Documentation of the mechanical systems that serve your collections storage and exhibition spaces is a very important element of achieving an optimal environment for preservation. System documentation can:

- Facilitate communication and a shared understanding of the functions and capabilities of the HVAC system for the entire Environmental Management Team
- Uncover previously unknown system malfunctions
- Identify opportunities for energy savings
- Allow for realistic goal setting

CHAPTER 5: Understand the Role of Dew Point

As we noted in Chapter 1, the dew point determines what combinations of temperature and RH will be possible in the storage environment. At a constant dew point, when the temperature goes up, the RH goes down and when the temperature goes down, the RH goes up. Therefore, the dew point is responsible for determining which temperature setting will give you which RH. Controlling the moisture content of the air—the dew point—is key to managing the risk of material decay. Collections care and facilities management staff should review the following questions:

- How does your mechanical system manage temperature?
- How does your mechanical system manage relative humidity?
- What is the dew point temperature throughout the year and how is it managed?

Remember that the Dew Point Calculator (www.dpcalc.org) can be used to determine what combinations of temperature and RH are possible for your storage areas given the dew point temperature you have to work with.

In buildings with humidity control, the dew point of the indoor air is controlled by the building's mechanical system. When outdoor dew points are high and the air is warm, you need a system that can both cool the air and wring the moisture out of it. Simply cooling the air isn't enough; without dehumidification, the moisture level indoors will be much too high. When outdoor dew points are

Quick Facts:

- Dew point represents the absolute moisture content of the air.
- Dew point determines which temperature will give you which %RH.
- If your building does not have humidification or dehumidification, the indoor dew point is the same as the outdoor dew point.
- If your building has cooling-based dehumidification, the indoor dew point temperature is within a few degrees of the temperature of the cooling coil of your mechanical system.

low, you need a system that can add moisture through humidification. In order to change the dew point of the outdoor air, the mechanical system must have the capacity to add or remove moisture.

If your collections are in a building with no humidity control system (which is the case for many historic buildings) you can't change the dew point temperature of the outdoor air. The only method available to you to control moisture in the air is through temperature regulation. As noted previously, temperature, relative humidity and dew point are interrelated—you can lower RH by raising the temperature or raise the RH by lowering the temperature.

5A Managing Dew Points in Practice

Almost every engineer, facilities manager, or building operator will say that the most challenging aspect of managing preservation environments is moisture control, which really means dew point control. A thorough understanding of the ways in which moisture control is achieved—or not—is a basic requirement for sustainably managing preservation environments. This is because adding or removing moisture from air can be very costly and wasteful of fossil-fuel-derived energy. Temperature control is much easier to obtain in real-world situations than humidity control. However, humidity control is vitally important for preservation.

Raise the Dew Point and Humidify the Air

There are two basic methods for mechanical systems to humidify the air and raise the dew point. One, steam (water vapor) can be introduced into the air stream. Low-pressure steam created by the mechanical system is injected into the air stream as the last stage in conditioning the supply air within the AHU. Two, evaporate liquid water directly into the air stream. This occurs when liquid water is atomized into the air stream by being forced through a small nozzle, or when it is evaporated from a cascading stream of water or from a foam pad. Because evaporation of water consumes heat, this method cools the air as well as humidifying it.

Lower the Dew Point and Dehumidify the Air

There are two basic methods for mechanical systems to dehumidify the air and lower the dew point. One method is to sub-cool and reheat. Sub-cooling followed by reheating is the most common method of dehumidification in large building systems. This method involves cooling the air to the desired dew point temperature and then reheating it to the desired temperature. Passing air over a cooling coil whose surface temperature is below the dew point of the moving air stream causes condensation, which drips off the coil and runs down a drain. Air leaving the cooling coil has a lower moisture content than before, but it is also cold and has an RH near 100%. This is why it must typically be reheated, raising its temperature and lowering its RH, before it is delivered to the building spaces.

Less common but recently gaining in popularity, a second method of dehumidification uses a desiccant wheel. Desiccant dehumidification makes use of the property of some chemical substances (silica gel, lithium chloride) to absorb moisture from the air at moderate temperatures, and then to release that moisture when heated to high temperatures. Desiccant dehumidification systems typically involve passing air over a moving, honeycombed wheel containing water-absorbing chemicals. As the wheel rotates, it then passes through a separate stream of heated "regeneration" air that is vented to the outdoors. This "regeneration" stream causes the chemicals to release the moisture so by the time the wheel completes a revolution, the chemicals are again ready to absorb moisture.

