Providing Safe and Practical Environments for Cultural Property in Historic Buildings—and Beyond

By Richard L. Kerschner

Introduction

The day I started as a newly trained conservator at Shelburne Museum in 1982, I stepped onto the path of creating and maintaining efficient, sustainable preservations environments. I quickly discovered that if I were to have any success in preserving over one hundred fifty thousand artifacts exhibited and stored in twenty-nine buildings spread over forty acres in the harsh Vermont climate, I would have to do it efficiently, and I would probably have to stretch the boundaries of acceptable temperature and relative humidity (RH) ranges for preservation of collections. Twenty-five years ago, conservators in the United States usually cited 20ºC (68ºF) and 50% RH as safe temperature and humidity limits for the preservation of collections. That was generally a correct answer. However, as I researched museum and historic building environmental standards and became more familiar with Shelburne's varied collections and the buildings that housed them, I began to realize that such restrictive standards were not only unreasonable for buildings that included a covered bridge and several barns, but they were probably unnecessary for the preservation of most of our artifacts. As I examined collections in the various exhibition and storage buildings, I found that most of the seventy- to one-hundred-fifty-year-old artifacts were in good condition, even though many had experienced minimal environmental control and been repeatedly exposed to seasonal temperature extremes of –18ºC (0ºF) to 32ºC (90ºF) and RH extremes of 10% to 95%. The artifacts in poor condition had been damaged by extreme conditions in attics that were too hot, in basements that were too wet, or in buildings that were too dry as a result of winter heating without humidification.

Sustainable Strategy

I determined that even though Shelburne Museum may not be able to achieve "ideal" museum environments for all its artifacts, conditions could be significantly improved by reducing RH extremes surrounding historic artifacts. If RH were kept below 65% in the summer, mold growth could be avoided, and significant swelling of organic materials could be prevented. If RH were kept above 35% in the winter, desiccation of collections could be avoided. Research indicated that our Canadian neighbors just one hundred kilometers to the north had been following these wider RH standards for several years (Eames 1980; Rogers 1976; Royal Ontario Museum 1979), and in the early 1990s, researchers at the Smithsonian's Conservation Analytical Lab would determine that these broader standards were safe for the large majority of historic artifacts (Erhardt and Mecklenburg 1994). In addition, Shelburne's artifacts had been "proofed" by high and low RH extremes for many years. The worst damage had already been done. By narrowing the range of RH that artifacts would be subject to in the future, we would ensure that no new damage would occur, even if the new environmental conditions were not ideal.

Adopting broader RH standards opened up additional possibilities for practical environmental control methods that fell well short of complete control, while still improving environmental conditions and eliminating the RH extremes that cause most artifact damage. Of course, whatever environmental improvements we devised would have to be efficient and affordable. Even if we could afford to purchase and install the equipment to create more ideal climates, we probably could not afford to operate and maintain such equipment for twenty years and beyond. Today we call this sustainability.

Building Classifications

One big question remained. What kind of environments could our various buildings support? We certainly did not want to create environments to preserve our artifacts, only to destroy the buildings that house them. As of 1985, only four of Shelburne's collections buildings had been built as galleries, and even they had little insulation and no vapor barriers. We knew that moisture introduced into such structures during a cold Vermont winter could result in serious building degradation. Fortunately, Ernest Conrad had just established a firm specializing in improving museum environments, and he was challenged by the question of what type of environmental improvements various building structures could safely support. In the course of his survey of Shelburne's structures, he devised a building classification system (Conrad 1995), later included in the American Society of Heating, Refrigerating, and Air-Conditioning Engineers *2003 ASHRAE Handbook: Heating, Ventilating, and Air-Conditioning Applications* (chap. 21, "Museums, Libraries, and Archives"):

- *Class 1* buildings are open structures such as covered bridges or open sheds. These structures have little potential for environmental improvements, although they sometimes protect important artifacts from the harsh elements (fig. 1).
- *Class 2* buildings are sheathed post-and-beam structures, such as barns. The only reasonable climate improvement for such buildings is ventilation to reduce heat and moisture accumulation (fig. 2).
- *Class 3* buildings are wooden structures with framed and sided walls and single-glazed windows, or un-insulated masonry structures—essentially a basic historic house. In these structures, one can use low-level heating to reduce high humidity levels, and employ summer exhaust ventilation (fig. 3).
- *Class 4* buildings are tightly constructed wooden structures with composite plastered walls and storm windows, or else they are heavy masonry structures, typical of high-quality historic houses. These buildings can support low-level heating and humidification in the winter and cooling and reheating for dehumidification in the summer (fig. 4).
- *Class 5* buildings are new-built structures with insulated walls with vapor barriers and double-glazed windows. These buildings can support complete HVAC systems with winter comfort heating and humidification, and summer cooling and reheating for dehumidification (fig. 5).
- *Class 6* structures are rooms-within-a-room, double-wall constructions with insulated and sealed walls, such as storage vaults specially built to support precision controlled heating, cooling, and RH control systems (fig. 6).

Environmental Improvement Actions

Armed with the knowledge of what our collections could withstand and what our buildings could safely support, we were ready to design and install practical systems to improve collections environments. In 1992 Shelburne Museum received a grant from the National Endowment for the Humanities, Division of Preservation and Access, to support a $1.4 million project to design and install practical climate control systems in twenty-seven of our collections buildings. Since it is unwise to design and install mechanical systems to reduce moisture in a building or filter out dust without first taking steps to reduce such problems at the source, our first actions included: installing rain gutters on buildings and storm drain systems to move water away from buildings; applying calcium chloride to dirt roads to reduce dust; and tightening up buildings by insulating walls, weather-stripping doors, and installing interior storm windows. Tinted, UV-filtering Plexiglas interior storm windows also significantly reduced harmful light entering collections areas.

