The Science of Objects and Collections

ABSTRACTS

1. Conservation research at the British Library
   Barry Knight, Head of Conservation Research, The British Library

2. Applications of spectroscopy in conservation research
   Paul Garside, Conservation Scientist, The British Library

3. Research on parchment conservation
   Mariluz Beltran de Guevara, Conservator, The British Library

4. Understanding the effects of temperature and RH on historic parchments
   Lee Gonzalez, Research Fellow, The National Archives

5. Identifying diverse materials in library collections
   Lesley Hanson, Conservator, The British Library

6. Heritage Smells!
   Lorraine Gibson, Senior Lecturer, University of Strathclyde

7. Non-invasive spectral imaging for identification and assessment of conservation materials
   Fenella France, Preservation Research & Testing Division, Library of Congress

8. Integrated modelling: the demography of collections
   Matija Strlic, Senior Lecturer, UCL Centre for Sustainable Heritage

9. Influence of the environment on collections in mass storage
   Ami Pass, PhD student, University of Lincoln

10. Energy efficiency of mass storage
    Patrick Dixon, Head of Building Services, The British Library

11. Understanding the environment in an archive store
    Kostas Ntanos, Head of Conservation Research and Development, The National Archives

12. Redefining environmental standards for libraries, archives and museum collections
    Nancy Bell, Head of Collection Care, The National Archives

13. The Identical Book Project and after
    Velson Horie, Collection Care and Conservation Consultant

1. Conservation Research at the British Library

Barry Knight, Head of Conservation Research, The British Library

Although the speaker was appointed as the first Head of Conservation Research at the British Library in 2003, there is a history of research into library materials and their conservation going back to before the formation of the British Library in 1972. Figures such as A.D. Baynes-Cope and Vincent Daniels carried out important work at the British Museum, and the library commissioned extensive work on graft copolymerisation as a method of strengthening brittle paper. However, the library had no overall conservation research strategy or means of assessing what research might be most useful to it.

The situation changed in 2004 when the Andrew W Mellon Foundation awarded a grant to the British Library to hold a meeting of representatives of major libraries and archives in the UK and Ireland, together with researchers from Europe and North America, to produce a list of priorities for conservation research on library and archive materials. These priorities were:

1. Life cycle prediction
2. The effects of the storage environment on different materials
3. Non-destructive methods of assessing damage to materials

As a result of this, it was possible to write a conservation research strategy for the British Library based on these priorities. Conservation research received a further boost when the Mellon Foundation awarded the library a grant of almost $750K to carry out the Identical Books Project between 2006 and 2009. This ambitious project sought to characterise and compare a collection of identical books in six different libraries in order to reveal the influence of their past storage environment on their present condition (addressing Priority 2) and to investigate the spectrum of volatile organic compounds (VOCs) emitted by books to see whether specific markers that would point to specific decay processes could be identified (addressing Priority 3). The funding allowed us to recruit Velson Horie to manage the project.

In addition to the Identical Books Project, the British Library became involved in two major EU-funded research projects, PaperTreat and SurveNIR, both of which addressed our research priorities. PaperTreat aimed to assess the short-term effects and long-term efficacy of the commercially-available mass deacidification processes, while SurveNIR aimed to develop a portable near infra-red spectrometer that would permit the rapid non-destructive evaluation of the condition of paper. Our involvement in all three of these projects greatly enhanced our research profile and our visibility on the conservation science stage. We were also able to exploit synergies between the projects, for example, using the SurveNIR machine to assess the condition of the identical books.

The conservation research strategy had not envisaged setting up an advanced conservation science facility with state-of-the-art equipment, since funds for this were not available nor likely to become available, and neither was it likely that

the necessary level of staffing could be attained. Instead the model adopted relied on collaboration with other cultural heritage institutions in London that at that time were well-resourced and had equipment available. Although this model was successful for a while, it became apparent that analysis of collection items was hindered by the difficulty of arranging short-term loans of material for analysis and by an understandable reluctance to allow sampling of original materials.

Thanks to Helen Shenton, funding became available in 2009 for a new permanent conservation scientist post, and we were able to recruit Dr Paul Garside from the Textile Conservation Centre. We were also very fortunate to be able to borrow the TCC's infra-red and near infra-red spectrometers. With an additional member of staff and analytical equipment on site, Conservation Research was able to offer a much better service to conservation staff, other library staff and readers. We were thus able to raise our internal profile as well as our external profile.

