HVAC Installation, Renovation, and Collections Environments

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AIC Connecting to Collections Care

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Today's Instructor:

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  Linden Preservation Services, Inc.
- Former Archivist, Preservation Environment Specialist, and HVAC Technician

Capturing Opportunity and Minimizing Risk

- HVAC – Heating, Ventilation, and Air Conditioning
  - "Mechanical Intervention"
- Needs vary from institution to institution – many may not require or be able to use mechanical intervention
- Never a one-size-fits-all solution
- Capital improvements can provide significant benefits – or create long-term problems
- Today's goal – understanding the mechanical design process to maximize preservation and sustainability, while minimizing potential for suboptimal or incorrect operation.

Concepts to Explore

- What are the keys to a successful HVAC project?
- How do we know what to ask for, and how to ask for it?
- Are there tools/strategies we can use for communication?
- Where are the critical points where things might start to go wrong?

Guiding Principles for the Cultural Heritage Design Process

AKA “Post-it notes to yourself…”

Guiding Principle #1: Integrated Process

- An integrated design process means that all members of the project team work together throughout the design, rather than working on design components separately
- This typically includes:
  - Architects
  - Mechanical engineers (HVAC)
  - Structural engineers, etc.
- In cultural heritage applications, should also include:
  - Collections professionals
  - Facilities staff
  - Cultural heritage preservation, facilities, and sustainability consultants

(Sidebar – a word on consultants)

- Don't be afraid to go there – especially where they fill a need
- May bring perspectives or expertise from the broader field that staff aren't exposed to
- Often fill a gap between the institution and the designers
  - Translator
  - Interpreter
  - Mediator
- From the institutional perspective – often most helpful when they are hired by, and represent, the institution (rather than working for the designer)
- Can provide external review of design proposals, and can lend legitimacy to the process.

Guiding Principle #2: The Collection Stays in the Foreground

- Not just about numbers and equipment
- Not every decision will be the collection "ideal"
  - But every decision should consider potential collection impact.

(this is part of why the involvement of collections professionals in integrated design is critical!)

Guiding Principle #3: Plan for the Long-Term

- Museums/Libraries/etc., are (generally) not rich.
  - Budget cycles for HVAC renovation run 30-40 years, not 15-20 – so choose equipment wisely!
- Don't design for today's environment – design for the environment 20+ years from now.
- Document, Document, Document
  - What decisions did we make and why?
  - How is this thing supposed to run?

Guiding Principle #4: Sustainability isn't just recycling.

- Designing for preservation only achieves part of our mission - preservation and sustainability go hand-in-hand.
- Design with the holistic building system in mind - from the outside in:
  - Where possible, let the building structure do the bulk of the work.
  - Mechanical systems should be used to trim inappropriate conditions – not try to control the outdoors.
- Planned operation should only use as much energy as necessary to achieve the desired conditions – avoid sub-optimal operation and design.
- Efficient equipment only gets you so far – most efficiencies are found in actual operation.

Guiding Principle #5: Speak Up.

- Communication is a two-way street
  - Collections professionals need to be conversant in HVAC
  - Engineers/HVAC professionals need to be conversant in preservation.
- Learn what you can.
- Ask questions.
- Understand what you're asking for, and why.
- Use external allies and consultants to bridge the communication gap where necessary.

Resources to help along the way…

ASHRAE Chapter 24

(Technically 2019 ASHRAE Handbook – HVAC Applications, Chapter 24: Museums, Galleries, Archives, and Libraries)

- ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
- First published in 1999, most recent update published in June 2019
- Committee comprised of preservation professionals, conservation scientists, engineers, and mechanical industry professionals
- Meant to provide design guidance to HVAC professionals working with cultural heritage

CHAPTER 24. MUSEUMS, GALLERIES, ARCHIVES, AND LIBRARIES

THIS chapter presents best practices and advice on planning, designing, and implementing environmental strategies for long-term preservation of cultural heritage that also support access in an economically and environmentally responsible way. It aims to support a holistic approach, taking into consideration the types of collections, buildings, and environmental control systems that can sustain appropriate conditions for specific collections with their own climate histories. It acknowledges that any strategy will have to be an integral part of heritage preservation as a whole. The chapter is applicable to museums, galleries, nonresidential historic buildings, reference libraries, and archives, as well as to both new and existing structures. It is not designed for buildings with public access that only hold collections not intended for preservation, such as school libraries.

