Beyond 70/50

Research-Based Environmental Standards for Sustainable Museum Collections in Gallery Spaces

Mueller

By Todd Garing

Museum facility managers face a fundamental question affecting everything from energy costs to collections preservation: What environmental conditions truly serve our collections best in gallery spaces?

For decades, the answer has been remarkably consistent: 70°F and 50% relative humidity, maintained year-round with minimal variation. This standard, commonly referred to as "70/50," has become so entrenched that many facilities managers consider it an unquestioned requirement for new projects and renovations.

However, research increasingly suggests that this traditional approach may not serve our collections, buildings, or operational sustainability as effectively as we once thought. The scientific evidence now points to more adaptable environmental management strategies that can enhance collections and building preservation, while significantly reducing energy use and operational costs.

This shift means more than just a change in thermostat settings: it's a fundamental reevaluation of how we balance preservation goals with operational sustainability. The implications for facility managers are significant, potentially influencing system sizing, energy use, capital costs, and long-term operational plans.

The Origins and Persistence of 70°F/50% RH

Understanding how 70/50 became the industry standard helps explain why change has been slow.

When I started working on museum projects in the early 1990s, clients nearly always specified environmental conditions at 70°F dry bulb and 50% relative humidity year-round. More than 30 years later, many facilities managers still receive specifications demanding these exact conditions, often justified by certification requirements or loan agreements for collections.

The widespread use of 70/50 is often attributed to Gary Thompson and his influential 1978 book, *The Museum Environment*. However, this attribution may be a case of selective interpretation. Thompson's more nuanced explanations and cautionary notes about environmental control have been frequently overlooked in favor of the seemingly straightforward temperature and humidity targets he discussed.

Beyond Thompson's influence, practical limitations reinforced the 70/50 standard. In humid climates, keeping a summer dewpoint below 50°F requires lower-temperature chilled water, specialized refrigeration equipment, or desiccant systems. These mechanical constraints, along with conservative strategies to mitigate environmental fluctuations, have led many cultural institutions to conclude that maintaining a 70/50 year-round ratio was the safest approach.

The persistence of this standard also reflects the generally risk-averse culture of museums. When collections preservation is the primary goal, the tendency is to play it safe, even if that caution might be unnecessarily costly or counterproductive.

Research-Driven Environmental Management

Nearly across the board, museum owners, facilities managers, and others are beginning to question whether they are specifying larger, more costly, and less energy-efficient mechanical systems than necessary, in order to achieve optimal preservation results.

Various scientific approaches have uncovered several important insights that question the traditional 70/50 standards. Research by institutions, such as the Image Permanence Institute (IPI), along with guidance from organizations including the Bizot Group, International Institute for Conservation of Historic and Artistic Works (IIC), American Institute for Conservation (AIC), Australian Institute for the Conservation of Cultural Material (AICCM), and the British Standards Institution (BSI), suggests that 70/50 may not be the optimal choice for collections, building envelopes, energy efficiency, or sustainability objectives.

The 2023 *ASHRAE Handbook—HVAC Applications*, Chapter 24, "Museums, Galleries, Archives, and Libraries" (MGAL)—is an excellent resource, providing comprehensive guidance driven by qualitative data, with explicit consideration of sustainability and building envelope limitations. This should be required reading for anyone involved in museum facility management, as it synthesizes current research and provides practical guidance for implementation.

A key finding from this research involves the response times of artifacts to environmental fluctuations, especially their hygric (moisture) response times. Most artifacts take a day or more to react to environmental changes, indicating that hourly and sometimes daily fluctuations in relative humidity pose little risk to most collections. This suggests that the stringent control usually recommended may be unnecessary for most collections.

The data also reveals that objects generally prefer cooler and drier conditions, subject to reasonably lower limits. This means that collections are frequently more stable under winter conditions, which are cooler and drier than summer conditions—exactly the opposite of what year-round 70/50 provides.

For collections with special sensitivity needs, targeted solutions, such as enclosed display cases or separate rooms with dedicated HVAC systems, can meet specific requirements, while enabling the rest of the building and its systems to operate more efficiently.

