Retrofitting old display cases

David Thickett*, Bethan Stanley and Kevin Booth
English Heritage
1 Waterhouse Square
138 Holborn
London
UK
E-mail: david.thickett@english-heritage.org.uk
Website: www.english-heritage.org.uk

*Author for correspondence

Abstract

Several aspects of case performance can be improved by refitting; security, lighting, relative humidity buffering, silver tarnish rate or pollution driven corrosion. Retrofitting methods need to be selected carefully. The interplay of factors can be complex in showcases and the effect of any changes needs to be monitored. Several case studies are presented demonstrating different approaches and their success assessed through monitoring environmental parameters.

Résumé

En modernisant une vitrine, il est possible d'en améliorer les performances dans plusieurs domaines: la sécurité, l'éclairage, la régulation de l'humidité relative, le degré de ternissure de l'argent ou la corrosion due à la pollution. Les méthodes de modernisation doivent être choisies avec soin. L'interaction de différents facteurs peut être complexe dans les vitrines et l'effet de tout changement doit être contrôlé. Plusieurs études de cas sont présentées pour démontrer différentes approches et leur succès est évalué au moyen du monitorage des paramètres environnementaux.

Synopsis

Diversos aspectos del desempeño de escaparates o vitrinas pueden ser mejorados con un cierto tipo de ajustes: la seguridad, la luz, la protección de la humedad relativa, el índice del deslustrado de plata o la corrosión generada por contaminación. Los métodos de mejoramiento de los diseños requieren ser seleccionados con sumo cuidado. La interacción de diversos factores puede resultar compleja en los ambientes creados en las vitrinas y es necesario controlar el efecto de cualquier cambio. Presentamos en este artículo diversos casos de análisis que demuestran distintos métodos y se evalúa sus aciertos mediante la observación de parámetros ambientales.

Figure 1. 1920s cases at Chesters

Keywords

showcases, relative humidity buffering, air exchange rate, carboxylic acids, preventive conservation

Introduction

English Heritage has responsibility for over 136 sites with collections across England. Where it is appropriate, modern cases are introduced, with specifications capable of achieving the required environments to protect varied collections. A 'standard' case has been developed by the Collections Team, which is capable of maintaining a suitable environment using passive environmental control (Thickett 2007). However, within certain spaces, the appearance of these modern cases may not be appropriate and this paper will discuss some of the measures implemented at English Heritage properties to improve conditions within original cases.

A clear understanding of the aims and limitations of retrofitting is vital, with careful consideration before the decision to retrofit is made. Generally any old or historic cases will not achieve the same level of performance as new cases, even when a significant amount has been spent on them. Therefore the decision to retrofit cases is generally taken for two reasons; firstly there may be a significant economic benefit to retaining and improving the environmental performance of an older case. This would include circumstances where cases may have been so ornately constructed or be so difficult to remove from sites that the benefits of a new higher performance case have been weighted up against the disruption and cost of moving the collections and old case.

In contrast, when dealing with historic cases, the importance of certain cases will necessitate modification, even if this is more expensive than replacing them with new, higher performance cases. Although the motivation will initially be to improve conservation performance, retaining an element of the appearance or authenticity of the original case may have equal importance to other parties. When modifying historic cases the motivations have often been more complex as they may be a valued part of the collection and add an extra dimension to the site.

At Chesters Museum in Northumberland, the cases have been monitored for a number of years, and data indicates the conditions are less than ideal for the archaeological small finds they contain (Figure 1). Despite these shortcomings, both staff and Trustees feel it is important to keep the historic cases as they add to the air of a 'Victorian Museum' and therefore the philosophy behind the acquisition and display of the collection.

When all options have been considered, and adapting an existing case is decided as the best outcome, it is then necessary to identify the most effective measures to improve the preventive conservation performance of the case.

Improving the RH control capacity of historic cases

Stokesay Castle contains an historic wooden desktop case displaying artefacts associated with the castle, including cast iron cannon balls and lead piping.

