Conservation Matters in Wales

On Display: Showcases and Enclosures

Post prints of a one day conference held on Thursday 14th June 2007
at The Oakdale Institute, St Fagans: National History Museum, Cardiff.

Conference organised by the Federation of Museums and Art Galleries
of Wales and National Museum Wales, supported by CyMAL.

national museum wales
amgueddfa cymru

Federation of Museums and Art Galleries of Wales
Ffederasiwn Amgueddfeydd ac Orielau Celf Cymru

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

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On Display: Showcases and Enclosures

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Publication produced by the Federation of Museums and Art Galleries of Wales and National Museum Wales, supported by CyMAL.

Edited by Jane Henderson, Cardiff University.

ISBN 978 0 7504 4565 8

Organised by R E Child, Jane Henderson, Heather Perry, Lynn Weaver, Chris Wilson.

Design and creation by Designworld www.designworld.co.uk

Aspects of the History of the Showcase

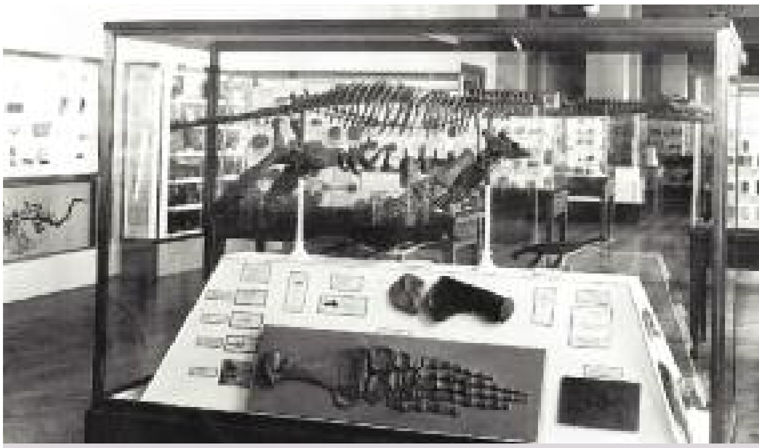
Caroline Buttler

The Development of the Showcase

Prior to the 15th century works of art were generally preserved in churches. The Renaissance saw the growth of private collections, known as Cabinets of Curiosities[1].

These were personal collections of things of wonder; they were also called Wunderkammer (wonder chambers). The term referred to rooms as well as ornate individual cases. The collections were eclectic and included objects from natural history (sometimes of dubious origin, such as unicorn horns), ethnography, archaeology, religious or historical relics, as well as works of art. It became very fashionable to own a Cabinet of Curiosities in the 17th Century and the objects would show the wealth and status of the owner. In Amsterdam, between 1600 and 1740, over 100 private collections were recorded [2].

During the 18th Century, the cabinets of curiosities began to be dismantled, some being transformed into more formal collections with stricter standards of scientific classification and curation. This period was a time of great colonial expansion and voyages of discovery, which resulted in vast new collections being made and brought back to Europe. The 19th century saw the foundation of many museums, both national and provincial. These institutions developed into public arenas for the display of knowledge and artefacts, rather than the private expression of individual interests. Objects in the new museums were displayed in showcases of styles that are still used today: tall glass-fronted cabinets with shelves, and low desk top cases.



Traditional display cases in the old geology galleries at the National Museum of Wales

Display cases from the old archaeology galleries at the National Museum of Wales

Controlling the Environment within Showcases

The damaging effects of the environment on museum specimens have long been recognised. In 1850, Dr Gustave Frederick Waagen, Director of the Royal Gallery in Berlin, reported to the Parliamentary Select Committee on the National Gallery in London that:[3]

The greatest enemy to pictures is damp; and to avoid that, we have a system of maintaining a medium temperature, not too cold and not too warm. In the winter… all the rooms are heated with warm air; but to avoid the great dryness of that air in every place, a vessel with water is placed in each room, and the air is moistened by the water…

Protecting specimens from adverse environmental conditions was developed in the 19th century by using display cases and cabinets of stable hardwoods, such as mahogany, and glass. These provided well sealed environments that gave some climatic buffering but did not give adequate protection for sensitive material.

Humidity Control

One of the first methods of modifying the environment within a display case was suggested in 1933 by Wilsden & Burridge[4] from the Building Research Station. They submitted a patent entitled *"Improvements in controlling the humidity of air in enclosed spaces such as containers, picture frames and rooms"*. Their idea was to control the humidity within a display case using salt hydrates. The enclosure was sealed so that all air entering the case was forced over a pair of such salts. They suggested using hydrates of zinc sulphate ($ZnSO_4{,}7H_2O$ and $ZnSO_4{,}6H_2O$) in sheet zinc containers. At a specific temperature a required level of relative humidity could be achieved because excess moisture was absorbed by one salt whilst the other would release moisture if the air was too dry. With limited air change and fluctuations in temperature the relative humidity could be controlled. Dry salts not saturated solutions were used to prevent any damage caused by liquid leaking or spilling or from crystals creeping over the sides of the container.

This method was described in 1936 by Stanley Cursiter[5], director of the National Galleries of Scotland, for the Trinity College Altarpiece panels. The panels were re-framed including a pedestal base containing trays of salt hydrates. Hepta and hexa-hydrates of zinc sulphate were used, which at 16°C gave a RH of 55%. The glass of the case was bedded in plasticine and the joints made air-tight with wax and surgical tape.

A showcase set into the floor at the National Museum of Wales

Silica gel was first suggested for use in museums to control the environment in 1956[6]. For the environment inside the case to be conditioned evenly it is necessary to have some circulation of air. This can be achieved by including a fan, possibly attached to a humidistat which will turn it off and on. The Canadian Conservation Institute have developed cases which incorporate a supply of conditioned air[7] through a 6mm tube which is then vented either by a 3mm hole or leakage. Other methods have been suggested to control the humidity in display cases, for example, an electrolytic water removal device[8], which uses a solid polymer electrolyte membrane to decompose and remove moisture.

Oxygen Control

Many of the processes that cause the deterioration of museum specimens could not occur without oxygen. However, creating an anoxic display case is a technically challenging and costly process.

One of the first anoxic cases made was to exhibit the American Charters of Freedom in the Rotunda of the National Archives Building in Washington, DC. The Charters include the Declaration of Independence, the Constitution and the Bill of Rights.

During the 19th century, the Declaration of Independence had faded badly, largely due to poor preservation techniques. In 1951, individual pages of the Charters were hermetically sealed in glass cases containing a humidified helium atmosphere, and put on display. However, in 1995, microscopic crystals and liquid droplets were detected on the inside surface of the cases. It was considered that the crystals were the result of glass deterioration and did not pose an immediate threat to the Charters[9]. The cases and parchments were monitored for 5 years until 2001 when the Charters were removed from display during renovations.

Conservation work was carried out on the documents and a new display method designed. The new cases were built by the National Institute of Science and Technology. Inside a titanium frame, an anoxic environment was created containing a humidified (40% RH) argon atmosphere at 19°C. The argon atoms are larger than those of helium and so less likely to diffuse out of the enclosure. The advantage of the new frames is that they can be opened if necessary, unlike the previous ones. The Charters were returned to display, in the renovated Rotunda, in September 2003[10].

The use of nitrogen to provide an environment for storage was investigated by a team from the Getty Conservation Institute considering oxygen-free showcases for the Royal Mummy Collection in the Egyptian Museum in Cairo. Similar designs are now being used in other museums, for example for the display and storage of the Constitution of India at the Parliament Library in New Delhi[11].

Anoxic cases are ideal for unstable specimens such as archaeological iron and water colours with fugitive pigments. However, their cost makes it unlikely that they will become standard in museums.

Showcase Design

Showcase design has developed over the last century: initially they were usually built of wood with glass and metal fittings. Some of these original products were very effective but can now no longer be used, for example mahogany, ebony and other hardwoods. As new materials such as plywood, MDF and plastics began to be incorporated into display cases they brought problems of off-gassing corrosive vapours and have to be sealed.

The interior design of cases has followed general fashion trends. In the 1960s and 1970s bright colours such as orange and bright greens were used as well as textured backgrounds, such as Hessian and Artex. The simple showcase with four glass walls and a wooden base has been complemented with cases designed for specific displays which can be revolving, suspended, attached to the ceiling or set in the ground.

Although old wooden cabinets have been replaced, it was realised that these display cases were beautiful in their own right and popular with the public. Some museums have now returned their galleries to how they looked in the past, for example the Victorian natural history gallery in Ipswich museum. There appears to be a place for both old and new styles of showcase in museums today. ■

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A large revolving paternoster lift which brings objects to the visitors as the cases revolve at the National Waterfront Museum in Swansea

Exhibit Showcases – The Designer's Point of View

Heather Maximea

Background

My perspective is as a museum consultant, not an exhibit designer *per se*, but our practice at LORD involves working closely with architects, designers, engineers and museum professionals in the creation or renovation and re-imagining of museum buildings and spaces. My job is focused on space and buildings, and building systems, but in each museum I work with I do detailed tours of the exhibits and hear staff talk about what works and doesn't work with their existing casework.