Industry Standards Evolution: Wider Ranges and Seasonal Flexibility

Modern industry standards recommend distinctly different approaches, compared to the traditional 70/50 approach. These newer standards permit ranges of dry bulb temperature and humidity levels, including controlled fluctuations. This can offer multiple operational benefits, such as more stable HVAC operation, reduced stress on the building envelope, and notable energy savings.

ASHRAE's MGAL guidance provides specific temperature and relative humidity specifications that differ substantially from conventional practice. For example, for Type A Control—the highest suggested classification for museum galleries—the long-term outer limits are 50–77°F dry bulb temperature, and 35–65% relative humidity. This represents a much broader range than traditional 70/50 specifications.

The ASHRAE approach includes seasonal adjustments to the annual average dry bulb temperature, allowing increases of up to 9°F, and decreases of up to 18°F. Short-term fluctuations plus space gradients are permitted at ±4°F for dry bulb temperature.

Type A control is further subdivided into A1 and A2 classifications for relative humidity management. Type A1 permits seasonal adjustments from the annual average relative humidity (±10% RH), while limiting short-term fluctuations plus space gradients to ±5% RH. Type A2 eliminates seasonal relative humidity adjustments, but permits short-term fluctuations plus space gradients of ±10% RH.

These suggested ranges are based on specific risk categories for general collections: the upper limit of relative humidity is determined by the risk of biological damage, the lower limit of relative humidity and temperature by the risk of mechanical damage, and the upper limit of temperature by the risk of chemical damage. Each collection needs individual evaluation to identify the most suitable environmental conditions.

Understanding the definitions behind these criteria is crucial for proper implementation. Long-term limits apply to the combination of annual average conditions and seasonal adjustments. Seasonal adjustment rates should not surpass short-term fluctuation limits within specified periods—30 days for relative humidity and seven days for temperature in Type A1 systems, for instance. Short-term fluctuations are those that occur more quickly than the seasonal adjustment rate.

Importantly, seasonal adjustments are bounded by long-term outer limits, but these limits do not constrain short-term fluctuations. Also, if annual average values are not centered within the long-term range, the outer limits may reduce permitted seasonal fluctuations while not affecting short-term fluctuation allowances.

Quantifying Energy Savings: A Washington, D.C. Museum Case Study

Recent energy modeling conducted for a museum project in Washington, D.C. demonstrates the substantial energy impact of various environmental conditioning strategies. Although these results are project-specific, similar analyses can be performed during early project phases to help owners make informed decisions about environmental specifications and their operational implications.

This project utilizes utility chilled water and steam, rather than building-level heating and cooling plants, which affects specific energy calculations, but does not alter the relative relationships between different environmental strategies.

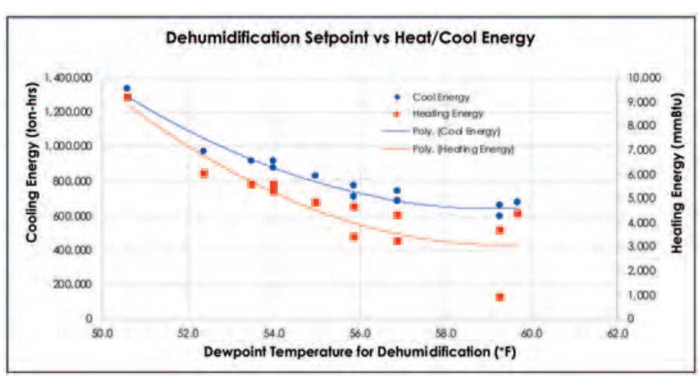

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Figure 1: Relationships between dehumidification and heating and cooling energy.

Impact of Dehumidification: The setpoint for dehumidification significantly influences both cooling and heating (reheat) energy use. As illustrated above, the impact is most noticeable in the 50–55°F dewpoint temperature range, where reheat energy consumption nears that of cooling energy at the 50°F dewpoint. This highlights why maintaining the dewpoint associated with 70/50 conditions requires considerable energy input.