Monitoring of the environment (Hanwell Humbug II dataloggers) indicated that the case experienced very high relative humidity (RH) levels because of its location and deterioration was observed. The hinged case construction had a lot of air leakage through the join between the lid and the case, with a slight warping of the wood, opening up the other lid joints. In was decided to try to reduce the RH by adding Prosorb to buffer the case and to improve the sealing of the case. Self-adhesive compression seals were added to the door edges. A wooden bar was also manufactured and fitted into the case below the back edge to allow the door to close onto the seal and ensure a tight fit. Moistop 622 was applied to the interior of the wooden case and new top bar with 3M 425 aluminium tape. This was to prevent the emissions of ethanoic acid, which has a strong influence on the deterioration of lead, as well as a significant accelerating effect on the deterioration reactions of archaeological iron.

Figure 2 shows a comparison of the three-month periods before and after the refit, but before the Prosorb has been added. The case is better sealed but the Moistop has blocked the buffering effect of the wood resulting in short term, larger RH variations. The addition of Prosorb to the case reduced the overall RH and fluctuations, providing a more suitable, stable environment.

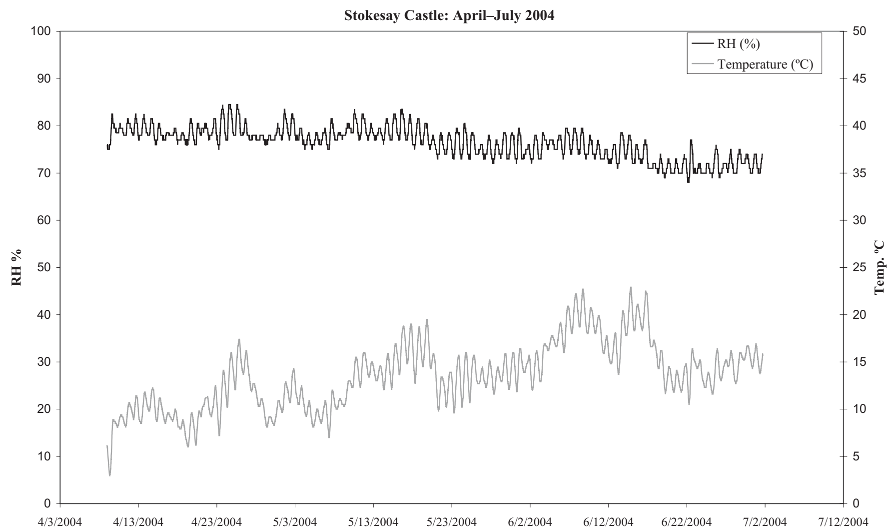

Figure 2a. Historic case

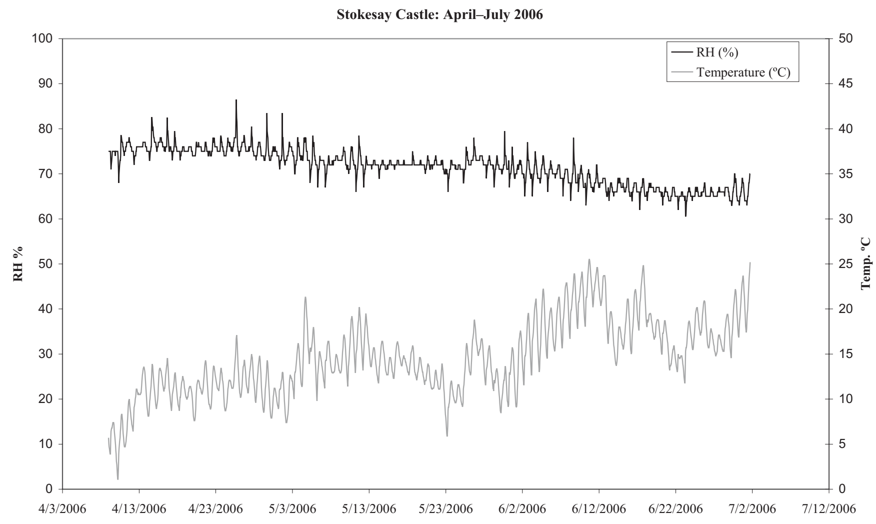

Figure 2b. After refit

Reducing silver tarnish rate in historic cases

Apsley House in central London presents a large collection of gilt and silver table-ware presented to the Duke of Wellington after his victories in the Napoleonic Wars. The very close proximity to exceedingly heavy traffic coupled with the permeability of the casement windows generates a high hydrogen sulfide concentration within the house, exceeding 1 ppm.

