an open door — or deliberate — ventilation or night air cooling to bring in fresh (but usually dry) air. The tighter the room, the lower the migration losses. The challenge is to strike the right balance.

CONDENSATION will occur on any surface colder than the dew point. Typical condensation sites are fermentation tank chiller coils, refrigeration coils, metal ventilation grates, metal door and window frames.

A high relative humidity (RH) setpoint increases the likelihood of condensation; it narrows the temperature/dewpoint spread. In a room maintained at 59°F and 80% RH, vapor does not condense unless it encounters a surface cooler than 53°F (the dewpoint). But if the room is held at 90% RH, the spread narrows to 2.7 degrees, and vapor will condense on any surface 56°F or cooler.

ABSORPTION losses are usually one-time events —absorption ceases when the moisture content is balanced with its surroundings. Nonetheless, case goods and flat cardboard are best stored outside the barrel room since the moisture they absorb weakens both fiberboard and glue.

Droplet Size

Small droplets are preferred for humidification. Why?

- ❖ They have a higher surface/volume ratio, and a larger total surface area for evaporation. Cutting the droplet size in half doubles the total surface area.
- ❖ Small droplets are lighter, less influenced by gravity and more apt to travel farther from the source. Large droplets may create wet spots, even puddles.
- ❖ Small droplets provide finer control when the room is close to the setpoint, reducing the chance of humidity overshoot.
- ❖ Large droplets, on the other hand, add water faster than small ones. When you need a lot of water, either when first starting up or to compensate for high vapor losses, large droplets get the job done faster.

Among the ways to reduce droplet size are: use a smaller nozzle orifice… increase the liquid pressure… and (with some system designs) reduce the liquid flow rate.

Refrigeration

If the refrigeration system is not designed for humidification, it may chill air below the dewpoint and dehumidify it.

Sometimes only a minor change is required for refrigeration to "play nice" with humidification — a different orifice to increase the coil face temperature, or possibly a change of fan motor or pulley ratio to increase air flow. A window air conditioner does not have this flexibility.

Water Quality

Water quality affects humidification systems several ways. Raw well water may contain microorganisms that could colonize in nozzles or tubing. A 5μ filter will keep them out of the humidification system.

Suspended solids in the feed water can plug the small orifices of high pressure nozzles. A good filtration system should be installed to trap particles larger than the nozzle opening.

Hard water contains dissolved solids that are released as dust when water droplets evaporate. Dissolved solids can also precipitate in high pressure nozzles, causing plugging and dripping.

Dissolved solids won't cause plugging in the Sentinel nozzle, but they can slowly accumulate and reduce atomizing efficiency.

A small reverse osmosis unit can eliminate dissolved solids problems. A water softener will not; it merely replaces insoluble calcium or magnesium salts with soluble sodium salts.

Noise

Wineries that host tastings or other events in the barrel room are sensitive to equipment noise. Even though humidification systems are fairly quiet, some users put mechanical equipment in a separate room.

Others may turn the system off for events. Most barrel rooms quickly regain the target humidity so this doesn't have a long-term impact.

A few wineries have installed an optional "kill" switch to suspend, then restart, humidification after an adjustable time delay.

Wetting

Wetting occurs when droplets hit something or fall to the floor before they evaporate. Wetting invites mold growth.

Wetting is most probable close to the nozzle(s) where the humidity is highest and evaporation slowest. As droplets travel further away, they find drier air and can continue to evaporate into vapor.

Other causes of wetting are: droplets are too large… the humidity target is too high…nozzles are partially plugged…and vapor has condensed on cold metal ventilation grates, doors or window frames.

Nozzle Location

Nozzles should be located far enough from racks or barrels so droplets can evaporate without wetting. It is also desirable that nozzles be placed to "cover" areas of high water vapor loss. They have the greatest need for make-up water; if you maintain humidity there, the rest of the space will take care of itself.

Sensor Location

The sensor should be in a place that's reasonably representative of the entire room, yet responsive to humidity changes. It should not be too close to the droplet discharge; this would cause excessive on-off cycling because the relative humidity in the discharge is always close to 100%.

Conversely, the sensor should not be tucked away in a backwater, which would cause the system to respond sluggishly to humidity changes.

Operating Costs

The variable operating costs of a humidification system are water treatment, electricity, filter maintenance and nozzle maintenance.

Setting A Humidity Target

The goal of a barrel manufacturer is to keep his barrels in good condition until delivery to the customer. He will typically set a humidity target around 50% RH.

The winemaker, on the other hand, wants to improve quality and reduce topping losses. He typically sets a higher target, usually in the 75% - 80% range. An even loftier goal could retard topping losses further, but with increased risk of wetting.

