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KNOW MORE THAN YOUR BOSS

Preface: The goal of the Know More Than Your Boss series of papers is to provide an education in the intricacies of environmental chamber operation and performance. There is some subjectivity based on our experience as a manufacturer and servicer of environmental chambers.

HUMIDIFICATION

Do you need humidification?

Everyone knows that to go from 4°C @ 85%RH to 21°C @ 45% you have to remove water molecules from the air (dehumidify), right? Truth is you actually have to add water vapor to (humidify) the air. How can that be? I mean, you ARE going from 85% to 45%. So why does this not make sense?

It has to do with the "RH" behind the humidity level. RH stands for relative humidity. At each temperature, there is an absolute amount of water vapor that air can carry (termed water vapor capacity). At 4°C, the absolute greatest amount of water the air can carry is roughly 5 grams per kg of air. At 21°C, that same kg of air can carry roughly 16 grams of water. At an even higher temperature like 37°C, the air can carry up to 40 or so grams of water. If any water vapor is introduced to these temperatures in excess of these amounts, you have water forming (or condensing) in the chamber because it can't hold any more water.

So how do we math this out? This is pretty serious math, so hold on to your bootstraps! Actually, I know this subject doesn't really keep you up at night. I also know that the last thing you want is to do math and rely on your calculation. So, might I suggest we use a shortcut? That shortcut is a term called "dewpoint". The dewpoint is the water vapor capacity of the air at a given temperature, hence the reason for the preceding paragraph.

That's right. Dewpoint is the temperature at which, below that temperature, condensation or "dew" forms. In the preceding paragraph with the 21°C air temperature and 16 grams of water/kg of air…that equals 100% RH. It also equals a 21°C dewpoint. If we sealed that box of air and lowered the temperature, condensation would form. If we raised the temperature, the RH would go down. Regardless, the sealed box would have a 21°C dewpoint. If you raise and lower the temperature of the box a 100 times, water would condense below 21°C and evaporate above it.

So I like really quick math. I hope you do too. My suggestion is to not do the math, but rely on the many dewpoint calculators and apps available. Go to www.dpcalc.org (Shown on top right) or my favorite is the Dew Point Calc app by Unlikely Reality Software (Shown on bottom right). It's free and lacks any advertisements.

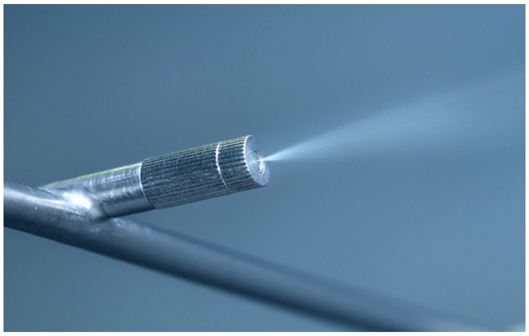
So back to the hard math…enter in your first temperature and humidity (4°C at 85%RH). This gives a dewpoint of 1.7°C. Then enter the second temperature and humidity (21°C at 45%RH) and you'll get 8.6°C. Since 1.7°C is less than 8.6°C, you need to add water vapor, or humidity, to go from a lower dewpoint to a higher dewpoint and vice versa.

So how do we relate this to the lab? Think about the air in which the environmental chamber is located. If the unit is in the lab, that air is typically kept at 21°C and about 35%RH. That would have a corresponding dewpoint of 5°C. Then calculate your dewpoint of your environmental chamber setpoints and compare. If the chamber dewpoint is higher, you need humidification. If it is lower, you'll need dehumidification. If it's within 15°C or so, you may need both.

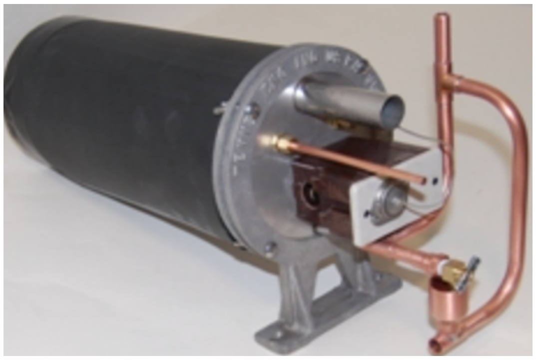
METHODS OF HUMIDIFICATION

The three most common methods of introducing humidification into an environmental chamber are ultrasonic, sprayer, and steam. Each has benefits in certain applications.

Ultrasonic humidification is a more recent development in humidification technologies. Essentially, a disc or plate (piezoelectric transducer) is vibrated at a frequency that vaporizes water into micro-sized droplets. The process consumes about 50 watts an hour and generates a cool mist.
Of the quantity of personal humidifiers sold, this technology makes up the majority – and for good reason. This type of humidifier isn't choosy about water quality. Tap water, deionized, or even well water can be used. Since it generates a mist only when electricity is applied, moisture levels can be precisely added.
The negatives of using this technology also mimic the positives. Since it can use any quality of water, it vaporizes the water with any contaminants. It also doesn't heat the water reservoir so periodic cleaning and/or UV light might be required to inhibit microbial growth. Additionally, the piezoelectric transducer has a limited life and must be replaced at scheduled times. Finally, most transducers need cool down times and shouldn't run at 100% duty cycles.
In summary, ultrasonic humidification is optimal for environmental chambers needing precise humidity control at moderate temperatures. It will require maintenance to keep them running well, but make up for some of that cost with electrical efficiency.



Sprayer systems take water under pressure and spray the water through a small orifice. This can add more water into a chamber faster than the other two widely used methods. A perfect application would be a plant growth chamber with a high humidity level and high turnover of air. In this type of chamber, exact humidity levels aren't necessary and very hard to maintain. Steam generators sized appropriately would consume a lot of electricity. Ultrasonic generators would have to be replaced often.
The downsides to this humidification method are that water quality affects long-term performance (mineral build-up may clog sprayer), and that it isn't appropriate for precise humidification. No matter how high a quality sprayer head is used, a certain amount of water isn't atomized and leads to water evaporating after the call for humidification. In the general sprayer area, there will often be microbial growth due to the constant supply of liquid water.



Steam Generators operate in a way distinctly different than the other two. Typically, water is put in contact with a hot metal and steam is created. This humidification system is very well suited for high heat environments. The heat from the steam generator adds to the heat of the chamber. Usually, microbial growth is non-existent in the "boiler" section.
Steam generators do have quite a few downsides and the marketplace is limiting their use in less than ideal situations. Our opinion is that any well insulated environmental chamber below 50°C probably isn't an ideal situation for a steam boiler. At these lower temperatures, the boiler causes the temperature inside the environmental chamber to rise necessitating the need for refrigeration when it otherwise might not. The electrical efficiency of a boiler and a refrigeration unit running can often be 2900 watts vs. an ultrasonic system running at 360 watts (for a 30cft chamber running at 40°C).
Another downside is that steam provides a warm moist air source that does two bad things at moderate temperatures. The first is that it adds a pulsing heat and humidity source to worsen uniformity data. Less intuitively, that warm moist air is collected on a cold evaporator causing microbial growth. Evaporators are typically aluminum finned copper pipes that aren't really conducive to getting 100% clean. Therefore, cleaning these chambers is often extensive.
Finally, the steam unit does have a lifetime that is shortened by high mineral content water - more so than the other technologies. Replacing a steam unit is typically not user serviceable.

SUMMARY

In summary, the type of humidification is often decided by the set-point of your chamber. Steam generators are relatively good for high heat applications. Sprayer-type units are good for humidifying large rooms with high air turnovers. Ultrasonic humidification is a decent choice when these situations don't apply.