Conservation Research in the British Library has now reached a stage where we are able to provide scientific back-up to conservators seeking to understand the objects they are working on, identifying original materials and conservation materials and monitoring their degradation processes, we support major library projects such as the Additional Storage Programme and the Newspaper Storage Building, we carry out our own research projects and we participate in external research projects such as the Heritage Smells project. We also provide support to curators and readers trying to read damaged, erased or faded text, visualising watermarks and identifying pigments. In an increasingly digital world, we speak up for the physical nature of real objects, and show that they still have plenty to tell us.

2. Applications of Spectroscopy in Conservation Research

Paul Garside, Conservation Scientist, The British Library

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The conservation of cultural heritage relies on a good understanding of the objects and materials being dealt with, allowing treatment decisions to be made which are appropriate, sympathetic and, as far as possible, unlikely to introduce new problems in the future. Often this relies on the expertise of individual conservators and an appreciation of the history, provenance and composition of a particular artefact; however, not all of these qualities are necessarily obvious, and an important aspect of conservation science is to provide techniques that will help interpret and understand objects, to better inform conservation, display and storage decisions.

Spectroscopic methods are of particular value when considering the types of item typically found in the Library's collection. Mid infrared (MIR) and near infrared (NIR) spectroscopy allow the chemistries (and to some extent the microstructures) of organic materials to be examined, and so are invaluable in identifying the composition of components (including paper, parchment, adhesives, glazes, sizes, waxes and plastics); they are also of great use in determining the manner in which such materials change over time and under various different conditions, allowing degradation and deterioration to be assessed and characterised. Raman spectroscopy can permit a similar assessment of organic materials, although it is often less suitable for their routine analysis within the context of an institution such as the Library; in addition, however, it can provide valuable information about inorganic materials, and so is particularly useful for the identification of the pigments, paints, dyes and inks found on many manuscripts. Visible reflectance spectroscopy is also useful for assessing coloured materials, such as pigments and inks, and can be used to assess colour changes associated with ageing and deterioration. A common advantage of all of these techniques is that they possess the ability to be used without sampling, thus permitting non-invasive investigations, and in many cases they are suitable for *in situ* analysis, reducing the need to handle potentially delicate objects.

Case studies provide good examples of the value of these difference analytical techniques:

Infrared spectroscopy (both MIR and NIR) has been widely used to identify the composition of unknown components, and to assess the state of degradation, of objects in the Library's collection, ranging from parchment manuscripts to modern synthetic polymers. For example: MIR has allowed a number of polymers, plasticisers, coatings and adhesives found in early recording media to be characterised, not only allowing the objects themselves and the technologies of the time to be better understood, but also permitting the most appropriate decisions on future conservation and storage of the items to be made. NIR has been used to assess the fragility of documents which had been partially burnt as a result of bombing during the Second World War, based on chemical changes associated with intense heat, and to map how this increased vulnerability varied across each sheet; this enabled the documents to

be adequately supported where needed, and avoided the risks associated with both excessive and insufficient treatment.

Infrared spectroscopy has also proven invaluable in characterising materials used to treat and store collection objects. The ability to identify adhesives, for example, allows past adhesive treatments to be reversed with the minimum adverse effect on the object itself. It has similarly been used to determine the nature of surface treatments (waxes and glazes) on metal objects, enabling their compatibility with the long-term stability of the object to be assessed. Importantly the composition of a wide range of plastics, foams and adhesives intended for use in display and storage solutions have also been assessed, permitting the most suitable (and cost effective) approaches to be chosen.

Examples of these types of analysis, and their influence on conservation decisions, will be discussed in more detail by other speakers.

Raman spectroscopy has been used at the Library to assess paints and pigments found in a variety of objects, including Chinese Qu'rans and 19th century Indian miniatures. These were of particular interest as their mixed provenances (the combination of traditional Islamic and native Chinese techniques in the case of the Qu'rans, and influence of both Indian and British methods in the miniatures) meant that important information about the objects and the cultures from which they derived could be learnt through a better understanding of the materials employed in their construction.

