Temperature, Relative Humidity, and Dew Point for Collections

Introduction

Preventive conservation is the practice of taking steps to avoid or mitigate damage to collections. One of the most significant acts of preventive conservation is the management of the collections environment, which includes the spaces in which collections are used, stored, and displayed. Where preventive conservation activities like re-housing can affect one or several objects, managing the environment affects whole collections. Collections environments can be evaluated by monitoring indicators like temperature, relative humidity, dew point, visible and UV light, and pollutants. Temperature, relative humidity, and dew point are relatively easy and inexpensive to monitor and have a very significant impact on the condition of collections. The first step in creating temperature and moisture conditions that are good for collections is understanding these three indicators and what they mean for cultural heritage collections.

Temperature

Heat is a key ingredient in chemical reactions. This includes a lot of the chemical reactions that play a part in the deterioration of materials. High temperatures can lead to such damage as yellowing and embrittlement of paper, shrinking and cracking of some plastics, and fading of color photographs, among others. Some chemically unstable materials, like 20th century plastics, deteriorate even at temperatures that are deemed appropriate for most other collections. The material preservation of those collections often requires cool or cold storage conditions.

Heat also plays a part in biological deterioration caused by mold and insects. High temperatures can lead to increased insect activity and can contribute to mold growth. It is for these reasons that low temperatures are often recommended for collections, though this isn't the case for all materials. Some materials, like modern paints and plastics, become brittle at lower temperatures, which makes them more vulnerable to damage caused by physical forces.

Dew Point

Dew point is one way of measuring the moisture content of the air. It is the **absolute** moisture content of the air and is not dependent on the temperature. While those familiar with monitoring collections environments may be more familiar with relative humidity as a measure of moisture, dew point can be extremely valuable when monitoring collections spaces.

Dew point is expressed as the temperature at which the air is completely saturated with water vapor, which can be confusing for some who are more accustomed to thinking about moisture in terms of weight or volume. One trick to understanding dew point is thinking about it as a feeling. While subjective, generally a dew point of 50°F feels dry, 60°F feels pleasant, 65°F feels slightly humid, 70°F feels muggy, and 75°F feels steamy. When it's raining, the dew point is equal to the temperature.

Another helpful way to think about dew point is to consider condensation. A cold can of soda will "sweat" on a hot day because the temperature of the can is below the dew point of the air around it. The cold aluminum cools the air immediately around the can to the point where it can't hold any more water vapor, and that water vapor becomes liquid water and sticks to the can in the form of condensation.

Dew point is important to collections environments in two major ways. The first is as an indicator of the performance of a building and its mechanical systems. The dew point inside a building with no vapor barrier and no humidification or dehumidification will be the same as the dew point outside because no moisture is being removed from or added to the air as it enters the building. Dramatic shifts in dew point in environments with mechanical systems that manage moisture indicate a change in settings or a malfunction. If a space has a dew point that is higher than the exterior dew point and there is no intentional humidification going on, there could be a leak or another source of liquid water that could turn into a major collections emergency if it is not addressed.

Monitoring dew point is also important for preventing condensation. Remember that condensation forms on materials that are at or below the dew point of the air around them. As liquid water can cause major damage to collections, this should be avoided at all costs. Avoiding condensation is particularly important for collections in cold and cool storage. Consider taking a photograph out of a storage freezer and placing it in a room that is 70°F with a dew point of 55°F. Condensation will form on that cold photograph even though the conditions of room are relatively dry. It is for this reason that conservators recommend a staged removal of objects from cold and cool storage.

Relative Humidity

Relative humidity (RH) is another way of measuring the moisture content of the air. The difference between dew point and relative humidity is that dew point is absolute and relative humidity is a ratio. This is why RH is expressed as a percentage. RH is **temperature dependent**. This means that RH can change with the moisture content of the air *and* with changes in temperature. Relative humidity is a useful measure of the moisture content of air because the amount of moisture that air has the capacity to hold is dependent on temperature. Colder air can hold less moisture than warmer air, which is represented visually in Figure 1. The way that air reacts to water vapor is similar to the way that most organic materials and some