This chapter is primarily directed at HVAC engineers and facility managers involved with indoor climate control projects in cultural heritage institutions, including new construction and extensions, renovations and upgrades of existing systems, and the adjustment of climate control strategies towards sustainability. Because this chapter has been widely used by allied professionals in a much broader context, it informs all stakeholders involved in the decision-making process on designing and implementing environmental strategies for cultural heritage collections. These include, but are not limited to, engineers, architects, collection owners, cultural heritage administrators, collection managers, conservators, conservation scientists, curators and registrars.

The information in this chapter focuses on mechanical and, to a limited extent, nonmechanical approaches to the control of temperature, relative humidity, and indoor air quality. Tables and graphs are used to provide clear and easy access to specific information, but the underlying text is necessary to understand the full context.

ASHRAE Chapter 24

- New updates include:
  - Detailed decision-making process for design projects
  - New environmental guidelines (T, RH, and pollutants) based on updated materials science
  - Guidance on building envelope capacity based on geography and necessary interior environment
  - New control design guidelines incorporating both preservation and sustainable operation
  - Updated guidance on equipment selection

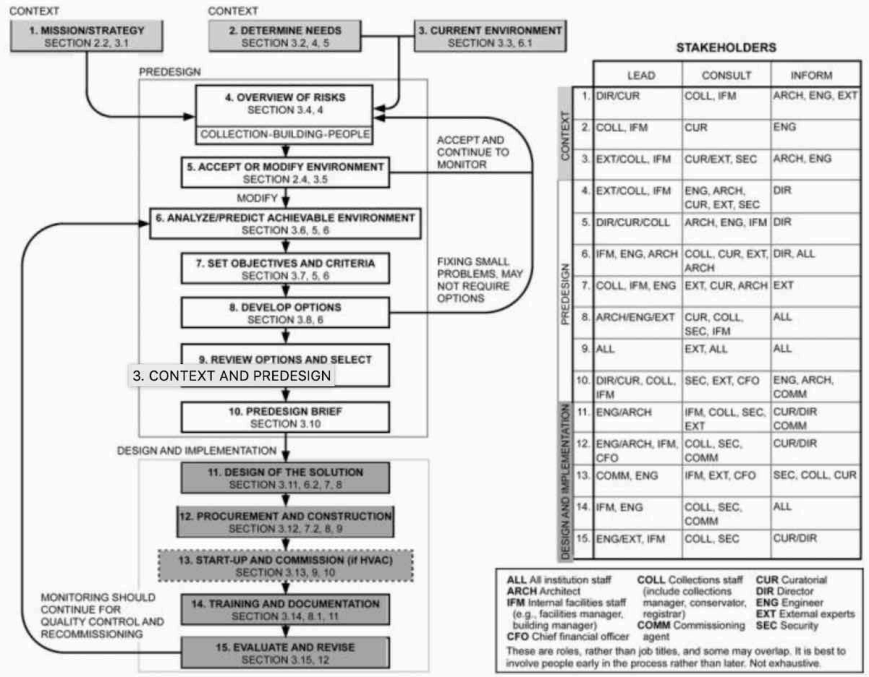


Figure 1. Decision Diagram for Environmental Management Strategies in Museums, Galleries, Archives, and Libraries
(based on Taylor, forthcoming)