5B Understand the Moisture Content of the Air

Peter Herzog, of Herzog/Wheeler and Associates prepared the following information for use during the Sustainable Preservation Practices workshops presented in 2010-11 to help participants develop their understanding of dew point:

Concept A: The capacity of air to hold water increases as air is warmed, and decreases as air is cooled.

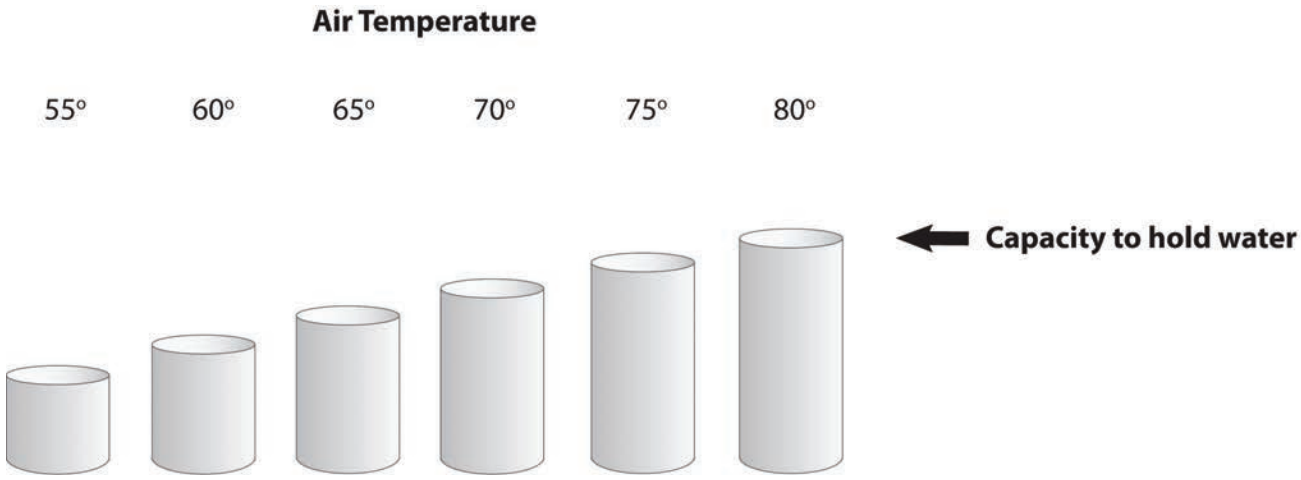


Figure 1: Visualize the water-holding capacity of air as a container that grows larger when it is warmed, and smaller as it is cooled.

Concept B: The actual amount of water in the air does not change with changes in air temperature.

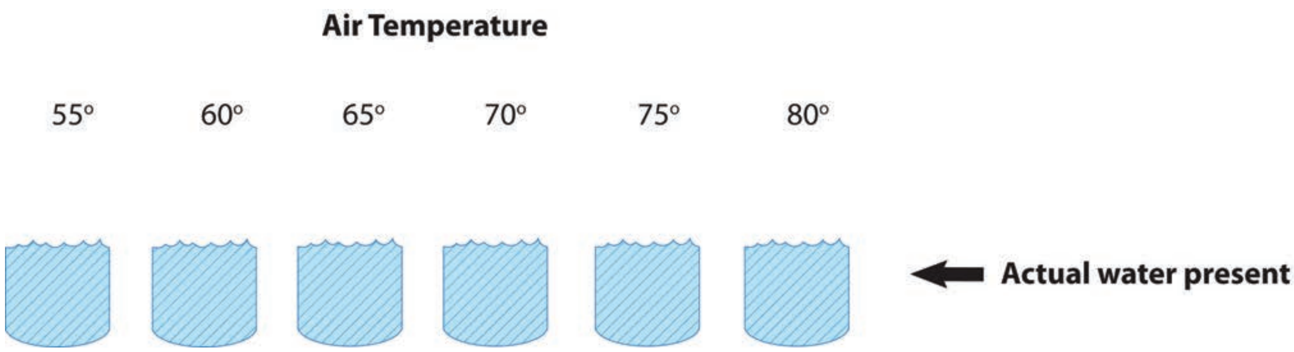


Figure 2: The actual amount of water in the air is called absolute humidity and can be expressed as a ratio of pounds of water in each pound of dry air.

