MUSEUM AND HISTORIC BUILDING ENVIRONMENT

Brown, J. P.; Rose, William B. Humidity and moisture in historic buildings: the origins of building and object conservation. *APT bulletin* 27, 3 (Issue title: Museums in Historic Buildings) (1996), pp. 12-23. http://palimpsest.stanford.edu/byauth/brownjp/humidity1997.html

The majority of artifacts in historic houses are made of natural organic materials: wood, leather, traditional adhesives (rendered down animal or vegetable matter), natural textiles, paper products, fur, bone, ivory. Empirical observation of the reaction of such artifacts to variations in relative humidity over the last eighty or so years has become progressively codified into recommendations for 'optimum' humidity levels for the preservation of these artifacts. The central concern of the recommendations is that humidity should not fall to a level which causes brittle failure of organic artifacts, nor rise to a point where mold growth can flourish. In particular, the recommended levels for mixed collections of organic artifacts center on controlling humidity in the range 30 to 70%RH; rather tighter control — typically 50 to 60%RH — has been recommended for valuable objects such as paintings and antique furniture. However, as we shall show, these figures have not arisen from detailed research leading to a clear understanding of the effects of humidity on organic material, but are in fact codifications of pre-WWII custom and practice, modified by the practicality of indoor environmental control in specific climates. (Authors' introduction)

Camuffo, Dario *Microclimate for cultural heritage* Developments in atmospheric science. Elsevier BV, Amsterdam (1998).

This book has been designed as a handbook for conservators and specialists in chemistry, architecture, engineering, geology, and biology who interact with the multidisciplinary field of art conservation. It was written to fill a gap in the literature related to the application of atmospheric sciences to art and cultural heritage, such as in gauging the effect of the atmosphere on a monument surface or a museum gallery. The aim is to provide a background familiarity with the physics and mathematics underlying the field and to give a detailed description and interpretation of the main microphysical phenomena which play a fundamental role in practical applications. The bases are given for nondestructive diagnostics to evaluate causes of damage and to predict outdoor deterioration influenced by meteorological factors, as well as the negative effects in exhibition rooms due to unsound technology and mass tourism. To this aim, fundamental principles in the design of heating, air conditioning, lighting, and conditions to reduce the deposition of pollutants on works of art are suggested. Theory and experience are combined to describe the complex condensation mechanisms and the fundamental role played by water in stone deterioration and the formation of crusts on monuments. This book combines a theoretical background with many years of accurate laboratory research, field surveys, and practice. The first part, devoted to applied theory, is a concise treatise on microphysics; it surveys basic ideas such as classical, kinetic, and statistical thermodynamics which are necessary for environmental diagnostics and

conservation. The second part, "Performing Microclimate Field Surveys," is devoted to practical applications of principles and shows in detail how measurements should be performed, with many suggestions and examples and the indication of some common errors to be avoided. (A.B.- AATA)

Camuffo, Dario; Pagan, Emanuela; Bernardi, Adriana and Becherini, Francesca. The impact of heating, lighting and people in re-using historical buildings: A case study. *Journal of cultural heritage* 5, 4 (2004), pp. 409-416.

Cassar, May *Environmental management guidelines for museums and galleries* The heritage. Routledge, London, New York (1995), 165 p.

The theme of this book is that the key to providing a stable collection is a stable environment, and that the key to a stable environment is a well-maintained building with effective environmental services. The book is organized in four parts. Part 1 introduces the subject of resource management in the museum context (chapter 1), examines the complex and often contradictory demands made by objects and people on museum space (chapter 2), and discusses the development of an environmental strategy--assessing existing conditions and designing and implementing a conservation audit (chapter 3). Part 2 adopts a broad approach to managing and monitoring the built environment. Chapter 4 sets the museum in the context of its local climate, and considers the implications which this has for the environmental design of the building itself. Chapter 5 describes the framework for the monitoring program which systematically assesses building, collection, and internal environment, and covers monitoring equipment (for humidity, temperature, visible light, ultraviolet light, pollution, and pests), and the effective use of this equipment. Part 3 examines the control options available in the display environment. Chapter 6 looks at centralized systems including air-conditioning systems, lighting systems, and energy efficiency. Chapter 7 looks at room-based systems. Chapter 8 looks at the control afforded by display cases and other environmentally controlled enclosures. Part 4 covers storage (chapter 9) and includes safe storage, types of storage, and the efficient utilization of storage space; and transportation (chapter 10) and includes modes of transport, packing materials and crates, and monitoring and controlling the moving environment. Also included are a glossary of terms, a select bibliography, a list of sources of other information (organizations), and an index. (AATA)

Cassar, May (editor). *Museums, environment, energy* Museums and Galleries Commission. HMSO, London (1994), 130 p.

