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Humidistatically Controlled Heating and Ventilation Systems

Alternative Methods for Control of Relative Humidity

Most people involved in the protection of cultural resources recognize the key impact relative humidity has on preservation. In the past, guidelines focused on narrow parameters within conventional heating, ventilation and air conditioning (HVAC) systems. This paper will look at ways to control relative humidity without using an HVAC system or having to introduce moisture in a building.

Historically, 55% relative humidity (RH) ±5% and a temperature of 68°F became the standard for most moisture-sensitive organic material, with a lower RH of 35% for metals. This standard was first developed in England from two areas of research: the optimum RH for painted wooden panels and feasibility studies by engineers on building environmental capabilities.

Institutions around the globe adopted these parameters and began trying to maintain them year round. Unfortunately, these strictures did not take into account the numerous types of building construction that are used to house and store cultural resources. Nor did they consider the varying geographical locations and climates worldwide or financial resources available to most museums. Museum and collection storage buildings range from new buildings to historic houses, and from old barns to concrete warehouse facilities. These facilities may have never had conventional HVAC systems installed and in all probability, were never designed to hold collections

In northern climates, heating old buildings that are insufficiently insulated and lack vapor barriers can cause interior humidity levels to plummet to levels as low as 10%, unless humidification is added. However, as humidification is supplied, it is continuously lost through building walls, condensing or freezing as it meets exterior temperatures. This, in turn, can weaken masonry, encourage wood rot and corrosion of metal beams.[1] One institution contacted during research for this article recalled a time when they added gallons of water to a portable humidifier each day in an attempt to maintain higher levels in just one room. Finally, the building's engineers contacted them and told them that the building's wiring was shorting out due to the excess condensation in the walls.

Areas that experience high relative humidities can also present problems for collections housed in older buildings. Insufficient insulation, filtration, and air circulation can result in problems with dust, pollution, and mold outbreaks.

As a consequence of these problems, institutions with collections in historic houses and old buildings have begun looking for alternative methods to control the relative humidity. Two methods that have found increased use in northern Europe and North America in the last 15 years are humidistatically controlled heating and humidistatically controlled ventilating systems.[2,3]

Although the principles of the two systems are fairly simple, both require careful evaluation of the collection and building preservation needs before determining whether these methods would be viable. To this end, it is imperative that institutions work closely with a conservator and an experienced engineer from the outset of planning.

Humidistatically Controlled Heating

Humidistatically controlled heating is most often used in winter to maintain RH levels without humidification. The technique is based on the principle that if the absolute humidity of a given volume of air changes, it is possible to maintain a stable RH by manipulating and varying the temperature.[4] In this system a control panel, sent information from a humidistat sensor, will constantly adjust interior temperatures to maintain a stable relative humidity. If the RH falls below a desired level or set point (e.g. 45%) the heating system remains off until the RH rises to the desired level again, and *vice versa*. Advantages with this system include increased protection to artifacts with decreased dangers of structural damage. Humidistatically controlled heating also lowers energy consumption and expensive equipment maintenance costs. However, temperatures can fall to very low levels, and there is a need for very tight control over temperature (indiscriminately turning heat up and down for human comfort can have a negative impact on the system and on the collection). Consequently, the system is most useful for museums or storage areas that are closed for winter or infrequently accessed.[5]

The system operates most efficiently in a tightly sealed building where the impact of outdoor changes in absolute humidity is lowered. Because it can be prohibitively expensive to modify an entire building, many institutions (non-historic) using this system opt for partial retrofits to portions of storage areas.

Klondike National Historic Site has had humidistatically controlled heating in a retrofit storage area for approximately 20 years. Located in a region of permafrost, the outdoor temperature ranges from -72°F to 95°F and humidity levels are quite high, ranging from 85% in October to 58% in May. The storage facilities are older frame buildings that typically remain cool and humid even during the hotter parts of summer. In winter, temperatures are allowed to fall to 32°F to maintain RH levels. During summer a minimal amount of heat is added (0-1 hour) to lower humidity levels (with an upper temperature limit of 75°F). The humidity remains constant at 55-60% throughout the year.[6]

Storage for the Newfoundland Museum is located in a concrete block building that was originally a tank depot and then machine shop. Since the retrofit and system installation, the storage area temperature ranges from 39°F-70°F but is generally 54°F-60°F. The RH varies from 41-57% with a maximum daily fluctuation of 4-5% for most of the year.

