Standards and guidelines for museum climate: Influencing factors, recent trends, and the ASHRAE chapter

Joel Taylor

Norsk Institutt for Kulturminneforskning

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Standards, guidelines, guidance

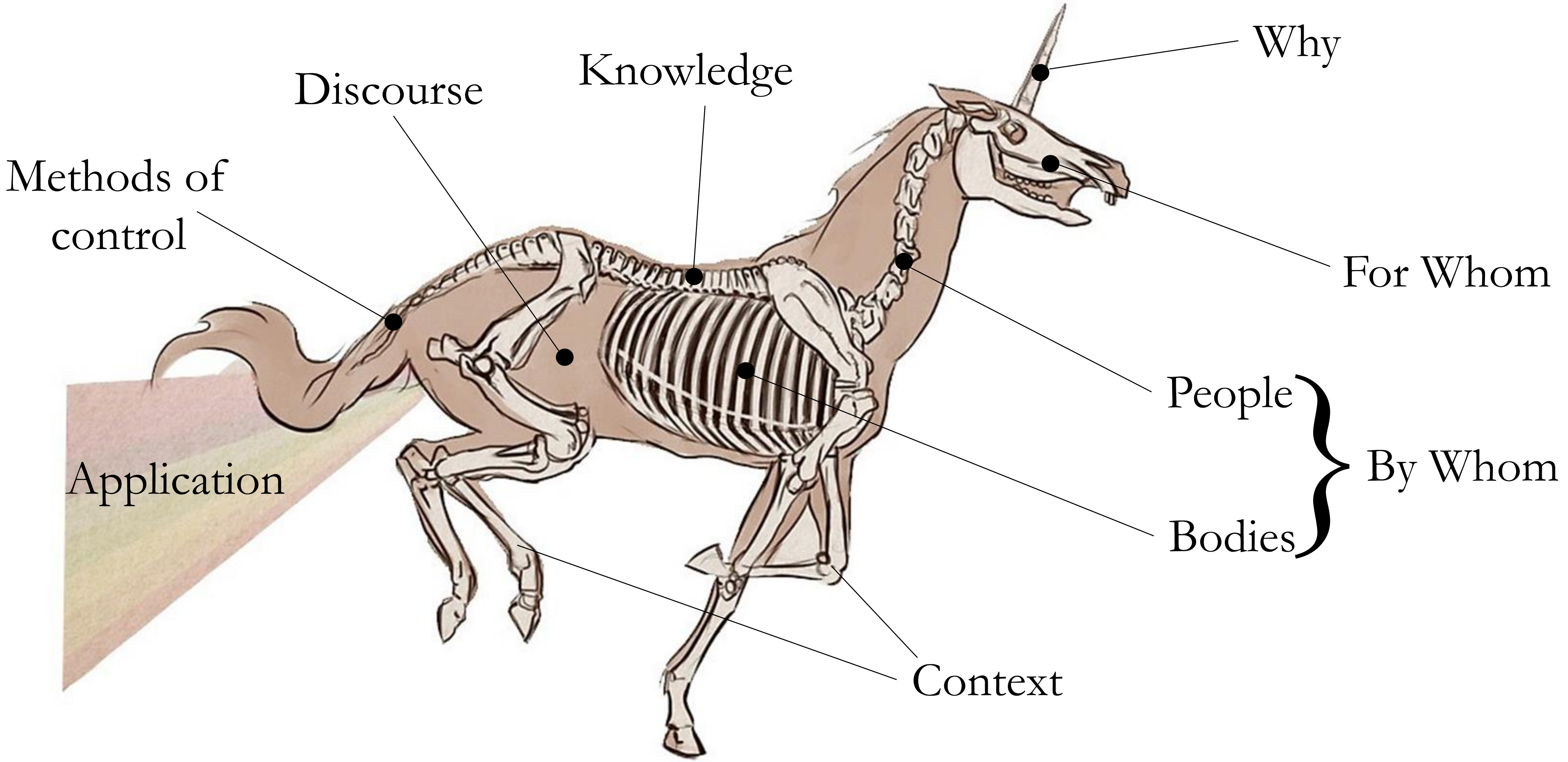
Standards often involve some legal compliance (include peer review or public comment).

Guidance comes from professional bodies (e.g. IIC/ ICOM-CC environmental guidelines).

Garry Thomson’s book became a *de facto* standard.

‘ASHRAE’ is a chapter in a book.

The anatomy of a standard



Igson (2017) 'Unicorn Anatomy'
https://www.redbubble.com/people/igson/works/29083861-unicorn-anatomy

The anatomy of a ‘standard’

• Why?	-What is the reason for the standard?
• For Whom?	-Who benefits from it’s existence?
• By Whom?	-Who was at the table?
• Bodies	• What kind of body produced it?
• People	• Who was literally at the table?
• Knowledge?	-What knowledge was available?
• Discourse?	-What issues were being discussed?
• Context?	-What is the scope of the document?
• Methods of control?	-What methods of control are implied?
• Application?	-How is it applied?

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ASHRAE: The basics

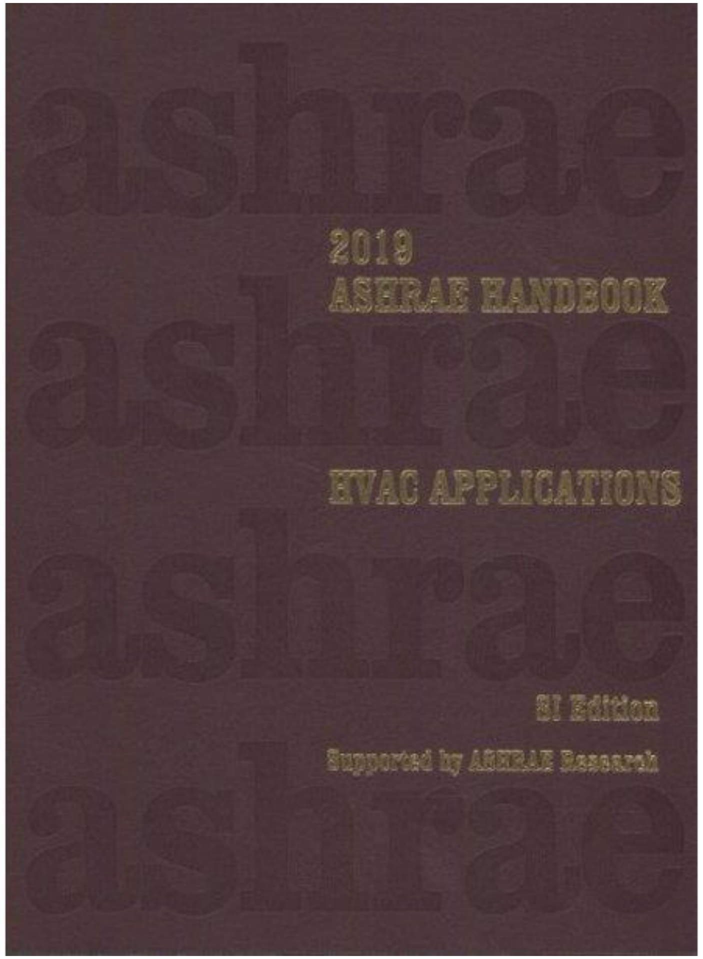
ASHRAE American Society for Heating Refrigeration and Air-conditioning Engineers

Applications Handbook, published every four years.

