Museum showcases: specification and reality, costs and benefits

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Abstract

This paper explores the practical application of the theory of museum showcases, including the contradictions within our specifications, how the management of the contract affects the final product, and the reality of the compromises made when you are confronted by the two main drivers of a project – programme and budget. Case studies of a range of gallery development projects at National Museums Liverpool illustrate some significant lessons learned from the procurement of showcases. The impact of case lighting and gallery ventilation systems on the measurement of air exchange rates is explored, and heat build up from lighting systems is shown to increase the air exchange rate by a factor of 4. The difficulty of ensuring that the recommended ventilation and off-gassing periods are upheld is discussed. Measurements of VOC concentrations within relatively air tight cases two years after installation showed that concentrations remain high. Communication of the associated risks and benefits to others on the project team within a formal project management structure is shown to be at least as beneficial as producing good technical specifications for the showcases.

Introduction

The cost of showcases is a major component of the budget for most gallery creation projects, and museum showcases are a highly specialised product with a comparatively limited number of suppliers. Frequently, the showcase microenvironment is the primary means of environmental control for vulnerable and valuable collections. In comparison to close control air-conditioning, showcases are a relatively cheap, energy efficient method of protecting collections [1]. There has been a significant body of published research into how to ensure that this microclimate protects the collections being displayed, and the specifications for showcases are usually rigorous in applying this knowledge. Despite this, museums too frequently end up with showcases that do not meet the specification, and do not provide the protective microclimate that is one of their primary functions.

National Museums Liverpool undertook a major review of showcase specifications and policy between 1997-1999 ahead of a complex, large scale, capital development project called Into the Future. This project ran from 1999 to 2005 and involved the procurement and installation of 150 display cases in a number of different galleries. Early in the project there was a decision not to install close control air-conditioning in most of the galleries, but to rely on high performance cases for environmental control. With such a large investment, it was important to define the showcase performance and ensure that the specifications were met. This paper discusses this process, and compares the approach to that taken in a subsequent project of smaller scale, the Reveal gallery at National Museums Liverpool's Conservation Centre.

Methods for assessing showcase performance

Air exchange rates

Air exchange rate measurements were carried out in several phases, with initial phases (2000 to 2005) being undertaken by BSRIA Ltd, using a nitrous oxide tracer gas decay method [2]. From 2006, measurements were undertaken by the authors using the carbon dioxide tracer gas method outlined by Calver et al. [3]

Measurement of air quality

Concentrations of aldehydes and VOCs were measured using passive diffusion samplers supplied and analysed by the Building Research Establishment (BRE), and organic acids were measured using passive diffusion tubes supplied and analysed either by Oxford Brookes University [4], or by Strathclyde University [5]

Polished coupons of lead, silver and copper were also placed in showcases for long term monitoring of the effect of VOCs on metal objects [6]. The coupons were visually assessed in comparison to control coupons that had been wrapped in acid-free tissue and stored in the laboratory for the same length of time.

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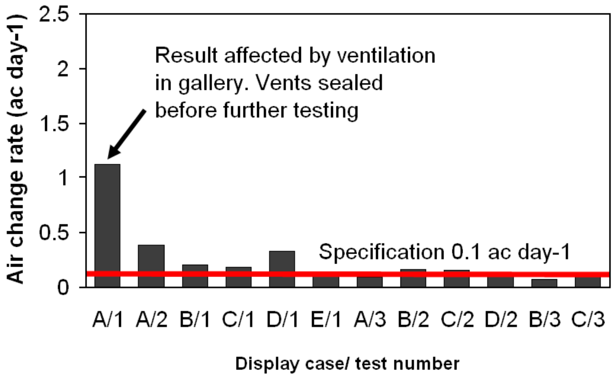


Figure 1. Air exchange rate measurements of Into the Future sample cases

Monitoring of temperature and relative humidity

Temperature and relative humidity (RH) monitoring was carried out using either Hanwell Humbug dataloggers, or a Hanwell radio telemetric monitoring system. During air-exchange rate measurements undertaken in house, temperature, RH and light levels in the showcases were recorded using an Elsec 764 Environmental Monitor.

Air exchange rates: how to test them and what they mean.

There has been much emphasis on quantifying and testing the air exchange rate of a display case [1, 3, 7], and an airtight case is still seen as being an important factor in providing the best microclimate for vulnerable collections on display. But what do we mean by air-tight? 0.1 air changes per day (ac day-1) has been proposed as a standard that museum cases can theoretically be built to meet [1, 8], but what are the costs of meeting this specification, and what are the benefits? Once an air-tightness specification is agreed, what is the best approach for ensuring the case meet this?

Different approaches to measuring air exchange rates

Two approaches to testing air tightness have been carried out by museums in recent years. The first approach involves contracting a specialist company, such as BSRIA Ltd (formerly the Building Services Research and Information Association) to measure the air exchange rates[1]). The costs of this are at least £500 per case tested, so that for large gallery projects, only a small fraction of the cases is usually tested. One of the recommendations from large gallery projects at other museums has been that in order to ensure that air exchange rate specifications are met, all cases should be tested [9].