Conservation Ventilation

Conservation ventilation employs fans controlled by a humidistat rather than by a thermostat. When the inside temperature exceeds 18°C (65°F) and the inside RH is higher than the outside RH, the fans are activated, and the hot, moist interior air is replaced by cooler, drier air from outside. This practical environmental control system was installed in nine of our class 2 barnlike structures, since it was apparent that during the summer, heat and RH levels inside these structures exceeded outside conditions, especially on upper levels on hot afternoons. A consulting engineer calculated that it would require about seven air changes an hour to effectively exhaust the hot, humid air and replace it with cooler, drier air from outside. However, simply installing and operating whole-house exhaust fans would solve one problem but create another—by introducing seven times as much dust into the collections areas. This problem was solved not only by exhausting air through the attic but also by using fans to draw air into the first floor or basement of the building through filters that trap the dust (fig. 7). Because the fans drawing air into the building are larger than the exhaust fans, the entire building is slightly overpressured, a condition that discourages dust from entering when visitors come into the buildings. A study conducted by the Getty Conservation Institute concluded that conservation ventilation lowers building RH levels by about 10% (Maekawa 1999). In addition, moving the air prevents mold growth, even when the RH is above 70%.

Conservation Heating

To reduce RH in our class 3 historic house structures, we use both conservation ventilation and conservation heating. Conservation heating is the practice of controlling the humidity in a building by adding or withholding heat. It is possible to dry out a cool, damp building simply by increasing the heat. Conversely, withholding heat and allowing a building interior to cool during cold weather will keep the humidity high enough to be safe for the artifacts even during cold Vermont winters. As with conservation ventilation, a humidistat activates the equipment, in this case a furnace or boiler. If the space RH exceeds the set point (55% RH) and the space temperature is below the maximum temperature set point (22ºC, or 72ºF), the heat is activated. The heat is turned off when the RH drops below the set point or the temperature exceeds the maximum temperature set point. In Vermont's temperate climate, conservation heating effectively keeps the RH below 55% in collections buildings during the fall, winter, and spring. Conservation heating is very efficient. Only small amounts of heat are generally required to reduce RH to 55%, even during the damp rainy seasons. During the winter, the heat is seldom called on, as the RH drops to a minimum of about 30% in our coldest and driest buildings. Although the buildings are uncomfortably cold, this method works very well for Shelburne Museum, since it is closed to public visitation from November through April. Conservation heating and ventilation work with nature instead of against nature—always a wise practice.

Low temperatures do not harm artifacts usually found in historic house museums, as long as items such as furniture are not moved or handled when they are very cold. In fact, the low temperatures reduce the rate of deterioration caused by chemical reactions in wood, paper, textiles, photographs, and other organic materials. One exception is paintings on canvas. Since research has shown that low temperatures can cause the paint and ground layers to crack (Mecklenburg, McCormick-Goodhart, and Tumosa 1994), we remove paintings from our historic houses that use conservation heating and store them in a warmer, humidified storage facility during the cold winter months.

Modified Use of Conventional HVAC Systems

With care, conventional HVAC systems can be used to improve collections environments in class 3 and 4 buildings. We have modified the operation of the HVAC system in our Hat and Fragrance Textile Gallery, a class 3 structure where we exhibit a rotating selection of Shelburne Museum's celebrated quilt and coverlet collection. High summer RH levels are reduced by the conventional means of supercooling the air with a cooling coil to condense out the moisture, then reheating the air to reduce RH before the conditioned air is discharged into the galleries. However, we do not introduce any moisture into this poorly insulated structure during the winter, choosing instead to allow the building to go cold, to keep the RH around 35%. Withholding heat saves money, and allowing temperatures to drop as low as –18ºC (0ºF) also slows chemical degradation and discourages insect activity in the textiles housed in the galleries.

The Stagecoach Inn is a good example of a class 4 structure with a complete HVAC system, including low-level humidification in winter. This building has plaster walls filled with vermiculite insulation, and tight interior storm windows. Care must be taken to minimize the amount of moisture introduced into a structure with limited vapor retarding ability, since water vapor can penetrate the walls and condense inside, damaging the wood structure. During the winter, the building temperature is reduced to 13ºC (55ºF), and a steam humidifier is used to introduce a minimum amount of moisture to maintain RH levels between 35% and 40%. At such a low interior temperature, it is very important to keep the air moving continuously, even when the heat is not on, to ensure that there are no cold, isolated interior walls where condensation could occur. Our engineer advised that moisture should not be introduced into buildings at temperatures below 13ºC (55ºF) because at lower temperatures, even small increases in air moisture content can significantly increase the RH and the risk of condensation on cold interior surfaces.

Humidified class 4 structures must be carefully monitored during cold weather. By observing condensation on the inside of double-glazed windows, the coldest surfaces in the building, while monitoring RH levels inside wall cavities, we have devised a good empirical indicator of a safe moisture level for our structures. Some haze on the inside of the windows is a warning that moisture is beginning to condense out on the coldest surfaces in the building. If droplets of water begin to run down the windowpane, the RH is too high and must be reduced. From experience, we have found that if the outside temperature is above 0ºC (32ºF), we can safely humidify the building to 45% RH. As the exterior temperature drops from 0ºC to –7ºC (32ºF to 20ºF), we allow the RH inside the structure to fall to 40%. As the outside temperature drops from –7ºC to –12ºC (20ºF to 10ºF), the RH set point is automatically and gradually reduced to a minimum of 35%.