LORD has produced a series of museum manuals, one of which is the *Manual of Museum Exhibitions* in which I wrote the chapter on exhibit spaces. In putting together this volume we were almost overwhelmed by how much there is to say about the whole practice of museum exhibits. This is a young and evolving field and one in which the conversations and controversies are ongoing. The discussions go on but what is essential is to find the right solution and balance for each new exhibit project.

Modes of Communication

The four main "MODES" of exhibits that LORD uses for planning are:

1. *Didactic / Aesthetic*
2. *Hand-on minds-on*
3. *Multimedia*
4. *Integrated environment*

Each of these has the potential to have art, artifacts or specimens involved, so each may have an element which requires enclosures. For example, the Multimedia exhibit *Peter Rabbit's Garden* includes small cases containing first editions of the Beatrix Potter books. An integrated environment may consist of a full-scale recreation of a time and place through replicated buildings, rooms, ship interiors, etc, but within it may contain authentic artifacts that will require some level of protection.

Types of Display

There are a number of different exhibit types.

- *Aesthetic:* typically used in art galleries, wall-hung, or floor or ceiling supported installations of art works, furnishings and decorative arts objects. Limited use of enclosures or showcases, mainly for portable items of high value.
- *Visible Storage:* a comprehensive exhibit based around dense display of comparative collections, accompanied by information. Visible storage is evolving, with many installations being requested by museums who want to make more of their collections accessible. Showcases in this instance must be designed for long-term, perhaps virtually permanent, display and for density.
- *Thematic:* a comprehensive exhibit based around a story, often including recreated and immersive environments, vignettes with real artifacts, casework, interactives, etc.
- *Plug & Play:* exhibits composed of separate exhibit elements which can be individually changed, often seen in children's and science museums, but also can be modular cases in which artifacts or specimens are changed regularly.

The Exhibit and Production Process

The development of any exhibit is a complex process, which includes a thoughtful development of ideas, a winnowing down of messages, research and selection of content, and a number of design and production stages leading to opening day.

Interpretive Plan or Design Brief

The Interpretive Plan summarizes the museum's vision for the exhibition. It describes the highlights of the visitor experience, defines communication objectives and identifies the uses of collections and media. Development of the plan may include:

- *Visioning workshops*
- *Schedule and budget*
- *Visitor experience – ideas, messages*
- *Collections resources and requirements*
- *Resources – gallery space, budget, in-house skills*
- *Collections review*
- *Front-end and formative evaluation*

The development of a realistic preliminary budget and schedule should be mentioned here, as this is where you may have the opportunity to advocate for enough time being allowed to do the job right. Starting at the hypothetical "opening date" and working backward through the necessary time for each phase can show where a project may be overly ambitious. Whether an exhibit designer is involved at this stage of planning varies widely. If there is an in-house designer, he or she may well be on the planning team from the word go.

In a museum without designers other staff may work through this stage on their own, then hire a designer to help them progress through the following stages. Yet again, the museum may hire an exhibit design firm to help them through the entire process.

Design Development, from Concept through to Shop Drawings

Design is the 3-Dimensional and graphic realization or "spatial interpretation" of the interpretive plan and concept. It involves several stages of development including:

- *Concept design*
- *Schematic design*
- *Detailed design*
- *Construction drawings, tender packages, specifications*

These design steps are similar to those found in architecture or interior design, and are planned to allow for sequential input and approval from the client at each stage of development.

Parallel to these processes on the design side are curatorial and conservation processes, which include selection of artifacts, development of conservation requirements, content research, selection of graphics, scripting and label writing, etc.

All through the Design Development phase, there should be opportunities for staff to review the emerging plans and to have significant input. Maintaining a strong presence, and taking the time to carefully review the design drawings as they emerge, can head off ideas which may not be workable from a conservation standpoint, and to agree to acceptable compromises.

Bidding or Tendering the Design Package

The bidding or tendering process allows for each part of the exhibit package, which may be broken down into separate packages for casework, reconstructions and replicas, multi-media, graphics, and other specialties, to be assigned to a selected specialist firm. In some cases, an exhibit design firm may act as a kind of general contractor and take responsibility for subcontracting out each specialty and delivering a finished product, or "turn key" exhibit. The critical thing here for the museum is to have control over evaluation of the bidders' capabilities to deliver a quality product, and over which bidder is ultimately selected.

Fabrication

During the fabrication period, when different parts of the exhibit may be in the hands of various outside firms, it is key to have a specified fabrication process and schedule which should allow for samples and prototypes to be signed off by the museum as being satisfactory before they go into final production. While fabrication of the major exhibit elements is underway other elements must run in parallel including detailed case interior layouts, final artifact selection, conservation, mountmaking and graphics.

Installation, Testing and Commissioning

One lighting designer complained to me recently that the critical moments for his job come right at the end of the exhibit installation process, when there is often not enough time available to do the job correctly. This occurs when delays and over optimistic forecasts of completion dates snowball, and the opening looms nigh.

Scheduling enough time for a careful installation process can only be achieved by allocating a realistic amount of time required for each function.

Evaluation

Your next exhibit will benefit from your evaluation of your current one. We at LORD believe it should be incorporated into the beginning, middle and end stages.

- Evaluate the exhibit against the Design Brief – how closely does the finished exhibit meet the material requirements laid out by the client? Are all exhibit elements acounted for? Are all interactives, lights, etc working as they should be? What deficiencies can be identified? What problems would account for any physical problems with the exhibit?
- Evaluate the exhibit via the experiences of visitors. Were the communications objectives met? What is the visitor's reaction to the design and layout, the colors, artifacts, interactives, etc?
- Evaluate the conservation systems, based on records kept during the exhibit preparation and the period of the exhibit itself.

Design Issues

The goal of the Exhibit Design and the finished product is to meet the Design Brief. The principles of the brief can be used as a checklist for evaluation during design or of the finished installation. The common aim of the design process for casework is to support the exhibit project specifically, but also to support the access, communication and conservation goals of the museum. One exhibit designer told me:
"The aim of good exhibit (case) design is to provide the best possible access to artifacts within the best aesthetic and within conservation guidelines."

Aesthetically Pleasing and Suitable

- Does the casework design fit the ambiance of the exhibit space and its architecture, the theme of the exhibit, the aesthetic selected by the designer and approved by the client?
- Is the quality of materials and finish suitable to the purpose?
- Is the case suitable to the scale of the material it contains?
- Is the casework, mountwork or display system visually intrusive?
- Does the showcase work with other designed exhibit elements?
- Do other exhibit elements such as lighting support the case design, or show up its flaws?
- Does the case accommodate for visitors of different ages, heights, or physical challenges?

Functional/Flexible

- Does the casework contain and protect the artifacts? Is it structurally stable, properly finished inside and out and airtight?
- Is there a useful internal volume or usable space? How much material can be displayed in the given volume and configuration and what are the constraints?
- Can the case be accessed, opened for installation, cleaning, etc, readily and safely?
- Can the case contain the desired interior climate and also exclude dust, pests and intrusion and can this be monitored?
- Are materials and finishes attractive, hard wearing, easy to clean and vetted for conservation?
- How flexible is the case design in terms of reconfiguring either the existing exhibit, or use for future exhibits?
- If the case has features that require power and data supply are these well accommodated and are these accessible to staff but not to patrons?

Effective

- Is the casework effective in contributing to the overall success of the exhibit in conveying ideas, information, messages?
- Does the casework work to the goal to make artifacts, art and specimens accessible, available, within conservation principles?
- Does the casework use colour, lighting, viewing heights, etc to optimize visitor comfort and ability to focus?

Accessible

- Are the case contents visually accessible?
- Is it intellectually accessible? Is the casework getting in the way of the perception, the message, through an aesthetic or style that is unapproachable or intimidating?

Cost Effective

- Is the casework within budget?
- What are the details of availability and acquisition, design, ordering, fabrication, installation and commissioning?
- What is the cost to lifetime ratio?
- Has the ease of fabrication and of maintenance been considered?

Secure and Safe

- Does the case control environmental factors?
- Is there accommodation for microclimate equipment or connections?
- Have all access and human safety issues for visitors been considered?
- Does it provide safety for staff working with cases considering the strength and stability, dealing with weighty elements, the quality of hinges and latches and the use of lifting and holding equipment?
- Does it provide a good structural stability, workmanship and finish?
- Does it provide security against intrusion and vandalism?

Sustainable

1. What is the case's life expectancy for materials, power and data systems? Will it last the life of the exhibit?
2. Can the casework be reused in future exhibits?
3. Are materials selected for "green" principles? Have sustainable sources, recycling, local sources and manufacturing been considered?
4. Are low-energy light sources incorporated? Will lights, power to interactives etc. (but not to microclimates) be turned off in closed periods?