Since 1999, there has been a chapter about Museums, Galleries, Archives, and Libraries (MGAL).

Deals with control of relative humidity (RH) temperature and pollution.

The 2019 had the most significant revisions.



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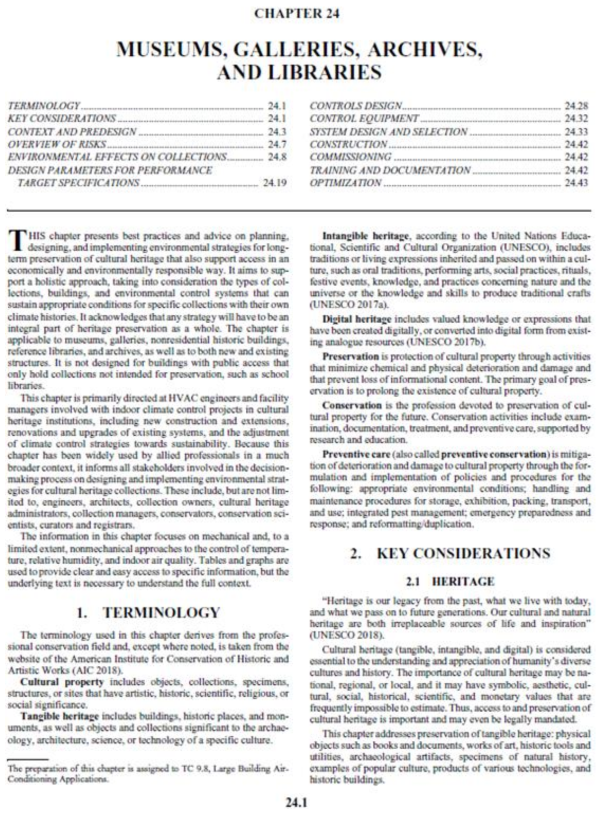
ASHRAE: The background (Why?)

A means for conservation field to engage with and influence the facilities/ engineering communities

Intended to offer pragmatic guidance for museum design, management

Classifies environments based on what might be expected (kind of museum, climate zone, etc.)

AA, A, B, C, D classifications with broad idea of climate risk



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.

1. TERMINOLOGY

The terminology used in this chapter derives from the professional conservation field and, except where noted, is taken from the website of the American Institute for Conservation of Historic and Artistic Works (AIC 2018).

Cultural property includes objects, collections, specimens, structures, or sites that have artistic, historic, scientific, religious, or social significance.

Tangible heritage includes buildings, historic places, and monuments, as well as objects and collections significant to the archaeology, architecture, science, or technology of a specific culture.

Intangible heritage, according to the United Nations Educational, Scientific and Cultural Organization (UNESCO), includes traditions or living expressions inherited and passed on within a culture, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge, and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts (UNESCO 2017a).

Digital heritage includes valued knowledge or expressions that have been created digitally, or converted into digital form from existing analogue resources (UNESCO 2017b).

Preservation is protection of cultural property through activities that minimize chemical and physical deterioration and damage and that prevent loss of informational content. The primary goal of preservation is to prolong the existence of cultural property.

Conservation is the profession devoted to preservation of cultural property for the future. Conservation activities include examination, documentation, treatment, and preventive care, supported by research and education.

Preventive care (also called **preventive conservation**) is mitigation of deterioration and damage to cultural property through the formulation and implementation of policies and procedures for the following: appropriate environmental conditions; handling and maintenance procedures for storage, exhibition, packing, transport, and use; integrated pest management; emergency preparedness and response; and reformatting/duplication.

2. KEY CONSIDERATIONS

2.1 HERITAGE

"Heritage is our legacy from the past, what we live with today, and what we pass on to future generations. Our cultural and natural heritage are both irreplaceable sources of life and inspiration" (UNESCO 2018).

Cultural heritage (tangible, intangible, and digital) is considered essential to the understanding and appreciation of humanity's diverse cultures and history. The importance of cultural heritage may be national, regional, or local, and it may have symbolic, aesthetic, cultural, social, historical, scientific, and monetary values that are frequently impossible to estimate. Thus, access to and preservation of cultural heritage is important and may even be legally mandated.

This chapter addresses preservation of tangible heritage: physical objects such as books and documents, works of art, historic tools and utilities, archaeological artifacts, specimens of natural history, examples of popular culture, products of various technologies, and historic buildings.

The preparation of this chapter is assigned to TC 9.8, Large Building Air-Conditioning Applications.

24.1

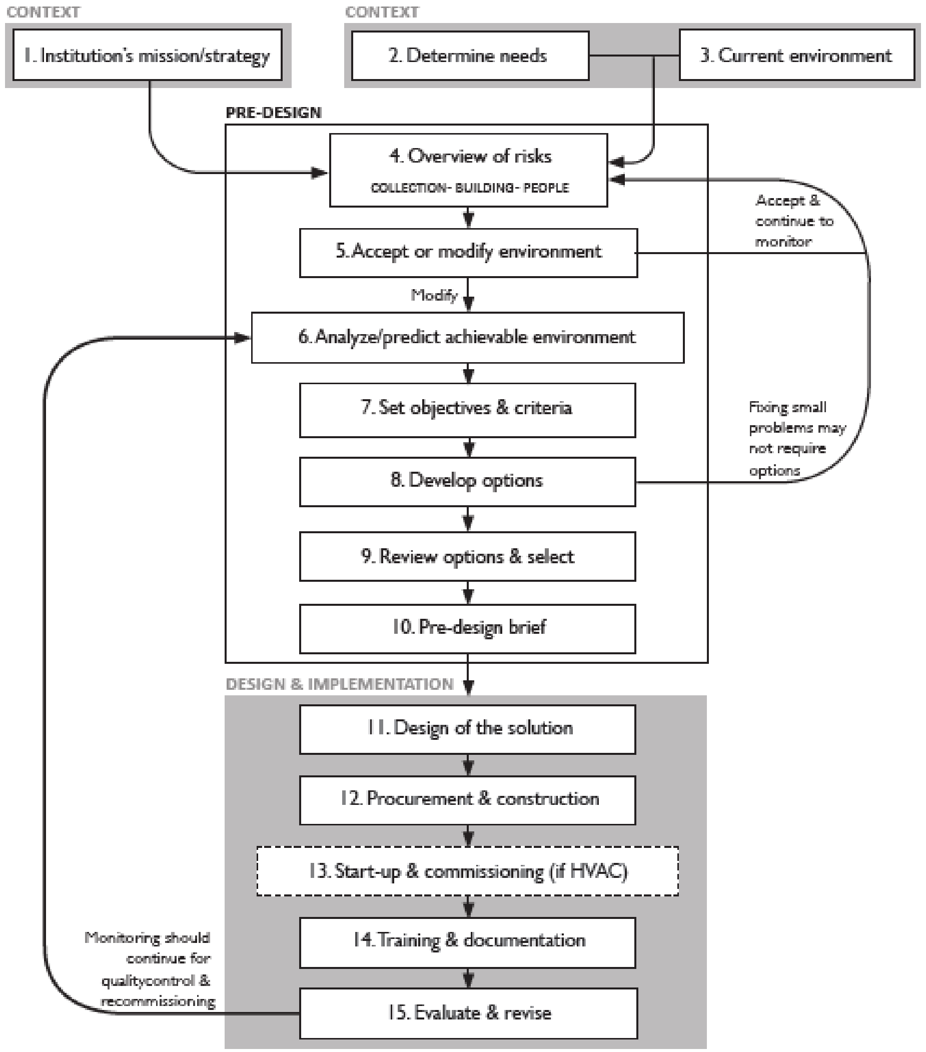
For whom?