Concept of Relative Humidity

We can combine Concepts A and B to illustrate the concept of relative humidity. For an example, we have chosen the absolute humidity of 0.0092 pounds of moisture in each pound of air.

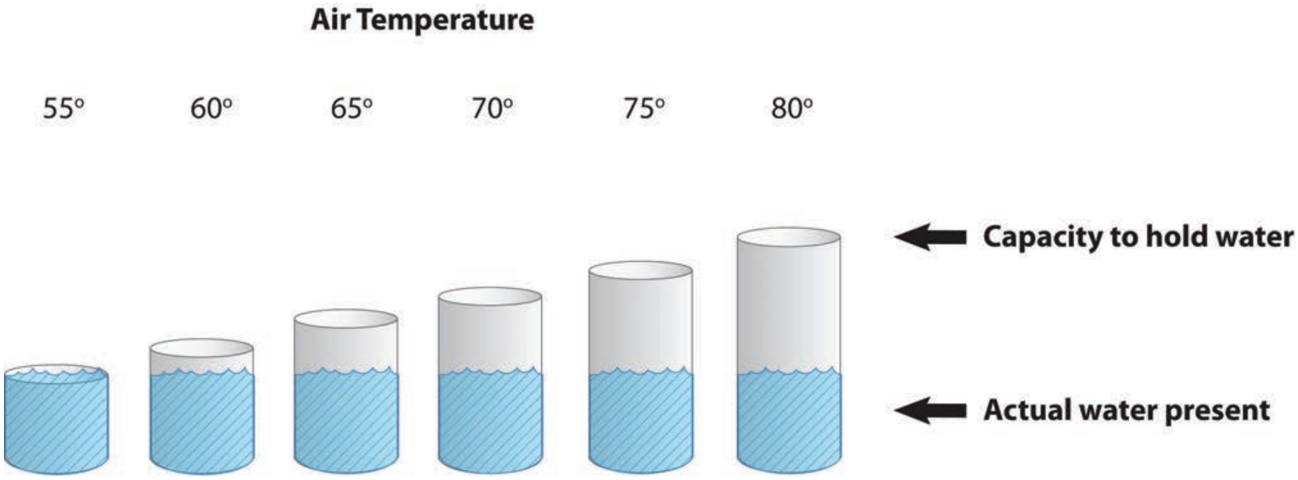


Figure 3: The relationship between the moisture-holding capacity of air at various temperatures and the actual amount of moisture present in the air.

Note that at 75°F the amount of moisture present represents one-half (50%) of the air's water-holding capacity at that temperature. The amount of moisture present relative to the amount the air can hold at 75°F is 50%...the relative humidity of that air is 50%.

At 60°F, the container (moisture-containing capacity) is about 85% full, illustrating that air of our example absolute humidity would have a relative humidity of 85% if cooled to 60°F.