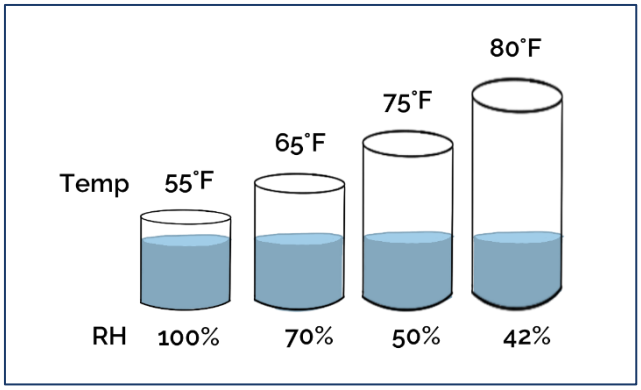

Figure 1: The same amount of moisture results in a higher RH in colder air than in warmer air

inorganic materials do, which is why relative humidity is a useful environmental indicator when thinking about the preservation of collections.

Much like heat, water is a key ingredient in many chemical reactions, including those that contribute to degradation. High relative humidity can result in a variety of chemical degradation reactions including metal corrosion, paper discoloration, and bleeding of dyes. RH also contributes to biological deterioration. Higher RH means more insect activity and increased risk of mold. Finally, high, low, and dramatically fluctuating RH can cause mechanical damage to materials. High RH can cause things like the swelling of wood and warping of paper. Low humidity can cause cracking in wood and ivory and embrittlement of paper. Large swings in RH can cause shrink and swell cycles that are particularly damaging to composite objects whose components swell and shrink at different rates.

The Temperature-Dew Point-Relative Humidity Relationship

While it is important to understand how each of these indicators affect collections individually, it is also essential to understand how they relate to one another. As mentioned, dew point is an absolute measure of moisture whereas relative humidity is a ratio that is affected by both moisture and temperature. This is important for collections environments because changing one variable without addressing the other may put collections at risk.

Consider a hot-humid summer day. It's 85°F outside and the dew point is 65°F (the average summer dew point in Philadelphia). At this temperature and dew point, the RH outside is 49%. Now consider a small Philadelphia archive in a building that has an HVAC system but does not have any additional dehumidification. If the air conditioning is set to cool the air to 70°F without removing any moisture from the air (changing the dew point), the relative humidity inside will be 83%. This means that the temperature of the air is safe for most collections, but the relative humidity is at a point at which there is risk of mold growth, metal corrosion, and several forms of chemical decay. Air conditioners do lower the dew point to some extent. This is illustrated by the puddles that form on the sidewalk under window air conditioning units. Hot air passes over a cold coil and condensation forms on the coil that is then drained out of the unit. Air conditioners are not, however, equipped to significantly dehumidify in hot-humid climates. Let's say the air conditioner in the small Philadelphia archive is able to remove enough moisture to lower the dew point to 57°F. The relative humidity in the collections space is now 64%, which still puts the collection at risk of mold and other forms of degradation.

The Image Permanence Institute has put together a helpful tool for understanding the interrelated nature of temperature, relative humidity, and dew point called the Dew Point Calculator.

The "Ideal" Museum Environment

Once collection stewards have a baseline understanding of how temperature and moisture affect collections, the next natural question is, "What are the ideal levels?" Unfortunately, there is not a simple, universal answer. It is easy to say that maintaining a temperature of 70°F and a relative humidity of 50% is good for most mixed collections, but these numbers don't consider a number of factors including collections that fall outside the "most mixed collections" designation, the climate region that the collection is located in, the capabilities of the building and mechanical systems, and the environmental and financial sustainability of maintaining those levels in a given space. What is

more important than maintaining the "ideal" temperature and moisture levels is finding a solution that balances all of these factors and reduces the risk of damage caused by temperature and moisture extremes.

When considering what that balance looks like for a particular organization, the resources developed by the Image Permanence Institute for sustainable collections environments are a great place to start.

Key Takeaways

- One of the most significant acts of preventive conservation is the management of the collections environment.
- Temperature and moisture are key ingredients in many chemical reactions related to material degradation.
- Dew point is an absolute measure of atmospheric moisture and can tell us about the health of the building and mechanical systems.
- Relative humidity is a ratio that is affected by temperature and moisture and can tell us about the health of collections.
- The "ideal" collections environment is a different for every collection.

Web Resources & Key Readings

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