For engineers, but wider audience use it (used internationally)

more recently…

Process that doesn't assume HVAC or 'problem'

Stakeholders – stages and levels of engagement



STAKEHOLDERS

Stage	No.	Lead	Consult	Inform
CONTEXT	1.	DIR/CUR	COLL, IFM	ARCH, ENG, EXT
	2.	COLL, IFM	CUR	ENG
	3.	EXT/COLL, IFM	CUR/EXT, SEC	ARCH, ENG
PRE-DESIGN	4.	EXT/COLL,IFM	ENG, ARCH, CUR, EXT, SEC	DIR
	5.	DIR/CUR/COLL	ARCH, ENG, IFM	DIR
	6.	IFM, ENG, ARCH	COLL, CUR, EXT, ARCH	DIR, ALL
	7.	COLL, IFM, ENG	EXT, CUR, ARCH	EXT
	8.	ARCH/ENG/EXT	CUR, COLL, SEC, IFM	ALL
	9.	ALL	EXT, ALL	ALL
	10.	DIR/CUR, COLL, IFM	SEC, EXT, CFO	ENG, ARCH, COMM
DESIGN & IMPLEMENTATION	11.	ENG/ARCH	IFM, COLL, SEC, EXT	CUR/DIR, COMM
	12.	ENG/ARCH, IFM, CFO	COLL, SEC, COMM	CUR/ DIR
	13.	COMM, ENG	IFM, EXT, CFO	SEC, COLL, CUR
	14.	IFM, ENG	COLL, SEC, COMM	ALL
	15.	ENG/EXT, IFM	COLL, SEC	CUR/ DIR

ALL All Institution staff; **ARCH** Architect; **IFM** Internal facilities staff (e.g. Facilities manager, Building manager); **CFO** Chief Financial Officer; **COLL** Collections staff (include Collections Manager, Conservator, Registrar); **COMM** Commissioning agent; **CUR** Curatorial; **DIR** Director; **ENG** Engineer; **EXT** External experts; **SEC** Security.
These are roles, rather than job titles, and some may overlap. It is best to involve people early in the process rather than later.

ASHRAE Handbook 2019, Taylor (forthcoming)

By whom?

International Institute of Conservation's role of conservation 1947

"understanding and controlling of agencies of deterioration"

Who was best prepared to do this in 1947?

- **Conservator**
- **Scientist**
- **Art Historian**

By whom?

Environmental Guidelines ICOM-CC and IIC Declaration (2014)

'It is acknowledged that the issue of collection and material environmental requirements is complex, and conservators/ conservation scientists should actively seek to explain and unpack these complexities.'

Who is best prepared to explain these complexities?

- **Conservator**
- **Scientist**
- **Art Historian**
- **Facilities manager**
- **Collections manager**

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By whom?

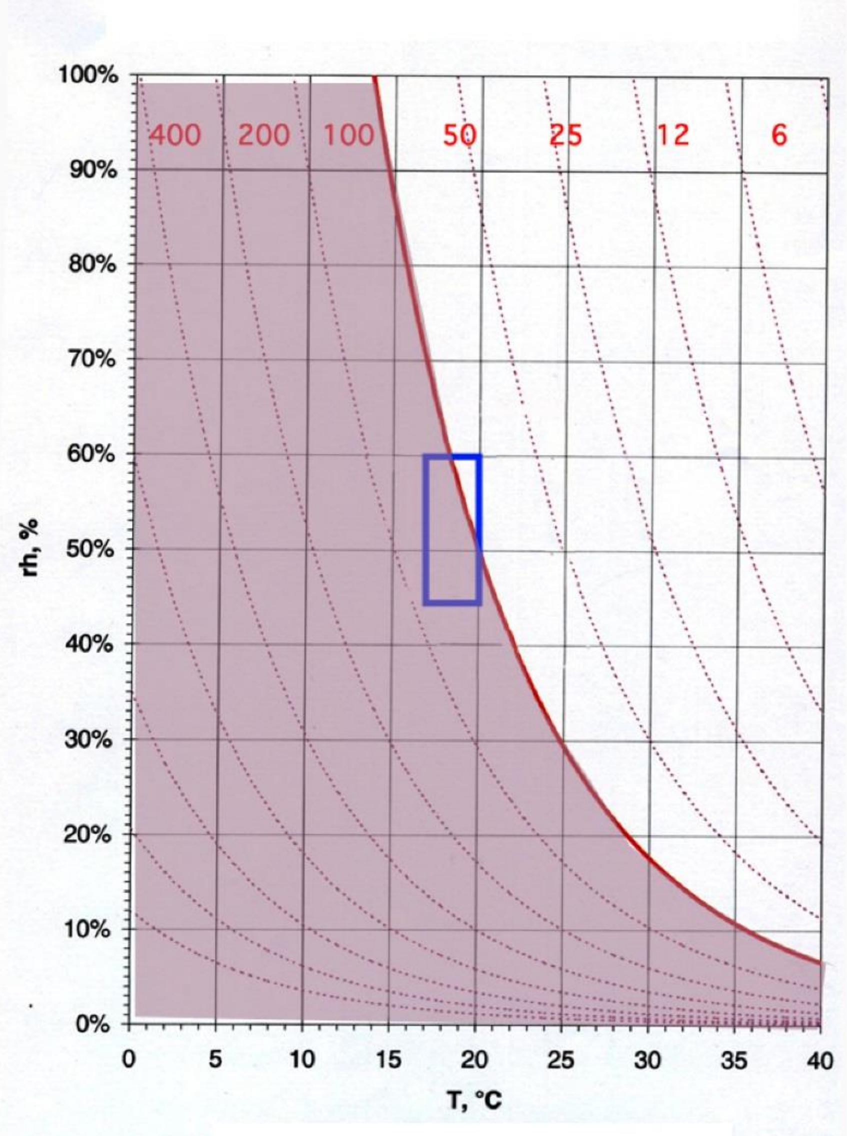
12 Angry Men (1957) MGM Studios

Knowledge

Two archival 'standards' - CCI (2000) and BS5454: 2000

Same collection types, same period

Different damage processes, different external climates



Ashley-Smith, J. (2018) 'Challenges of managing collection environments', *Conservation Perspectives (GCI Newsletter)* 33(2), 4-9

Knowledge

"the standard specification of +/- 4 or 5% in RH control is based more on what we can reasonably expect the equipment to do than on any deep knowledge of the effect of small variations on the exhibit."