Includes five contributions from a conference held in London in 1991 on "Saving energy for a better environment." These are: 1) "Museum environments and energy efficiency," by William T. Bordas; 2) "A survey of energy use in museums and galleries," by Tadj Oreszczyn, Tim Mullany, and Caitriona Ni Riain; 3) "Air-conditioning, energy efficiency and environmental control," by Alfred Reading; 4) "The National Gallery Sainsbury Wing air-conditioning system," by Sean Ascough; and 5) "Lighting design and energy efficiency in museums and galleries," by Michael Carver. Also included are two commissioned case studies: "Environmental improvements and energy efficiency in Whitby Museum (UK)," by David Pybus and John William Morris; and "The National Museum of Photography, Film and Television in Bradford (UK): an exercise in environmental control, energy efficiency and financial savings," by Tim Whitehouse, intended to illustrate how two museums of different size and scale of operation have succeeded in improving environmental control and energy efficiency. A concluding chapter, "Managing priorities for environmental control and energy-efficient practice in museums," is provided by May Cassar. (AATA)

Cassar, May; Taylor, Joel. A cross-disciplinary approach to the use of archives as evidence of past indoor environments in historic buildings. *Journal of the society of archivists* 24, 2 (2004).

This article describes a methodology developed in consultation with English Heritage, the National Trust and Historic Royal Palaces. It links past environmental conditions in historic houses to object deterioration, using information from a range of disciplines. These include environmental history, building science, archival research and preventive conservation. The methodology was devised in order to integrate qualitative and quantitative evidence for a novel simulation of historic buildings. Application of the methodology has illustrated the value of integrating different strands of research to provide a robust synergistic approach to the complex problem of assessing natural ageing in historic materials. This approach will aid the understanding of both past internal climates and future object deterioration. (Author's abstract)

Conrad, Ernest The realistic preservation environment (Presented at NARA 14th Annual Preservation Conference: Alternative archival facilities). (1999)
http://www.archives.gov/preservation/storage/realistic-preservation-environment.html

There is a popular misconception that a realistic environmental criteria to preserve artifacts is that which is a compromise between opposed needs of the building, the occupant, and the collection at a cost which an institution is willing to pay. This philosophy completely misses the mark. Too much of our history has been lost using this rationale.
A realistic environment is not a compromise where two extremes are averaged into one, such that neither is appropriate. But rather, it is a balance in which the different needs can all be

satisfied through a realistic analysis of factual data followed by cost conscious design choices to achieve that end, both in first cost and operating cost.
In the "realistic" world, this philosophy is often easier said than done. But it's not really all that difficult, so long as the design choices focus on factual measured data, from both the past as well as the present.
How then does one achieve this cost conscious balance? There are over 8,000 different combinations of climate control design choices in the commercial marketplace today. Only a step-by-step logical process of analysis will succeed in arriving at the one choice most appropriate. It is a team process which can be divided into the three following steps: classify envelope ; identify heat loads ; perform moisture inventory. (Author's introduction)

Conrad, Ernest A. Balancing environmental needs of the building, the collection, and the user. In *Abstracts of Papers Presented at the Twenty-Fourth Annual Meeting, Norfolk, Virginia, June 10-16, 1996, by the American Institute for Conservation.* American Institute For Conservation, Washington D.C. (1996), pp. 15-18.

A six-part classification system is presented based on three major climate-control categories, including examples of the kinds of collections and/or use which could be considered for each type of space. This system is in wide usage as a tool in the balancing act often needed in historic house museums. (Northeast Documentation Conservation Center)

Conrad, Ernest A. The dews and don'ts of insulating. *Old House Journal* 24, 3 (1996), pp. 36-41.