Relative Humidity Effects: When the same data is shown as a function of relative humidity and reheat setpoints (see above), energy savings associated with higher relative humidity setpoints follow a linear pattern at a given temperature. However, data indicate diminishing returns as relative humidity and temperature near the upper limits of this analysis.

Cooling Temperature Sensitivity: Cooling energy is highly responsive to dry bulb temperature setpoints, with diminishing returns above 74°F. This suggests that small adjustments to cooling setpoints can result in substantial energy savings.

Heating Temperature Impact: Heating energy demonstrates similar sensitivity to heating dry bulb temperature setpoints, with diminishing returns below 65°F. The combined impact of these cooling and heating sensitivities indicates that optimal energy performance is achieved over broader temperature ranges than traditional specifications typically allow.

Humidification Energy: The energy required for humidification varies with the relative humidity setpoint, exhibiting diminishing returns below 40% relative humidity. When using adiabatic humidification systems instead of steam, the overall energy impact of increasing humidity setpoints is significantly reduced. However, higher humidity setpoints in colder climates can lead to condensation problems that damage building envelopes, finishes, and potentially collections.

Deadband Importance: Narrow deadbands between cooling/heating and dehumidification/humidification setpoints increase system short-cycling and operational conflicts. When no deadband exists—meaning identical setpoints for heating/cooling or humidification/dehumidification—systems tend to overshoot due to response times, and setpoints often require opposing operations, leading to excess energy use and overshooting. When deadbands reach 4°F or higher, reheat energy requirements are significantly reduced or eliminated.

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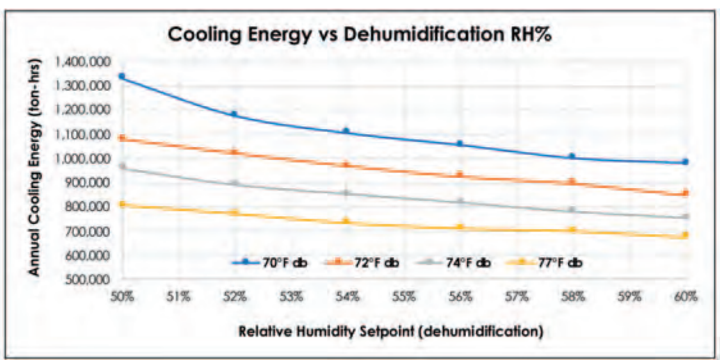
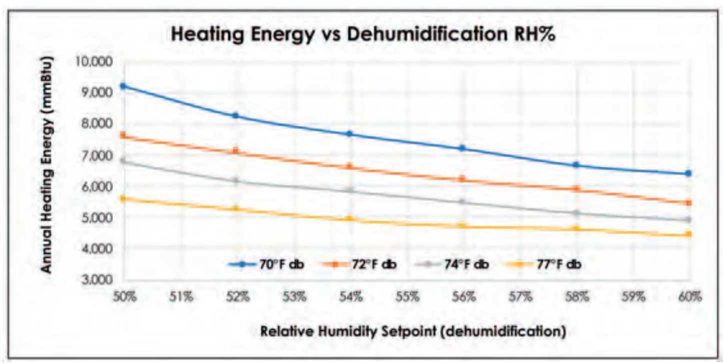
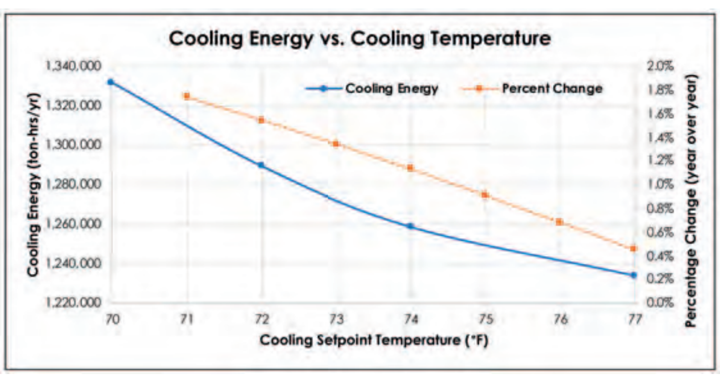




Figures 2 and 3: These two graphs show the impact of dehumidification on heating and cooling energy when cooling dry bulb and dehumidification setpoints are adjusted. The relationships between cooling and heating are mostly linear; however, there are signs of potential diminishing returns at higher relative humidity (RH%) and temperature setpoints.



