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Best Practice and Standards in Environmental Preservation for Cultural Heritage Institutions: Goals, Knowledge, Gaps

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With common issues and concerns, a growing convergence of institutions – libraries, archives, museums and historic houses – face the same challenges for cultural heritage preservation. These include storage, display, research and exhibition areas that meet the needs of preservation, while also allowing the increasing demand for access to original historic materials. The needs, demands and requirements for collections and all cultural heritage have long been recognized, and it is nothing new for the cultural heritage field to have to deal with funding challenges and the need to prioritize resources in a difficult economic environment. This puts an even greater emphasis and broader and encompassing focus on the need for best practices and "appropriate" standards for environmental preservation. This is critical since the range of environmental parameters has now greatly expanded to include economic, political and climatic challenges, while also requiring the need to address the digital age and global explosion of demand for access to knowledge.

In this new climate of change it is imperative that cultural heritage professionals and practitioners collaborate to share and integrate the knowledge required to underpin environmental guidelines, recommendations and standards that are based upon real material science, rather than accepted practice, since as organizations are called upon to justify costs and allocation of resources, we need to ensure that energy, money, personnel and other resources are being utilized most effectively for the long-term preservation of collections.

Goals

The underlying goal of best practices in environmental preservation is to attain the optimum conditions for the protection of items of cultural heritage. This should be closely aligned with the specific material-based needs of the artefact. Environmental controls for preservation of cultural heritage items are long overdue for revision, since conservation recommendations often impose rigid controls that do not relate to local environmental conditions and are inclined to misinterpretation as people fail to relate to a range rather than a specific number and set-point. Nor are they necessarily based upon a true understanding of the underlying needs of various materials in collections. Furthermore, standards should enable, not deter cultural heritage professionals from optimising the preservation of our collections, while at the same time recognising the need to move from a reliance on accepted or historic practice, toward standards that are based upon evidence based material science needs of collections.

The current economic, political and ecological climate challenges us to address these issues and develop standards that are both optimal for the specific artefact and location, and can be met without greatly expanding the carbon footprint. Closely aligned with this is the need to address climate change issues and ensure sustainability for institutions – including libraries, archives, museums and historic houses. Current economic, political and climate changes challenge cultural heritage professionals to address the revision of standards in the context of these issues.

There is a global move toward reducing energy costs and the carbon-footprint of human activities. The preservation of cultural heritage is not exempt from this mandate, as institutions are forced to consider how they can both justify the costs involved (e.g. humidification) as well as implementing ways of reducing energy costs for controlling environments to preserve our heritage. The impact of global warming seems to indicate a greater range of variability on external climates – a higher incidence of storms, extreme events and seasonal fluctuations. These factors all indicate the need for greater control of these fluctuations to try to reduce the impact of these changes on cultural heritage, but this needs to be achieved within the backdrop of reduced budgets, funding, while also addressing actual material tolerances in terms of upper and lower limits, and rates of changes.

The growing convergence of cultural heritage institutions – libraries, archives, museums and historic houses – all need to address the common issues of storage, exhibition and access in conjunction with the implementation of standards requirements for environmental control. Due to human comfort factors, the environmental conditions in spaces may differ to meet the needs of those requiring access to the collection. This this often results in fluctuating conditions that can cause damage, as well as tolerance levels that may not be the best for the specific collection.

Figure 1. Converging Issues for Cultural Heritage Institutions

The environment for cultural heritage that needs to be controlled can be defined in terms of a "macro to micro" perspective, and standards for cultural heritage need to be considered in the context of a spectrum leading from the macro environment down to the micro environment:

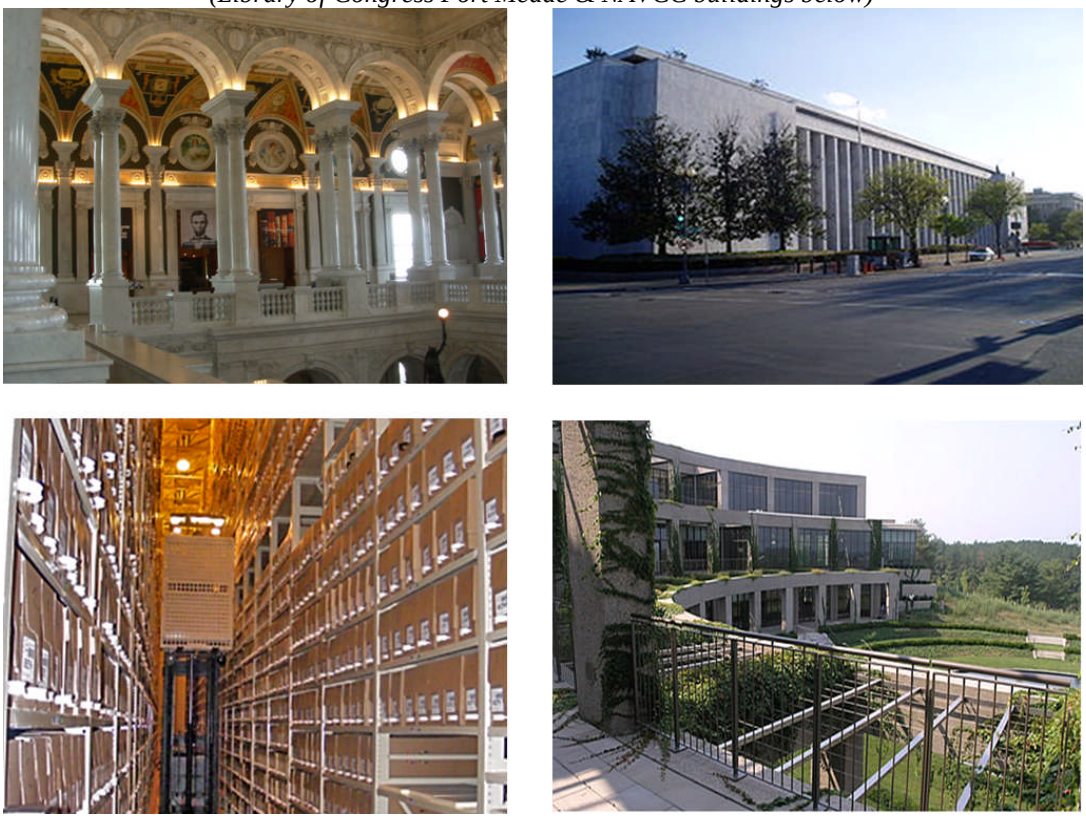
- The building (historic architecture or modern)
- The room (storage / exhibition / research)
- The case (display / storage / long-term visual storage)

Figure 2. Impacts on Environmental Control: Building, Room, Case

The building may be historic architecture or of more recent construction – modern, or increasingly customized buildings for specific storage needs of cultural heritage materials. Buildings are comprised of a range of materials with specific properties that may or may not be capable of achieving current environmental standards. There are issues of cost for both maintenance of the existing structure or the upgrade of the infrastructure and systems. Whether the building can be retrofitted and the cost of this, often elicits extensive debate when institutions are trying to determine the best option for meeting standards for environmental control. In addition there are energy costs involved with the building type and construction of humidification and other environmental control systems within the building. These also impact the building itself, which is of additional concern when the building is considered of cultural heritage. The vagaries of mechanical systems in maintaining stable environmental control also need to be considered, since mechanical breakdown can create more risk of potential damage of materials. The variation from a tightly controlled temperature and relative humidity (RH) environment to one reflecting the external ambient conditions can be severe, depending on both the seasonal and geographical location of the collection.

To achieve required set-points and ranges specified in standards, buildings may be customized, zoned or divided into separate components to meet the often conflicting needs of storage, exhibition, research and access, and collection versus human occupancy requirements. Customized buildings for long term storage control include the British Library Additional Storage Project (ASP) building at Boston Spa, the Library of Congress Fort Meade module storage to maintain conditions of reduced temperature and RH, and the Library of Congress National Audio Visual Conservation Centre (NAVCC) building.