Universal Design Principles

Museums provide an almost perfect laboratory for exploring and exemplifying the principles of open or universal accessibility, often termed *Universal Design*. The Center for Universal Design at North Carolina State University describes the intent of universal design to simplify life for everyone by making products, communications and the built environment more usable by as many people as possible at little or no extra cost. Many of the design features that are user-friendly and flexible are simply good design practices, rather than requirements of codes, standards or guidelines.

In the USA, the Smithsonian Institution is a leader in promoting universal design principles in exhibit design. Museums which have incorporated the principles into facilities, exhibit and communications design include the Cincinnatti Children's Museum.

Qualities of Good Design

The Exhibit Designer's ideal showcase may be described as *"the right exhibit showcase for the right situation".* A good exhibit design eliminates the invisible frontier between the spectator and the medium and itself becomes the interface with the visitor.

A well designed case will encompass the following qualities:

- The casework, backdrop or props should support but not supplant the authentic experience or the message
- The interface with the user should be easy and simple
- The interface should be so transparent that it virtually disappears
- The interface should be designed to bring the viewer to the content and the content to the viewer

Ralph Appelbaum described his work for the American Museum of Natural History Fossil Halls:

"We discovered that the most effective design was one that seemingly vanishes – that helps to focus attention on the subject by orchestrating an array of details of which the visitor may not even be consciously aware."

The Conservator's Ideal Showcase (or a display case that does the job and keeps everyone happy including the objects)

Andrew Calver

Introduction

Display cases or object enclosures come in many shapes and sizes from very small cases built into graphic panels to massive enclosures such as that used for the ss Great Britain to provide a microclimate where the visitor is within the 'display case'. Conservators often spend considerable time drawing up display case specifications only to find that the cases, when installed, fail to meet the specification in some way. It is thus important to understand the functions of a display case, how these can be achieved and what the common pitfalls are. Although in many ways storage cases serve the same functions as display cases the ideal can be met more easily by the conservators as the 'design police' may not be as interested, resulting in poor functionality. This is thus a plea for more attention to be given to storage units as well.

The purpose of display cases includes:

- *Security – prevent loss or damage*
- *Microclimate – provide conditions different from ambient gallery*
- *Access – provide an opportunity to get closer*
- *Aesthetics – to 'showcase' objects*
- *Safety – to protect visitors from objects*

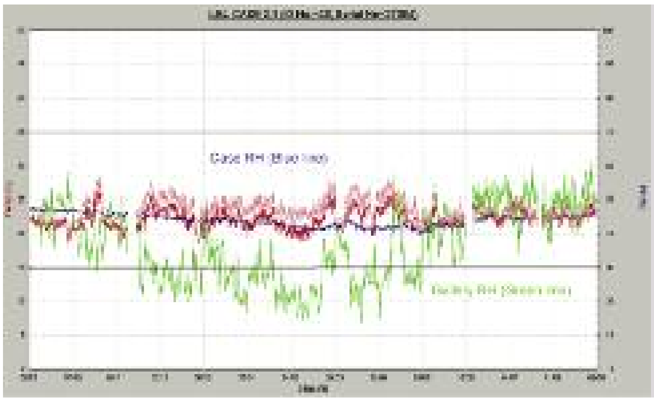

Figure 1. Comparison of case and gallery conditions

The primary purpose of a display case is security. There is a wide variety of security standards available for display cases but some, especially those that are not designed for museums, can be very insecure i.e. cases used in shop fitting. The MLA display case guidelines provide a good starting point[1] and must normally be met to ensure Government Indemnity[2] cover. An important point often neglected is that all sides of the case should be secure, not just the glass but also any solid panels. Framing will be required for very high security cases and this is often disliked by designers. Locks and their positions are very important: it is pointless having anti-bandit glass and a high security lock if there is only one lock at the bottom of a large case and the door can be levered open. There is a new British Standard [3] for security glazing, BS EN356, which replaces BS 5544 but not very many case manufacturers are using this specification yet and it has several levels of security. Laminated not toughened glass should always be used.

For conservators the main purpose of using a display case is to provide a micro environment. Well sealed cases can dramatically reduce the amount of dust in cases, preventing soiling and reducing cleaning costs. Well sealed cases, normally less than 1 air change per day can also be used to provide relative humidity (RH) conditions that are different from the exhibition space either using buffers such as silica gel or mechanical systems. Low air exchange cases and a sufficient quantity of buffer make it possible to stabilise a display case to the mean annual RH of the gallery. *Figure 1* shows how a display case can provide stability, preventing the case environment dropping to the very low winter RH levels experienced in the gallery.

Display cases will dramatically reduce the level of externally generated pollutants but well sealed display cases can potentially have high levels of internally generated pollutants that are emitted by construction materials or even the objects themselves. It is very important to test all display materials and avoid, wherever possible, materials such as wood based products that are known to cause problems. Metal, glass and some plastics are ideal but are not always practical. Wood products such as MDF are favoured for lining panels as they are easy to fabricate and allow mounts to be easily attached. Normally these wood based boards can be covered with a barrier film and then fabric wrapped but in the last few years there has been a preference amongst museum designers for paint finishes rather than fabric which has caused problems with this technique. All materials used in the construction and fabrication of the display interior should be stable and chemically inert after the requisite curing period, however it is often found that sufficient time for curing has not been allowed or that coatings have been incorrectly applied. This can lead to very high levels of volatile organic chemicals in display cases even after several years.

It is often argued that to increase access objects should not be shown behind glass and there is a trend for more objects on open display. However, to provide physical protection for these objects they are often further away from the visitor. Thus putting objects in display cases normally allows the visitor to get much closer to objects and allow better viewing conditions at lower light levels. Open displays also require far more cleaning and an increased maintenance cost. In some cases display cases are used to protect the public from hazardous objects.

Display cases will often form an integral part of a design concept. Designers often want to be quite creative with the design of cases or other enclosures. This can be very successful but care needs to be taken that the primary function of the case is not lost.

Display cases are often a matter of compromise and it is important that conservators are aware of what is important for their particular collections. Display cases are very expensive and it is not normally possible to justify the highest possible specification all of the time so the risk to the collection must be properly assessed. It is also important that the conservator understands the viewpoint of the other members of the team to appreciate why they may not like some of the things that we take for granted. ■

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Monitoring in Enclosures

Sarah Lambarth and David Thickett

Introduction

When objects are put on display they are very often placed inside showcases for purposes of security, protection from visitors and to enable certain environmental conditions to be maintained. The focus here is on monitoring environmental conditions inside showcases but across the 135 sites with collections that English Heritage is responsible for many other types of enclosures can be found. For example there are microclimate print frames, voids between panelling and tapestries and the wall behind them and secondary glazing for stained glass windows. The monitoring for showcases outlined below has been used (or adapted for use) in these other types of enclosures.

Temperature and Relative Humidity

The most common types of conditions measured in showcases are relative humidity (RH) and temperature. The data gained can be used to check that the environment in the showcase is as desired and if real time data is available they can also be used to indicate if a problem has arisen, which can then be investigated immediately. English Heritage regularly uses data loggers or radiotelemetric systems to monitor RH and temperature levels in showcases and in rooms, particularly when new displays are installed. During a variety of showcase testing, it was found that the position of the data logger or sensor can affect the data collected.

Figure 1 shows the RH recorded over five days in a showcase. A data logger was placed in both the display and silica gel areas of the showcase. It can be seen that the recorded RH in the two sections varies widely meaning that monitoring equipment placed in the silica gel area does not necessarily provide data representative of the environment in which the objects are kept.

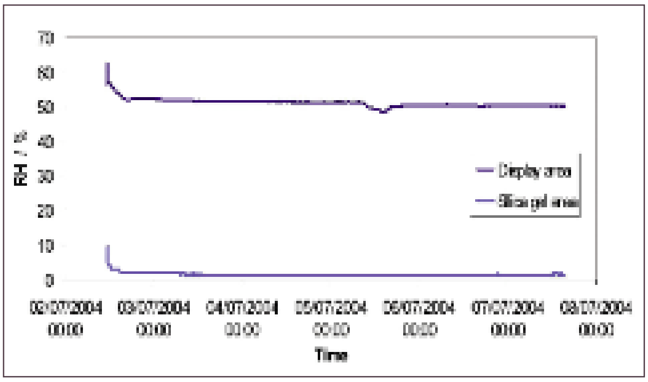

Figure 1. RH over five days in two different areas of a showcase

There can be a difference in temperature and RH throughout a showcase. The distribution within one showcase was measured at eight points: in the centre and at the side, at the front and rear of the showcase and on the baseboard and at the top of the showcase using four ACR Smart Reader 002 data loggers with additional external probes for a four week period. It was found that there was not much difference in readings in positions at sides and centre so only those for the side positions are shown. There was a significant difference of nearly 10% between the readings at the top and base of the showcase for both RH (*shown in Figure 2*) and temperature.