Thomson (1986), 116.

The result, not the process, remained.

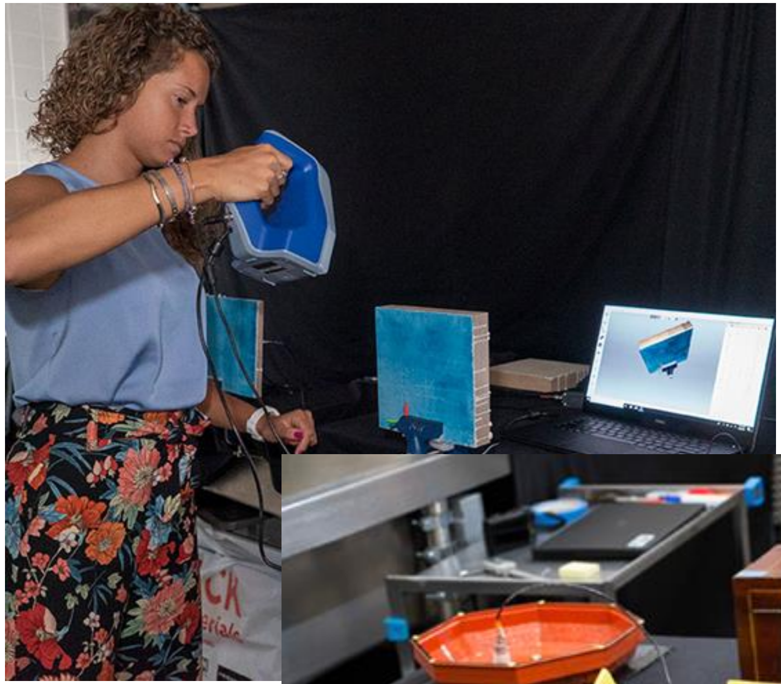
Thomson G. (1986) *The Museum Environment. 2d ed.* London: Butterworth-Heinemann

Still many knowledge gaps

Cause-effect information not well understood

Evidence based on mock-ups

Influence of existing damage on object response not known

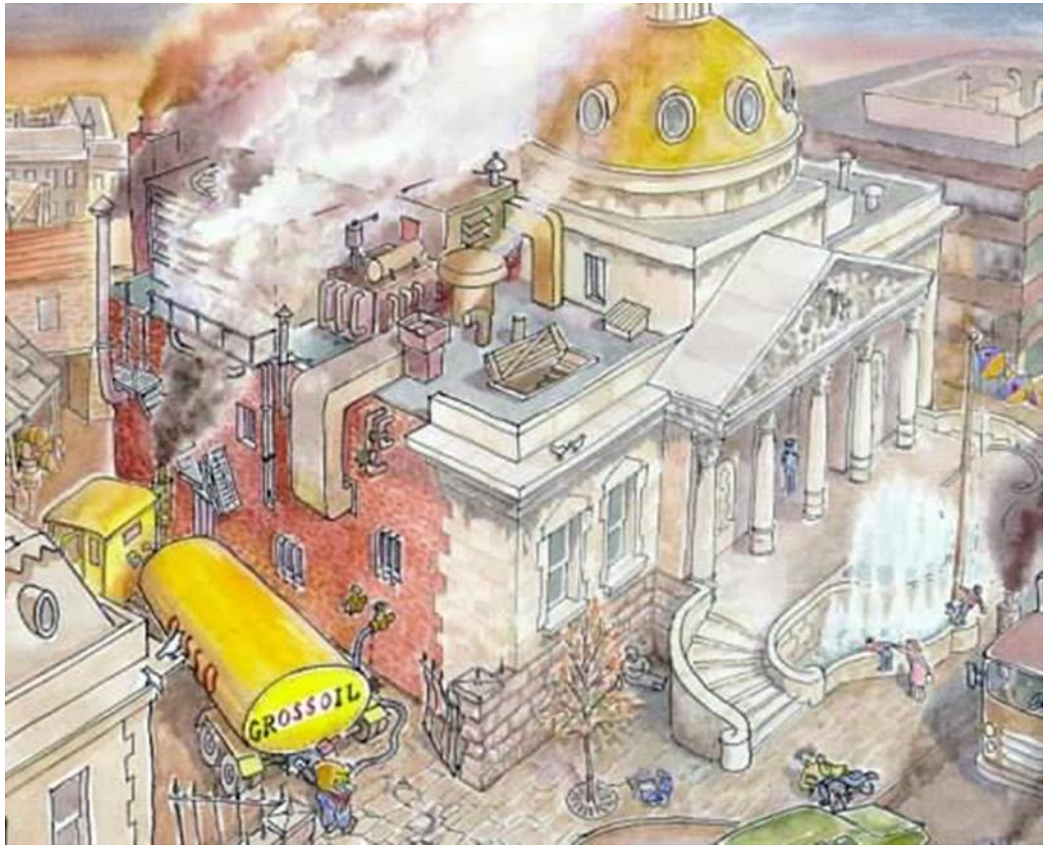


J. Paul Getty Trust

Discourse, topics of the period

"The debate on standards was driven by the social responsibility of reducing non-renewable energy consumption and creating a sustainable future".