Digital Controls and Monitoring

None of the environmental control methods described could be practically employed without the use of digital controls. The 1991 National Endowment for the Humanities grant provided funds to connect all twenty-seven collections buildings through underground wiring and to purchase and install digital controls and the Johnson Controls Metasys building management system. Although control of the various building systems is decentralized to twelve control panels that operate independently if communications are disrupted, all the systems can be monitored and adjusted from a central computer.

Many companies manufacture reliable digital controls: Honeywell, Andover, Control Pak, Johnson Controls, and ASI are a few in the United States. Once properly programmed, any of these digital systems can work very well. The challenge is in designing simple control sequences and developing a good relationship with a control technician who understands these somewhat unconventional control strategies. In our opinion, it is best to select the control company with the best reputation for customer service in your area and install the control brand that it sells and services. Of course, it is important to check references carefully.

The second crucial aspect of a successful environmental control system is a good monitoring program and reliable RH sensors. We have over one hundred temperature and RH sensors hardwired to our climate control computer, and we use five Preservation

Environmental Monitors (with Climate Notebook analysis software) and eight hygrothermographs to monitor conditions in our buildings continuously. In our experience, sensors manufactured by the Finnish company Vaisala are best for accurately sensing RH at the temperature extremes sometimes experienced in our less-than-ideal environments. RH sensors should be calibrated at least yearly—every six months in critical buildings. I spend about 20% of my time monitoring, adjusting, and troubleshooting environmental control systems in twenty-two buildings. Without the computerized building control system and reliable sensors, it could be a full-time job.

And Beyond—Practical Environmental Control for New Buildings

Since conservation heating and ventilation and modified conventional HVAC systems were working well in our historic buildings, it was decided to extend these practical environmental control ideas to new buildings. The opportunity arose when we lost the use of a significant off-site storage building and it became apparent that it would cost less to build a new structure on-site than to lease existing off-site storage with even minimal environmental control.

Collections Management Building

In 2000, planning began for construction of a new 930 m^2 (10,000 sq. ft.) two-story storage building (fig. 8), the Collections Management Building. A well-insulated, modern, barnlike building was proposed for construction on a well-drained site. The building was originally designed to utilize the practical environmental control principals and systems successfully employed in our historic collections buildings—i.e., conservation heating and ventilation. During the planning process, our director decided to include a library and collections management space on the second floor, introducing people into the structure and reducing storage space by 40%. Since conventional winter humidification and summer air-conditioning were now required for the occupied space, an aluminized polyester film vapor barrier was added to the building specifications. Conservation heating and ventilation were still deemed sufficient to maintain a safe environment for the carriages, furniture, wood sculpture, metals, glass, and ceramics to be stored in the 465 m^2 (5,000 sq. ft.) first floor. The cost of the building doubled, from $600,000 to $1.2 million, because of the requirements for a conventional HVAC system for the occupied second floor and an elevator.

There were a few surprises when the new building came online in 2002. Fortunately, we had planned to keep the storage area empty during the first winter to evaluate the building systems before loading in collections. We had planned to withhold heat and allow the first-floor storage area to go cold during the winter to maintain a reasonable RH level of at least 35% without adding moisture—a successful practice in our historic barns. We soon discovered that this new construction was nothing like our cold, damp wooden historic barns, for which high humidity was the major problem, even during cold winters. The new concrete and steel building was so well insulated that we could not successfully reduce the temperature below 10ºC (50ºF), even by blowing cold air into the first-floor storage area for a few hours. The heat from the ground and the fully conditioned floor above, combined with heat generated by the two ventilation fan motors in the storage space, prevented the storage area from cooling below 10ºC (50ºF) for any appreciable length of time, and when the outside temperature fell below –18ºC (0ºF), the interior RH dropped below 20%.

However, as the year progressed, we found that when the conservation heating and ventilation system serving this storage area was completely shut down, the temperature and RH levels were steady and safe, changing only gradually with outside conditions. The storage area RH seldom exceeded 60% during the winter, spring, and fall, and summer temperatures remained below 24ºC (75ºF), with summer RH levels topping out at 65%. By installing a steam humidifier to introduce some moisture into the space during the coldest winter months, we are able to maintain a safe environment that ranges from 45% RH in the winter to 60% RH in the summer, at temperatures ranging from 10ºC (50ºF) in the winter to 24ºC (75ºF) in the summer. We can maintain these favorable conditions so efficiently because this well-sealed and insulated first-floor storage space is sandwiched between the ground, with a year-round temperature of about 10ºC (50ºF), and the fully conditioned space above, and it is filled with large wooden artifacts that act as a significant humidity buffer. The “Engineer’s Report” generated by Climate Notebook analysis software shows temperature and humidity measurements for 2006 in this storage space (fig. 9).

In essence, we are providing environmental control for a 930 m^2 (10,000 sq. ft.) partially occupied building at the cost normally associated with a 550 m^2 (6,000 sq. ft.) building, gaining 370 m^2 (4,000 sq. ft.) of environmentally controlled storage at no initial cost for HVAC equipment. Energy costs for the 465 m^2 (5,000 sq. ft.) storage area are also very low, since maintaining preservation conditions for the stored collections requires operation of just a circulation fan and humidifier during only the two coldest months of the year. The building is so well insulated and sealed that the steam humidifier provides most of the heat for the occupied portion of the building during the cold winter months. Energy usage is highest during the spring and summer, when both cooling and heating are required to supercool and reheat the air to dehumidify the occupied portion of the building.