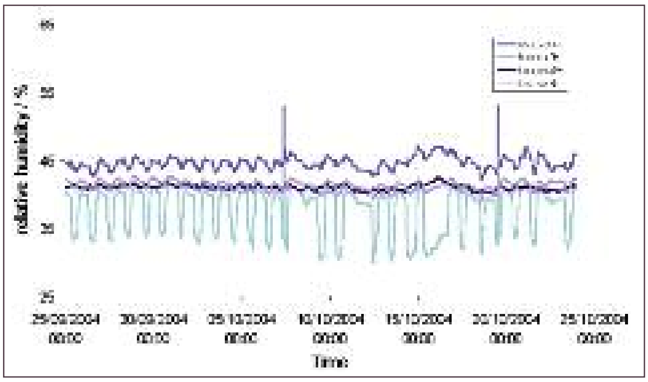

Figure 2. Difference in RH at different positions within the showcase

For this showcase the large differences in the RH were caused by tungsten–halogen lights located at the top front of the showcase. This is why the daily fluctuations of RH are greatest for the logger in this area[1].

These examples show that the positioning of monitoring equipment needs to be carefully considered. However other factors which may need to be considered include the aesthetic effect on a display and the accessibility of the equipment for maintenance. In a display recently installed in the Gatehouse at Kenilworth Castle objects, including many loan items, were put on display within showcases to protect them from the environment and to meet the tight loan specifications. Two sensors were placed in each of the showcases, one for the mechanical environmental control system and the other to monitor RH and temperature. The showcases containing loan objects cannot be opened without representatives of the lending organisation present. So it was necessary to make sure the sensors could be accessed for maintenance without opening the main part of the showcase. In most of the showcases the mechanical control unit sensor was placed at the bottom of the showcase near the pipe drawing the air out of the showcase and the sensor for the control system was placed in the bottom of the showcase between the air inlet and outlet pipes. This allowed only the actual sensor to be in the showcase whilst the rest of the unit was accessible from underneath the showcase. This also meant that it was possible to pull the sensor completely out the showcase if necessary. A large tapestry was hung in one very large vertical showcase, where large stratification of RH was a concern. As only one sensor was available, trials were run during the setting up of the display (when seven sensors could be used) to determine the best position for the sensor in this case. From the results of these trials the probe was positioned in the middle of the back of the showcase. Most of the sensors were incorporated into the showcases at the design stage and air tight seals were developed to ensure that the sensors would not affect the sealing of the showcases.

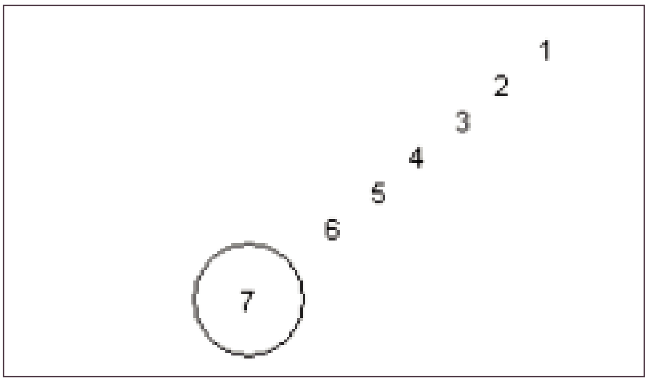

Figure 3. Showing position of surface temperature sensors and LED light

As mentioned earlier showcase lighting can severely impact on the environment within the showcase. Recent developments with LED lighting are making it an increasingly popular choice in showcases. One reason is that LED lighting has a much higher efficacy than tungsten-halogen lighting; however some heat may still be given off. A test of an LED spot light was carried out for one spotlight placed within a test showcase. The surface temperature on the casing of the lamp and at six points on the showcase baseboard moving away from the lamp at approximately 10mm intervals (*see Figure 3, where position 7 was on the lamp casing*) was monitored using Pt -1000 platinum resistance sensors attached to an ACR Smart Reader 007 data logger. The air temperature within the showcase was also measured. The light was switched on between approximately 10.30 and 17.00, mimicking museum opening hours.

The results showed that the centre of the area where the light falls had an increase in surface temperature of approximately 3°C and the air temperature within the showcase increased by 0.7°C during the time the light was switched on. This is a comparatively small temperature increase compared to other light types, however the use of multiple spot lights inside the showcase would give higher air temperature gains, modify the RH and increase the air exchange rate. The other point to consider is where the spots are focused in order to avoid heating the surface of the objects. *Figure 4* shows the temperature increase at position 5.

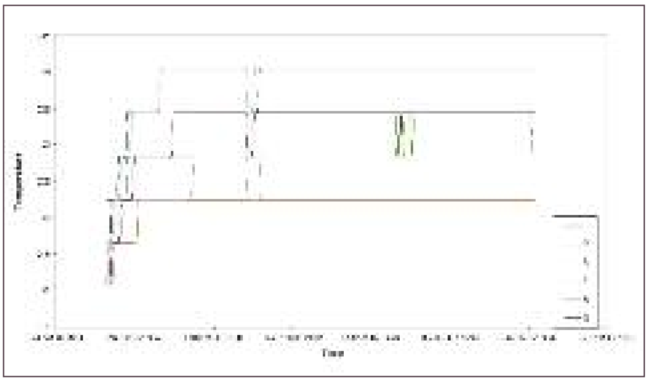

Figure 4. Temperature increase during the day at position 5

Air Exchange Rate

Air exchange rate (AER) has been shown to be an important parameter when producing effective conservation showcases. A lot of work has been done in recent years on fast and cost effective ways to measure AER. The method now favoured is to inject carbon dioxide gas into the showcase and then to measure its decay. This method is outlined in Calver et al. 2005[2].

English Heritage is responsible for a number of sites which have small displays of collections, mostly archaeological material found at that site. Much of this archaeological material is iron so the aim is to keep the relative humidity within the showcases below 30% which is done by using silica gel in a "draw" below the display compartment. As we do not have the staff resources to regularly monitor the RH levels within the showcases and change the silica gel accordingly it is necessary to be sure that the silica gel will keep the RH conditions below 30% for at least six months so that the silica gel only has to be changed twice a year at most. Recently a display was installed at Castle Acre Priory. The showcase designed specified that the air exchange rates of the showcases should be 0.4 air changes per day, a specification reached by using Thomson's equation for calculating hygroscopic half-life[3].

Measurements of the AERs for three showcases containing objects were carried out to check that they met the specification. The AERs of all the showcases were below 0.4 air changes per day, meaning that the showcases exceeded the required standard. Monitoring temperature and RH inside the cases confirmed they were performing to the required specification.

Another display which has recently opened is the Buried Lives Exhibition at St Peter's Church in Lincolnshire. This includes skeletal remains excavated during the 1970s and 1980s. Temperature and RH were monitored within the church for 12 months. This showed the RH to be very high and to pose a threat of mould growth on the remains. It was decided to display the finds in showcases and to use dehumidifiers to achieve a RH inside the showcases in the region of 60%.

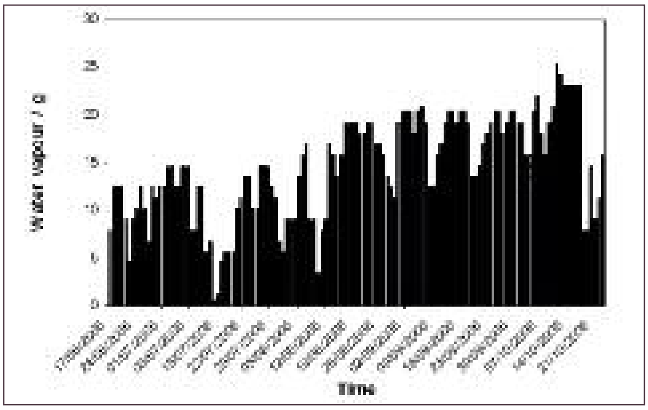

Figure 5. Excess water to be removed from showcase per hour

In order to determine the capacity of the dehumidifiers needed the amount of water likely to ingress the showcase needed to be determined. The excess moisture in the air over and above the moisture content at 60% for the temperature at which the data was recorded was determined, then considering the showcase volume and AER the mass of water to be removed from the showcase per hour was calculated. The results of this are shown in *Figure 5*. The largest mass of water to be removed per hour was just over 25g; this could then be checked against the manufacturer's specifications for dehumidifiers.

Dust and Pollution

Another factor important to showcase performance is the ingress of external dust and pollution. On the first floor of Ranger's House the Wernher Collection is displayed in eighteen showcases, installed during a representation project in 2002. In 2005 the performance of these showcases was reassessed and as part of this levels of dust and internal pollution in the showcases compared to in the room were measured. Clean glass slides were exposed in the showcases and in the room for 28 days and microscopy and image analysis were then carried out on the slides to determine the amount of dust collected as the percentage area of the slide covered. The ratio of dust ingress into the showcase compared to the room was then calculated as a percentage so that a comparison between the showcases could be made. The results, displayed in *Figure 6*, show that those showcases with higher AERs allowed greater dust ingress[1].