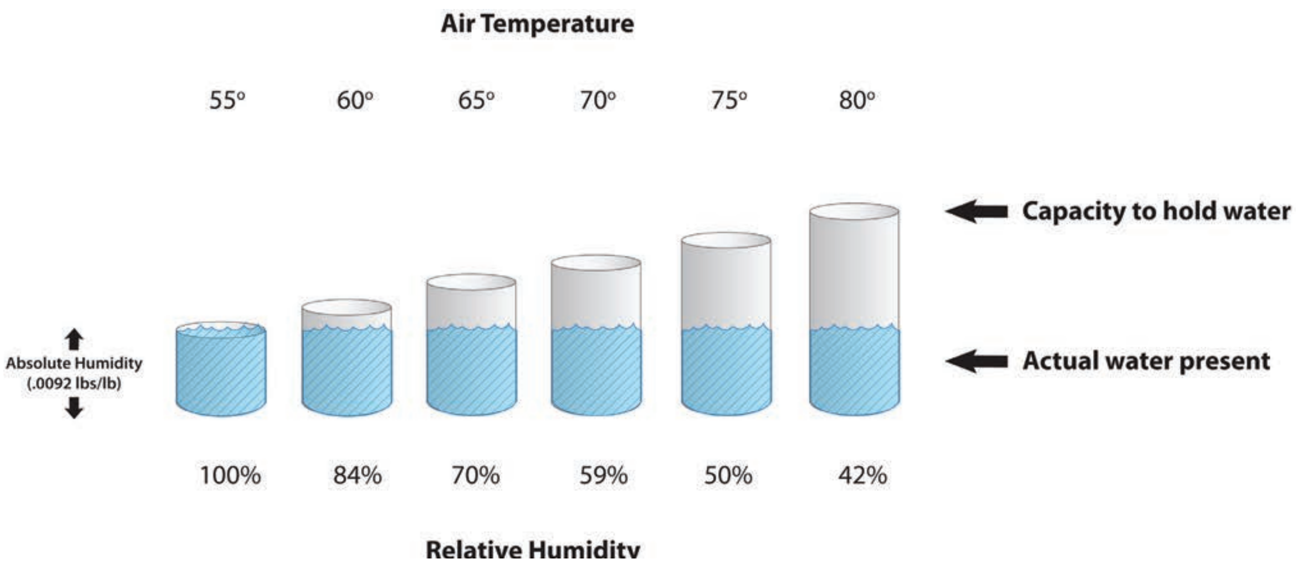


Figure 4: The relationship between air's capacity to hold moisture and its temperature, absolute humidity and relative humidity.

As Figure 4 illustrates, air of an absolute humidity of 0.0092 pounds of moisture per pound of dry air will be saturated (reach its dew point) at 55°F. Therefore an indirect way of describing the absolute humidity of the air would be to say: "Air with this much moisture in it would reach its dew point at 55°F".