Decorative Arts Storage

Our most recent innovation is controlling RH in the 300 m^2 (3,200 sq. ft.), infrequently accessed Decorative Arts Storage Building (fig. 10), using only conservation heating and direct refrigerant expansion (DX) cooling, as opposed to expensive supercooling and reheating, which requires running air-conditioning and heating at the same time for three seasons of the year. The Climate Notebook “Engineer’s Report” (fig. 11) shows the temperature and RH in Decorative Arts Storage for 2003, the year before environmental improvements were made. The histograms show the temperature and RH measurements that fall within the established “safe” zones. Note the high RH, indicated in blue on the right chart, especially during the summer.

As long as a DX cooling unit, such as a window air conditioner, is running, the space is dehumidified quite effectively. However, once the unit turns off, the RH can increase rapidly. The key to dehumidifying a space effectively using DX cooling is to keep the air conditioner running. If the unit is undersized for the space, it will run for longer periods of time, dehumidifying quite effectively without making the space too cold. Keeping the room warmer will also lower the RH. The goal is to keep the summer temperature in the Decorative Arts Storage Building below 25ºC (77ºF) and the RH below 60%.

We began by superinsulating a thirty-year-old frame structure using blown-in, densely packed cellulose insulation. This hygroscopic material has a better insulating value than fiberglass battens and stops all air movement—and hence most moisture movement—within the wall and roof cavities. The cellulose is treated with a fireproofing agent, so enveloping the structure with densely packed cellulose effectively fireproofs the building. The cellulose is treated with borates to prevent mold growth and insect infestation in the insulation. The building was insulated during the winter, and, once the process was complete, the building interior warmed from –12ºC to 5ºC (10ºF to 40ºF), simply because it retained heat from the ground.

An American Standard Freedom 90 Comfort-R home heating furnace and Allegiance air conditioner were installed. This state-of-the-art gas furnace is designed to increase dehumidification by varying the speed of the fan that moves the air over the cooling coils. When the DX cooling unit is just starting up and the cooling coils inside the air handler are not yet cold, the fans slow to decrease the airflow and keep the air in contact with the cooling coils for a longer period of time, thereby condensing more moisture out of the air.

A difficulty in applying the concept of DX cooling for dehumidification is that most engineers in the United States tend to oversize air-conditioning units for buildings to ensure that the occupants remain cool even on the hottest days of the summer. Therefore, they are not accustomed to sizing a DX cooling unit to run continuously to reduce the building temperature to only 25ºC (77ºF). Engineers calculated that a 5 to 10 kW cooling unit would be required to effectively cool and dehumidify this building. The insulating contractor estimated that a 3 kW unit would be more than adequate to cool the space, especially if we wanted it to be undersized to maximize dehumidification. To ensure that we had enough cooling, a two-staged 5 and 10 kW unit was installed. After two summers of operation, the second stage has never been called upon, and the interior temperature remains below 22ºC (72ºF), even on the hottest summer days. The estimate of 3 kW of cooling for an undersized unit to dehumidify this very well-insulated, infrequently accessed storage space was correct.

The museum's Johnson Controls Metasys digital building management system is used to control the American Standard heating and cooling system so that conservation heating reduces high humidity whenever interior temperatures are below 22ºC (72ºF), which in Vermont is most of the spring and fall and all of the winter. The heat is seldom activated in the winter because the interior RH seldom goes above 50% when outdoor temperatures are below freezing. When the temperature is above 22ºC (72ºF), DX cooling dehumidifies the space. With the exception of one brief equipment failure, temperature and humidity levels remained very steady during 2005, topping out at 27ºC (80ºF) and 60% RH in the summer and decreasing to 2ºC (28ºF) and 42% RH in the winter (fig. 12). The equipment failure during April 2005 is a good reminder that even practical climate control systems require constant and careful monitoring to ensure that safe conditions are maintained. Outside temperature and humidity conditions for 2004 are included for comparison (fig. 13).

It cost eight thousand dollars to insulate Decorative Arts Storage, and the entire climate control system cost only sixteen thousand dollars and uses very little energy. This work was funded by a grant from the Institute for Museum and Library Services, a U.S. government agency that funds conservation and collections care projects. Shelburne Museum has recently received funding from another U.S. government agency, the National Endowment for the Humanities, to insulate its 152 m (500 ft.) long Circus Building and install conservation heating and cooling in 2007. We anticipate that more cooling capacity per square meter will be required for the Circus Building than for Decorative Arts Storage, because the public will be entering and exiting this exhibit building much more frequently than staff enters the storage building. Properly sizing the Circus Building cooling system for effective dehumidification should be easier because of the recent introduction by Mitsubishi of ductless modulating heating and cooling systems that automatically adjust cooling capacity based on load. Such a system should not only effectively dehumidify the building but also operate efficiently, thereby reducing the cost of providing safe environments for Shelburne's artifacts. Since this system uses a heat pump for heating and cooling, it may also be possible to control it to provide conservation heating.

Conclusion

It is important to emphasize that all of these practical environmental improvement methods have disadvantages as well as advantages, and the decision to use them involves careful compromise. Conservators must know their collections intimately to ensure that artifacts requiring more stringent temperature or RH conditions than practical environmental improvements provide are stored or exhibited in more tightly controlled areas. Fans used for conservation ventilation can be quite noisy, and filter boxes need to be added to historic structures. Conservation heating results in cold buildings that are inhospitable to off-season tour groups or education classes. Comfortable access to collections is definitely limited during cold weather. Hot-air furnaces are a risk in collections areas. If not properly maintained, furnace fireboxes can rust and crack—damage that can result in puffbacks of soot that could contaminate collections.