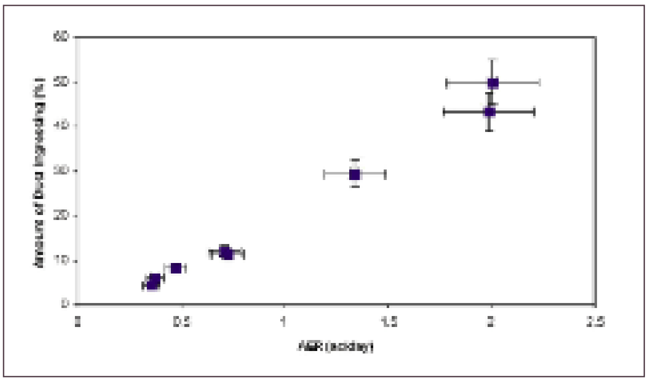

Figure 6. Amount of dust ingress into showcases over 28 days

The ingress of sulphur dioxide and nitrogen dioxide was assessed using commercially available diffusion tubes. The tubes were again exposed for 28 days in the showcases and room. The results showed that the showcases provided protection from the pollutants with the sulphur dioxide concentrations inside the showcases below the detection limits for diffusion tubes[1]. It is however necessary to be cautious when assuming that a lower measurement in the showcase means the showcase is stopping pollution ingress as it could be that the pollutants are actually being absorbed on the surface of the objects in the showcase and not reaching the diffusion tube. Pollution levels vary from site to site and can also vary seasonally so it is essential to carry out several measurements over a year. English Heritage currently exposes tubes four times a year for month-long periods. Some standards for acceptable pollution levels for certain types of materials can be found in the literature but these are not yet comprehensive.

Metal coupons can be used to assess the rates of corrosion inside enclosures. English Heritage regularly uses silver and lead coupons. As tarnish on silver is only a very thin layer a visual measurement method is used. The extent of tarnish is recorded using a colorimeter because it has been found that change in b* correlates well with visual perception during the early stages of tarnishing. For corrosion on other metal coupons it may be desirable to know the identity of the corrosion product and/or measure the amount of corrosion. For example if lead methanoate were identified as the corrosion product on a lead coupon then it could indicate that the cause of this corrosion is possible emissions from a paint or lacquer. The metal coupons allow monitoring over a long period of time and show the effect of the pollutants.

Although excellent sealing is something to strive for in new showcases there are well known problems associated with good sealing, primarily that any emissions harmful to objects given off by showcase materials are trapped in the showcase. This can lead to an increased rate of deterioration of the objects.

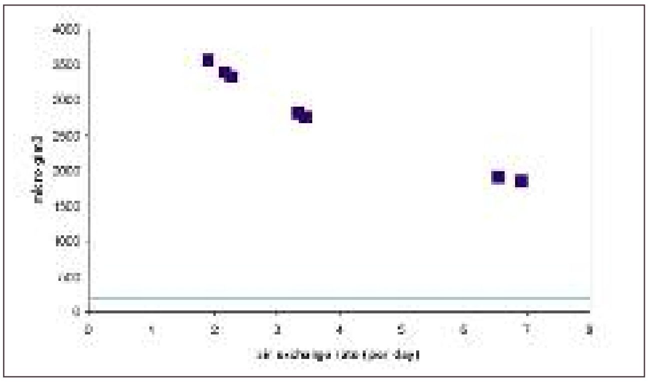

Figure 7. Decrease of methanoic acid levels as AER increases

At Kenwood House soon after new paint was applied to the inside of a showcase displaying jewellery the lead solder was corroded. Carboxylic acid measurements showed that there were very high formic acid emissions inside the showcase and the corrosion product was identified by x-ray diffraction as lead methanoate. In order to try and allow this to vent out of the showcase a series of holes were drilled in the showcase. *Figure 7* shows a negative correlation between AER and formic acid levels measured in the showcase. In this instance even after increasing the AER the formic acid levels were still much higher than the 192mg/m3 level (*the pale blue line in Figure 7*) for lead as suggested by Tetrault *et al*. 2003[4], so the showcase had to be refitted.

Conclusion

There is a variety of environmental factors which can be monitored inside showcases and with thoughtful positioning of sensors data can be collected. Monitoring can be used to gain important information about showcase performance. It is necessary though to have a clear idea of the purpose of the monitoring so that the methods used can provide pertinent information. ■

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ss Great Britain: Science and Technology Underpin Enclosure Design

David Watkinson and Mark Lewis

Introduction

Enclosures can provide uncontrolled environments that simply protect their contents from the elements or offer controlled conditions operating within specified parameters. In either case materials science and technology are essential components within a suitable design. Even basic structures with uncontrolled interiors present design problems; carelessly choosing a steel roof for a shed may result in condensation dripping onto collections. Controlled environments present much greater technical challenges. The design parameters of an enclosure can be addressed by asking and answering a sequence of standard questions related to the needs of the object. What is the preservation problem? How can it be dealt with? What controls are needed to solve it? How can these controls be technically achieved and can they be indefinitely maintained? Finally, does the enclosure successfully achieve the stated goals?

Preservation of the wrought iron steamship ss Great Britain illustrates how these questions can be addressed and reveals the interdisciplinary nature of conservation. This brief paper identifies linkage between concepts, ethics and science in the successful design and commissioning of a climate controlled enclosure designed to preserve one of the technological cornerstones of western society. While the paper offers a full overview of the project, the reader must follow up the references to gain information on experimental detail and decision making rationale.

History and Problem

The ss Great Britain is one of the many engineering marvels created by Isambard Kingdom Brunel. The ship was launched in Bristol in 1843 as the biggest iron ship in the world and the most innovative, as her structure remains the blueprint for modern hull design *Figure 1* (Greenhill and Allington 1997, Corlett 1990). She was screw driven and designed as an ocean going liner. After storm damage the ss Great Britain found a new role carrying emigrants to Australia and eventually ended her life as a storage hulk in the Falkland Islands. Having been holed and abandoned in shallow water at the end of her working life, the ship was salvaged in 1970 and returned to Bristol where she was housed in the original dry dock where she was constructed *Figure 2*.

Although the ship was a visitor attraction it was rapidly corroding away in the damp rain washed dry dock *Figure 3*. This was not slowed by the shipyard maintenance practices and sporadic restoration that was applied over a 30 year period. In the late 1990's a co-ordinated conservation plan established the importance of the ship (Cox and Tanner 1999) and established her condition (Turner et al 1999) with the aim of preserving the ship and improving her worth as an information resource. Sampling and analysis of the wrought iron hull revealed the presence of chlorides within corrosion products (Turner et al 1999). These act as corrosion accelerators for wrought iron (Turgoose 1982a and b, Selwyn et al 1999). The bulk of these chlorides were present in exterior sections of hull that were originally below the waterline and interior surfaces

Figure 1. The ss Great Britain

Figure 2. ss Great Britain in her dry dock at Bristol (image courtesy of ss Great Britain Trust)

Figure 3. Ongoing corrosion of the ss Great Britain

Figure 4. Artists impression of desiccated enclosure (image courtesy of the ss Great Britain Trust)

that were submerged in water, when the ship was holed and abandoned in the shallow waters of Sparrow Cove.

The Solution

An in-depth consultative review led by Eura Conservation examined the options available for either reducing or preventing the action of chloride as corrosion accelerators in wrought iron (Turner et al 1999). This identified the removal of water from the corrosion process as a treatment option that was both technically attainable with predictive success. The chloride ridden section of the hull was to be left entirely untreated and enclosed within a desiccated environment to control its corrosion *Figure 4*. The controlled area would include the interior of the hull, which would be sealed from the environment by an airlock door system to reduce transfer of moisture inwards from the atmosphere. Other treatment options considered were problematic in some way. The success of many was limited and un-quantifiable, while others were impractical within the constraints of visitor access. While a common approach for archaeological iron involves chloride removal by alkaline washing (North and Pearson 1975 and 1978), these methods remain unpredictable (Selwyn and Logan 1993, Watkinson 1996, Selwyn and Argyropoulos 2005). Washing also offers technical and safety problems on a scale necessary to treat the 324 foot long ss Great Britain. Protective coatings are much used, but are ineffective at preventing the corrosion of corroded chloride infested iron surfaces.

While the choice of treatment was based on evidence provided within published literature, it was now necessary to identify the corrosion process occurring on the hull and scientifically investigate how atmospheric moisture influenced it. Results would be extrapolated to determine how the moisture content within the protective enclosure would influence corrosion of the iron hull.