Holmberg, J. G.; Burt, T. Preventive conservation methods for historic buildings: Improving the indoor climate by changes to the building envelope. In *Conservation without limits: IIC Nordic Group XV Congress, August 23-26, 2000, Helsinki, Finland.* Koskivirta, Riitta, ed. Loimaan Kirjapaino, Loimaa (2000), pp. 71-88.

This report concerns the control of the relative humidity in three historic buildings. An upper limit of 65% RH was used. A large technical survey on museum storage rooms in Sweden showed that unheated but dehumidified buildings could be an acceptable alternative to traditional buildings with mechanical and electrical systems for indoor climate control. The authors describe measurements of air infiltration, RH, and temperature at three unheated historic palaces in Sweden: Skokloster, Läckö, and Salsta. The descriptions are aimed at conservators, curators, and other museum staff, rather than engineers, although some technical explanations are included. As a result of the measurements, three solutions for improvements were tried: at Skokloster, almost nothing was done; at Läckö, the building envelope was improved by installing inner windows, and dehumidification was installed; and at Salsta, the building envelope was improved by a Temperierung system, in which copper pipes carrying warm water were installed within the walls. (Author's Abstract)

Kleinmanns, Joachim. Die Temperierung historischer Gebäude: eine Methode zur Verhütung feuchtebedingter Bauschäden = Tempering of historical buildings: a method for preventing building damage due to moisture. *Klima in Museen und Historischen Gebäuden: die Temperierung = Climate in museums and historical buildings: wall heating.* Boody, Frederick; Großeschmidt, Henning; Kippes, Wolfgang and Kotterer, Michael, Schloss Schönnbrunn. Kultur- und Betriebsges. mbH, Vienna (2004), pp. 193-208 (on CD).

Salination of masonry, fungal and algal colonization, and, as a result, pest infestations in wooden building parts are the major forms of damage due to humidity in historic buildings in open-air museums. Control of the climatic conditions is indispensable for avoiding damage. At the end of the 1970s, the Westfälisches Freilichtmuseum (Westphalian Open-Air Museum) in Detmold, Germany, began trying to influence room humidity through heating. From 1979 until 1987 conventional heating systems were installed, which proved unsatisfactory at preventing damage. Only after 1988, with the installation of several tempering systems, could satisfactory results be achieved. Both moisture-dependent building damage and building-specific energy requirements were drastically reduced. (Author's abstract).

Lloyd, Helen; Staniforth, Sarah. Preventive conservation and "A madness to gaze at trifles": A sustainable future for historic houses. In *Tradition and innovation: Advances in conservation: contributions to the Melbourne Congress, 10-14 October 2000.* Roy, Ashok; Smith, Perry, eds. International Institute for Conservation of Historic and Artistic Works, London (2000), pp. 118-123.

Museum standards for preserving cultural material need to be interpreted sensitively if they are to ensure sustainable access to fragile historic house interiors presented as homes still in occupation. High standards of preventive conservation can be achieved by adapting traditional housekeeping practices, recorded in 18th- and 19th-century manuals. Conservators have revived methods to protect collections from physical damage, biological infestations, pollution, light, and inappropriate levels of temperature and relative humidity. To ensure that vulnerable collections are properly maintained, conservators equip historic house managers with an understanding of preventive conservation and technical information to aid monitoring and documentation, staff training, and management. In conclusion, the authors emphasize the need to establish a sustainable balance between conservation and access. (A.A.- AATA)

Michalski, Stefan. Leakage prediction for buildings, cases, bags and bottles. *Studies in conservation* 39, 3 (1994), pp. 169-186.

A complete summary of equations for leakage of enclosure is given, including vapor diffusion through still air in openings, and infiltration of air/vapor/particulate mixture. Stack pressure due to temperature and relative humidity difference drives most infiltration. Experiments confirmed the diffusion and infiltration equations for small and medium-size enclosures. Leakage for a carefully made display case with ordinary materials has been reduced

to the microbarometric limit of about 0.03 of an air change per day. Simplified table and charts of leakage are given for 0.1, 1.0, and 10 m enclosures, as a function of crack width, hole width, and wall permeability. (AATA)

Oreszczyn, T.; Cassar, M. and Fernandez, K. Comparative study of air-conditioned and non air-conditioned museums. In *Preventive conservation: practice, theory and research: Preprints of the contributions to the Ottawa Congress, 12-16 September 1994.* IIC, London (1994), pp. 144-48.