Visible spectroscopy has also been shown to be valuable in examining and identifying pigments. In particular ease of use of the technique, combined with the relatively large areas that can be assessed, means that it is valuable in assessing differences in superficially similar regions of colour; for example, where a repair has been made using a paint of the same hue but a difference composition, where editorial changes have been made to a document using a different ink, or where different pigments have been employed for specific cultural reasons.

Overall, spectroscopy is of great value in assisting informed conservation decisions, and research carried out using these techniques not only enables a greater understanding of objects in collections, but also allows the methods themselves to be developed and refined to increase their suitability, ease of use and accessibility in future.

3. Research on Parchment Conservation

Mariluz Beltran de Guevara ACR, Paul Garside, The British Library

The manuscripts collected by Sir Robert Bruce Cotton (b. 1571, d. 1631) include some of the greatest treasures of English literature and history, including the Lindisfarne Gospels, two contemporary examples of Magna Carta and the unique manuscript of 'Beowulf'.

In 1731, they were housed in Ashburnham House, Westminster, where a fire broke out, destroying or damaging a quarter of the manuscripts

To support the conservation work, and to better understand the history and current condition of the manuscripts, a variety of analytical techniques were employed to assess the artefacts; these methods included near infrared (NIR) spectroscopy, mechanical testing, microscopy and moisture uptake experiments.

The overall aim is to increase accessibility considering the long-term preservation of the Burnt Cotton Collection which is one of the foundation collections of the British Library, and also to develop a knowledge base which will be of great value when considering other similarly damaged parchment manuscripts.

4. Understanding the effects of temperature and RH on historic parchments

Lee Gonzalez, Research Fellow, The National Archives

This presentation will provide an up to date evaluation of the present issues surrounding the understanding of how temperature and RH affects the structural components of parchment. It will also summarise the aims and objectives of a 3 year research project: 'From structural change to perceived damage' (SC2P) supported by the Science and Heritage Programme.

This presentation will describe:

a) The structural composition of parchment;

b) The problems associated with measuring structural alterations at varying temperature and relative humidity;

c) The questions that need addressing to further understand the effects on temperature and RH on parchment structure;

d) How the SC2PD project will address some of these questions.

In spite of the widespread understanding that storage conditions cause physical change to parchment documents; there have been few published scientific studies that have investigated the structural alterations that occur with changes in temperature and RH. There remains a need to understand more fully, which temperature and RH conditions cause damage to parchment records, and the significance of this for parchment storage.

Parchment is a heterogeneous matrix of collagen and its denatured form – gelatine. Because collagen at the surfaces of a parchment is exposed, it is the first to be denatured, usually through the action chemicals during the manufacturing procedure. Denaturation of collagen therefore processes inwards from the surface to the centre of a parchment. Consequently, parchments have a collagen core interfaced with a gelatine exterior.

Defining appropriate storage temperature and RH for parchments can be complex. Firstly, the optimal storage conditions for collagen and gelatine are different. Secondly, a parchment sheet may not degrade uniformly and different areas may have higher proportions of gelatine. Thirdly, the rate of structural change can be extremely slow, and there may be a considerable period before visual damage is observed.

Producing a method to evaluate condition of a parchment is complex. We have yet to agree what physical properties can be lost, and whether the loss of properties equates to a loss in some value that the object conveys. Moreover, condition assessments can be unreliable because individuals may have different opinions about the extent or type of condition, opinions of physical

condition may alter with time, and parchments may have existing physical damage that may obscure observations.

If we are to understand, which temperature and RH conditions are appropriate for parchment storage, we firstly need to understand the process of nano-structural alteration, and how this will affect a parchment record's perceived condition. Understanding this relationship is essential because it will enable archives to identify the critical structural alterations needed before the visual condition of a parchment record is irreversibly changed.

The purpose of the SC2PD project will be to investigate the progression of nano-structural change through to visual damage in parchment. The project will then use this information to aid the understanding of which temperatures and RH induce the required nano-structural change to cause visual damage.

5. Identifying diverse materials in library collections

Lesley Hanson ACR, Conservator, The British Library

The British Library Collections comprise a broad range of items and materials that challenge the standard notion of what a book is and what a Library holds. The preservation, storage and access needs for these items present the conservators with many challenges beyond those associated with Books and Paper.