Figure 3. The Building Structure: Historic Architecture, Modern Customised
(Library of Congress Fort Meade & NAVCC buildings below)

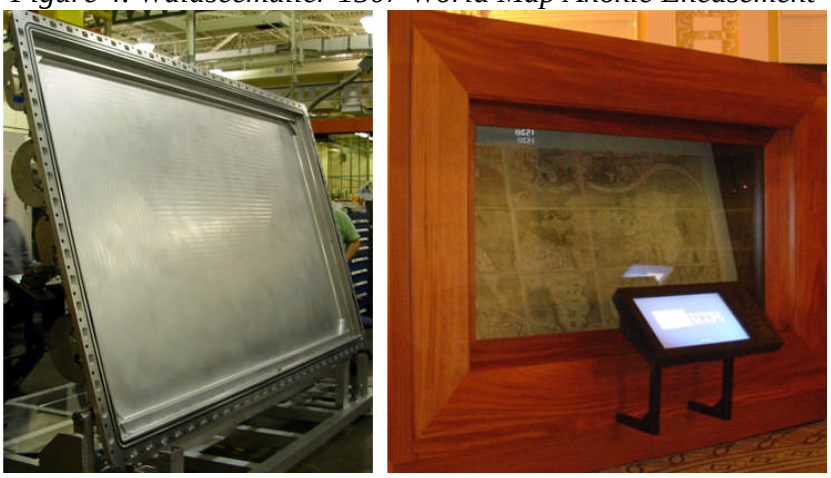


As noted above, the top level of macro to micro environment spectrum is the building that houses and influences the collection needs to take into account the effect of external factors. These include not only meeting standards, but also the energy costs of controlling the environment, political mandates for reducing energy costs, and climate changes – both geographic and local variations that can vary widely from the limits set by standards, as well as global changes in climatic conditions. All these are impacted by economic considerations for individual cultural heritage institutions as they struggle to meet and justify the costs required for energy and resources to achieve required environmental standards.

The next level in the macro to micro spectrum is the room, or defined space within the building. Traditionally rooms or spaces within cultural heritage buildings are divided based upon the required level of access, as well as the specific content of the collection. While this distribution of collections based upon subject may seem more logical and simplify cataloguing, it should be considered whether this adequately addresses the needs of the collection. A better allocation of resources may be the separation of materials according to the differing environmental needs of the collection materials, while also optimising conditions for the control of environmental parameters commensurate with the collection materials' tolerances to minimise damage. Rooms can also be modified by adapting the entry (e.g. double sets of doors to reduce fluctuations in RH and temperature) and access to maintain better conditions. Monitoring can establish the level of control within rooms both with passive or active control, and these levels of control need to be related to the material tolerance of collection items.

At the micro level of control is the exhibit, display or visual (long-term) storage case that is capable of creating and controlling a microclimate for more fragile artefacts and those requiring separate cases. The use of visual storage (encasement for display and storage) helps minimise the potential impact of handling when an item of significant cultural heritage is moved from storage to display. More importantly it assures that the environmental conditions of the local environment remains stable. The challenge in creating efficient visual storage systems is the selection of materials that are capable of achieving the required hermetic seal that can attain a low rate of leakage and tight control of the microclimate. While the initial cost outlay may seem larger than for less controlled spaces, the long-term energy costs of this type of environmental control are greatly reduced since a passive environment is constantly maintained and the stable buffering against external fluctuations minimizes the risk of damage for the artefact. In addition, the conditions can be customised to control the specific environmental parameter that is the major cause of deterioration for the material based needs of the artefact, whether it is RH, temperature, oxygen or pollutants. An example of this is the Waldseemüller 1507 world map, where protection of the map due to the requirement for long-term exhibition necessitated an anoxic and lowered RH encasement. This has been engineered to allow a 150 year seal due to a truly hermetic seal with lowered energy costs due to passive control of the encasement.

Figure 4. Waldseemüller 1507 World Map Anoxic Encasement



The concept of cases or microclimates can be extended to storage areas where encasing cultural heritage materials helps buffer the environment to achieve the required material tolerances in relation to external changes, while addressing the need to optimise preservation requirements.