It's not hard to maintain a moderate RH target, say 50-60%; the air is far from saturation and droplets evaporate quickly.

Higher set points present a bigger challenge. The air is closer to saturation and has less "room" for additional vapor. Droplets live longer and are more likely to hit something before they evaporate.

The best approach is to set a conservative target initially, and increase it gradually as experience dictates.

Technical Information

Humidity is a general term referring to the concentration of (gaseous) water vapor in air. The vapor concentration may be expressed in traditional units (for example, gm/cc; pounds per cubic foot), or using two specialized terms mainly reserved for atmospheric water vapor: relative humidity; and dewpoint.

To understand them, we must first consider **saturation**.

The **saturation value** is the vapor concentration in equilibrium with liquid water at a particular temperature. If both the liquid and vapor phases are present, liquid will evaporate, or vapor condense, until equilibrium is established. At equilibrium, there is no further net evaporation or condensation. At this point, the concentration of vapor is at a maximum (for that temperature) — the saturation value.

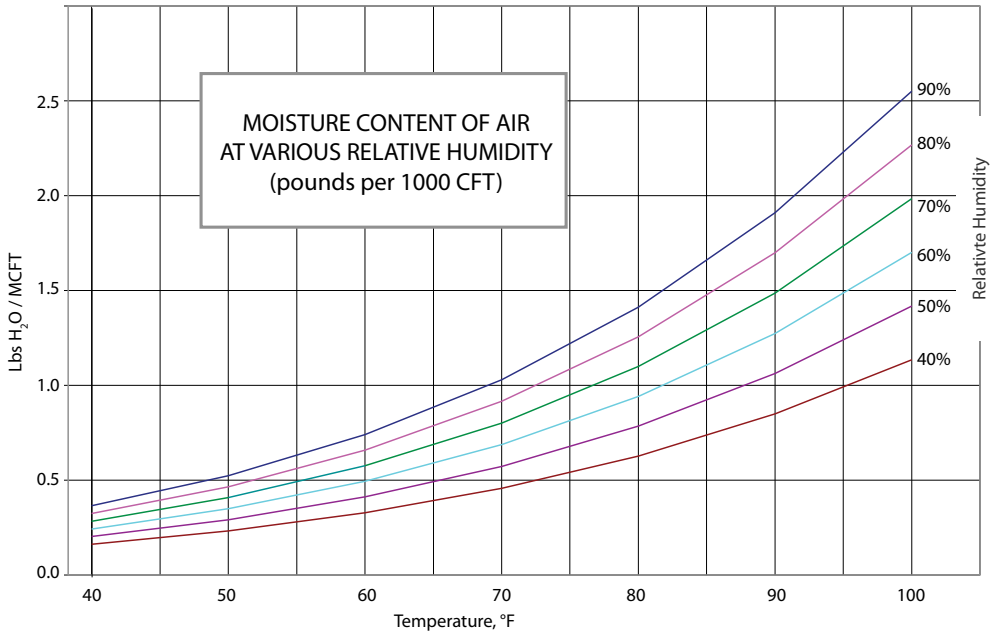
The saturation value increases with temperature. Warm air holds more moisture than cool air, and has the higher saturation value.

Relative humidity (RH) indicates how much water vapor is in the air relative to its maximum value—the vapor concentration divided by the saturation value.

Relative humidity depends on both vapor concentration and temperature. If two sections of a room have the same vapor concentration, but are at different temperatures, they will have different relative humidities. The cooler area, with a lower saturation value, has the higher RH.

Dewpoint is another way to express the amount of water vapor in air, but as a temperature. When air is cooled, its relative humidity increases. If it is cooled to the dewpoint, the RH reaches 100% and vapor begins to condense as liquid.

If the air is cooled further, below the dewpoint, water vapor will continue to condense until it is again in equilibrium with the liquid; that is, until its concentration has been reduced to the saturation value.



This chart allows you to determine the moisture content of air knowing its temperature and relative humidity. With it, you can judge the impact of ventilation, night air cooling, open doors, and so forth.

For example, a warehouse maintained at 78% RH and 60°F has a moisture content of about 0.64 pounds of water per 1000 cft.

Bringing in nighttime outside air (say at 40°F and 60% RH with a moisture content of 0.24 lbs per 1000 cft), requires the humidification system to make up losses — in this example, 0.4 lbs water per MCF air exchanged.