Unconventional systems are not well understood by some HVAC contractors and engineers. Therefore, careful selection, training, and close supervision are necessary to ensure that the systems are properly designed, installed, and maintained. As with traditional HVAC systems, a conservator or well-trained collections care specialist who thoroughly understands the systems needs to monitor building environmental conditions regularly and troubleshoot equipment problems.

However, such compromises can definitely pay off in lower equipment and installation costs, lower fuel costs, and lower maintenance costs for less equipment and simpler equipment. By knowing the environmental conditions that will and will not harm our collections, by embracing broader safe temperature and RH standards, by using new energy-efficient technology, and by working with nature instead of against it to eliminate temperature and RH extremes, we can preserve our collections and historic buildings for future generations and maybe even manage to afford to keep our museum doors open for future generations.

Author Biography

Richard Kerschner is the Director of Preservation and Conservation at the Shelburne Museum in Shelburne, Vermont. He holds an MA and a Certificate of Advanced Study in Conservation from the Cooperstown Graduate Program and is a Fellow of the International Institute for Conservation and the American Institute for Conservation, where he serves as Treasurer. He conducts research, lectures, and consults on practical environmental control for collections housed in historic buildings.

Figures

Figure 1

The Cambridge Covered Bridge, a class 1 building. Photo: © Shelburne Museum, Shelburne, Vermont.

Figure 2

The Horseshoe Barn, a class 2 building. Photo: © Shelburne Museum, Shelburne, Vermont.

Figure 3

Prentis House, a class 3 building. Photo: © Shelburne Museum, Shelburne, Vermont.

Figure 4

Dorset House, a class 4 building. Photo: © Shelburne Museum, Shelburne, Vermont.

Figure 5

The Pleissner Building, a class 5 building. Photo: © Shelburne Museum, Shelburne, Vermont.

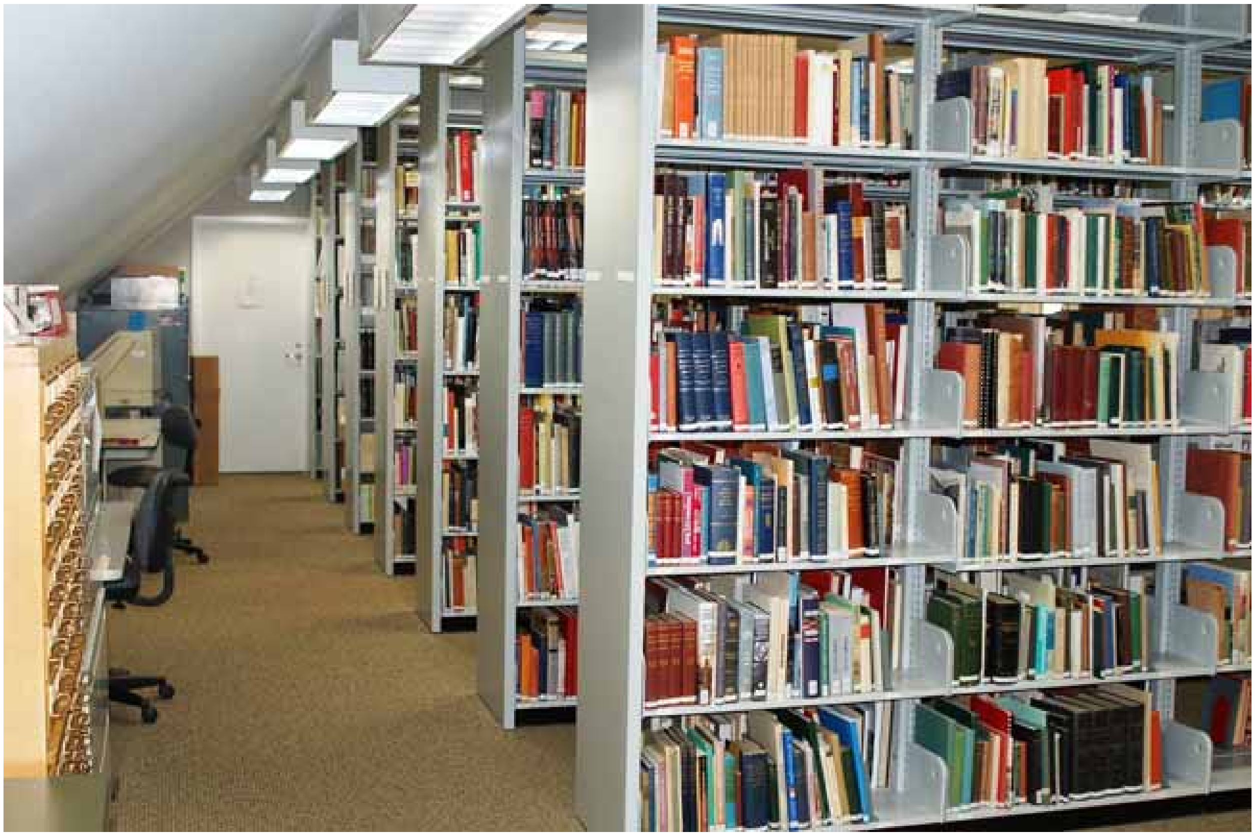

Figure 6

The Shelburne Museum Library, a class 6 building. Photo: © Shelburne Museum, Shelburne, Vermont.

Figure 7

A basement intake fan assembly with dust filter. Photo: © Shelburne Museum, Shelburne, Vermont.

Figure 8

Collections Management Building. Photo: © Shelburne Museum, Shelburne, Vermont.