A large portion of the silver is displayed in a series of showcases in a single room. Most of the cases date from before 1840 and were commissioned by the Duke of Wellington to display this material. A number of additional cases were added in 1995, designed to fit visually with the existing cases. A blue woollen felt was used as a display fabric in the 1995 refurbishment, despite this material's well known adverse effects on silver. English Heritage took over management of Apsley House in 2005. Silver tarnish rate measurements with colorimetry (details in Appendix 1) and scanning voltametry indicated that the tarnish rate was significantly higher inside the cases than in the room (Thickett *et al.* 2005). Hydrogen sulphide concentrations measured with diffusion tubes were also found to be higher within the cases. As wool is known to emit carbonyl, but not hydrogen sulfide, the likely internal source of the hydrogen sulfide was therefore the dark blue dye used on the fabric. Carbonyl sulfide was not measured as no method is commercially available, but it is a potent agent in accelerating silver tarnish and almost certainly contributing to the tarnish observed (Brimblecombe 1993).

It has been observed experimentally that the deterioration of silver due to wool deterioration requires not only heat and high relative humidity levels but also light to significantly accelerate silver tarnish (Howell 2000). The lighting scheme utilised natural light through three large windows to supplement the fibre-optic lighting installed in 1995. Small samples were taken across the width of the base fabric from one case located between two of the windows. The wool samples were analysed with infra-red spectroscopy and the tyrosine content quantified from the second derivative of the absorption band at 1120 cm^{-1} (Odlyha 2006). The wool was found to be much more deteriorated at the edges of the base than in the middle, where the wall blocks direct light. As a holding strategy, blinds were used to reduce the light levels from several thousand lux to 200 lux until funds could be found to replace the showcase fabrics.

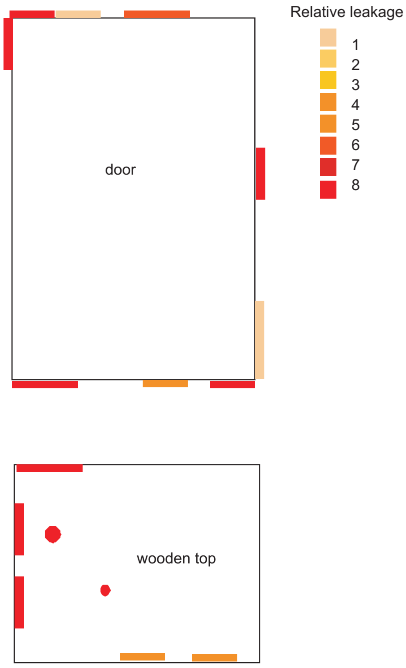

Figure 3. Leakage from case

The fabric was replaced in 2006 and attempts were then made to further seal the showcases to reduce tarnish rate. The cases had large holes in their tops for the fibre-optic lighting cables, which were sealed with 3M 425 tape and Dow Corning silicone sealant. Silicone compression seals were applied to all four edges of each case door. A leak detector was used to confirm complete sealing for the doors and fibre-optics and to determine any further gaps in the case structure, see Figure 3. Additional leakage was detected from cracks in the top of the case and these were sealed with silicone. Air exchange rates and silver tarnish rates were measured before and after this process. An average case decreased its air exchange rate from 5.75 to 0.23 day^{-1} and the silver tarnish rate was reduced by a factor of almost four. These results are in accord with reductions in tarnish rate inside showcases recorded in other properties (Thickett *et al.* 2005).