Defining corrosion and experimentally determining storage conditions

Analysis of the hull identified the corrosion products present and revealed that the corrosion process was similar to that occurring on archaeological iron infused with chloride (Turgoose 1982a and 1982b, Selwyn et al 1999). While the corroding hull contained the corrosion product akaganeite (βFeOOH) and also free chloride ions, it would likely form ferrous chloride as it dried within the desiccated storage environment (Watkinson and Lewis 2004). The influence of both these corrosion products on iron corrosion was studied experimentally in a series of laboratory based test procedures (Watkinson and Lewis 2004, 2005a, 2005b).

These used a climatic chamber that controlled relative humidity (±1%) and temperature (±0.5°C) and contained a balance (±0.0001g) that recorded weight change every 5 minutes. Since iron gains weight when it corrodes, this experimental set up is able to determine how the moisture content of the atmosphere influences the corrosion of iron in the presence of chloride corrosion products. The relative humidity at which no corrosion occurs was identified for iron powder mixed with the βFeOOH corrosion product. This is the flat line on *Figure 5*, which shows the iron is not gaining weight at 12% relative humidity as time progresses. The other lines on *Figure 5* show that as relative humidity increases so does weight gain. This is due to corrosion of iron and uptake of water. Simply stated: a steeper line indicates quicker weight gain and thus a faster corrosion rate for iron. Similarly, in *Figure 6* ferrous chloride does not corrode iron at 19% relative humidity; does so only slightly at 22%; and corrodes it much more quickly at 35%. Clearly, making the environment as dry as possible slows corrosion of chloride infested iron and may prevent it if relative humidity is low enough.

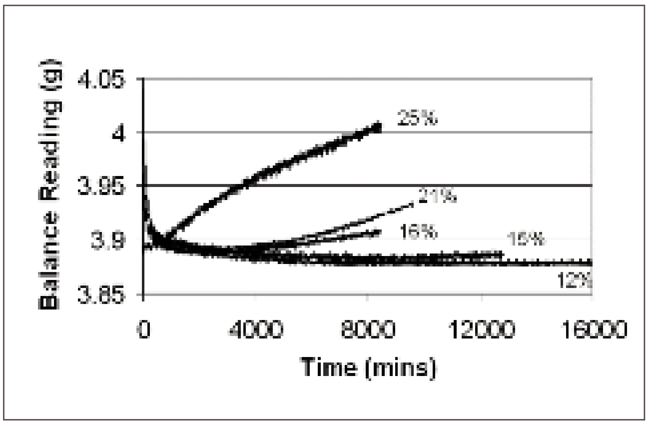

Figure 5. Response of iron powder and βFeOOH mixtures to differing relative humidities. Weight gain represents oxidation of iron

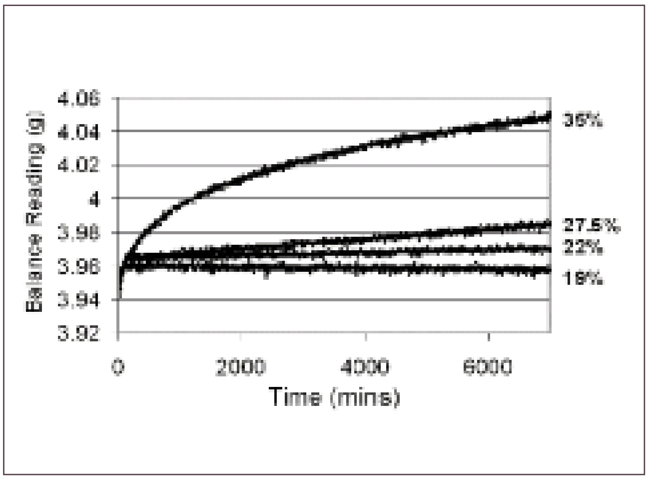

Figure 6. Response of iron powder and ferrous chloride mixtures to differing relative humidities. Weight gain represents oxidation of iron

Figure 7. Desiccated air distribution nozzles

Figure 8. Desiccation plant

Figure 9. Preparing the upper hull for painting (image courtesy of Eura Conservation)

Figure 10. The paint system (image courtesy of Eura Conservation)

Interpreting these results for controlling corrosion of the ss Great Britain by environmental desiccation, means that all corrosion can be stopped by drying below 15% relative humidity. It can be very much slowed from 15% to 21% relative humidity and not much corrosion occurs until relative humidities above 25% are attained.

Since design of a desiccation plant and expenditure of energy to run it depends on the tolerances to which it operates, a cost benefit decision has to be made on whether to prevent corrosion or to control it to negligible levels. For the ss Great Britain the plant was constructed for a working relative humidity of 20%, although there was capacity in the system to produce humidities lower than this. This offers an example of scientific research facilitating management decisions in full knowledge and understanding of their outcomes.

Reasoning and rationale can now play a central role in the decision making process. Science clearly underpins conservation in these contexts.

Desiccation Plant within the Enclosure

While the initial design allows for specified visitor numbers and water ingress from the adjacent basin into the dry dock, extra desiccation capacity must be present to deal with unexpected rises in these values from factors like high visitor numbers. Other design factors included flooding the surface of the glass plate to a depth of 50cm to aid cooling within the enclosure and channelling the dried air onto the metal surface where it is required *Figure 7*. The air leaves the desiccation plant with a relative humidity between 0% and 3% *Figure 8*. Sensors detect its value on the exterior of the hull and within the ship itself. These have shown relative humidity values lie between 15% and 25% according to the position of the sensor and that fluctuation in humidity is limited.

Other Conservation Procedures

The well preserved upper reaches of the hull were treated with a rigorous protective coating regime that stripped off the old paint by hydro-blasting with pressurised water lances *Figure 9*. A paint system devised by Eura Conservation was applied that comprised: zinc rich epoxy primer (Leigh 111) followed by a two part epoxy system (Leigh L653), which was top coated with a urethane system to resist light damage (Leigh C237) (Watkinson et al 2005b) *Figure 10*. Fragile sections of the hull were treated at lower pressure (8bar) with Australian crushed garner, cleaned to SA2.5 and allowed to flash rust

Figure 11. Missing sections of the upper hull

Figure 12. Infill of missing sections of the upper hull

before coating with an epoxy that was tolerant of small gaps and unevenness on surfaces (Leigh M111) *Figure 11*. Gaps in the upper hull were filled with epoxy resin patches *Figure 12*.

The Enclosure in Practice

Overall the treatment is a success *Figures 13 and 14*. Visitor numbers have exceeded target values and public feedback has been very positive. The award of the Gulbenkian Museum Prize for 2006 has offered international recognition for the ship as a museum and its innovative conservation. The target relative humidity is achieved most of the time and the plant has had limited down time. The desiccation system has coped with the occurrence of more free water in the dock than was initially expected, due to leaks from the dock walls. Also leakage from failure of a seal in the glass roof lasted a few weeks, but did not influence the relative humidity in the dock space. Seals at the interface between the glass roof and the hull have rewarded the extensive testing that accompanied their selection by not leaking. Ongoing monitoring of the environment will be used to calculate the long-term effectiveness of the procedure, as will photographic evidence that records the appearance of selected areas of the hull on weekly basis.

To further understand the control system the influence of failures to maintain operational relative humidity have been modelled as short term fluctuations of 6 hours every 2 days on laboratory samples (Watkinson and Lewis forthcoming). As expected, corrosion reactions between iron and βFeOOH and iron chloride respond to large rises in relative humidity more quickly than to small fluctuations above the operational relative humidity value of the plant. Reaction rate is slow below 30% relative humidity, but 6 hour fluctuations above this value in the presence of βFeOOH can be expected to initiate limited corrosion. All laboratory tests offer worst case scenarios, due to the surface area of the iron powder and the quantity of corrosion products used. ■

Acknowledgements

Matthew Tanner and the ss Great Britain Trust and the Heritage Lottery Fund for funding the research programme. Robert Turner of Eura Conservation for professional consultation and discussion.

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Figure 13. The waterline plate (image courtesy of ss Great Britain Trust)

Figure 14. Visitors walk around the port side of the ship 'below the waterline' in the desiccated environment

Securing Showcases, Display Cases and Enclosures

Peter Osborne

Introduction

As in most situations, security, or more appropriately, protection, is a matter of common sense and can be effective without the need for complicated procedures. Having said that, there is more to a case than putting something inside and closing the lid. What is a show case? Come to that what is the difference between a show case, a display case and an enclosure? What is a case going to be used for, how can it be defined and how should it be secured? So many questions, but until they are answered there is no way of knowing what sort of case is appropriate for a particular display or project and what sort of protection is necessary. However, before the questions can be answered some idea of the material that is to be displayed needs to be determined.