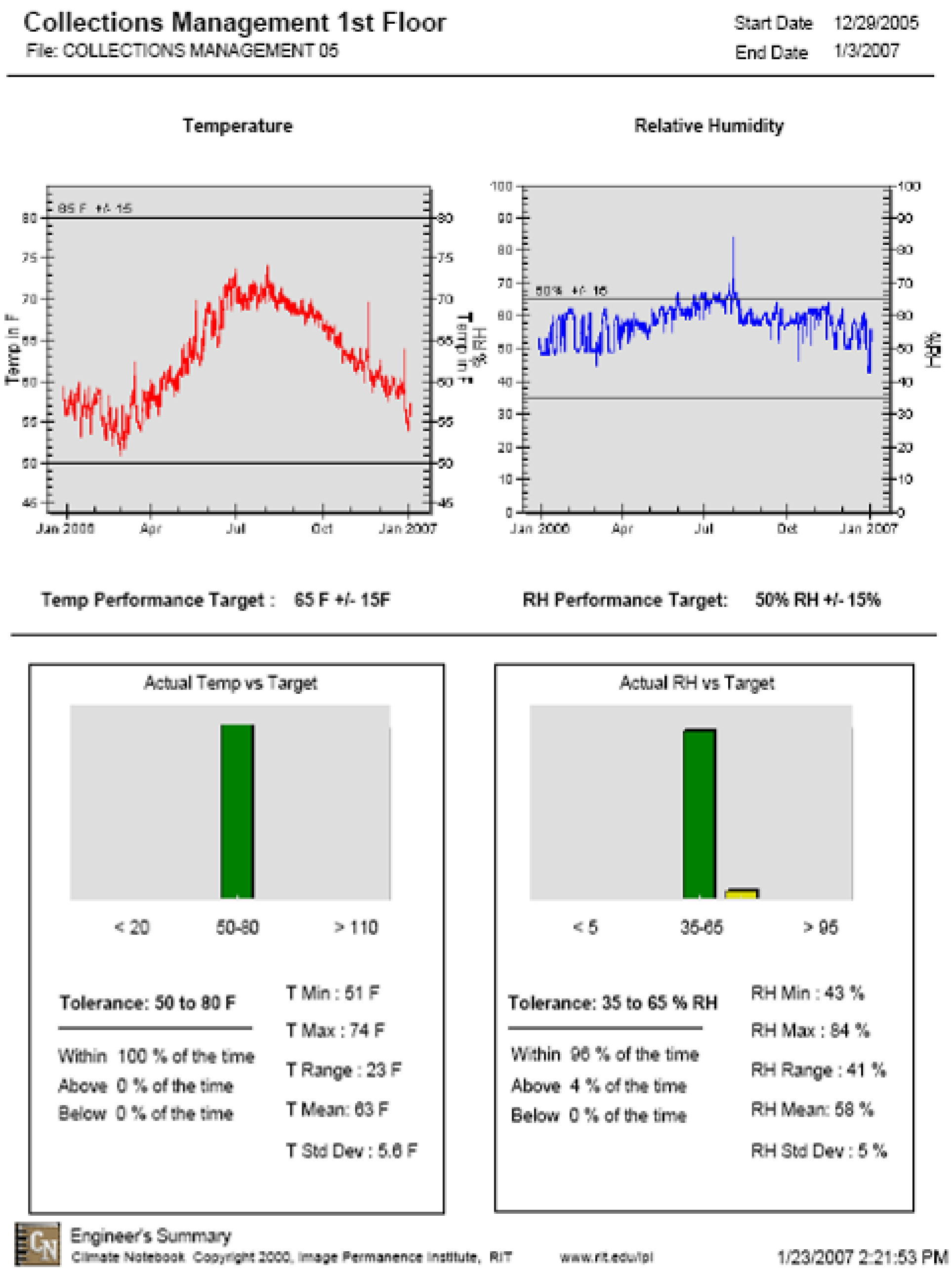

Figure 9

2006 Climate Notebook “Engineer’s Report” for the Collections Management Building storage area. Report: Climate Notebook software, © 2000, Image Permanence Institute, Rochester Institute of Technology.

Figure 10

Decorative Arts Storage Building. Photo: © Shelburne Museum, Shelburne, Vermont.