Work has been undertaken to identify these items and provide recommendations and cost-effective solutions for collections that require different environmental parameters to BS 5454. This has involved surveying discrete collections, testing of old, current and potential housing materials to understand and prevent further deterioration and applying solutions from other conservation disciplines.

The Conservation Research section undertook mid-near infrared testing for materials identification on plastics and polymers, adhesives, foams, varnishes, lacquers and coatings. Oddy and A – D strip testing was used to ascertain the suitability and stability of storage solutions.

Deterioration of collection items has been observed in part as a result of well-meaning but uninformed choices in the past for housing and storage and a “have a go” approach to treatments. Areas of expertise needed have been identified and a recognition of the importance of closer working relationships across disciplines with experts from other institutions – particularly with conservation scientists.

New recommendations come with a need for continuous monitoring, testing and analysis, but also with an understanding that cost-effective, cheap solutions can work.

6. Heritage Smells!

Lorraine Gibson, Senior Lecturer in Analytical Chemistry, Dept. of Pure and Applied Chemistry, University of Strathclyde

A Mellon-funded project between the University of Strathclyde and the British Library involved indoor air sampling in national libraries and archives across the U.K. and Ireland. Sampling sites were chosen to include rooms with paper-based collections and locations which acted as 'sampling blanks'. Interestingly no sulfur dioxide was measured in any of the surveyed locations, regardless of content. On the other hand a large variety of volatile organic compounds (VOCs) was measured with acetic acid vapour and furfural being consistently measured at higher concentration in locations where paper-based materials were stored. This observation, together with VOC results obtained from sampling books with polymeric-based traps, led to the idea of the Heritage Smells project. Which simply put asks the key question; can we develop portable non-invasive tools based on our sense of smell that will aid (i) characterisation of materials, (ii) identification of objects at risk from deterioration or (iii) identification of volatile chemical hazards released from previously treated objects? This short presentation will summarise the results of the Mellon project and introduce the key concepts of the newly launched AHRC/EPSRC Heritage Smells interdisciplinary grant.

7. Non-invasive spectral imaging for identification and assessment of conservation materials

Fenella G. France, Preservation Research and Testing Division, Library of Congress

The conservation of our cultural heritage provides an ongoing challenge: How best to understand the nature of the wide range of materials that make up our national treasures? Advances in non-invasive analytical techniques include hyperspectral and spectral imaging systems developed for astronomical imaging and remote sensing that have been adapted and customized for libraries and museums. The Library of Congress has been developing the application of hyperspectral imaging to the preservation of cultural heritage materials. This serves as a powerful technique for assessing collection objects utilizing an imaging system that captures the spectral response of materials from the ultraviolet, visible and near infrared regions of the spectrum (UV-VIS-NIR). The imaging system comprises a 39 Megapixel monochrome camera (7216 x 5412) MegaVision E6 back, and APO-Digitar 5, 6/120 lens, and the camera setup is integrated through customized software with light emitting diode (LED) illumination panels that span the spectral range of 365nm to 1000nm for reflected, transmitted and raking (side-lighting) imaging modes. The non-destructive spectral imaging can be used to characterize cultural heritage objects by capturing the unique chemical spectral response of these materials; including substrates (paper, parchment, photographic materials, ceramics) and media (inks, pigments, colorants, glazes). The full width at half maximum (FWHM) spectral curves for individual LEDs ranges from ±3 to ±15nm. Remote sensing imaging spectroscopy has demonstrated that many surface features have diagnostic absorption features that are 20-40nm wide at FWHM, enabling these spectral imaging systems to acquire data in bands of a width that provides sufficient resolution for the direct identification of a wide gamut of organic and inorganic materials. Capturing UV, VIS and NIR spectral data in various illumination orientations minimizes handling of fragile items and allows greater capacity for materials analysis and post-acquisition processing. All images are accurately registered, enabling almost unlimited combinations of spectral wavebands for processing and characterization. Filters for fluorescence and polarizing have been integrated into the system to expand the current imaging capabilities.