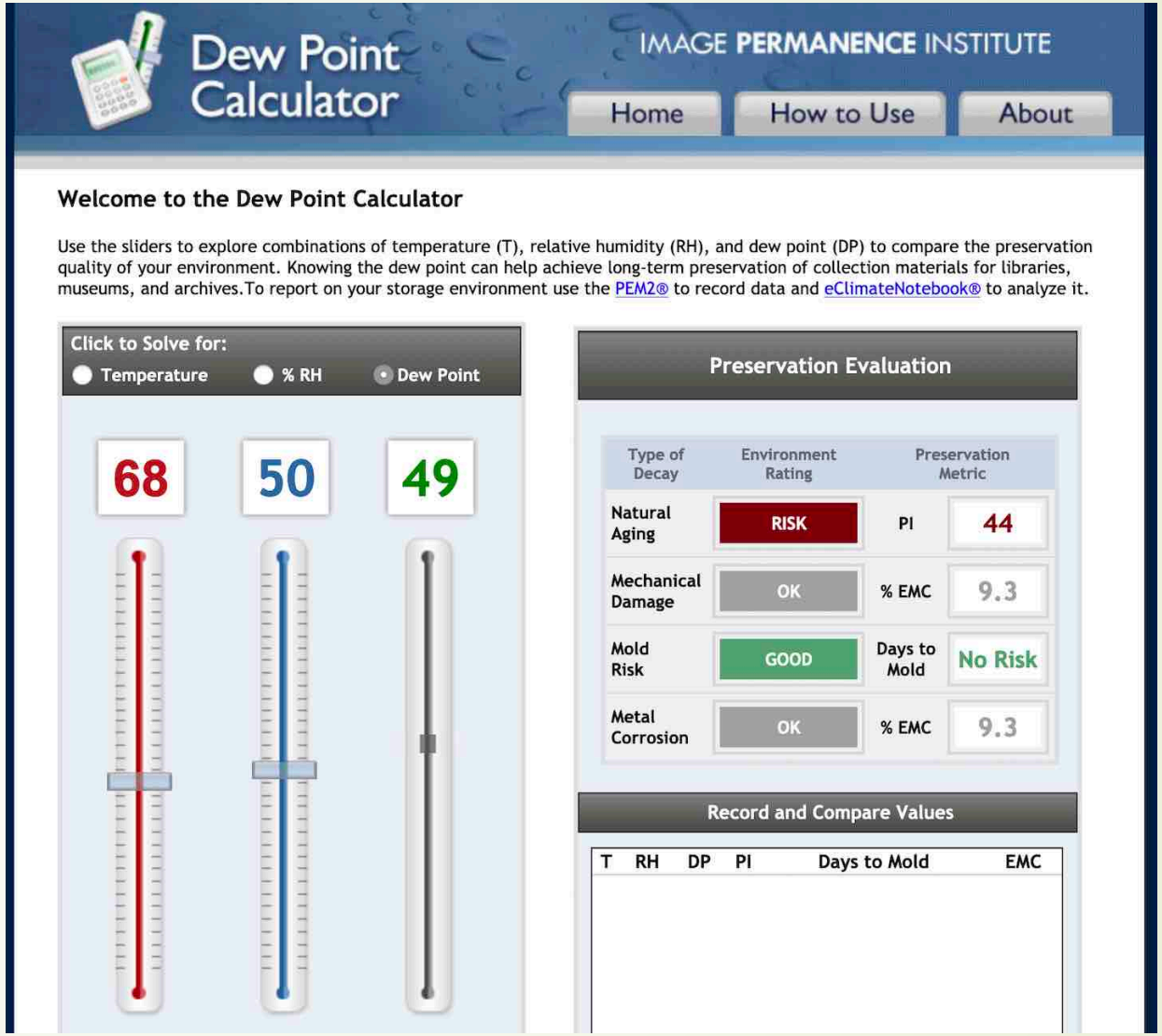
Image Permanence Institute (IPI)

- IPI's Guide to Sustainable Preservation Practices for Managing Storage Environments
- IPI's Methodology for Implementing Sustainable Energy-Saving Strategies for Collections Environments

While geared toward the operation and optimization of existing systems, both resources present operational goals that can be used to inform the design process

Dew Point Calculator (IPI)

- Free online tool (www.dpcalc.org)
- Slider values show relationship between temperature, relative humidity and dew point
- Includes IPI's Preservation Metrics, allowing comparison of preservation quality and degradation risks at different environmental conditions
- Great for discussing the preservation impact of various design considerations with the integrated design team.