RELATIVE HUMIDITY OF SATURATED SALT SOLUTIONS					
Salt	10°C	15°C	20°C	25°C	30°C
	50°F	59°F	68°F	77°F	86°F
Potassium Chloride	86.8% RH	85.9% RH	85.1% RH	84.3% RH	83.6% RH
Sodium Chloride	75.7	75.6	75.5	75.3	75.1
Potassium Iodide	72.1	71.0	69.9	68.9	67.9
Sodium Bromide	62.2	60.7	59.1	57.6	56.0
Magnesium Nitrate	57.4	55.9	54.4	52.9	51.4
Potassium Carbonate	43.1	43.2	43.2	43.2	43.2
Magnesium Chloride	33.5	33.3	33.1	32.8	32.4
Lithium Chloride	11.3	11.3	11.3	11.3	11.3

From: "Humidity Fixed Points of Binary Saturated Aqueous Solutions", Greenspan, Lewis; J. Research of the National Bureau of Standards, v81A, Jan/Feb 1977

Measuring Humidity.

Techniques to measure relative humidity vary widely in convenience, accuracy and cost. Electronic units are the most relevant for the winery.

Electronic units work by detecting a change in an underlying property — typically capacitance, resistance or thermal conductivity — that correlates to humidity. Depending on the technology employed, accuracy can be as good as 3-4 points for better units, but as poor as 10-15 points for many.

The Sentinel 5850 RH sensor uses an integrated circuit that tracks the capacitance of a thermoset polymer. Its intrinsic accuracy is 3.5 points.

Calibration

Calibrating a humidity sensor against a known standard increases accuracy. For example, when the Sentinel sensor and controller are calibrated together, accuracy improves to better than 0.5% RH.

The calibration of an instrument degrades over time, as a consequence of wetting, corrosion, aging, or replacing either the controller or the sensor. Some devices can be recalibrated by putting the sensing element in a controlled environment of known humidity, letting it stabilize and then adjusting the read-out to match.

Known Humidity Standards

Room humidity—measured with a sling psychrometer—can serve as a reference point for calibration. However, air currents or temperature changes will affect the reading.

A better approach is to use a saturated salt solution as a standard. (A saturated solution contains both solids and free liquid in equilibrium.)

The chart above shows the equilibrium vapor humidity for several saturated solutions. For best accuracy, select one that's close to your desired operating point. Use only chemically pure salts and distilled water. The humidity reading will be incorrect if contaminants are introduced.

Sentinel 5850 System

The Sentinel 5850 Humidification System uses air turbulence to shear water into tiny droplets which evaporate to water vapor. A fast moving discharge of tiny droplets spreads water vapor throughout the room,

A standard 5850 system has a regenerative blower (1.0 Hp, 10A, 120V) for atomizing air, one Sentinel nozzle, and a humidity sensor and controller. It attaches to a hose bib for water. There is no pump.

The water feed rate controls droplet size; reducing the rate increases residence time in the atomizing zone and makes smaller droplets. Most wineries are running at 1.5 – 2.5 gph which produces droplets 5-15 microns in diameter.

The Sentinel 5850 is currently deployed in barrel rooms from 750 sq.ft. to 10,000 sq.ft., the largest to date.

System Control

The controller interrogates the humidity sensor at one-second intervals and turns the atomizing system on and off as necessary. A LED readout displays the RH continuously. The display is steady when the humidity is at the target setting, and flashes when it is low and calling for additional water vapor.

The controller holds two user settings: the RH setpoint (humidity target, adjustable from 20-95% RH in 1 point increments); and the deadband (the allowable range around the setpoint, adjustable from 1.0 to 3.0 RH points in 0.2 point increments).

Nozzle Operation

The exit velocity of the nozzle is about 40-50 ft/sec and its penetration is about 50-75 feet. Eddy currents promote lateral mixing and spread the discharge. Both work to distribute water vapor throughout the room, far from the nozzle.

The liquid supply to the nozzle is low pressure water — typically 5-10 psi from a hose bib. The air supply also runs at low pressure: 2-3 psi. The regenerative blower is quiet and maintenance-free.

The nozzle's discharge angle is adjustable (180° solid angle). The air connection is a PVC slip union that mounts on the blower air line; the water connection is a 1/4" quick connect fitting.

Sentinel 5850 Blower

Sentinel 5850 Controller

Fogmaster entered the barrel room humidification market in 2000 with the delivery of systems to six cooperating wineries. They had barrel rooms of 600-3,600 sq. ft., ceilings of 12-20 ft. and humidity goals of 75-84%. Most installations reached the target humidity within 2 hours of startup and thereafter ran 10-15% of the time (3-4 minutes in 30) to replenish water vapor losses.

Today, the Sentinel® 5850-H humidification system is providing reliable humidification for users on four continents.

Fogmaster works with each customer to tailor a system to his facility.
We will be happy to answer any questions you may have, whether you're in the market for humidification or just "kicking the tires."

When it comes to winery humidification, Fogmaster is the place to start.

THE Fogmaster® CORPORATION

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