Knowledge

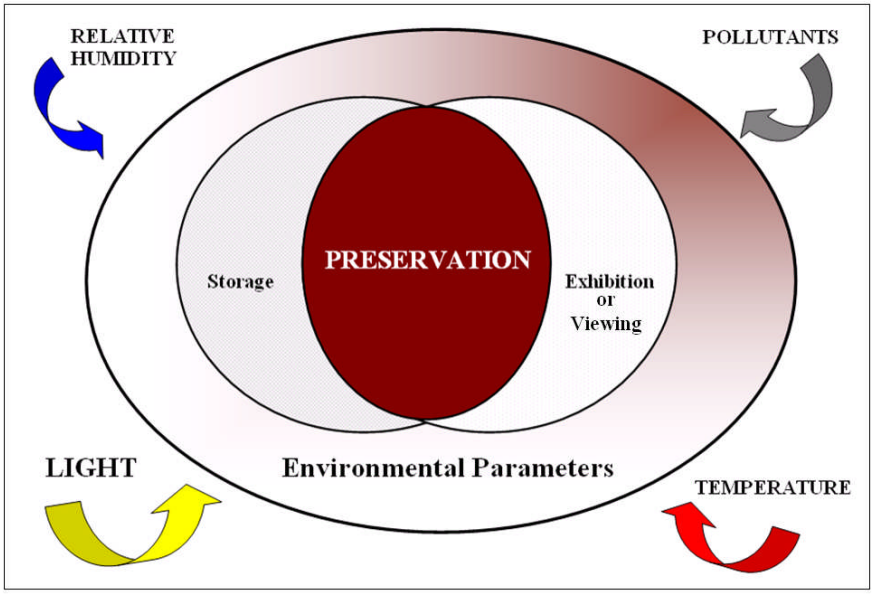
In the 1970s, Garry Thomson's "The Museum Environment" recommended 50 or 55±5% RH and a temperature of 19 or 24 ±1°C for winter and summer, respectively. This established an overarching requirement for controlling and limiting fluctuating conditions. Continued research in the field further recognized the need for drier and cooler conditions. Standards such as British Standard 5454, state that the temperature and relative humidity should be at fixed points within the range of 13-16°C and 45-60%, respectively, with time for acclimatization if materials are moved to different conditions. To promote longevity, the

Library of Congress special storage modules are maintained at a constant 10°C and 30% relative humidity. There do exist a number of standards and guidelines for recommended display and/or storage conditions for archives and libraries; including British Standards (BS), International Organization for Standardization (ISO), National Information Standards Organization (NISO) and the American National Standards Institute (ANSI), and published recommended practice adopted by specific organizations such as the National Archives and Records Administrations (NARA, USA) American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc (ASHRAE), the European Committee for Standardization (CEN) and many locally adopted guidelines. Each organisation setting standards, guidelines and recommendations have different underlying needs and motivations for setting the standards.

These consensus standards and advisory bodies comprise a range of professionals with varying expertise, and these differing backgrounds mean that there will often be fundamental differences in setting specifications. For example, a preservation scientist will develop recommendations from a materials science background that focus on the structural materials tolerances to specific deterioration factors as well as the rate of change. This emphasis is therefore on different priorities from those of a mechanical engineer, who is basing recommendations on known limits and tolerances of machinery rather than materials.