Assessment

In order to make an informed decision and to determine the level of protection that will be needed an assessment should be carried out to include the following:

- *The type and nature of the material*
- *Its risk value, for example is it controversial, political, weapons, collectable or easily disposable?*
- *Its historical value*
- *Its monetary value*
- *Is the material part of the permanent collection?*
- *Is the material on loan?*
- *Loan agreements*
- *Insurance and Indemnity requirements*

Design

Once material has been identified and evaluated, a case can be specified for the purpose. At the same time the level of security and protection can also be determined with a reasonable amount of accuracy. At this stage a suitable type of case may already be available or a new one will need to be made. The various elements can now be considered according to the need starting with a preferred design, and more questions. Will it be free standing on legs or mounted on an enclosed base with storage facilities? Will it be wall mounted or floor to ceiling with opening front sections or rear door entrance? Will it be stable enough to take the weight of objects and construction material? Will it have a wooden or metal baseboard? Will it have top openings, side openings – hinged or sliding, or will the whole top be removable?

Construction

The first consideration and cause for concern on any case is the glazing. In older cases the glazing is usually bad news because it is thin, fragile, will easily break under impact and probably is not held in its frame with any degree of support. New cases are much better as the glass is thicker with one or more laminates in a more substantial frame. The more laminates there are to a section of glass the stronger it is. A section of glass 20mm thick with seven or more laminated layers is the minimum required to provide anti-bandit qualities. This type of glazing will be adequate to protect high profile material such as silver collections and rare manuscripts. However even this type of glazing may require up-grading beyond 20mm when guns are to be displayed.

The weakest part of glass is the edges which will break more easily than the centre of a panel. Cases need frames for the glass panel to fit into so that all edges are concealed and shielded from attack. Cases with no frame where the glazed sections are bonded together at the edges are fine providing they are not intended for high profile or high value material. Where glass bonding is featured separate provision will be needed to access the case and appropriate locking facilities installed. Some cases will feature sliding glass sections with various forms of locking. This type of case is vulnerable where a wedge can be driven between the two panels and the glass cracked or split. On large floor to ceiling cases with sliding doors, because of the length of unsupported glass, there is enough flexibility to prize the two panels apart sufficiently to insert a long instrument, such as tongs, and remove small items. Where case frames are made of wood it is sometimes easier to break away the wooden frame so that the glass falls away.

Hinges

Hinges are one of the weaker points of a case and can be easily attacked by unscrewing exposed screws or bolts, driving the pin out of its housing or forcibly levering away from the body of the case. Therefore hinges should be concealed with no part of the hinge visible or accessible from the outside. Hinge bolts can be inserted to support each hinge and strengthen the physical integrity of a case to a considerable degree. With two hinge bolts and two opposite lock tongues an opening section can be greatly protected against attack. A concealed piano hinge running the whole depth or length of an opening is extremely difficult to attack or remove providing good quality locks are fitted.

Locks

Locks come in all shapes and sizes and are made to perform in different ways. In principle there should be two locks per opening on every case, preferably with two different keys. All modern locks should be tamper proof and bought or ordered from a reputable dealer or manufacture. It is likely that if a new case is being purchased the case manufacturer can provide and fit quality locks.

The method of opening the case will in most cases determine the type of lock required. Hinged openings will require locks that throw the lock bolt into the frame of the case. Sliding openings will require locks that will extend the lock bolt to hook into the frame; these are referred to as 'hook-bolt' locks. Clamp locks can be used to keep two sections of glass together whilst snap locks can be fitted directly into glass panels.

Access Control

One misplaced or lost key can negate everything else that has been done to produce a good case and of course objects within such a case are wide open to theft or abuse. Key management is an essential element of a good security programme. Common sense and good housekeeping should prevail. All of the following points are valid and should be incorporated into a coherent policy and strict operational procedures:

- *There must be firm policy governing the use of keys*
- *Strict disciplines must be administered regarding issue and storage of keys*
- *The number of keys in existence must not be more than is absolutely necessary*
- *The number of staff in possession of keys must be kept to the barest minimum*
- *Case keys should never leave the premises*
- *Storage of keys must be adequate for operational needs*
- *Good quality key cabinets must be provided*
- *Key cabinets must be located within a secure part of the building*
- *Access to key cabinets must be strictly limited and controlled*
- *A record of each key issued must be kept on a daily basis*
- *Signatures should be obtained from persons withdrawing keys*
- *Case keys should be kept separate from other keys*
- *Tags must not state the location or contents of cases*

When considering or selecting locks and keys a reputable manufacturer should be selected together with expert advice. If a new case is being considered it is possible that the case supplier will be able to provide suitable locking facilities.

Location and Invigilation

Where old cases are deployed it may be necessary to provide constant human invigilation to prevent undetected tampering or theft. The stronger the case the less invigilation will be needed. Where a case has bandit-proof qualities, which include alarm sensors, it is not usually necessary to provide constant invigilation other than a regular check over a given period. Such cases could easily be monitored remotely by CCTV at a location elsewhere in the building. Cases will inevitably be positioned within a gallery according to the material inside and the nature of the display or exhibition. Whilst this is fully appreciated, cases, especially older types, should not be located adjacent to entry or exit doors. Whether old or new, cases must never be positioned next to a fire escape door where an escape can be made directly outside if a smash-and-grab was made.

Alarms

Most people are not too familiar with modern technology and electronics which is why fitting alarms to cases can be a confusing issue if not thought through properly. The best way to overcome this problem is to engage the services of a competent and trustworthy professional. This is not always an engineer who may know all about alarms but turns out to be a bit of a salesman for the company. Power will be needed to operate the alarm units which will determine the location of the case which may interfere with the exhibition layout. Consideration will also be required regarding wiring, signal transmission, monitoring and response. The different types of alarm units are many and varied and should be chosen with the help of an experienced professional person. Alarm units can detect most activities such as vibrations, breaking glass, shocks, movements, changes in air pressure, changes in temperature, changes in light, contact breaks and false key activity. Each unit has to be set within specified parameters to avoid false alarm activations such as cleaners banging their brushes around the base of a case or changes in light from day time to night time. Where a number of cases are in use, especially in different parts of a building, each alarm unit will need to identify its location.

Easy Solutions

There are still a number of old cases in existence that do not meet modern day requirements or standards of protection. Nevertheless these cases continue to be used and probably will be for some considerable time to come for whatever reasons. Old cases can be unstable and weak and should never be used to display valuable, fragile or delicate material. If such cases are used a number of improvements can be made to increase the protection of the contents.

- Glazing could be fortified by adding an inner layer of security film to the inner face of each glass panel.
- The case may be made of wood and fitted with furniture locks. To overcome this problem the lid can be drilled and screwed down with one or more screws. The screw heads can be capped to blend in with the wooden structure.
- A further layer of protection can be achieved by constructing and installing a Perspex box inside the body of the case. The Perspex box should be fixed down so that if the case is unlawfully opened the objects are still contained and safe within an enclosure.
- Where older cases are being used they should be located away from entrances or windows and preferably within sight of staff so that tampering can be detected.
- Attention can be drawn to tampering or opening of older cases by placing a battery operated alarm unit within the case that will activate when disturbed. In the event an alarm might well deter an intruder from continuing the action.

Criminal Activity

Some of the known methods of breaking into a case are:

- *Unscrewing panels on a display case body*
- *Breaking glass around a lock where the lock has been inserted into the glass*
- *Prising open glass or wooden lids*
- *Lifting sliding glass panels over locking device*
- *Forcing locks with picking instruments*
- *Attempting to break the base or floor beneath the case* ■

Energy Saving Vs Traditional Lighting

Mark Dale

Introduction

Initial lights was founded in 2005 by the author and Mr Paul Fallowfield, to provide new innovations in LED lighting. LED technology is advancing at a phenomenal rate and there are very few outlets for this emerging market in the UK and Europe. With the current focus on environmental and cost saving issues, the need to be able to provide a diverse range of new products to customer specifications is paramount.

History of Lighting

- Incandescent lamps were developed from an early experiment in which current was passed through filaments of noble metals such as platinum. There were problems with the filament burning out after just a few minutes until Edison used a carbon rod filament in 1879.
- William David Coolidge an American physicist conducted critical experiments that led to the use of tungsten as filaments in light bulbs in 1910.
- In 1923 the Hungarian inventor Tivadar Millner developed tungsten lamps working with Pál Túry to develop large-crystal tungsten technology for the production of more reliable and longer-lasting coiled filament lamps.
- Nick Holonyak Jr developed the first visible light-emitting diode in 1962 while working as a consulting scientist for General Electric Company.
- In 1976 Ed Hammer at General Electric invented the helical compact fluorescent lamp. He proposed a long thin high efficiency tube coiled into a form that would match the size and light distribution of a frosted incandescent lamp. However GE felt that this complex shape was not compatible with high speed manufacturing techniques and the idea was shelved.
- Whilst working for Nichia corporation, Shuji Nakamura invented the first high brightness gallium nitride LED whose brilliant blue light is (when combined with yellow filters) the key to white LED lighting. This went into production in 1993.
- In 1995 a Chinese firm, Shanghai Xiangshan, marketed the first successful compact fluorescent bulbs.