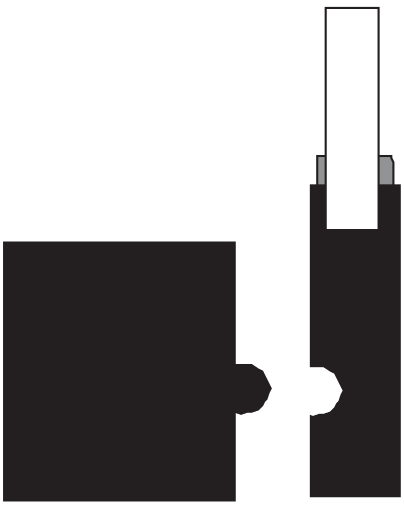
Figure 4. 1840s case door section

The original 19th century case doors had a worked profile, possibly to minimise dust ingress, see Figure 4. It was thought this may be effective at reducing water vapour movement through infiltration around the door as well and this was compared to modern compression seals. The door of one original case was left unaltered and its performance compared with a recent case of the same size and similar original air exchange rate before sealing. The air exchange rates and observed RHs within the two cases were very similar indicating that the old joinery techniques provided an efficient seal, comparable with modern compression seals.

Improving the RH buffering capacity of recent cases

A series of modern showcases that display silver in a corridor at Apsley House, were in an area proposed to warm food for functions. The introduction of hospitality places new demands on showcases. Previous experience had shown that the food warming equipment may generate high relative humidity levels. It was unclear if this would accelerate the silver tarnish, as the effect of RH on silver tarnish at the sulfide concentrations occurring in most museums is still unclear. However, the silver objects are coated with a protective cellulose nitrate lacquer and high relative humidity levels have been shown to rapidly deteriorate this lacquer (Luxford and Thickett 2007). The air exchange rates of the four cases ranged from 4.3 to 7.1 day^{-1} and new compression seals were fitted to improve case air tightness. This process was not straight forward as the hinged doors were quite tightly fitting and there was not enough room to fit even a 1 mm seal, especially along the hinged side of the door. As the cases were not historic (dating from 1995) the doors were removed and a groove routed around the inner face to take the seal. The new seals reduced the air exchange rates to between 0.6 and 0.9 day^{-1}. This provided sufficient protection against the short–term bursts of high RH expected from the hospitality events.

Charles Darwin lived at Down House with his family between 1842 and 1882 and formulated his theory of natural selection there. The upper floor of the house was developed in 1995 to present a museum with artefacts from Darwin's voyages and natural history specimens and new cases were installed. Environmental monitoring indicated that the humidity levels within the showcases were too low during the winter and spring period due to the comfort heating.

The cases were examined and a number of modifications made to improve their performance. New seals were introduced between the glass and tops of the frames to ensure compression, as original extruded silicone seals between the glass and the side of the frames were not effective, see Figure 5. Each case was found to have four 11 mm diameter holes in the metal frames (showcases are often made from standard templates incorporating a large number of holes for potential fitting of lighting, locks, etc). The holes were blocked with 3M 425 tape and silicone sealant. One case demonstrated a drop in exchange rates from 7.91 to 0.21 day^{-1} after this was