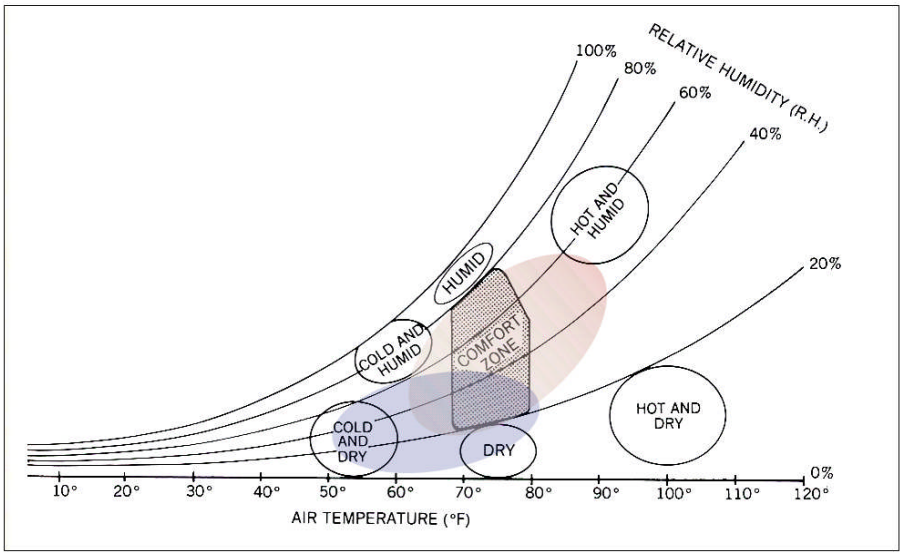
In terms of the knowledge that currently exists, it is well established in the preservation field that there is a recognized overarching need to control and limit fluctuating conditions for a range of materials. The standards outline the main environmental parameters that require control and attention, such as maintaining temperature and relative at fixed points in a range, controlling levels of visible and ultra-violet light, and pollutants. To promote longevity, customized buildings and specialized storage have evolved (e.g. Library of Congress special storage modules maintained at a constant 10°C and 30% RH), and there are many detailed studies in the literature that investigate and advance the knowledge of changes in materials based on scientific studies. In addition there have been significant developments in relevant technology and engineering.

Figure 5: Effect of the Environment on Preservation



As illustrated in Figure 5, the deteriorating effects of RH, light, temperature and pollutants, both for storage and exhibition must be taken into account. There is also recognition that cooler and drier conditions are beneficial but that the needs of collections and humans often do not coincide,as highlighted in Figure 6. Most institutions raise temperature to address the needs of humans working in or accessing collections and collection areas.

Figure 6: Collection Needs and Human Comfort



Therefore there is a need to both maintain and better understand the required environment, while addressing the needs of collections versus human comfort. The adaptation of current standards and existing knowledge to local environments and circumstances needs to be better managed so as to create stable versus fluctuating conditions. In order to balance preservation and access, we need to more effectively utilize scientific, technology and engineering advances. There are two areas that should be addressed: Linking these developments with material properties, and through increasing access while preserving the original artefact.