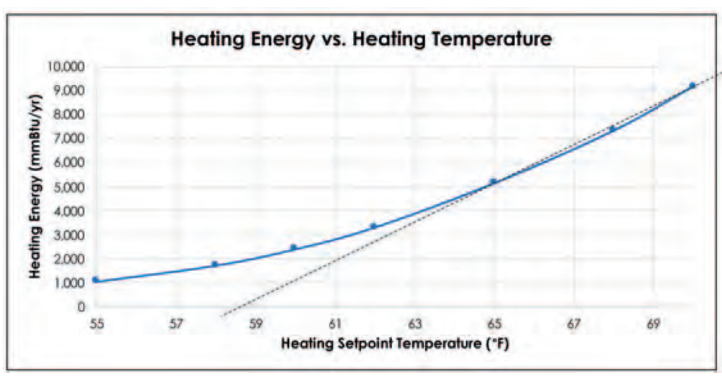


Figure 4: This graph shows clear indications of a diminishing return at the high end of the temperature range. In this instance, any efforts to reduce the use of chilled water will likely have a substantial impact on performance.

Figure 5: This graph shows the linear relationship between heating energy and heating setpoint within a typical *temperature range.*

Managing Interdependent Variables: Temperature Float Impact on Relative Humidity

One critical consideration often overlooked in environmental specifications for collections is the mathematical relationship between dry bulb temperature and relative humidity. Controlling dry bulb temperature is significantly easier to achieve than controlling relative humidity. However, since relative humidity depends upon both moisture content and temperature, temperature variations will cause changes in relative humidity, even when absolute moisture levels remain constant.

For example, if a space maintained at 70°F and 50% RH is permitted to float ±4°F, the resulting relative humidity will be 42% (an 8% decrease) at 74°F, and 56% (a 6% increase) at 66°F. For these conditions to remain within acceptable ranges, ASHRAE Type A2 specifications would be required, which permit a variation of ±10% RH.

This relationship means that dry bulb temperature fluctuations must be evaluated in conjunction with acceptable fluctuations in relative humidity. Facilities managers cannot specify tight relative humidity control while allowing significant temperature variation, or vice-versa, without understanding these interdependencies.

Practical Implementation: Balancing Collections Care with Operational Efficiency

Based on current research and proven energy modeling results, several practical strategies can be implemented to optimize environmental conditions, while maintaining proper collections conservation standards in gallery spaces.

Maximize Cooling and Dehumidification Setpoints: Within the limits established by collection requirements and building envelope constraints, higher cooling and dehumidification setpoints provide the most significant opportunities for energy savings.

Minimize Heating and Humidification Setpoints: Lowering heating and humidification setpoints and considering appropriate deadband offer substantial energy savings, while often improving collections stability and reducing the risk of condensation along the building perimeter. For normally occupied spaces, human comfort may establish the practical lower temperature limits.

Separate Sensitive Collections: Rather than designing entire facilities to meet the most restrictive environmental requirements, it is worth identifying collections that require intensive environmental control and providing them with separate or supplemental systems. This approach limits energy-intensive conditions to areas in which they offer clear benefits in terms of preservation.

Design for Flexibility: If owners prefer to try less conservative setpoints while maintaining the option to revert to traditional specifications, mechanical systems should be sized for conservative values while operating at less conservative settings. This strategy offers operational flexibility, while minimizing system replacement costs in the event of changing requirements.

Consider Seasonal Strategies: Evaluate whether seasonal adjustments in relative humidity, with lower fluctuations, could provide better outcomes than no seasonal adjustments with higher fluctuation tolerances. The optimal approach depends on the climate, specific characteristics of the collection, and the building envelope's performance.

Proportional Adjustments: As cooling and dehumidification setpoints are raised, proportionately lower heating and humidification setpoints should be used to maintain or improve annual collections stability, while maximizing energy performance.