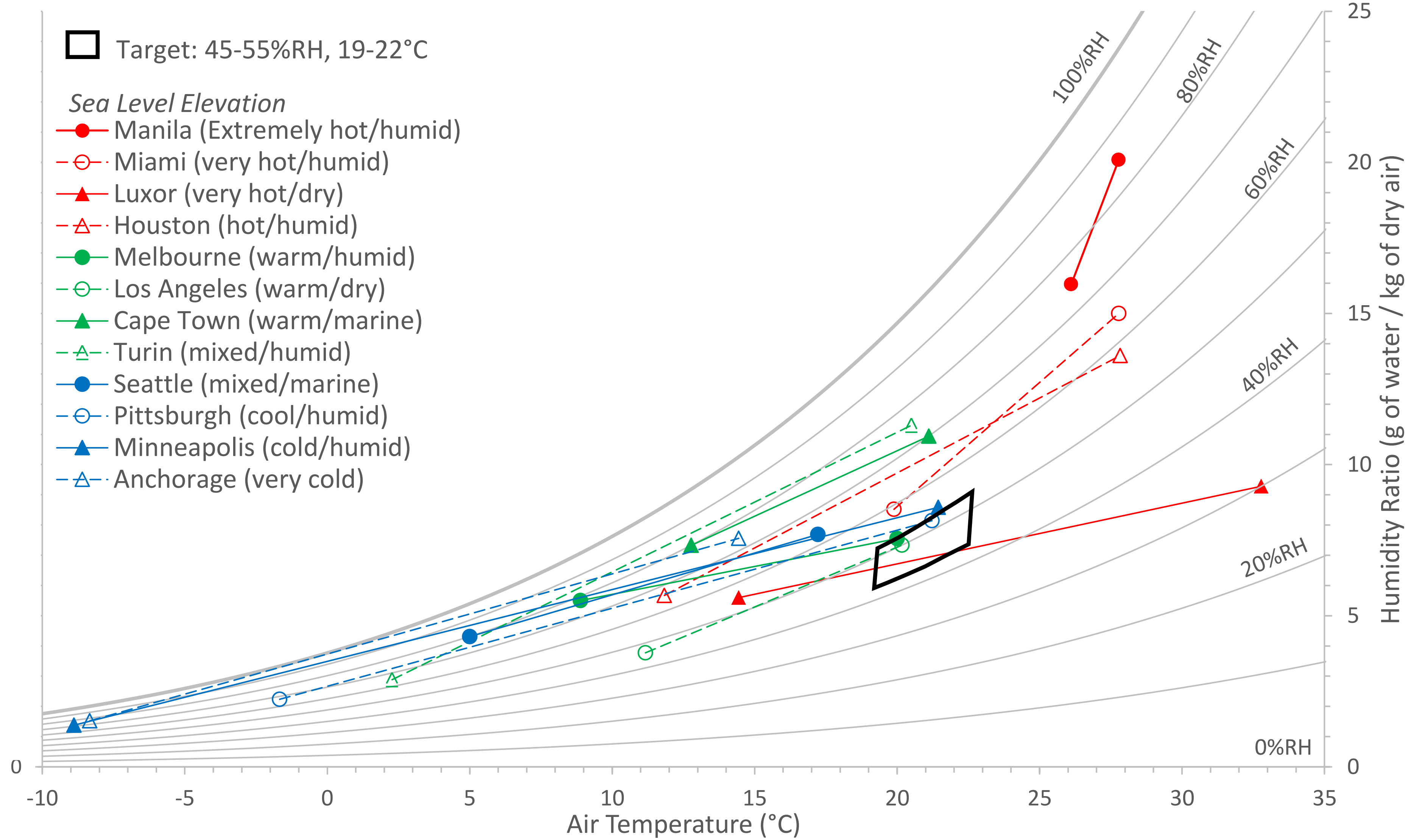
Kirby-Atkinson 2016, 5



Tim Padfield www.conservationphysics.com

Kirby Atkinson, J. 2016 'Preventive conservation and the environment: Summary of IIC Hong Kong Congress panel discussion' *Studies in Conservation*, 61. Sup 1, p.1-6.

Context, location



Taylor, J. & Boersma, F. (2018) 'Managing Environments for Collections: The Impact of International Loans on Sustainable Climate Strategies', *Presented at IIC Congress Preventive conservation: State of the Art*, Turin

Methods of control (what's possible)

Guidance at National Trust UK informed by technical possibilities

Conservation heating – successful approach in UK

- Closed during winters
- Temperature not important
- Physical damage main concern

Knole House. National Trust

Methods of control (ASHRAE)

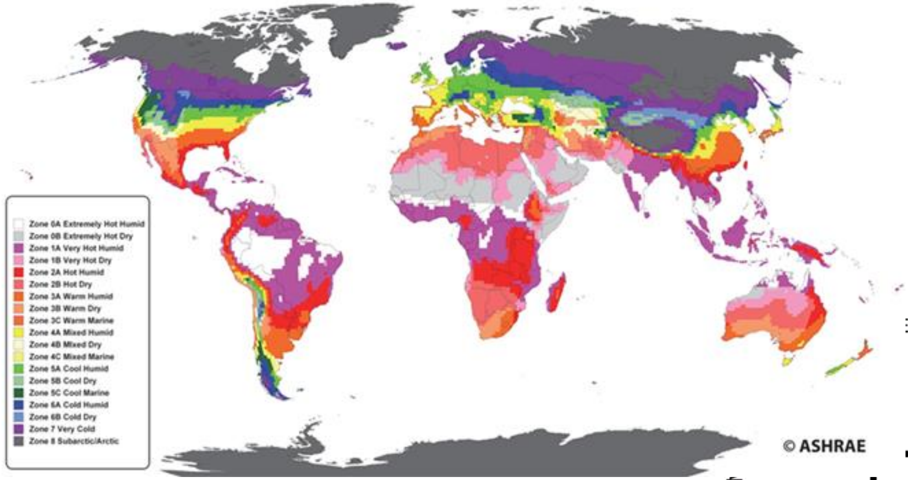
Climate zone (and envelope)

Zoning (collection/ non-collection, public, non-public, low-occupancy)