Current Lighting Technology

Incandescent technology has not changed much since its conception and is still widely used today. However there are significant moves being made to ban these types of bulbs due to their highly inefficient nature.

Fluorescent lighting is relatively efficient but due to the difficulties in disposal of the hazardous chemicals such as mercury, they are becoming less viable and will begin to decline in usage over the coming years.

Halogen lamps are widely used due to the low unit cost and high light outputs. However they are considered inefficient and a potential fire hazard by some health and safety professionals.

High-pressure sodium lamps turn 50% of the electrical energy into visible light. Because their output is much more pleasant to look at, they have replaced mercury vapour in streetlight applications. However, there are significant issues with disposal.

Low-pressure sodium lamps provide energy-efficient outdoor lighting compared to high-intensity discharge lighting, but they have a very low colour rendition index. Low-pressure sodium lamps require up to ten minutes to start and have to cool before they can restart. Therefore, they are most suitable for applications where they stay on for hours at a time such as highway and security lighting.

Compact fluorescent is the most common energy saving type lamp currently available. They require a ballast to supply the correct voltage and current making them bulky. They also contain mercury making them difficult and expensive to recycle.

LED represent the latest technology and can produce over 130 lumen per watt. A light bulb is considered energy efficient if it produces 40 or more lumen per watt. They cannot be dimmed effectively yet, but that is set to change shortly.

Over the lifetime of an LED bulb it will be more efficient and cost effective than an equivalent 9w compact fluorescent.

Bulb type	Cost per Kw/h (£)	Quantity of bulbs	Power consumption (W) per bulb	Power consumption total (Kw/h)	Cost per hour (£)	Cost per day 10 hours (£)	Cost per year 350 days (£)
Halogen	0.0746	100	50	5	0.3732	3.732	1306.20
LED	0.0746	100	5	0.5	0.03732	0.3732	130.62
Compact fluorescent	0.0746	100	9	0.9	0.0672	0.672	235.20

Table 1. Cost comparison between Halogen and LED replacements

Future of Lighting

Incandescent

Significant moves have been made to phase out incandescent light bulbs and it is looking increasingly likely that these measures will be implemented in Europe over the next 2 years. In Australia the prime minister has mandated that all incandescent bulbs will be banned within 2 years. Australia is the biggest single CO_2 polluter after the USA.

CFL

Energy efficient CFL bulbs have been the only true alternative for some time now, but as the improvements in technology take hold, other energy efficient products will become available. One big issue affecting the use of CFL energy saving bulbs is the levels of mercury contained in the coating of the glass. In April 2007 the USA implemented a voluntary scheme to limit the amounts of mercury within these products.

LEDs

LEDs are improving at an incredible rate; they are roughly doubling in light output per watt approximately every 18 months. We can expect some very exciting improvements during the next 12 months.

OLEDS

Organic LEDs are a novel and very attractive class of solid-state light sources, which are flat, thin, and very lightweight. OLEDs generate a diffuse, non-glaring illumination with high colour rendering. They are currently being used as displays for many of the latest mobile phones. OLEDs could also be used in lighting systems with controllable colour, allowing users to customize their light atmosphere.

Low and High Pressure Sodium

These products are a highly efficient light source. However they have the same disposal issues as compact fluorescent bulbs in that they also contain mercury. There are no published plans to change the operation or manufacture of these products in the foreseeable future. ■

	Halogen	CFL	LED
Running Costs	£1,306.20	£235.20	£130.62
Replacement Costs	£100	£500	1200
Total	**£1,406.20**	**£735.20**	**£1,330.62**

Table 2. Cost comparison year 1

	Halogen	CFL	LED
10 Year Costs	£14,062.00	£3,852.00	**£2,636.82**
10 Year Savings per 100 light bulbs	Nil	£10,210.00	**£11,425.18**

Table 3. Cost comparison 10 years

The Big Box: Specifying an Archive Storage Facility

Gary Tuson

Producing a design brief which clearly communicates what you are trying to achieve is an essential step in a building project. Time spent on this brief will have far greater benefit of time spent than at virtually any other stage of the project. Visiting other sites, brainstorming, writing functional design briefs, consulting and rewriting are all essential elements in this process and will be rewarded later in the project.

The design and specification of any building stems from the functions that building performs. In the New Glamorgan Record Office (NGRO) its functions originate in its mission statement; to collect, preserve and make accessible. Around half of the area of the NGRO, around 1600m^2, will be archive storage. Preservation will be a major functional driver in the design of the storage facility but the needs of a growing collection and public access must also be taken into account. It can be a case of balancing these competing requirements.

Standards are a very useful tool in any specification process. Standards allow you to benefit from detailed work carried out by experts in their field and provide a tool to help maintain quality levels. Referring to a standard can set a clear minimum acceptable standard against which it is very difficult for anyone to argue on the basis of time or cost. In an archive store the specification for preservation is largely determined by BS5454 (2000)[1]. This includes sections on the choice of site, building construction, security, lighting systems and fire precautions. It also details the environmental conditions to be achieved.

For frequently accessed documents BS5454 specifies a temperature of between 16°C and 19°C at a fixed point +/- 10°C and a Relative Humidity (RH) of 45-60% at a fixed point +/- 5%. A guide to the Standard recognises the paramount importance of stability and allows for a slow season drift in temperature and RH. These specifications can be presented as the requirement in an output specification which does not describe how a building will achieve the temperature and RH but specifies that it shall. It is the design team's job to achieve these outputs. However, especially if adopting one of the Office of Government Commerce (OGC) recommended integrated procurement routes, there is need to look more carefully into this issue and, in particular, ensure that Whole Life Costs (WLC) are taken into account.

Probably the cheapest way to build an archive store in terms of capital cost is to erect a lightweight shed and control the internal environment with lots of HVAC. However, such a solution will consume massive amounts of energy resulting in high operating costs. Alternatively, a storage facility which uses the design of the building to achieve as much stability as possible although likely to require a greater initial capital outlay will result in lower running costs. These are likely to outweigh the increased capital costs i.e. it will have a lower WLC.

Such an approach also addresses a significant risk. A store which uses HVAC as the primary source of control is likely to be affected by equipment downtime for maintenance and repair. Even worse, future budget cuts may even make the high running costs of the system unsustainable. In such extreme cases all the preservation benefits accrued through the use of HVAC would be lost.

Emergency preparedness provides a good example of how there may be a need to balance conflicting objectives. In the event of a disaster the ability quickly to clear the building is important. However, if the specification simply states that the building must be capable of being cleared as quickly as possible, a designer may decide that large warehouse doors are required. This would seriously compromise security and the environmental performance of the building. Consideration needs to be given to what is an acceptable timescale for clearing the building.

The same applies to the objective of providing for access. BS5454 provides two levels of temp and RH; one for frequently and one for infrequently used documents. If demand for access is entirely predictable and is not required immediately the lower temp and RH is desirable with provision for acclimatisation facilities. However, if the service provided demands access to all of the archives at any time a decision will have to be made shifting the balance towards access and away from preservation.

Another key issue is specifying the amount of storage space, including room for expansion. With archive storage costing anywhere from £1500 to £2500+ per m^2 accurate estimation is very important. Underestimating the storage requirement will reduce the life of the building: overestimating will significantly increase costs and, consequently, may endanger the whole project.

For expansion space it is common to provide for 20 to 25 years. As a very rough rule of thumb, beyond this the costs of building do not provide an adequate payback on the investment. An estimate of quantities can be made based upon recent rates of accession, identification of any large accessions likely to be received and an assessment of the impact of the new facility on rates of accrual. These will always be estimates but there is one very important factor in specifying the amount of storage which does not have to be an estimate: the size of the current collection.

A full survey of existing holdings is an essential requirement in the specification process but it is also possible to go beyond this. One of the opportunities afforded by a move is that of a complete reorganisation of storage. The move to the NGRO will reorganise the Collection from storage by deposit to storage strictly by size. This has significant cost and preservation benefits. To determine the storage area required in the NGRO a list of ideal storage types was devised based upon various standards such as the Benchmarks for Collections Care[2]. A full survey of the Collection was then carried out measuring how much of each new storage type would be taken up by each existing shelf. The database this survey produced enabled accurate predictions of space requirements to be made. It has also provided an effective tool in project managing preparations for the move to the new building.

I have attempted, very briefly, to outline some of the key considerations that need to be taken into account when specifying an archive store. There are very many more and all require far greater consideration and information than space here allows. In conclusion, it cannot be overstressed that time spent in these early stages of a project will have a huge payback in the future. ■

References

1. British Standards Institution 2000 Recommendations for the storage and exhibition of archival documents, London, BSI.

2. Resource 2002 Benchmarks in collections care for museums, archives and libraries: A self assessment checklist, Resource, London.

Side elevation of the New Glamorgan Record Office showing the heavyweight repository block to the rear