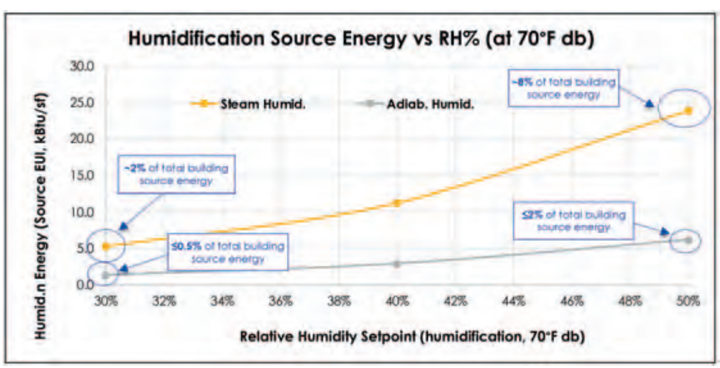


Figure 6: This comparison between the currently specified adiabatic humidification system and a steam-based system shows that the adiabatic humidification system involves substantially lower energy use.

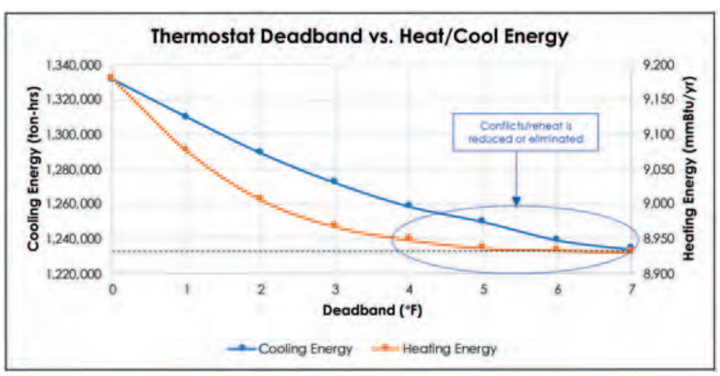


Figure 7: This simplified study used the Base Design as the point of reference and shows the impact of expanding the deadband (demonstrated through an increase in the cooling setpoint) while maintaining the same dewpoint and heating setpoints. In this case, an expanded deadband should be considered.

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Temperature-Humidity Integration: It is worth developing control strategies that take into account the mathematical relationship between temperature float and variations in relative humidity, ensuring that both parameters remain within acceptable ranges.

The Path Forward

The evidence strongly suggests that adjusting environmental conditions represents the single highest-impact strategy for reducing energy consumption in museum facilities—likely exceeding the benefits of highly efficient lighting, daylighting, energy recovery systems, high-performance HVAC equipment, or solar installations. Moreover, adjustments in environmental conditions can often be implemented more easily and at lower cost than major system modifications.

The shift from conventional 70/50 specifications to research-based environmental management offers multiple benefits:

- improved collections preservation through conditions that better reflect scientific research related to materials;
- reduced stress on building envelopes by making allowances for seasonal variations;
- significant reductions in energy costs and consumption;
- lower carbon footprints; and,
- reduced capital costs for mechanical systems.

However, successful implementation requires careful consideration of specific collection characteristics, institutional risk tolerance, building-envelope performance, and operational capabilities. The goal is not simply to abandon established practices, but to replace convention with science-based decision-making that serves both preservation and sustainability objectives.

For facilities managers, this represents an opportunity to lead institutional conversations about striking a balance between preservation goals and operational sustainability. The research now exists to support these discussions with quantitative data rather than assumptions, potentially transforming how cultural institutions approach environmental management in the decades ahead.

The question is no longer whether we should move beyond 70/50, but how quickly and systematically we can implement these research-based environmental standards to preserve and protect our collections. 🏛

Todd Garing, PE, LEED AP BD+C, is President of Mueller Associates, Inc. The author acknowledges contributions from the Mueller Associates engineering team, and Sustainable Building Partners, in developing this analysis. Todd can be reached at: tgaring@muellerassoc.com.