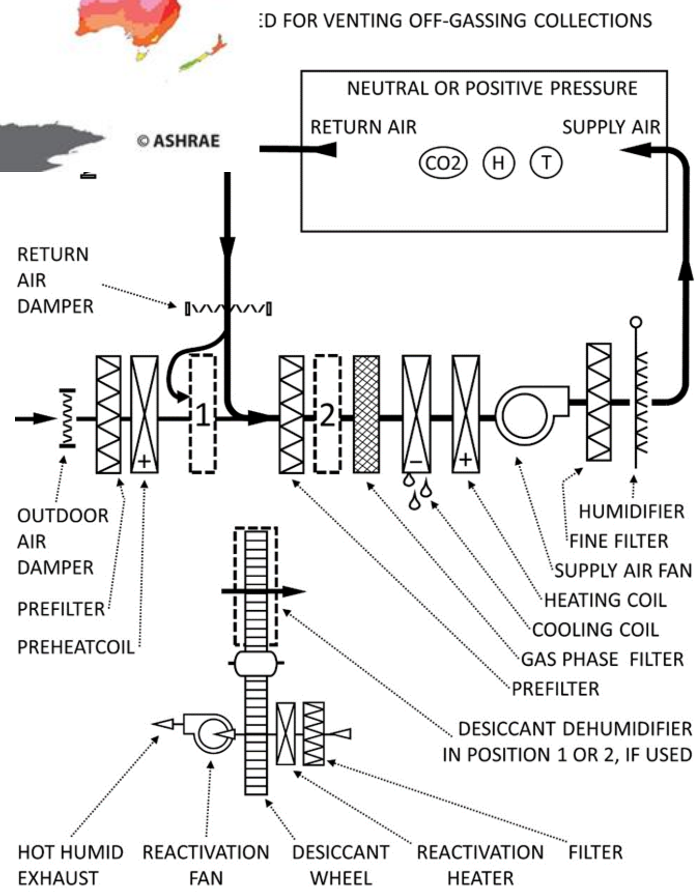
System design & selection

Controls guidance

Dual heating/cooling set points, esp. low-occupancy spaces



ANSI/ASHRAE Standard 169-2013



ASHRAE Applications Handbook 2019

ASHRAE Control classification table

Table 3 Temperature and Relative Humidity Specifications for Collections

Type	Set Point or Annual Average	Maximum Fluctuations and Gradients in Controlled Spaces: Class of Control	Short Fluctuations plus Space Gradients	Seasonal Adjustments in System Set Point	Collection Risks and Benefits
General Museums, Art Galleries, Libraries, and Archives All reading and retrieval rooms, rooms for storing chemically stable collections, especially if mechanically medium to high vulnerability.	50% rh (or historic annual average for permanent collections) Temperature set between 15 and 25°C *Note:* Rooms intended for loan exhibitions must handle set point specified in loan agreement, typically 50% rh, 21°C, but sometimes 55% or 60% rh.	**AA** Precision control, no seasonal changes	±5% rh, ±2 K	Relative humidity no change Up 5 K; down 5 K	No risk of mechanical damage to most artifacts and paintings. Some metals and minerals may degrade if 50% rh exceeds a critical relative humidity. Chemically unstable objects unusable within decades.
		A Precision control, some gradients or seasonal changes, not both	±5% rh, ±2 K	Up 10% rh, down 10% rh Up 5 K; down 10 K	Small risk of mechanical damage to high-vulnerability artifacts; no mechanical risk to most artifacts, paintings, photographs, and books. Chemically unstable objects unusable within decades.
			±10% rh, ±2 K	RH no change Up 5 K; down 10 K	
		B Precision control, some gradients plus winter temperature setback	±10% rh, ±5 K	Up 10%, down 10% rh Up 10 K, but not above 30°C	Moderate risk of mechanical damage to high-vulnerability artifacts; tiny risk to most paintings, most photographs, some artifacts, some books; no risk to many artifacts and most books. Chemically unstable objects unusable within decades, less if routinely at 30°C, but cold winter periods double life.
		C Prevent all high-risk extremes	Within 25 to 75% rh year-round Temperature rarely over 30°C, usually below 25°C		High risk of mechanical damage to high-vulnerability artifacts; moderate risk to most paintings, most photographs, some artifacts, some books; tiny risk to many artifacts and most books. Chemically unstable objects unusable within decades, less if routinely at 30°C, but cold winter periods double life.
		D Prevent dampness	Reliably below 75% rh		High risk of sudden or cumulative mechanical damage to most artifacts and paintings because of low-humidity fracture; but avoids high-humidity delamination and deformations, especially in veneers, paintings, paper, and photographs. Mold growth and rapid corrosion avoided. Chemically unstable objects unusable within decades, less if routinely at 30°C, but cold winter periods double life.
Archives, Libraries Storing chemically unstable collections	Cold Store: −20°C, 40% rh	±10% rh, ±2 K			Chemically unstable objects usable for millennia. Relative humidity fluctuations under one month do not affect most properly packaged records at these temperatures (time out of storage becomes lifetime determinant).
	Cool Store: 10°C 30 to 50% rh	(Even if achieved only during winter setback, this is a net advantage to such collections, as long as damp is not incurred)			Chemically unstable objects usable for a century or more. Such books and papers tend to have low mechanical vulnerability to fluctuations.
Special Metal Collections	Dry room: 0 to 30% rh	Relative humidity not to exceed some critical value, typically 30% rh			

Note: Short fluctuations means any fluctuation less than the seasonal adjustment. However, as noted in the section on Response Times of Artifacts, some fluctuations are too short to affect some artifacts or enclosed artifacts.

ASHRAE Applications Handbook 2015

Type of Collection and Building	Type of Control	Long term outer limits (Note 1)	Annual Averages	Seasonal Adjustments from Annual Average (Note 2)	Short Term Fluctuations plus Space Gradients (Note 3)	Collection Benefits and Risks (See Table 3, Sensitivity of Unproofed Objects to RH Fluctuations, for examples of objects in each sensitivity category. See Table 5 Classes of Chemical Stability for lifetimes of objects at various temperatures.)
Museums, Galleries, Archives and Libraries in modern purpose-built buildings or purpose-built rooms. **Temperature at or near human comfort.**	**AA** Precision control, no seasonal changes to rh	≥35% rh ≤65% rh ≥ 10°C ≤ 25°C	For permanent collections: historic annual average of rh and temperature. In public display areas, human comfort temperatures can apply.	No change to relative humidity Increase by 5 K; Decrease by 5 K	±5% rh, 2 K	Mold germination and growth, and rapid corrosion avoided. No risk of mechanical damage to most artifacts and paintings. Some metals, glasses, and minerals may degrade if rh exceeds a critical value. Chemically unstable objects deteriorate significantly within decades at 20°C, twice as fast each 5 K higher.
	A1 Precision control, seasonal changes in temperature and rh	≥35% rh ≤65% rh ≥ 10°C ≤ 25°C		Increase by 10% rh. Decrease by 10% rh. Increase by 5 K Decrease by 10 K	±5% rh, 2 K	Mold germination and growth, and rapid corrosion avoided. No mechanical risk to most artifacts, paintings, photographs, and books; small risk of mechanical damage to high-vulnerability artifact. (Current knowledge considers the specifications A1 and A2 as causing the same low risk of mechanical damage to vulnerable collections. Slow seasonal adjustment of 10% rh is estimated to cause the same mechanical risk as rapid fluctuations of 5% rh, due to significant stress relaxation occurring within three months of a slow transition.) Chemically unstable objects deteriorate significantly within decades at 20°C, twice as fast each 5 K higher.
	A2 Precision control, seasonal changes in temperature only	≥35% rh ≤65% rh ≥ 10°C ≤ 25°C		No change to rh. Increase by 5 K Decrease by 10 K	±10% rh, 2K	
Museums, Galleries, Archives and Libraries needing to reduce stress on their building, e.g., historic house museums (depending on climate zone). **(Note 4)**	**B** Limited control, seasonal changes in rh and large seasonal changes in temperature. (Note 5)	≥30% rh ≤70% rh ≤ 30°C (Note 6)	For permanent collection: historic annual average of rh and temperature.	Increase by 10% rh. Decrease by 10% rh. Increase by 10 K Decrease by up to 20 K	±10% rh, 5 K	Mold germination and growth, and rapid corrosion avoided. Chemical deterioration halts during cool winter periods No risk of mechanical damage to many artifacts and most books. Tiny risk to most paintings, most photographs, some artifacts, some books. Moderate risk to high-vulnerability artifacts. Objects made with flexible paints and plastics that become brittle when cold, such as paintings on canvas, need special care when handling in cold temperatures. Chemically unstable objects deteriorate significantly within decades at 20°C, twice as fast each 5 K higher.
	C Prevent rh extremes (damp or desiccation) and prevent high temperature extremes.	≥25% rh ≤75% rh ≤ 40°C (Note 6)	Within 25% to 75% rh year-round. Temperature usually below 25°C		Not continually above 65% rh for longer than X days. (Note 7) Temperature rarely over 30°C	Chemical deterioration halts during cool winter periods. Mold germination and growth, and rapid corrosion avoided. Tiny risk of mechanical damage to many artifacts and most books; moderate risk to most paintings, most photographs, some artifacts, some books; high risk to high-vulnerability artifacts Even greater care is needed than provided in B when handling objects made with flexible paints and plastics that become brittle when cold, such as paintings on canvas. Chemically unstable objects deteriorate significantly within decades at 20°C, twice as fast each 5 K higher.
Collections in open structured buildings, historic houses	**D** Prevent very high rh (dampness).	≤75% rh	Relative humidity reliably below 75% rh.		Not continually above 65% rh for longer than X days. (Note 7)	Chemically unstable objects deteriorate significantly within decades at 20°C, and twice as fast each 5 K higher. Conversely, cool winter season can extend their life. Mold germination and growth, and rapid corrosion avoided. High risk of sudden or cumulative mechanical damage to most artifacts and paintings because of low-humidity fracture; but avoids high-humidity delamination and deformations, especially in veneers, paintings, paper, and photographs.