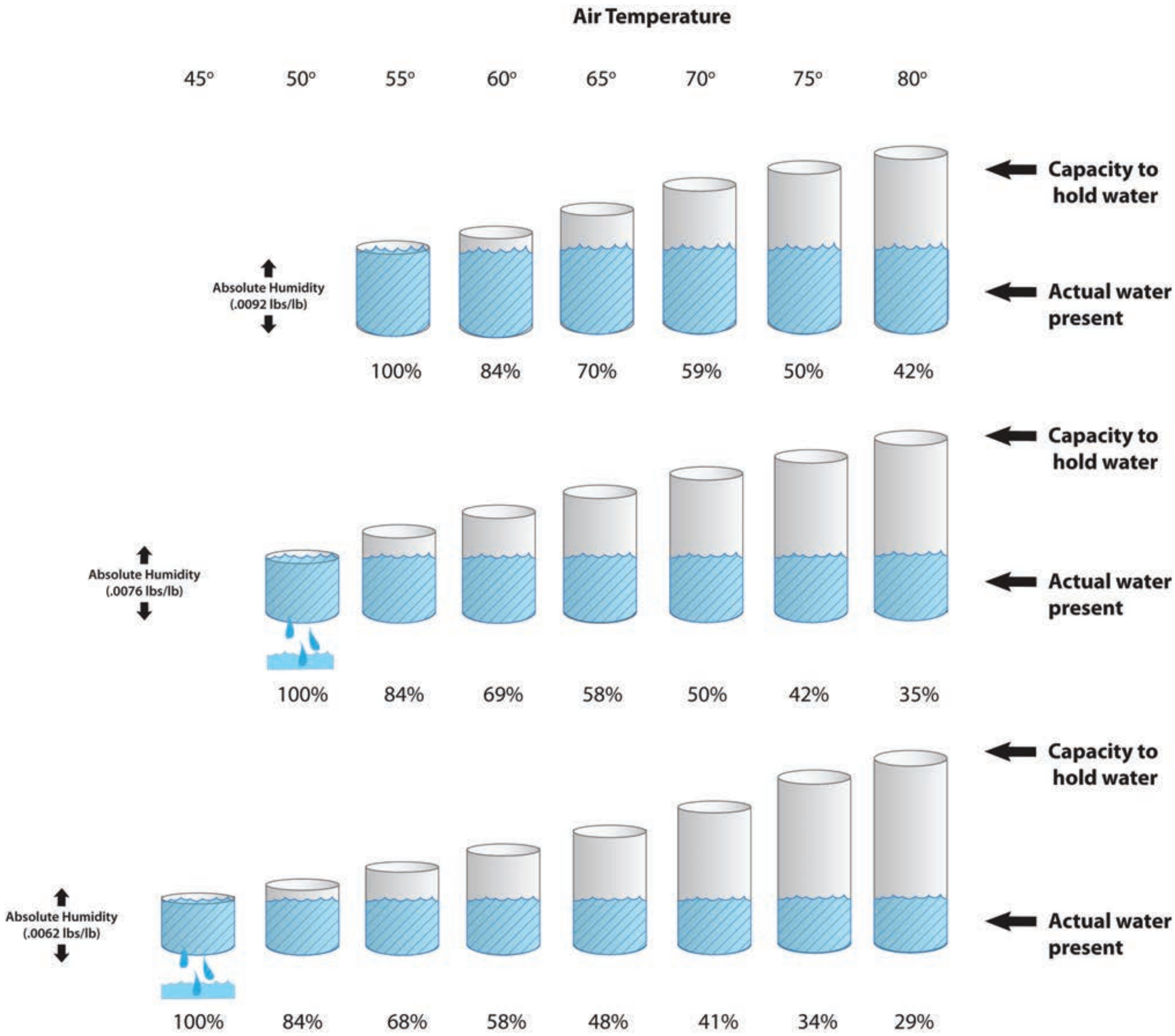
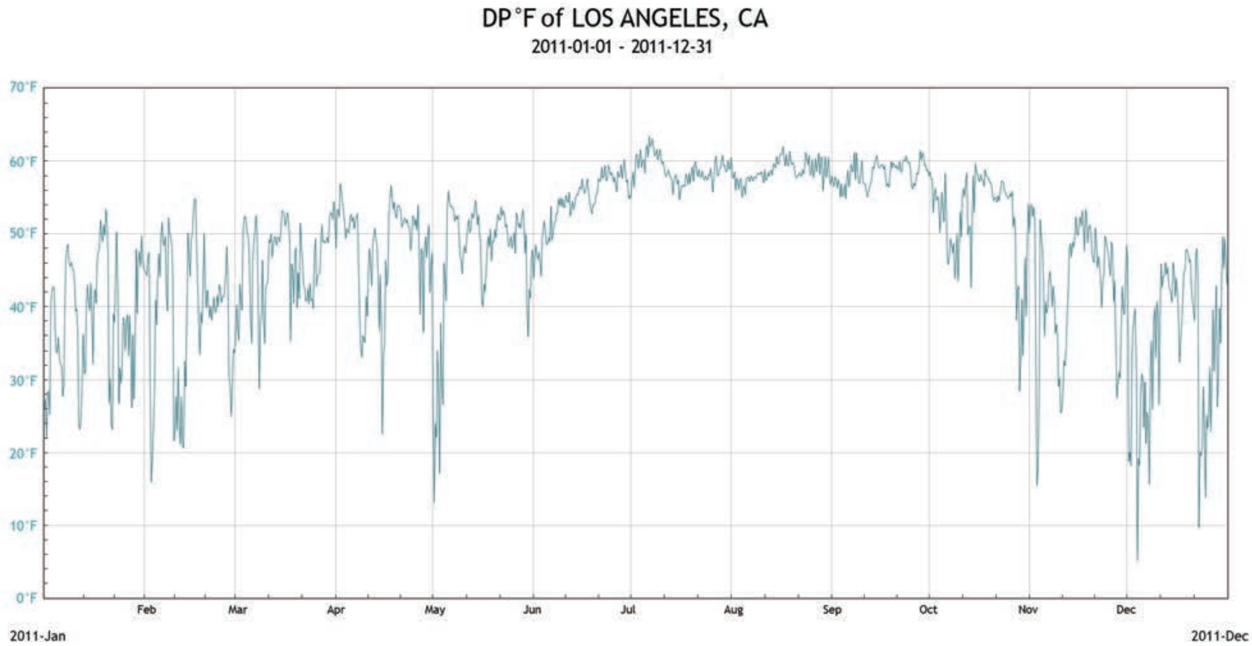


Figure 5: The absolute humidity/relative humidity/temperature relationships for air with a range of absolute humidities.

Note that each absolute humidity has a corresponding temperature, at which that air would be saturated, and water would begin to precipitate out or dew would form; i.e., its dew point temperature. Reading top to bottom, the three absolute humidities shown have corresponding dew point temperatures of 55, 50 and 45°F.

For most climates, the outdoor air moisture content (absolute humidity), and therefore its dew point temperature, is constantly changing. It is not uncommon for outdoor dew point temperatures to range seasonally from a high of 75°F to a low of 5°F. The dew point temperature in Los Angeles has a smaller range; rarely going above 60°F or below 25°F. This is illustrated in the following graph.