Advanced imaging characterization of materials provides greater access to the object and enhanced non-visible and visible preservation and obscured information in registered, high resolution digital images. In addition to spectral characterization and identification of materials, this non-contact tool has the capacity to monitor storage and exhibition changes or deterioration in parchment, paper and other materials due to environmental conditions, and assess treatments that can modify the chemical and spectral responses of cultural heritage materials. Critical components of the ongoing development of the Library imaging program include: the development of a spectral reference database, the integration of data from other non-invasive analytical techniques, and a full analytical mapping of objects for non-destructive analyses of collection materials. In addition, the resulting cube of spectral data acquired

creates a new “digital cultural object” that is related to, but distinct from the original. Coordinating the relationship between these two enables greater access to preservation and scholarly information since identification of materials enables preservation decisions to be made, and provenance, geographical (spatial) and temporal information to extend knowledge about the collection object, without the requirement for samples to be taken. The range of data this *object* contains enhances interaction between a range of professions, allowing multidisciplinary collaboration for integration of preservation, sociological and cultural information. The digital data balance preservation and access to the original, requiring standardized processing, metadata and data management. Significant advances in technology have enhanced the field of spectral imaging, which have been further enhanced through improvements in image capture techniques and specific post-image processing. While the Library has endeavoured to utilize open source software, the need for a standardized product and procedures led to analysis and comparison of a range of freely available and off-the-shelf (OTS) image processing software packages. Due to the complexity of analysis, the application of more mature spectral processing software has provided the required results, and the ability to install and utilize robust and sophisticated algorithms.

Hyperspectral imaging, with its ability to spectrally classify materials and map the distribution of these components across the surface of heritage materials has begun to be used as an initial examination for all Library collection items. This provides a baseline for determining and identifying where visually similar but spectrally different compounds are located on the object. The spectral mapping generates an overview of areas of interest, including those illustrating spectral anomalies to suggest regions where complementary instrumentation techniques should be utilized to complete examinations. The identification of conservation materials requires the spectral reference database materials for accurate classification.

As a specific example of the application of spectral imaging in the Library: the origin of Portolan charts (early nautical charts) has perplexed generations of cartographic historians. There is little to indicate how the charts evolved, but they demonstrate a high level of accuracy from their initial production in the 1300s in Italy, Portugal and Spain. The Library conducted research into five representative portolan charts in the collection covering the period 1320 to 1633 to assess and characterize components of these charts. This began to address a range of questions: Were colorants commensurate with the time period and geographical location? If differences from what was expected were observed, did these give insight into trade routes? Characterization of colorants present on the charts was confirmed through the use of additional non-invasive analyses, including portable x-ray fluorescence and x-ray diffraction. Spectral data for comparative assessment of the colorants present on the Portolan charts were obtained from a range of naturally aged pigment reference samples. Spectral data matched well for vermillion, an opaque red pigment used since antiquity. Originally derived from the powdered mineral cinnabar, the technique for synthesizing vermillion became widely known in Europe by the 14th century, greatly reducing the cost. When compared with x-ray diffraction, there was a clear positive for cinnabar on the red of the charts, while x-ray fluorescence confirmed the presence of mercury.

The Library has conducted spectral imaging of a variety of collection materials prior to exhibition, including daguerreotypes, Herblock political drawings and maps, to detect any non-visible changes due to display conditions. Objects are imaged under the same conditions during and after exhibit to assess changes from the baseline images, and provide a real-time conservation monitoring tool specific to the specific object and environment. Analyses are currently underway, including assessing optimal storage conditions. The development of a spectral reference database is part of a broader initiative at the Library: the Center for Library Analytical Scientific Samples (CLASS). These reference samples include paper, parchment, pigments, modern digital media, plastics and housing materials, and have been either naturally or artificially aged. Access to the data about these and Library collection objects will be available through CLASS-D (the digital framework that houses the standardized file formats), with samples of the physical reference materials made available upon request.

8. Integrated modelling: the demography of collections

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In the recent decades, an impressive amount of knowledge on paper-based collections and their environments has been accumulated. Many chemical degradation mechanisms are known in detail, non-destructive tools to rapidly characterise objects have been developed, and environmental changes can be predicted, however, a general model of interactions between archival and library collections, the environment and the users is still lacking.

In the Collections Demography project (2010-2013), such a model will be built by exploring the analogies between books as individuals and collections as populations. The useful lifetime of an object will be defined through the lens of values attached to objects and by applying an appropriate dose response function.