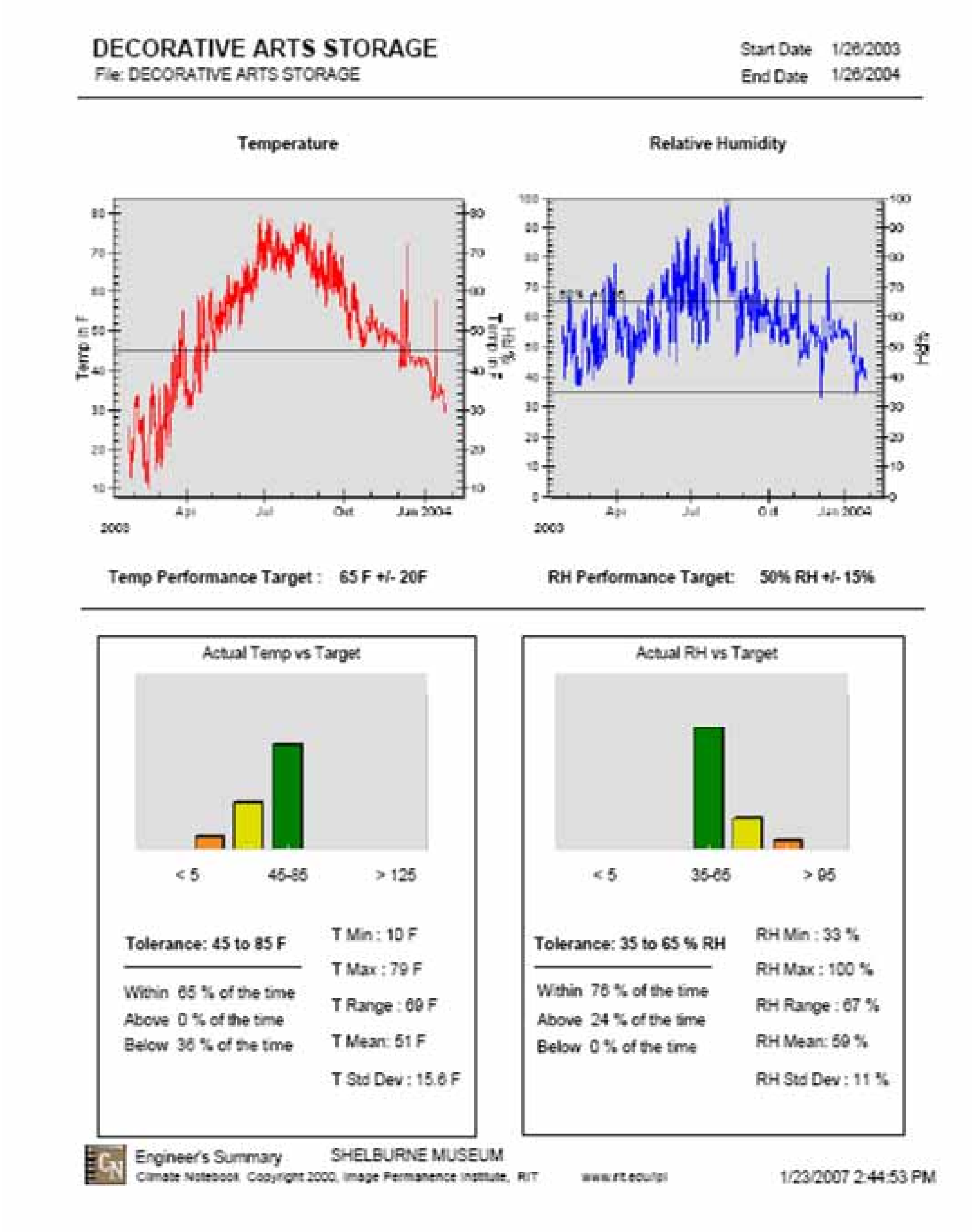

Figure 11

2003 Climate Notebook “Engineer’s Report” for the Decorative Arts Storage Building prior to environmental improvements. Report: Climate Notebook software, © 2000, Image Permanence Institute, Rochester Institute of Technology.