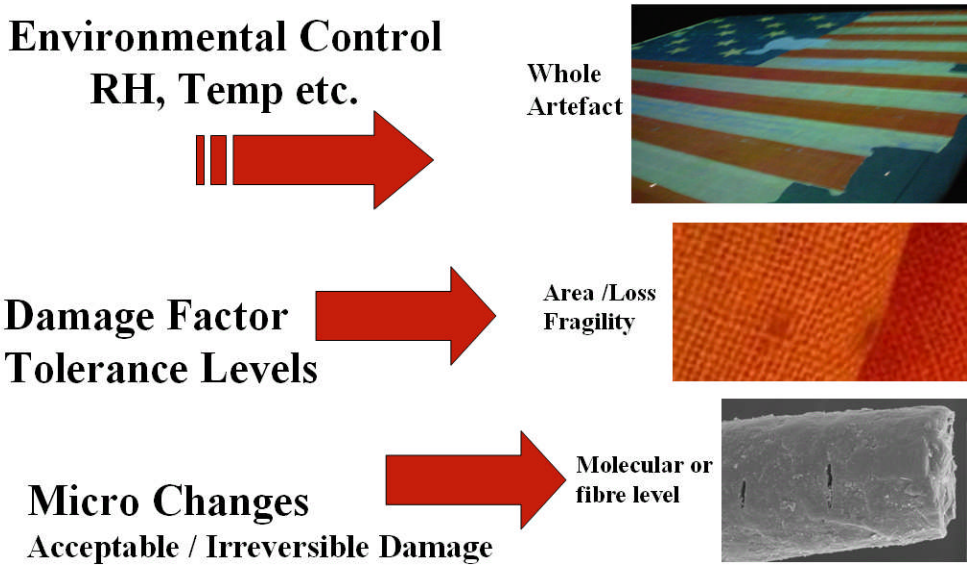
Gaps

The challenge in applying the above listed standards, guidelines and issues to cultural heritage preservation, is that many of these past recommendations and standards adopted for preservation applications were not based upon a true understanding of known changes in cultural heritage artefacts based on research into cultural materials. They need to be critically assessed in light of advances in knowledge of changes in cultural materials based on scientific studies. This should include specific research into changes in paper and other substrates to better define appropriate set-points for specific parameters, and safe ranges for specific material requirements. This knowledge needs to be linked with engineering capabilities, building structures (historic or modern), types of collections (including mass treatments) and local climate parameters. Other factors to be considered include the effect of and rate of change in the environmental parameter, linked with the acclimatization required for the adaptation of an artefact to changes in environmental parameters while minimizing risk of damage.

Gaps in what is known include the effects of fluctuations and cycling for relative humidity responses of specific materials, including the differing requirements for materials and material composites for storage, microclimate and display areas. In addition, the buffering necessary in relation to linking this data with building control systems and the levels of control that can be attained, maintained and are required also need to be considered. This should incorporate the impact of local climate adaptations based upon measured material properties and the upper and lower tolerances that can occur without inducing unnecessary damage. In addition the control of levels of light, pollutants, and temperature are further areas of investigation. Collaborative research efforts between the British Library (BL) and the Library of Congress (LC) are underway to realistically address some of these issues and their implications for two of the world's largest collections, collectively encompassing over 250 million items. These issues need to be further researched with regard to implementing scenarios for cost effective solutions and material specific parameters.

Further considerations for defining required research include determining the major cause of deterioration for specific materials so that the best utilization of energy and resources can be employed to best address the optimum preservation requirements of collection materials. The determination of deterioration from environmental parameters needs to evolve from an understanding of the impact of each damage parameter and how this impacts the individual artefact or collection material. Currently we simply control overall environmental parameters such as RH and temperature, but a disparity exists in the understanding of what happens at the micro level in terms of molecular changes that lead to irreversible damage, or alternatively, acceptable changes that do not adversely affect the mechanical stability of the artefact. Therefore by increasing our understanding of the tolerance levels and micro changes we can reduce the potential for damage and optimize preservation and long-term accessibility to the collection. We need to address the extensive materials science needed to define the rate of change, tolerances and range of environmental control for common cultural heritage collection materials.

Figure 7: Artefact and Material Properties: Macro to Micro



The global impact of this lack of information translates into ongoing discussions of internationally agreed standards for cultural heritage buildings and collections. Until we can incorporate material science with an understanding of the impact of local, regional and global variations, we will not be able to arrive at balanced and accurate consensus standards and recommendations that we can use in protecting our collections.

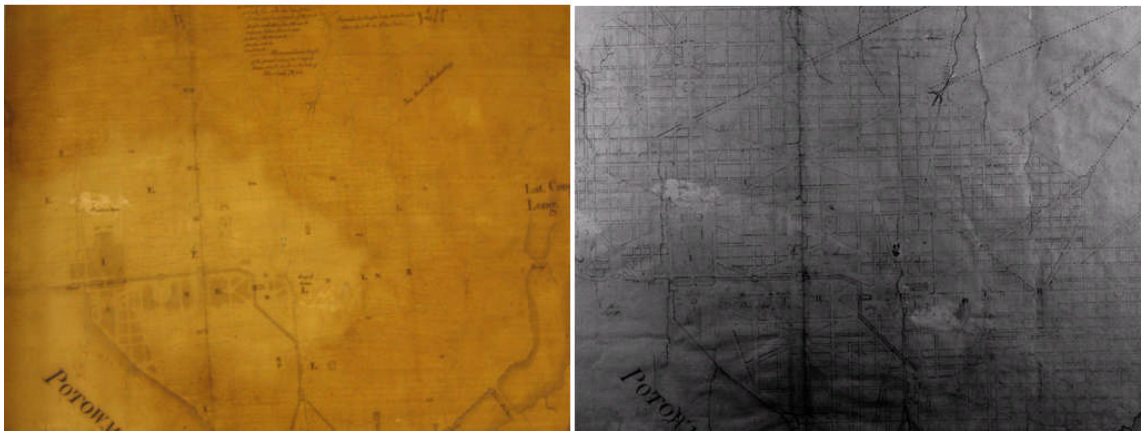
One effective way of increasing our global knowledge base for cultural heritage materials and collections is through the development of a preservation reference materials database and repository. The Library of Congress is currently undertaking the development of an open source software architecture / platform through the utilization of a customized Resource Description Framework (RDF). By ensuring open access, this would allow international access to data with data interoperability. Enhanced access through attention to the use of standardized file formats will ensure proprietary software and file format structures do not impose barriers for access to the collection. The reference collection would comprise a wide range of reference materials of new, naturally aged and accelerated aged samples including but not limited to the following:

- Physical samples:
  - Characterized reference papers such as the ASTM 100 year study
  - Naturally ages mass deacidification paper samples
  - Naturally aged book collections such as the Library of Congress Barrow collection (books from 1500-1900)
  - Pigments
  - Leather samples
  - Stone samples
  - Fibre samples
- Digital files associated with both LC collection objects and above reference samples (hyperspectral images, FTIR, Raman, XRF, SEM etc)
- Extant and associated international database collections

The importance of these samples is the availability of well-characterized aged samples that are more relevant in terms of the measured materials properties, since they reflect the changes manifested in actual artefacts, as opposed to starting with material analysis of new and accelerated aged samples. This gives a better understanding of the impact of environmental parameters on aged materials that have already undergone various levels of deterioration as well as exposure to treatments and other effects.

More effective utilization needs to be made of non destructive techniques that can enhance the preservation of original artefacts with greater access to the digital object – since this can often provide the researcher with more information than can normally be accessed visually from the original. The development of hyperspectral imaging – integrated narrow band spectral imaging – with low heat, low light exposure LED conservation lighting to reveal information from the ultra-violet, visible and infrared spectral regions allows for non-destructive characterization of inks, colorants, substrates and treatments, while also revealing information not apparent in the visible region. Utilization of the digital images and spectral combination of images allows increased access to objects, while enhancing their preservation through reduced handling and exposure to changing environments.

Figure 8: L'Enfant Plan of Washington D.C. (1791): Viewing in Visible Light and Infrared



This brief overview of standards development demonstrates that there are a number of key issues that need to be addressed in the review of current standards, and future developments. These issues include the importance of enhanced understanding of material specific properties and the tolerance and rate changes that should be included in more appropriate environmental standards for cultural heritage. This needs to be achieved while addressing storage, exhibition and research access requirements and balancing the needs of preservation and access. Monitoring and determining the relevant major deterioration factors that lead to damage should integrate risk factors related to the impact of the local environment – both climate and culture. Incorporating the need for energy efficiency in light of reducing costs and meeting government mandates is another critical component of the current economic and political environment. The overarching need to establish a consensus for international agreed standards for cultural heritage loans underpins the assessment of risk versus value and what is acceptable loss that allows access while optimising preservation.

Conclusion

In order to adequately preserve our cultural heritage for future generations is it imperative to establish and apply an advanced knowledge of materials science to protect our collections in relation to:

- tolerances and actual damage, and
- control of deteriorating factors rather than bulk parameter control

To achieve this we need to focus on international research collaborations that allow the implementation of consensus standards optimized for protection of cultural heritage buildings and collections. This has to be objectively based in economic and political reality – achieving preservation in the setting of the current focus on economic, energy and climatic responsibility. This will allow the best allocation of resources that enables us to balance preservation and access, while providing standards that enable international agreement and best conditions for cultural heritage.

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Selected Related Publications

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc (ASHRAE) Chapter 21: Museums, Libraries and Archives

ANSI/NISO Z39.48-1992 (R2002) ISSN: 1041-5653: Permanence of Paper for Publications and Documents in Libraries and Archives

ANSI/NISO Z39.79-2001 ISSN: 1041-5653: Environmental Conditions for Exhibiting Library and Archival Materials

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