Working through the Design/Construction Process

Design and Project Management

HVAC design processes, the ASHRAE recommendations, and basic project management phases look quite similar

For example:

Initiation (PM) = Context (ASHRAE)	Planning (PM) = Predesign/ Design (ASHRAE)	Execution (PM) = Construction (ASHRAE)	Monitoring and Control (PM) = Commissioning (ASHRAE)	Closure (PM) = Training and Documentation (ASHRAE)

Initiation/Context

- Collection and Facilities – Team Up!
- Document existing operation and risks
  - …Environmental Monitoring…
- May include external consultants for analysis/assessment of existing conditions and needs – including mechanical assessment
- In larger settings – may incorporate feasibility study or other formal process
- (US) Funding may be available to help: see NEH Sustaining Cultural Heritage Collections Planning grants

Planning/Predesign

- Definition of needs – is there a difference between the environment you have and the environment you need?
  - Keep in mind realistic capabilities of the building you're in
  - Can you separate people and collections?
  - Start with mitigating risk – then consider improving overall conditions.
- May or may not include architects or engineers at this juncture
- Key product at this stage – Program Requirements document

Program Requirements/Design Parameters

- KEY document for entire design process
  - Typically collaboration between collections, facilities, and an external consultant
  - NOT meant to dictate – it's a starting point to facilitate decision-making
- Lays out institutional needs/desires for project
  - Environmental Conditions (and why)
  - Zoning (how many air handlers serving which spaces)
  - Equipment preferences
  - Operational requirements (ie, limited outside air, no economizer control, humidification)
  - Control preferences

Unit Requirements:

- **Pkg 1 – Textiles Storage:**
  - Winter:
    - i. Temp: 55 Degrees
    - ii. RH: 40%
    - iii. DP: 40 degrees
  - Summer:
    - i. Temp: 60 Degrees
    - ii. RH: 55%
    - iii. DP: 40 Degrees

- **For Textiles Unit (typical for all three):**
  - Two filter banks
    - Pre-filter – merv 8
    - Final – merv 13
  - Minimum OA
    - Driven by CO2 sensors
  - Subcool/reheat configuration
    - Specifications:
  - Humidifier if necessary
  - 1-2 air changes/hour
  - Destratification Fans
  - Unit sensors
    - Return T/RH
    - Discharge Supply Air T/RH
    - Discharge Cooling Coil T/RH
    - Mixed air T/RH
  - Space Sensor
    - T/RH
    - drives humidifier, sensible temperature con
  - Dehumidification based on CC Leaving air temperatu
  - Pressurization – Neutral to Positive
    - Not negative

General Temperature Safe & Risk Zones

Temperature	Description	Risks
68°F/20°C and higher	"Room"	• Elevated risk for chemical decay for most materials • Increase in biological activity in damp conditions
55-67°F 12-19°C	"Cool"	• Cool temperatures slow the rate of chemical decay • Good for most materials except film and color photographs
33-54° F 1-11°C	"Cold"	• Beneficial for film and photograph collections • Good for most materials • Exercise caution with certain media, including oils and acrylics
32°F/0°C and lower	"Frozen"	• Best for acetate film and color media collections • Recommended for decaying acetate and nitrate media

General RH Safe and Risk Zones

Relative Humidity	Risks
70% RH and higher	• High risk for mold growth, mechanical and biological damage • Elevated risk for chemical decay
65% - 70% RH	• 70% RH – Begin practical risk for mold growth • >65% RH – Elevated risk for mechanical damage and chemical decay
55% - 65% RH	• >60% RH – Potential for mechanical damage in certain materials • >55% RH – Oxidation risk for certain metallic components (typically iron, silver, copper, bronze)
35% - 55% RH	• Minimal risk to most materials
35% RH and lower	• >30% RH – Tiny risk to most paintings, most photographs, some artifacts, some books. Moderate risk to high-vulnerability artifacts. • <30% - Elevated risk of mechanical damage to hygroscopic materials • <30% - Generally safe for inorganic materials (watch for exceptions such as shales)

The Kickoff Meeting

- Often the first time the full integrated design team is in the same room
- Usually includes:
  - Team Introductions
  - Discussion of the Program Requirements
  - Walkthrough of the spaces (collections and mechanical rooms)
  - Overview of the full design process
  - Review of additional business matters
- Generally initiates the design process

The Kickoff Meeting is also a great time to share resources that the institutional team is using.