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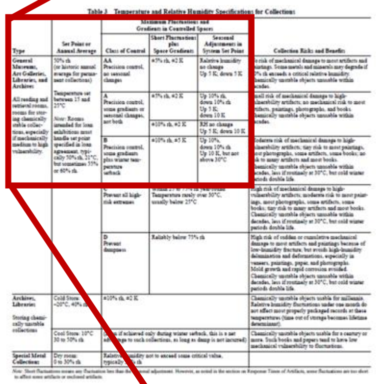
ASHRAE 2015

Table 3. Temperature and Relative Humidity Specifications for Collections



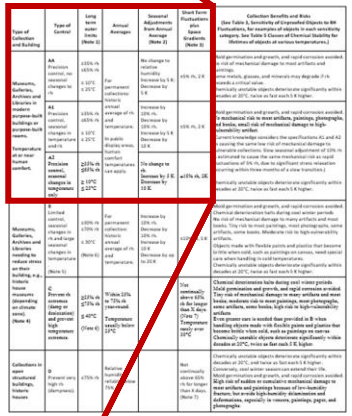
Type	Set Point or Annual Average	Maximum Fluctuations and Gradients in Controlled Spaces		
		Class of Control	Short Fluctuations plus Space Gradients	Seasonal Adjustments in System Set Point
General Museums, Art Galleries, Libraries, and Archives	50% rh (or historic annual average for permanent collections)	**AA** Precision control, no seasonal changes, with system failure fallback	±5% rh, ±4°F	Relative humidity no change Up 9°F; down 9°F
All reading and retrieval rooms, rooms for storing chemically stable collections, especially if mechanically medium to high vulnerability.	Temperature set between 59 and 77°F *Note*: Rooms intended for loan exhibitions must handle set point specified in loan agreement, typically 50% rh, 70°F, but sometimes 55% or 60% rh.	**A** Precision control, some gradients or seasonal changes, not both, with system failure fallback	±5% rh, ±4°F	Up 10% rh, down 10% rh Up 9°F; down 18°F
			±10% rh, ±4°F	RH no change Up 9°F; down 18°F
		B Precision control, some gradients plus winter temperature setback	±10% rh, ±9°F	Up 10%, down 10% rh Up 18°F, but not above 86°F

ASHRAE Applications Handbook 2015

ASHRAE 2019

Table 13. Temperature and Relative Humidity Specifications for Collections

Type of Collection and Building	Type of Control	Long term outer limits (Note 1)	Annual Averages	Seasonal Adjustments from Annual Average (Note 2)	Short Term Fluctuations plus Space Gradients (Note 3)
Museums, Galleries, Archives and Libraries in modern purpose-built buildings or purpose-built rooms. **Temperature at or near human comfort.**	**AA** Precision control, no seasonal changes to rh	≥35% rh ≤65% rh ≥50°F ≤ 77°F	For permanent collections: historic annual average of rh and temperature. In public display areas, human comfort temperatures can apply.	No change to relative humidity Increase by 9°F; Decrease by 9°F	±5% rh, ±4°F
	A1 Precision control, seasonal changes in temperature and rh	≥35% rh ≤65% rh ≥50°F ≤ 77°F		Increase by 10% rh. Decrease by 10% rh. Increase by 9°F; Decrease by 18°F	±5% rh, ±4°
	A2 Precision control, seasonal changes in temperature only	≥35% rh ≤65% rh ≥50°F ≤ 77°F		No change to rh. Increase by 9°F ; Decrease by 18°F	±10% rh, ±4°F {2 K}



ASHRAE Applications Handbook 2019

Table 3, 2015	Table 13, 2019
Control class based on precision	Control type based on building
Set point: 50%/20°C or annual avg.	Set point: Annual avg.
Loans coupled with set point	Loans separate
Seasonal changes/gradients	Seasonal changes/ gradients
AA: +/-5%, 9°F seasonal	**AA:** +/-5%, 9°F seasonal
A: short OR long term shifts	**A:** short AND long term shifts
Outer limits	Outer limits
AA - B: limits from set point	**AA - B:** 35-65% RH (B: 30°C)
C: 25-75% RH, <30°C	**C:** 25-65%RH, <25°C (75%/30°)
D: <75%	**D:** <75%RH (65%, with mold check)