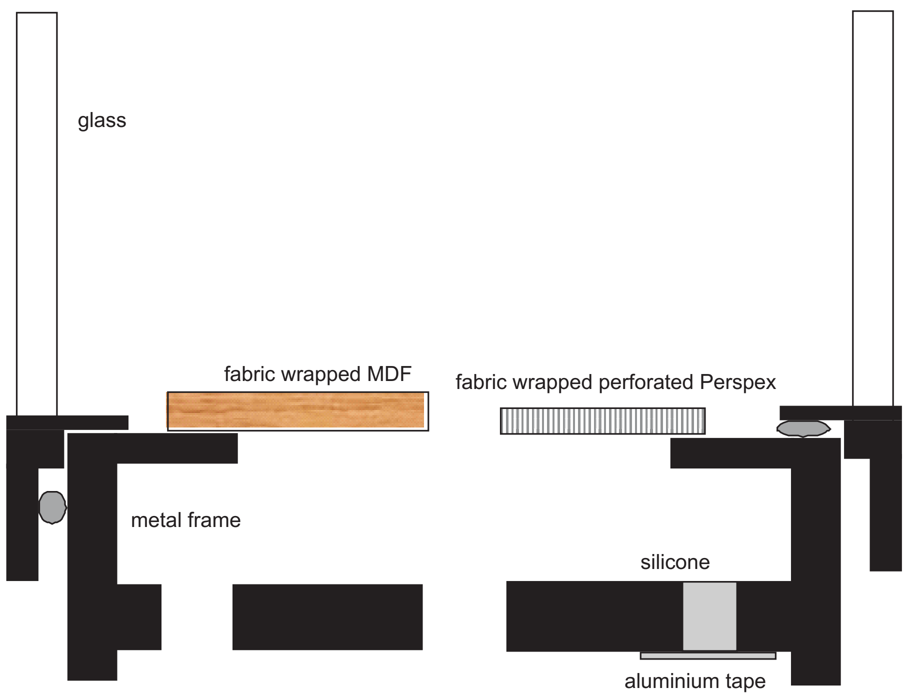

Figure 5. Case cross-sections Down House; left before refit, right after refit

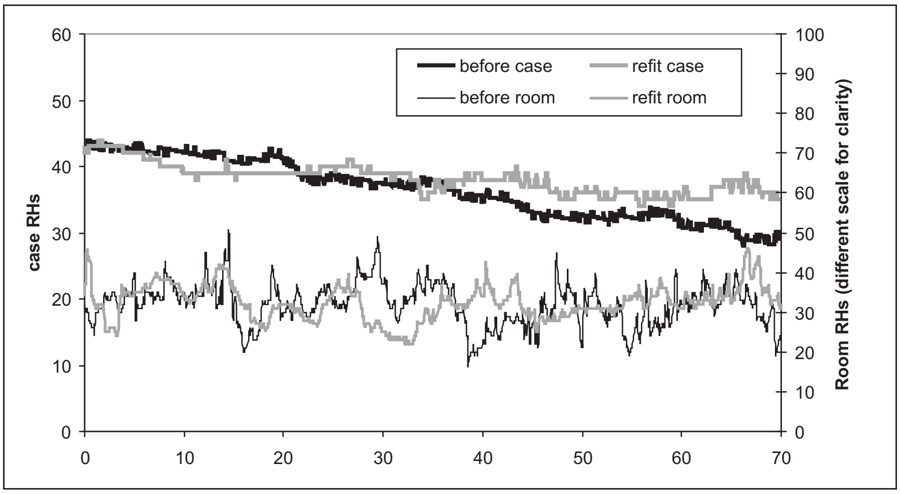

Figure 6. RH in case and room before and after refit

undertaken. Lastly it was found that the close fitting of the MDF baseboards was preventing air exchange between the silica gel facilities and display volume. MDF baseboards were replaced with Perspex ones, with 20 mm holes covering 30% of their surface to allow good air movement through them. Each case had 500 g of Prosorb granules preconditioned to 50% RH, added to the silica gel facility, giving a loading in excess of 65 kg/m^3. The cases are now able to retain an RH above 40% throughout the winter and spring heating period, despite the room RH dropping to 20% for long periods.

Removing inappropriate materials to stop corrosion

Efflorescences were observed on soft white Mytilus shells at Down House. They were analysed as calcium chloride nitrate ethanoate by infra-red spectroscopy, matching a standard from the Infra-Red and Raman User Group database (IRUG). Three potential sources of ethanoic acid were suspected.