To explore the aspect of values, interviews and workshops will be organised with library/archival users, not only to identify which sets of values are of key importance (e.g. utility, existence, aesthetic), but also whether and how they depend on the material condition of an object. The latter will be modelled based on a dose response function describing material change in dependence of not only temperature and relative humidity, but also typical pollutants found in archival and library collections: nitrogen dioxide and acetic acid. Future indoor environmental conditions will be modelled based on climate change predictions and building models, and will again include physical as well as chemical parameters (pollution).

The integrated model will enable us to explore various scenarios of collection care and management, particularly how changes in the environment and strategies of access/use might affect the useful lifetime of paper-based collections. This will feed into institutional policies, but will also affect environmental guidelines and standards.

This exciting interdisciplinary project involves conservators, art historians, chemists, environmental, building and material scientists alongside statisticians and ensures a holistic approach. The project is supported by the AHRC/EPSRC Science and Heritage Programme.

9. Influence of the Environment on Collections in Mass Storage

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University of Lincoln[1]; British Library[2]

There have been a significant number of developments in the design of archive and library storage over the past two decades. A notable design feature is to create high density, automated facilities similar to those used in the commercial warehouse sector. This borrowed technology has been adapted to meet the necessary standards for the storage of paper-based material (BS 5454), notably introducing facilities to aid in preservation-quality environmental conditions. The British Library, in response to the demand for increased storage, has built one such facility in Boston Spa. Providing storage for 20% of its collection, this new facility has a sophisticated building management system that goes beyond simple temperature and relative humidity control. It also offers a reduction in the oxygen content of the atmosphere, one of the major catalysts for decay, as part of the fire suppression system.

Like many other institutions, the British Library has been renting storage space from the commercial sector, such as the Armstrong Gun Factory situated in Woolwich. However, this historic building has not been designed to meet library or archive storage standards. Built in 1858, the building offers only basic environmental control, and as such, the collection is at risk from exposure to varying environmental conditions. These conditions rarely conform to the British standard (BS 5454). The collection housed in Woolwich, therefore, has now been transferred to the new facility in Boston Spa. The *en masse* collection move presented a unique opportunity to study, and gain an understanding of, how a real collection will respond to moving from a historic building environment to a highly controlled, low oxygen conservation environment.

As part of a three year AHRC-funded research project, ten books, containing temperature and humidity recording dataloggers, were placed within the mass of books in the Woolwich collection. Following equilibration to the storage environment, these ‘dummy books’ were transferred to the new facility in Boston Spa in November 2010, along with the Woolwich collection. The dummy books will monitor internal changes in RH and T as the collection equilibrates to its new environment.

This research aims to understand and quantify the influence of the low oxygen environment on the significant collection at Boston spa. Key research questions are: to what extent does the buffering capacity of the mass of paper govern the interaction of the collection with the environment? What effect does the degradative state of the paper, the average age of the collection, influence how it interacts with the environment? What is the effect of a reduced oxygen environment on the preservation of the collection?

Laboratory-based investigations are currently under way to determine; the effect of buffering capacity on collection interaction with simulated environmental conditions; the effect of a reduced oxygen environment (5-15%) on the decay rate of paper exposed to accelerated ageing conditions (80°C) in a controlled oxygen and humidity environment; and identification of markers to measure the influence of the environment, including using moisture sorption as a potential degradation marker.

11. Understanding the environment in an archive store

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The National Archives (TNA) is the official archive of the UK government. One of the main aims of TNA is to preserve and protect its 11 million records that date back over 1000 years and occupy approximately 180 kilometres of shelving. The majority of TNA's collection is stored in 15 repositories on the Kew site. The three main repositories are in the 1978 building referred to as Q1 and further 12 are in the 1996 Q2 building. The larger Q1 repositories are open plan, with an area of approximately 6500m^2 each. The repositories in Q2 are approximately 700m^2 to 1000m^2 each, and are arranged over four floors.