Both these sites have been able to maintain acceptable RH levels, energy expenditure has been extremely low and the cost of operation very favorable for both institutions.

For historic houses the problem of controlling environment is made more difficult by the need to protect the historical integrity of the building. Consequently, the ability to maintain RH levels without retrofitting to install conventional HVAC can be a useful approach. Although the system works less efficiently than in a tightly sealed building, acceptable levels of RH can be maintained for most objects, and the dangers of structural damage eliminated.[7]

Richard Kerschner of the Shelburne Museum in Vermont has been using this system in 20 of its 33 historic buildings for approximately the last 10 years. He is able to maintain a minimum level of 35% RH during the winter increasing gradually in the spring to a maximum of 55% in summer. Objects that require tighter environmental control are removed during winter months. A partial compromise is practiced at his institution in order to keep programming, exhibits, and other departments on board and cooperating—key for successful implementation and operation of the system. Buildings are closed October 3, and the heat turned off. From October 3 to December 15 scheduled tours are still allowed at midday. For tours, the heat is turned on very briefly. Fortunately, there is still enough moisture in the buildings that RH is not driven too low. Additionally, the temperature differential has not been high enough or sustained enough to cause condensation problems. From December 15 through March 15 there is complete humidistat control and the buildings are closed completely.[8]

Humidistatically Controlled Ventilation

Poorly sealed buildings in areas of high relative humidity can have condensation and mold problems and are good options for humidistatically controlled ventilation. This is especially so for buildings whose interiors remain cool in spring and who can experience influxes of warm humid exterior air. Sensors on the interior and exterior of the building measure temperature and humidity conditions. At certain values (e.g., the exterior RH is lower than the interior RH or would be lower if heat were added), dampers will open and bring in exterior air. Fans circulate the air and exhaust it out. If the RH is too high outside, the ventilation system will re-circulate air inside the building. Those institutions using the system must use good particulate filters to ensure that pollution and dust levels do not rise with the increase in air circulation and ventilation.

The Society for the Preservation of New England Antiquities (SPNEA) has used this system in five of its 44 historic buildings for the last two years. An additional step that SPNEA took to improve environmental conditions was to identify and block sources of water from buildings. This included cleaning and repair of gutters, windows and roofs, rebuilding foundation walls and installing foundation drainage where possible. The result of these combined efforts has been a dramatic reduction in mold problems. In addition, staff find the air quality much more comfortable when leading tours (although it should be realized that this method does not have a great effect on summer temperatures).

The Museums at Stony Brook on Long Island, New York uses this system in its storage facilities. Storage for a 200-plus carriage collection is located in what were previously lumber sheds. Mold from this dirty, damp, closed environment (the RH never got below 45% and was often very high) was wreaking havoc on the original varnish of the carriage collection. The building was retrofitted to increase insulation against the exterior environment, fans and ventilation were added and the air handling capacity increased. The Shelburne Museum has also installed humidistatically controlled ventilation in their carriage barn which also has a very large carriage collection; and the Clermont State Historic Site, New York has had the system installed in the visitor center which is situated in a historic carriage house.

The improved air circulation and filtration systems have been successful in controlling the humidity and particulate problems inside the buildings and none have re-experienced mold outbreaks.

Conclusion

These two systems represent unique alternatives for institutions that want to improve the environment in storage and exhibit areas[9] without having to install conventional HVAC systems and humidification equipment. Environmental consultants or engineers familiar with the system can help determine whether these systems are viable and help design an appropriate system. Systems can range from fairly simple to complex, depending on the size of the building and modifications required and number of buildings under control. Costs can range from a few thousand to several thousand dollars. However, capital expenditure is low in comparison to square foot costs for conventional HVAC systems. Additionally, the institution has increased protection for its collection, lowered potential damage to its buildings and will experience lower energy expenditure and maintenance costs in comparison to conventional methods of control.

References

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7 Kenneth M. Elovitz, "Practical Guide to HVAC for Museums and Historic Renovation," *ASHRAE Journal* 41(4), 1999, 48-98.

8 Richard Kerschner, "A Practical Approach to Environmental Requirements for Collections in Historic Buildings," *JAIC* 31, 1992, 65-76.

9 For more information on Humidistically Controlled Heating see also *Technical Note* 2:8 *Low-Tech Solutions to Boost Low RH in Winter Climates of the Exhibit Conservation Guidelines* produced by Division of Conservation, Harpers Ferry Center, National Park Service, 1999.

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