The MDF baseboards will emit ethanoic acid if not properly sealed. Aluminised films provide the best protection (Thickett 1998) but when the board is fabric wrapped, identifying sealing below the fabric is difficult. A microwave moisture meter was utilised as it responds very strongly to the aluminised films even through the fabric. With these baseboards no aluminised film was detected and the fabric was removed to investigate

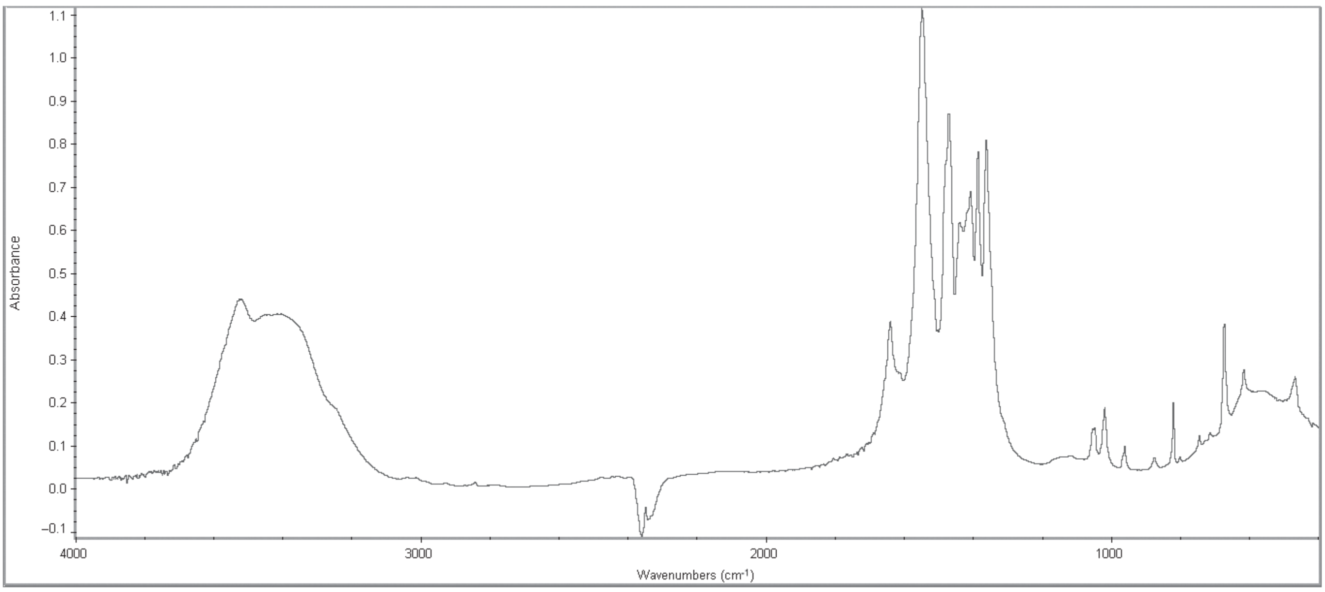

Figure 7. FTIR spectra of corrosion on shell

further. The MDF had a clear applied lacquer. This was analysed as Dacrylate 903–1 with infra-red spectroscopy. This lacquer has commonly been used in the UK since 1995 and although it blocks emissions of methanal, it has almost no effect on ethanoic acid emissions, which pose a much greater risk to most artefact types (Thickett *et al.* 1998). The MDF baseboards were replaced with perforated inert Perspex boards.

The shells were also adhered to hardboard bases that carry the original labels introduced by Lyell when he collected the shells in Patagonia in the 1830s. These were retained as they form an integral part of the artefact. They were also thought to be a lesser source of ethanoic acid, due to their much smaller exposed surface area than the MDF and as ethanoic acid emission from woods is known to reduce slowly with time. Nevertheless, it is worth noting that corrosive species such as oak can have significant emissions even after 200 years.