The Collection Care Department has been monitoring environmental conditions (relative humidity and temperature) very closely in the repositories since 2008. Over 12 million individual data points are collected every year. To interpret and interrogate the data, a comprehensive annual environmental assessment report (AEA) is carried out. The AEA enables a retrospective evaluation of the preservation storage environment by creating a comparative and accessible annual record of the conditions in the repositories. This assessment marks a distinct departure from evaluating environmental performance based on a narrow range of environmental conditions as a success measure, to an evaluation based on the assessment of a range of interdependent factors that impact on the preservation of the collection. These are: chemical degradation, environmental stability, the probability of mould growth and the impact of the external environment on the conditions achieved inside the repositories. Furthermore, the AEA makes an important contribution to the understanding of the collections' environment; providing critical evidence to inform TNA's strategic plans, preservation policy along with upgrades and maintenance of the building and its systems.

Environmental monitoring data also provided the cornerstone in the development of a computer simulation model of the three repositories in Q1. Created in collaboration with the Centre for Sustainable Heritage, University College London, the model used *EnergyPlus* software to examine several what-if scenarios with a view to optimising environmental management and meeting energy usage and carbon dioxide reduction targets, whilst providing an appropriate preservation environment in storage. The model shed light on the interaction between building, outdoor and indoor environment and the collection. The main outcomes of the scenario testing indicated savings in energy load between 20% and 40% are possible whilst maintaining appropriate environmental conditions in storage. The highest energy savings would be achieved at TNA by seasonally cycling the air-conditioning system set point for relative humidity and temperature.

On a smaller scale, the investigation into the interaction between the records and their surrounding environment continues with experiments exploring the capacity of archival boxes, in which the collection is stored, to buffer against

changes in space conditions. Environmental monitoring data loggers were placed in cut-outs in the centre of paper records and also on top of the records inside typical archival boxes. The boxes were subjected to changes of ambient relative humidity inside an environmental chamber and the response inside the boxes was recorded over time. Initial results show up to three weeks time lag for the same ambient relative humidity change to occur inside the centre of a full archival box. The experiments continue in order to compliment the results of the modelling and refine TNA's environmental control strategy.

Finally, to complete the picture and improve storage conditions for vulnerable material, further evidence on physical make-up of the archive was required. The aim of mapping the archive in terms of material was to locate specific types of material with a view to moving it to repositories where storage conditions can be more easily adjusted to their requirements. Building management software was used in order to present the data in usable, visual format. Data from TNA's catalogue, collection surveys and CAD drawings were combined, so that each storage bay in the repositories was coloured according to the physical material stored there. The resulting maps illustrate what materials are present in The National Archives collection and how they are distributed in the repositories, providing for the first time a visual representation of the collection by material type in storage.

The first practical outcomes of the increasing understanding of the collection and its environment are a new operational strategy and schedule for the air-conditioning system, and the creation of a dedicated repository for all photographic and film material, with conditions more favourable for their long-term preservation than the general conditions for paper based material in the repositories.

12. Redefining environmental standards for libraries, archives, and museum collections

Nancy Bell, Head of Collection Care, The National Archives

A range of published standards are available which are usefully applied to collection management and conservation activities. Whether intended to serve a national, international, or professional audience, or designed to meet legal or technical regulations, standards offer a critical starting point, a measurable benchmark against which performance can be evaluated. Published standards are a powerful tool for conservators and collection care managers since they are based upon the collective view of experts and the synthesis of research.

Recently, environmental standards developed within the last ten years in the UK have been criticised for being overly prescriptive and heavily reliant on energy intensive heating, ventilation and air-conditioning systems. A statement issued by the UK National Museum Directors' Conference (NMDC) that 'museums need to approach long-term collections care in a way that does not require excessive use of energy, whilst recognising their duty of care to collections', supports this view. This claim was further debated in 2009 through an AHRC/EPSRC Science and Heritage Programme research cluster 'Environmental Guidelines: Opportunities and Risks (EGOR). In response to these events a project was initiated to develop an environmental standard for the UK to help users make judgements about specifying safe environmental conditions which meet the requirements of particular collections while taking account of the need to reduce energy use. It is against this background the development of British Standards, Publicly Available Specification 198 was launched.

This presentation will present an overview of PAS198 drawing particular attention to how scientific evidence is being used to underpin environmental standards and will give a prospective view of how scientific research currently underway in the UK has the potential to improve and deliver a next generation of environmental standards.