Take a close look at the annual dew point temperature for your regional climate. Anytime outside air is brought into a storage space and the dew point temperature (absolute humidity or moisture content) is higher than the desired condition, moisture will have to be removed from that air. Similarly, any time outside air is brought in when its dew point temperature is lower than the desired condition, moisture will need to be added.

Example of Cooling Coil Dehumidification

We can use Figure 5 to illustrate how all of these concepts are applied to the common process of removing moisture from air (dehumidification) using a cooling coil.

Assume that the entering outside air is 75°F and 50% relative humidity, and
Assume the desired storage space condition is 65°F and 50% relative humidity

Consulting Figure 5, we observe the following:

- The outside air at 75°F and 50% RH has an absolute humidity of 0.0092 lbs. per pound of air and a corresponding dew point temperature of 55°F.
- The desired space conditions of 65°F and 50% RH has an absolute humidity of 0.0062 lbs. per pound of air, and a corresponding dew point temperature of 45°F.
- The outdoor air clearly contains more moisture than the desired air conditions, indicating that some moisture must be removed.

- Cooling the outdoor air to 65°F would achieve the desired temperature but would not remove any moisture, and result in a rise in the relative humidity to 70%.

- Cooling the air further to 55°F would result in saturated air of 100% relative humidity, but with no reduction in the actual water present.

- Cooling the air to 50°F would still result in saturated 100% RH air, but because saturated air at 50°F has less capacity to hold moisture than air at 55°F does, some amount of water will precipitate out, resulting in a lower absolute humidity and corresponding dew point temperature.

- Cooling the air to 45°F still results in saturated 100% RH air, but causes enough moisture to precipitate out to arrive at the desired absolute humidity and corresponding dew point temperature of 45°F.

- Heating the air back to 65°F will achieve the desired temperature and relative humidity.

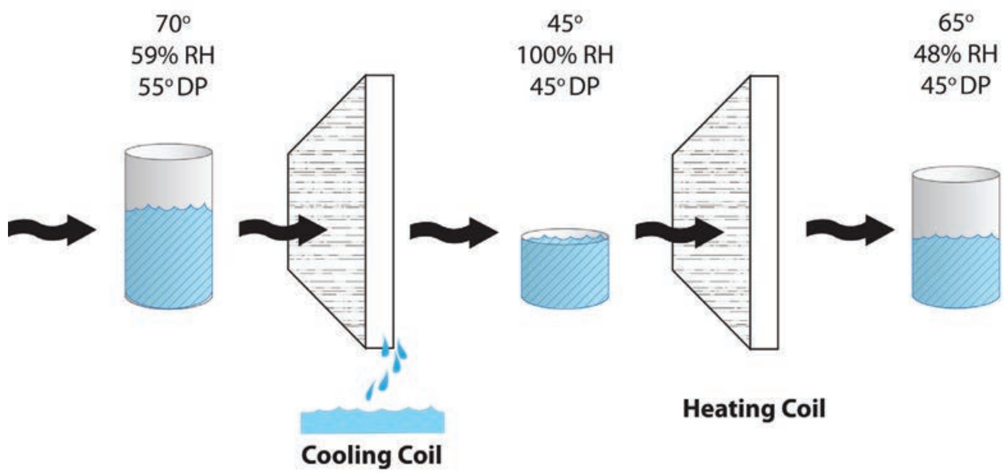


Figure 6: The process of sub-cooling and reheating described in this example.

The process of sub-cooling and reheating involves shrinking the air's water-holding capacity down to the desired dew point temperature and then increasing it again to achieve the desired relative humidity.

Figures 5 and 6 demonstrate a critical factor in controlling climates when outdoor air of elevated dew point temperatures is brought into storage areas. Achieving the desired temperature and RH requires the ability to dehumidify the outdoor air down to the desired dew point temperature. If the cooling coil in Figure 6 could only cool the air to 50°F and 100% RH, the goal of 65°F and 50% RH could not be reached. As Figure 5 shows, a dew point temperature of 50°F would require one to choose between an elevated humidity (58%) at the desired temperature or an elevated temperature (70°F) at the desired humidity.

CONCLUSION: It is important to understand that the best possible cooling season storage climate (coolest possible at acceptable RH) is determined by the HVAC system's lowest achievable dew point temperature.