Several of the adhesive joins had failed. The original adhesive was almost certainly some form of animal glue and hence does not emit ethanoic acid. Several later repairs using different adhesives were observed and polyvinyl acetate, PVAc was suspected, which is a strong source of ethanoic acid (Down 1996). Small samples of the original adhesive and later additions were taken and analysed with infra-red spectroscopy. The original adhesive was confirmed as animal glue and PVAc was identified in two later additions as well as several non-ethanoic acid emitting adhesives. The two PVAc adhesives were removed physically, as they had already failed. Two years after the replacement of the MDF and removal of PVAc, no formation of ethanoate salts on the previously affected shells has been observed under microscopic examination.

Blocking emissions from paint

Bookshelf cabinets at the Iveagh Bequest, Kenwood were converted to display jewellery in 1999. Although these particular pieces have no historic value, English Heritage has many such examples converted from historic furniture over the past hundred years in its properties. Great care was taken with the fabric-wrapped pin boards for the jewellery, and the Victoria and Albert Museum was consulted extensively on inert materials. Unfortunately the tested inert paint finish applied to the other internal wooden surfaces was not considered a sufficient match with the untested wall paint and the latter was used inside the cases.

The following August, white corrosion crystals were observed on the solder of jet jewellery. The corrosion was identified as lead methanoate with X-ray diffraction and the jewellery had to be removed from the cases. Carboxylic acid analyses within the cases with diffusion tubes indicated concentrations of methanoic acid of between 3000 and 6000 μgm^{-3}, see Figure 8. The lead methanoate corrosion and high methanoic acid concentrations are characteristic of emission from paints. The paint was known to be from the Dulux range, but the exact identity had not been recorded. Analysis with colorimetry and infra-red spectroscopy indicated that it was an eggshell paint and likely to be 1060-Y. This paint had undergone extensive tests previously at the British Museum after a very similar problem. It did produce high concentrations of methanoic acid and lead methanoate corrosion. Tests to assess any drop off in corrosivity with time had unfortunately shown that even after three years it remained highly corrosive.

Three approaches were tried to mitigate the paint's effect inside the cases. The air exchange rate was increased to reduce the concentration of methanoic acid in the air. A series of holes were drilled into top and bottom panels of the case doors to take advantage of the stack effect to maximise air exchange (Michalski 1994). The methanoic acid concentrations were reduced to below 3000 μgm^{-3} (see Figure 8), however these concentrations still pose a very high risk of corrosion (Tetrault 1999). Trials were then undertaken to remove the paint. Hot stripping was found to be ineffective. Although dichloromethane

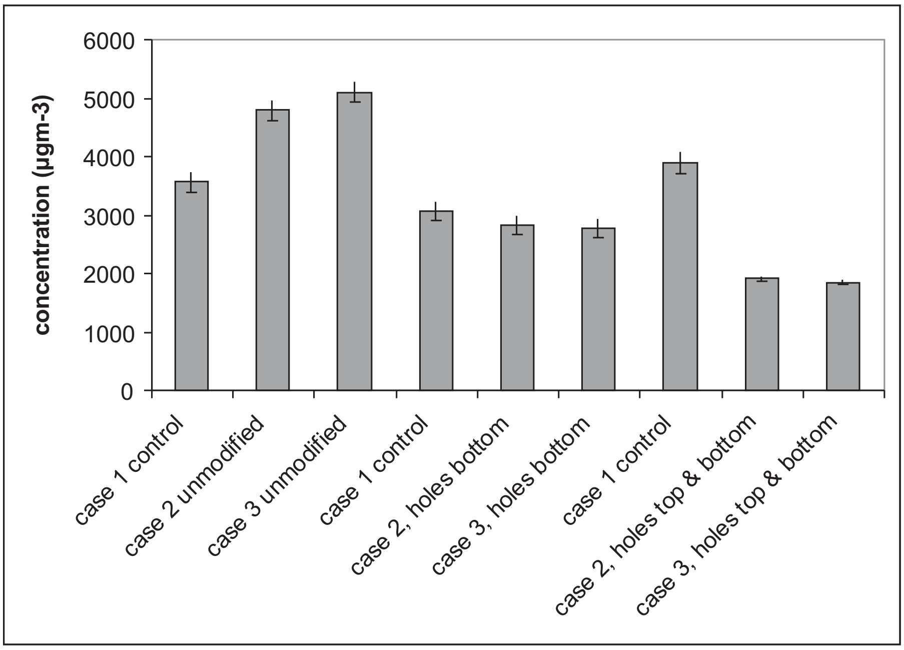

Figure 8. Carboxylic acids in painted case

based strippers were found to effectively remove the paint, the dichloromethane was found to permeate into the wood and was detected in the case air after four weeks. This posed a significant risk to the silver present in some of the jewellery and was not a suitable approach.