13. The Identical Book Project and After

C Velson Horie, Collection Care and Conservation Consultant
www.horie.co.uk

For a conservator, the intended end result of any action is the preservation of an object. This action can be at any level, from the repair of a page to changing of inter-national political structures. An action that influences at many of these levels is likely to have a greater long term effect in improving the preservation of objects. The Identical Book Project[i] (IBP) was designed to make a difference at a number of levels. These were expressed in the aims of the project, initially and as it developed. Because this was run as a partnership, there were a range of aims for each participant. These were expressed as objectives, deliverables, outputs, outcomes, aspirations etc.

IBP was funded by the Andrew W Mellon Foundation, from 2006 to 2009. It was a partnership of the 6 UK Legal Deposit Libraries, 2 major UK national archives and 2 academic research departments.

Aims:
To provide information about the differential condition of books in the libraries, relating these findings to the environmental history of the books.
To develop knowledge about the volatile organic compounds (VOCs) present in the stores and books of the institutions.
To develop familiarity with research skills, enabling them to grow in house.
To bring the institutions together for synergistic research.

So what did we achieve? How are the lessons being applied and taken forward?

The research material
One of the immediate problems posed by the research method was the interface between two very different ways of approaching conservation.
Active conservation changes an individual object over a short time period. Systems, tools and people have developed and refined to achieve desirable changes. The outputs of this conservation treatment is a conserved object whose before and after states can be assessed to demonstrate the increased value of the object in comparison with the costs of conservation.
Passive conservation deals with many objects, perhaps millions at a time, with the aim that the process will improve the preservation of the objects. A successful treatment occurs when one cannot see any difference between the before and after states. The justification of passive conservation is the comparison of the projected loss of value if nothing is done against the costs of the conservation.

The project attempted to use existing and emerging technologies to assess the condition of individual objects. This database would allow the comparison of condition across the various variables measured, e.g. age, publication type, library. In total, ca 1,800 items were assessed at considerable cost to the project budget and the holding institutions. The major conclusion was that the physical condition of libraries' holdings was very similar, probably because the

environmental conditions within the libraries was similar over the last 100 years. The other major conclusion was that, although measuring (and therefore comparing) the condition of individual objects gave valuable baseline information, the costs (time, money and risk to objects) of current methods are prohibitive. Some other method(s) had to be found.

Value of objects

During the lifetime of the project, a number of major library initiatives were underway in the UK e.g. Additional Storage Building for the BL (low O_2, completely mechanised warehousing for printed materials) and expansion of digital holdings and access. The duty of libraries to treat every item as an individual yet manage millions at a time is resulting in increasing use of industrial methods of physical and information management. The large and growing costs of preserving paper objects need to be justified in terms of their value. The conservation community has to be part of the debate and decision on what to preserve and how much resource to devote to preservation.

The smell of books

Harnessing the dusty library smell to assess book condition attracts considerable interest. As the IBP discovered, a quick, non-contact, automated method of assessing book condition is required if the books in existing collections are to be monitored. To date, the best candidate for this is sniffing the atmosphere around an item producing volatile organic compounds. Out of the IBP has emerged Heritage Smells[ii], a project funded by the Science and Heritage Programme, which aims to develop this technology for diverse collections.

Library based research

The baseline data gathered during the IBP will be valuable if they can be projected long term trends. Conservators who had been involved in the project came together to collaborate in documenting the changes and re-measure the books over coming years. A major finding of the IBP was that it is not possible to reconstruct the history of storage conditions of the item in the collections because of the paucity of item level records. In addition, Strlic showed that the variability in relative humidity and temperature conditions across a single store can be greater than that between stores[iii]. This group is developing new ways of integrating separate collection and conservation management systems.

Research applied to conservation care

This project aimed to demonstrate the transfer of basic knowledge to conservation. It demonstrated that the challenges of libraries are of a different type and scale to similar efforts with other collections and require the use of skills from other fields such as industrial processing and statistical epidemiology. The systems are being built to achieve this.

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[i] http://www.bl.uk/aboutus/stratpolprog/ccare/events/BL%20Paper%20Conservation%20V7.pdf

[ii] http://www.chem.strath.ac.uk/people/academic/lorraine_gibson/research/heritage_science

[iii] Strlič, M et al, Are the Identical Books still identical? Correlating the measurements, in *Advances in Paper Conservation Research*, ed. C.V.Horie, British Library (2009) 36-37