- Consider walking the architecture/engineering teams through tools such as Dew Point Calculator, to illustrate why certain environmental design conditions are important to preservation.
- If using ASHRAE Chapter 24 for guidance, ask teams if they're familiar with the new content – point out aspects that are important to you, and ask them to comment on how they might be incorporated.

Design Phases

- Depending on the engineer/contractor, may see up to four phases of design:
  - Preliminary – meant to provide potential options for design, including broad pricing ranges
  - Schematic – based on team discussions, documents the basics of selected design intent for review by the team before moving into detailed drawings.
  - Design Development – incorporates comments from the Schematic phase and produces a nearly full set of drawings, usually with intervals for review (ie, at 50% and 90%) – (may serve as the basis for bid documents)
  - Construction Documents – adds the final detail for construction, including final equipment/fixture selections (may serve as the basis for bid documents)

Design Reviews

- For the institution, CRITICAL part of the design process – opportunity to assess the design progress at multiple phases
- This should be a critical assessment –
  - Does the design match the program requirements (or the agreed upon adjustments)?
  - How will collections workflows be affected by the design? (ie, transition between environments or zones)
  - Does airflow impact storage layout or design?
- This is to time to ask why certain choices are made, assess their impact on collections, and reconsider options if necessary.
- Institution should ask for at least four review points – at schematic, at least two during design development, and final construction documents.
- Individual reviews should be conducted by Collections, Facilities, and any external consultants

For smaller projects -

- May not go through a full design process
- Request that contractors provide "cut-sheets" (product specifications) for the equipment they intend to use
  - If specifications include information for multiple models, ask them to clarify which model/size they are using and why
  - Work with staff or consultants to ensure that the selected equipment will work for the environmental requirements – smaller "package" units in particular are rarely designed for moisture control.

Execution/Construction

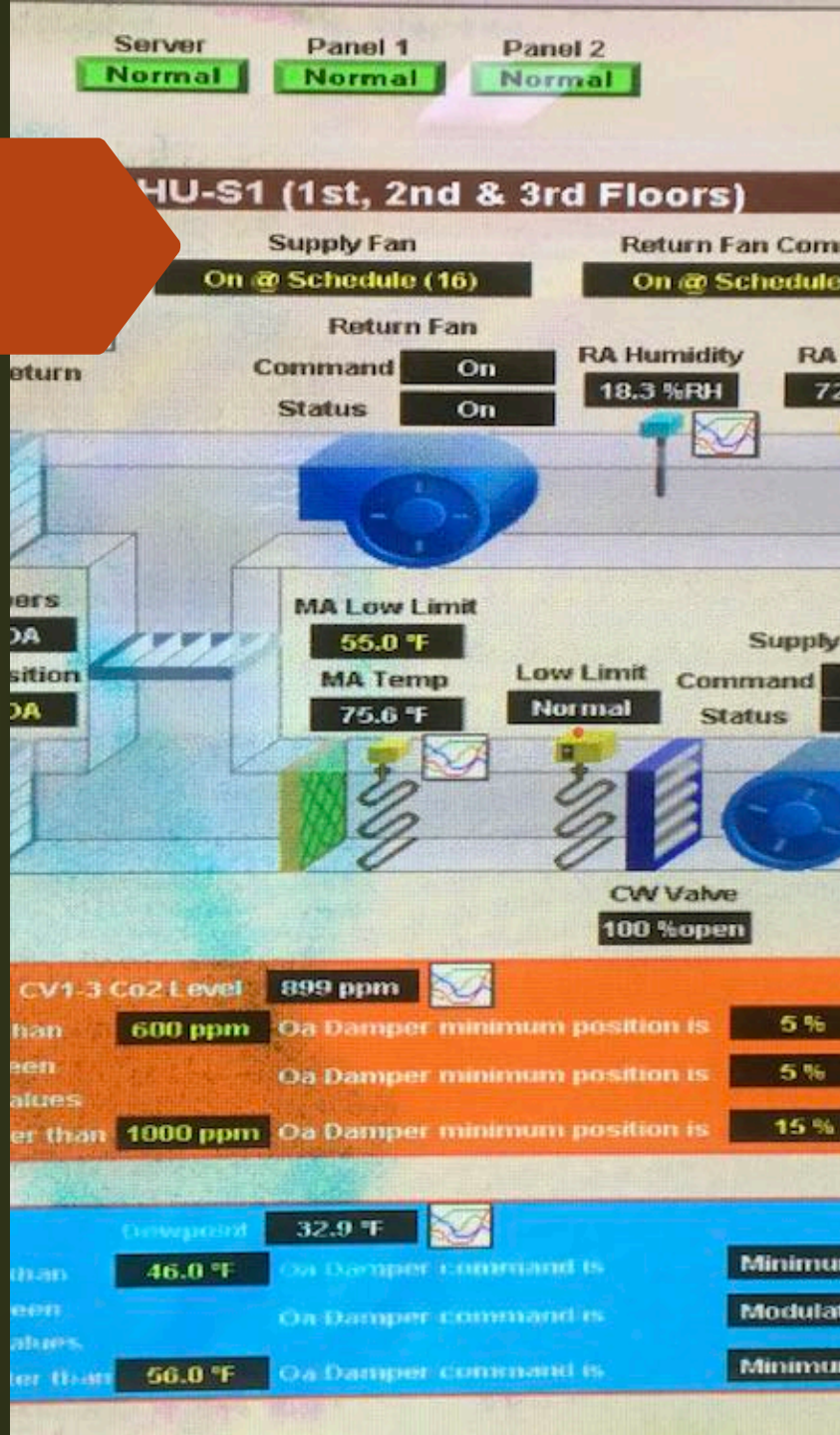
- The project may start to impact actual spaces – communication and timing are critical
  - Seasonal timing
  - Access/workflow
  - Protection of collections
  - Collection moves?
- Change orders/"value engineering"
  - May be driven by budget or construction discoveries
  - Must be critically reviewed for impact on collections