New close fitting MDF boards were constructed to fit the back, sides, top and bottom of the case and block the emissions from the paint. The boards were sealed with Moistop 622 and 3M 425 and then fabric wrapped. After fitting the boards, diffusion tube measurements could not detect methanoic or ethanoic acid in the showcase environment. The detection limits of those measurements were 42 and 70 μgm^{-3}, well below the lowest reported threshold for lead corrosion (Tetrault 1999).

A risk assessment was undertaken for the remaining cases, containing portrait miniatures, and the watercolours and supports were considered not to be at risk. The supports were mainly ivory, and although no work exists for the effect of methanoic acid on ivory, ethanoic acid is reported to not affect bone at concentrations below 20,000 μgm^{-3}, well above those found in the cases. Many of the portrait miniatures have copper alloy frames. Whilst these concentrations do not pose a risk to copper (Tetrault 1999), cast copper alloys often contain lead which segregates into discrete lead particles and can corrode at these concentrations. The frames were analysed with X-ray fluorescence (Bruker Tracer III) to determine any lead present. Approximately 8% of the frames had lead and these were subject to microscope examination for any signs of corrosion. None was observed after eight years of display, but as a precaution it is planned to install fans with activated charcoal filters into the two cases containing the frames with lead.

Conclusions

The variety of issues and solutions detailed in these case studies illustrate the number of factors that need to be considered before any modifications are undertaken. It is vital to understand the mechanisms that are causing the damage and therefore which aspects of the cases need to be improved to prevent wasted resources. At Apsley House much of the work concentrated on preventing damaging elements (light and hydrogen sulphide) from entering the case from the external environment. In contrast, at Kenwood and Down House the majority of the modifications were undertaken to remove the internal pollutants produced by elements within the cases.

Often a combination of factors contributed to object deterioration, so an initial modification had to be followed by further work. At Stokesay Castle improving sealing of the case to allow efficient introduction of silica gel was undertaken. The reduced air exchange then raised concerns regarding the build up of ethanoic acid necessitating all wooden surfaces being sealed with aluminium laminate. The utilisation of environmental monitoring, analysis of corrosion products and air monitoring all facilitated an accurate analysis of the deterioration factors and consequent modifications. They were also important in confirming the measures implemented were successful. The jewellery cases at Kenwood House continued to be monitored during the modifications, allowing measures to be revised until a satisfactory solution was found.

It is hoped that this paper has demonstrated re-fitting showcases can significantly improve their performance, provided there is a clear understanding of the factors causing damage and the potential consequences of these modifications through the use of monitoring.

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Appendix: Silver tarnish determination by colorimetry

Coupons were cut from sterling silver (92.5% silver, 7.5% copper), lightly abraded and a 3 mm punch was used to indent the centre of the coupon. The raised indent (on the opposite side from which the punch struck to avoid the accelerating effect of any transferred iron from the punch) was measured with a Minolta 2600D colorimeter. The coupon was exposed set into a Melinex holder to allow handling without touching the silver, but allowing open exposure of the silver surface to the air. The coupons were exposed for periods between 30 days and one year and the surface measured again with the colorimeter. The tarnish rate was expressed as an increase in b* per month. This parameter has been found to best correlate with perception of the early stages of silver tarnish in trials with forty curators, conservators and conservation scientists. Although b* is not an independent variable and would normally be inappropriate for this kind of analysis, a* was always invariant in the changes of surface reflectance measured for silver, allowing b* to be used in this way in these instances.