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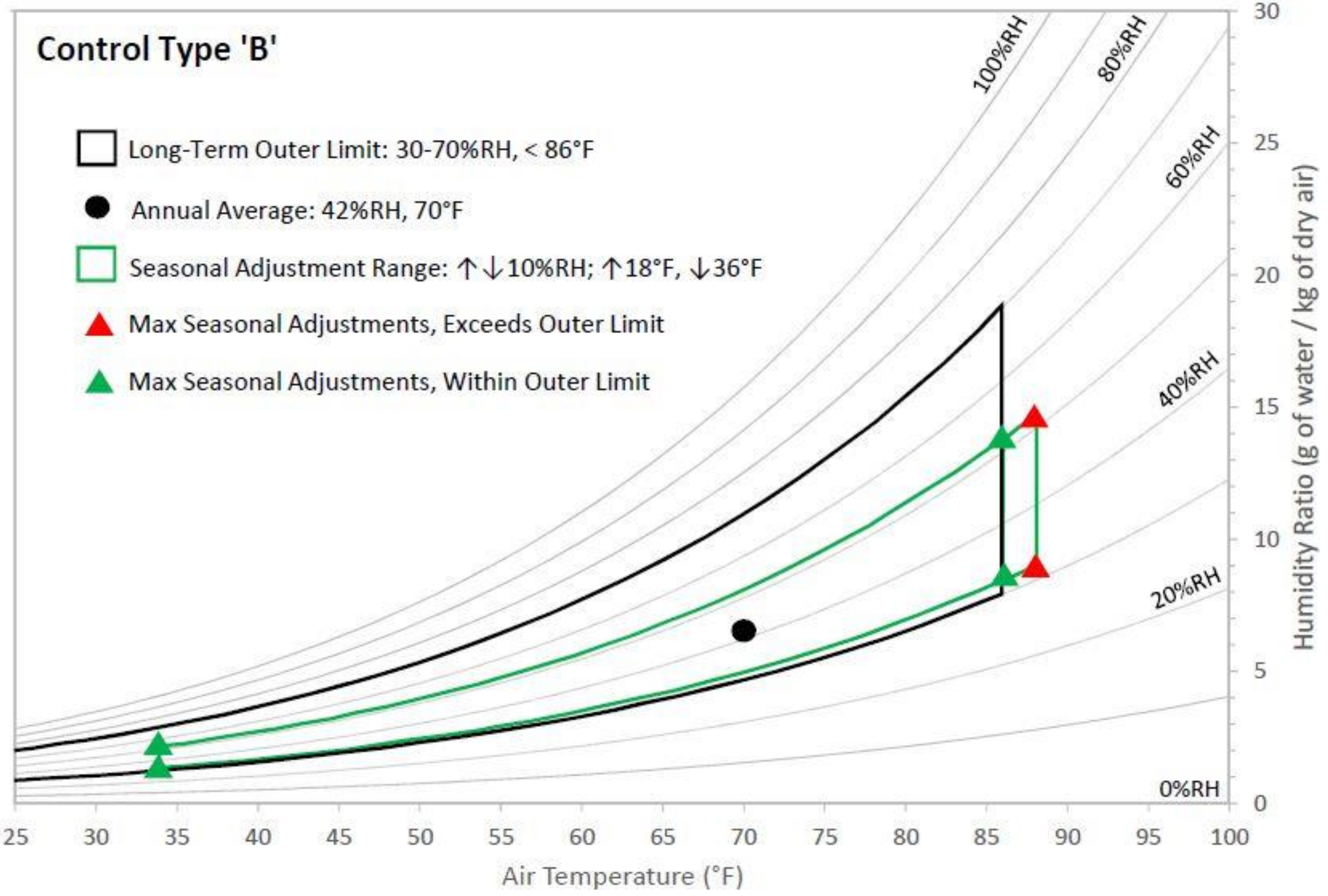
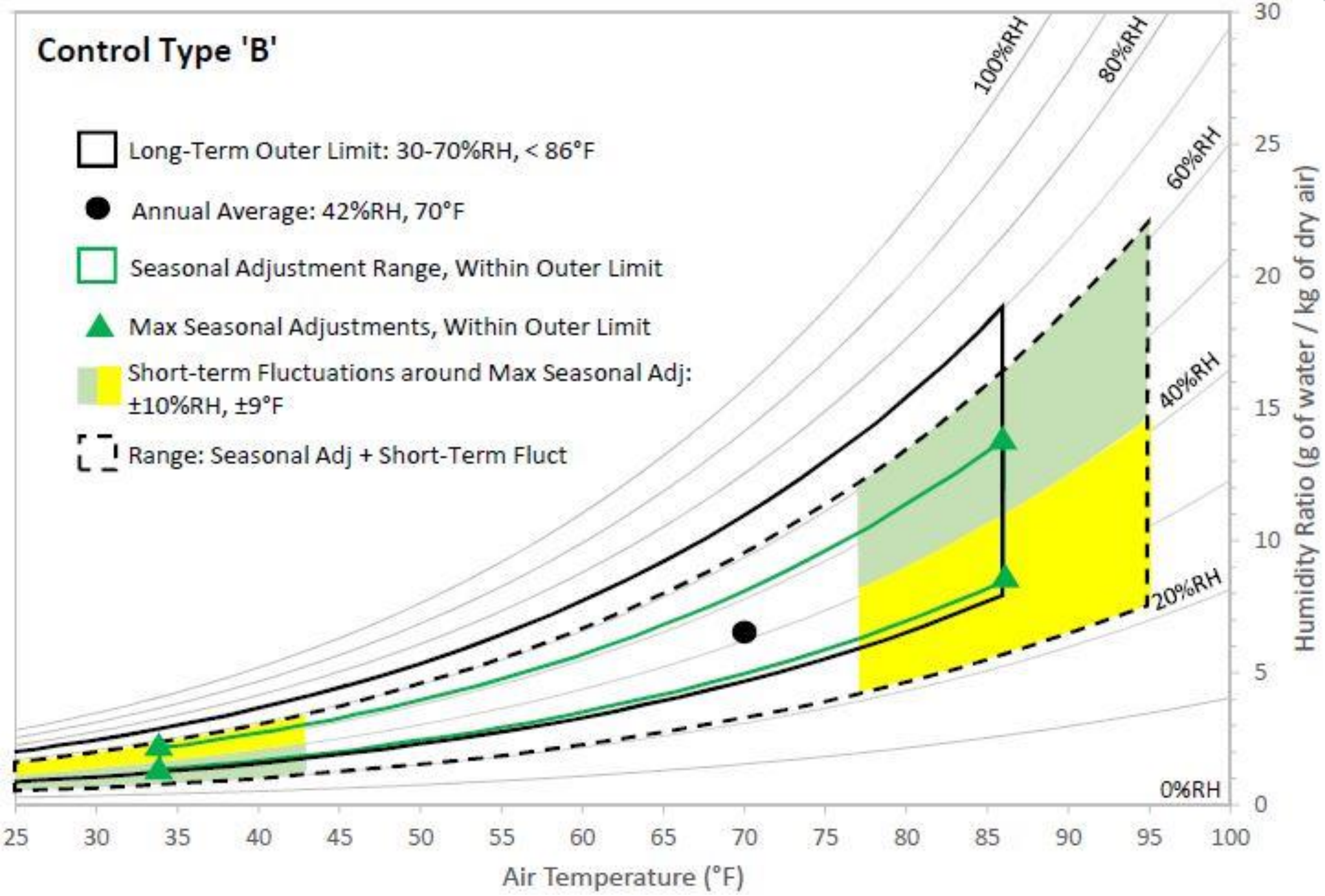
Process: An example



Beltran, V. and Taylor, J. (2018)

Process: An example



Beltran, V. and Taylor, J. (2018)

Closing words

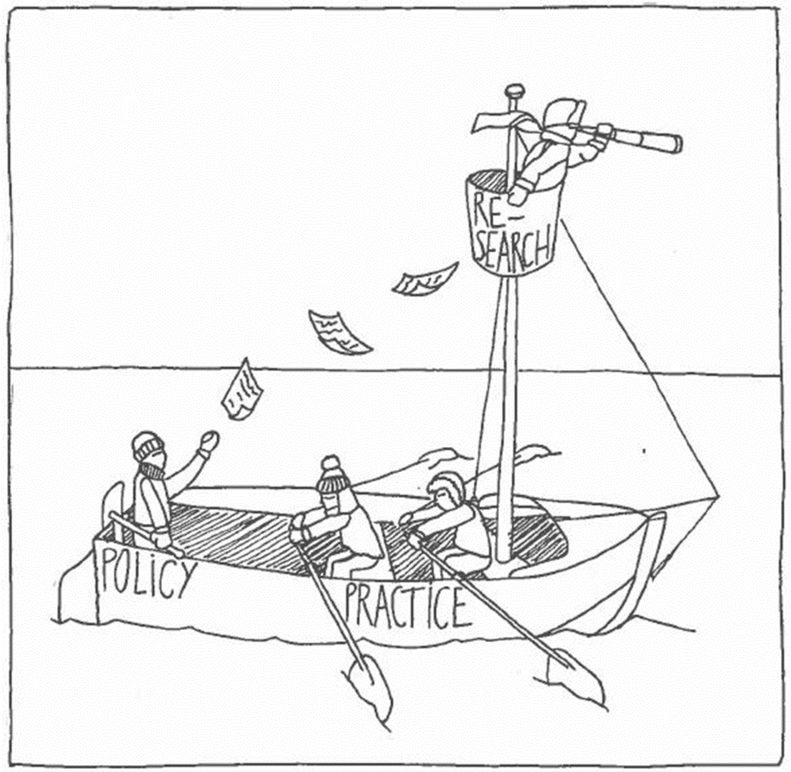
Standards have many influences, good and bad.

They're of their time and place.

Concepts can be adjusted, depending on purpose.

New guidance (including ASHRAE) involves sustainability and decision processes.

Becoming more complex, more collaborative.



Practice, theory and research

THANK YOU

joel.taylor@niku.no

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