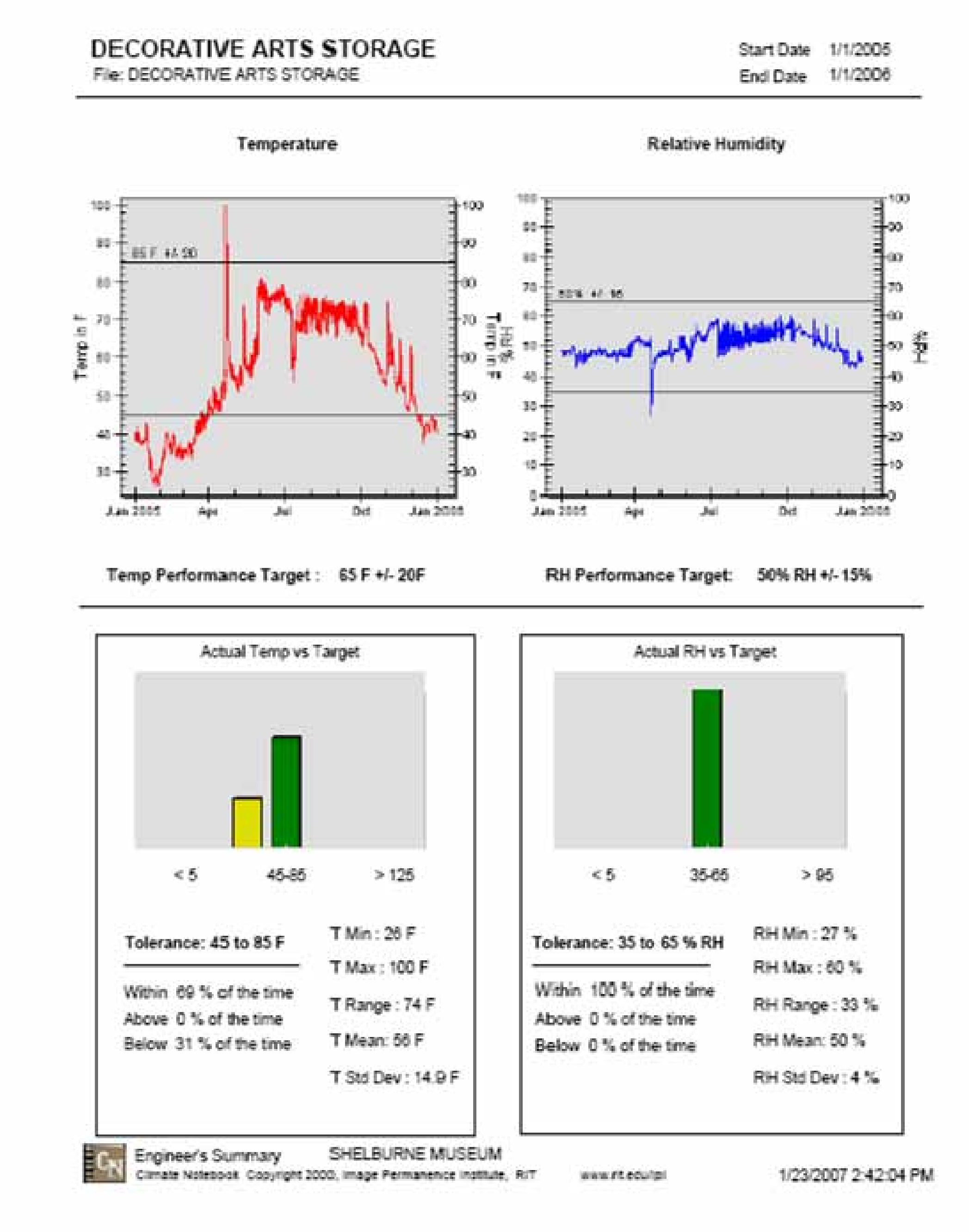

Figure 12

2005 Climate Notebook "Engineer's Report" for the Decorative Arts Storage Building after environmental improvements. Report: Climate Notebook software, © 2000, Image Permanence Institute, Rochester Institute of Technology.

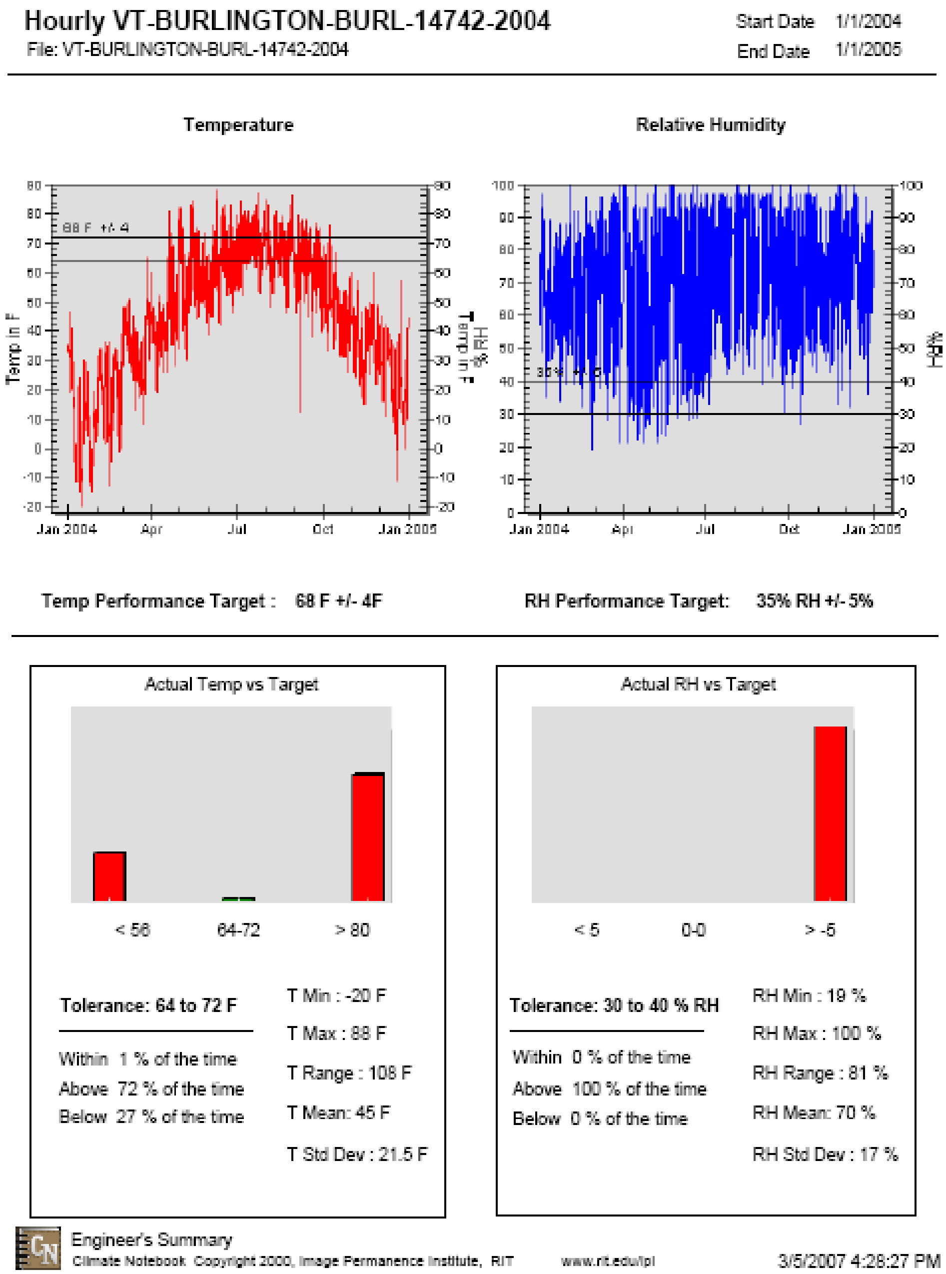

Figure 13

2004 Climate Notebook "Engineer's Report" for outside temperature and relative humidity for Burlington, Vermont. Report: Climate Notebook software, © 2000, Image Permanence Institute, Rochester Institute of Technology.

Suppliers

Metasys Building Management Software
Johnson Controls Incorporated
5757 N. Green Bay Avenue
P.O. Box 591
Milwaukee, WI 53201
http://www.johnsoncontrols.com

Preservation Environmental Monitor and Climate Notebook Software
Image Permanence Institute
Rochester Institute of Technology
70 Lomb Memorial Drive
Rochester, NY 14623-5604
http://www.imagepermanenceinstitute.org

Temperature and Humidity Sensors
Vaisala, Inc., Boston Office
10-D Gill Street, Woburn, MA 01801
http://www.vaisala.com

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