Museums are increasingly becoming aware of the need for good environmental control in order to slow down the effects of environmental instability on objects. In theory, air conditioning can provide this level of control, but at a price. For example, many museums are housed in historic buildings where it is very difficult and expensive to install air conditioning, and maintenance and operating costs are high in terms of energy and personnel. Furthermore, the introduction of air conditioning in an historic structure is questionable. Using monitored data from historic house museums with and without air conditioning, the authors examine the level of environmental control that air conditioning provides in practice. Analysis of monitored temperature and humidity data suggests that air conditioning does not always provide tight control or a more stable environment. A new attitude to environmental control is required among both building designers and museum professionals in order to achieve agreement on an acceptable level of environmental control at an affordable price. (AATA)

Padfield, Tim. The dangers of installing air conditioning in historic buildings. In *Old cultures in new worlds: Washington, District of Columbia, United States of America, October 10-15, 1987: Symposium papers.* ICOMOS United States Committee, Washington, DC (1987), pp. 432-439.

Condensation within walls and roofs of buildings in a cold climate is an inevitable consequence of warming and humidifying the air within them because the dew point of the air inside the building is, for several months of the year, higher than the temperature of the outer surface of the building. The vapor barrier, which is often installed to prevent diffusion of humidified air into the walls, is not usually able to prevent transfer of moisture through air flow caused by the buoyancy of warm humid air in a tall building or by the pressure difference generated by the air-conditioning equipment. The museum buildings of Washington, D.C., both old and new, testify to the difficulty of maintaining a humidity within that will preserve the collections without at the same time damaging the building. Sensors installed within the structures have clearly demonstrated the complexity of the patterns of air flow and of moisture transfer. Condensation, ice formation, corrosion, and rot in walls and roofs may show no symptoms but still cause serious damage over the years. For historic buildings that house historic collections, the specification for the interior climate must be a compromise based on a study of the construction of the building, the local climate, and the nature of the collection. In particular, it may be necessary to change the interior climate slowly through the seasons to minimize the difference between the inside and outside temperature and water vapor pressure.

(A.A. - AATA)

Padfield, Tim The role of standards and guidelines: Are they a substitute for understanding a problem or a protection against the consequences of ignorance?
http://www.padfield.org/tim/cfys/ppubs/dahlem.pdf

Two environmental standards, for relative humidity and for light, are discussed in detail as examples of how poor definition of standards and a lack of understanding of the underlying physics leads to irrational, expensive and sometimes damaging distortion of the way museums are built and operated. The relative humidity (RH) standard is so strict that it can only be attained with mechanical air conditioning. A 50% RH standard is high enough to cause condensation damage to buildings in cool climates yet low enough to cause damage to objects that have attained a stress free condition at a high relative humidity in a church or a historic house. The lighting standard defines permitted illumination, which is based on the photosensitivity of the eye, instead of the permitted flux of photons in the spectral energy band which predominantly causes fading. We need, or need to publicise, standards and guidelines for the use of ancient and weak materials, such as lime mortar, which are disregarded by modern industrial craftsmen but are essential for responsible restoration of old artifacts and buildings. The conservation profession must develop rational and attainable environmental and material standards suitable for the whole range of historic relics. (Author's abstract)

Padfield, Tim; Borchersen, Karen *Contributions to the Copenhagen conference 19 - 23 November 2007 Museum Microclimates.* The National Museum of Denmark, Copenhagen (2008).
http://www.nationalmuseet.dk/graphics/konferencer_mm/microclimates/pdf/musmic150.pdf

The articles collected in this volume give a snapshot of current opinion and research in the preservation of artifacts through manipulation of their environment. There is little about exotic environments such as oxygen free enclosure or cold storage but abundant advice and information about reducing fluctuations of temperature and relative humidity in spaces that are within the environment for human comfort but not in accord with current standards for the museum environment. (Editor's introduction)

Thomson, Garry *The museum environment* The Butterworth series on conservation in the arts, archaeology, and architecture. Butterworths, London; Boston (1978), 270 p.