Monitoring and Control/Commissioning

- Takes different shapes, depending on project/ institution size and engineering/contractor team.
- Can happen both before and after the Closure phase, depending on the type/length of commissioning
- Commissioning should be requested at the initiation of the project

Mechanical Commissioning

- Typically performed by a third-party agent (ie, an engineer who is not part of the design team)
- Ideally, begins at the outset of the project – the commissioning agent can act as quality control for the engineering throughout the process
  - In many cases, isn't actually engaged until the final stages, after constructions is complete.
- Standard practice is to force equipment into various operating modes to see how it responds
  - Even with "extended" commissioning, rarely monitors new equipment through normal performance and seasonal operation
- Only covers mechanical performance – NOT preservation impact



Preservation Commissioning

- Usually conducted by a preservation environment consultant – not an engineer
- Geared toward assessing the performance of new equipment for both preservation and long-term sustainability
- Typically extends for 12-18 months after construction completion, and incorporates optimization testing
  - Designs are based on models – actual installed operation may be quite different
  - Goal is to find optimal operation based on actual installation and the holistic building system, include the collections.
- Often involves deploying independent dataloggers throughout the newly installed system and collections spaces.

Closure/Training and Documentation

- Final training should be a team process for the institution, with Facilities (and, to an extent, Collections) receiving instruction from the design team.
- May be continued – especially if Preservation Commissioning is performed.
- Documentation:
  - As-Built drawings – NOT construction documents. Final drawings must reflect system as installed, including any construction changes.
  - Written Sequence of Operation – the plain-language logic of how the system is supposed to work. Programming in the controls system is NOT sufficient.
  - Warranties – particularly what might void them (such as optimization testing)
  - Operators Manual
- Master copies of all of these should be deposited in the institutional repository – use copies should remain with Facilities.

In closing…

We Have to Understand Our Context:

- Many humanities collections exist in medium to large institutions
  - Big buildings with complex mechanical systems
  - Specialized staff responsibilities
  - Large utility costs
- But smaller structures and organizations matter too
  - Solutions and specific stages of process may be different
- Principles are the same.

The Design Process Reflects Our New Reality:

- No more ‘magic numbers’
  - They’re not sustainable
- HVAC design is often about risk management – not just a pursuit of ideals
- You have to figure out the best environment/design for your institution and collection
- Optimal starts with integrated design: a partnership among the team (internally and externally) and a holistic understanding of the system needs.

Thanks for joining in!

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