The second approach follows the development of a method for measurement of air exchange rates that can easily be employed by conservators or conservation scientists in-house. This has led to the potential to test many more of the installed cases [3]. Other factors then need to be considered – staff resources to carry out the testing, and the impact on the installation programme if every showcase is tested individually (and potentially may need adjusting before exhibits can be installed).

National Museums Liverpool employed the first of these approaches for testing showcases for the Into the Future project. In this instance, we were able to stipulate that the showcase contractor should produce sample cases or prototypes for testing. Five sample cases selected to represent the different case types were produced, and air exchange rate measurements were carried out by BSRIA Ltd, using a tracer gas decay method [2]. The results are illustrated in Figure 1. Initial air exchange rate measurements indicated that none of the cases were within the specification of 0.1 ac day-1. An air exchange rate of 1.3 ac day-1 was recorded for one of the cases (case A test 1) located immediately below the inlet to the gallery ventilation system, which may have affected the result. After the vents were sealed and the system shut down, the case was re-tested and found to have an air-exchange rate of 0.38 ac day-1 (case A test 2). Additional silicone sealant was applied by the manufacturer to selected areas of the cases, and they recalled one desktop case (case D) to their factory for re-alignment. The cases were then re-tested, and the air-exchange rates had improved so that all the cases finally had an air-exchange rate of less than 0.12 ac day-1 (test 2 cases C and D and test 3 cases A, and B in Figure 1). When the final cases were installed in the galleries, the initial investment in sample cases and testing programme proved its worth. The installed cases selected for testing were different to the initial sample cases, but were again chosen to represent the main case types.

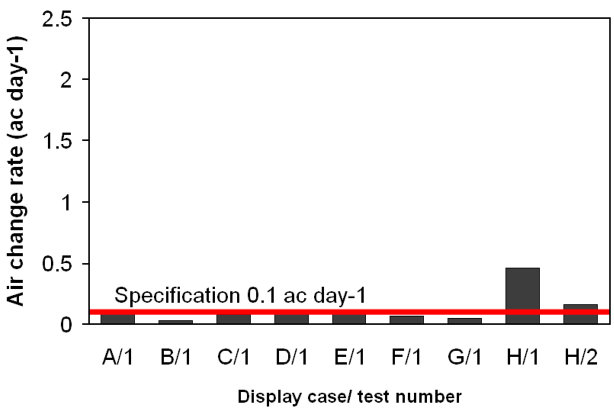


Figure 2. Air exchange rate measurements of Into the Future final cases

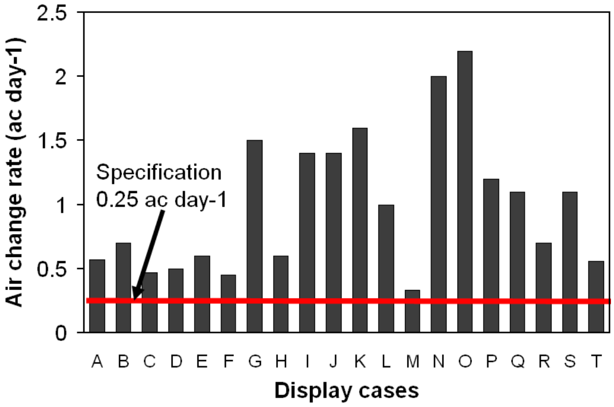


Figure 3. Air exchange rate measurements of Reveal cases

All the cases had an air exchange rate of less than 0.12 ac day-1 the first time they were tested (Figure 2), with the exception of the case H, a desktop case. The initial air exchange rate measured for AM/08 was 0.46 ac day-1, and it was noted that there was some play in the locks of this case and that the glass lid was not closing onto the sealant. The case was realigned by the case installation team, and the air exchange rate improved to 0.16 ac day-1.

In comparison, a more recent gallery project (Reveal: the Hidden Story of Objects) of much smaller scale employed the in-house testing method developed by Calver et al. [3], with the aim of testing every showcase as it was installed. However, testing was left until the final weeks of the exhibition installation. 20 out of the 25 display cases were tested, either before installation of the objects or afterwards. Even though the air-tightness specification had been relaxed to 0.25 ac day-1, none of these cases were within the specification, and there was insufficient time to rectify the problem and significantly improve the air-tightness before objects were installed. Figure 3 illustrates the results from the air exchange rate measurements for these cases, with air exchange rates between 0.3 and 2.2 ac day-1. The results are from measurements made over 12 hours overnight, and represent the performance of the cases without taking account of the impact of the case lighting systems, which is discussed in more detail below.

0.1 AIR CHANGES PER DAY – IS IT WORTH IT?

We changed the case specification for the Reveal project from 0.1 to 0.25 ac day-1, since it was felt that the additional cost incurred in the construction of cases of 0.1 ac day-1 was not warranted by the benefits. Some case manufacturers currently quote a premium of 5-10% of the case cost for manufacturing a display case to a specification of 0.1 ac day-1, with the increase relating entirely to additional installation costs. The care taken over the alignment of the case, and the sealing of joints is a major factor in producing an airtight case.

The assessment of the sample cases for the Into the Future project included monitoring temperature and relative humidity in the empty showcases, and in the gallery environment. The aim of the monitoring was to investigate the response of cases with different air tightness to variations in ambient conditions. Figures 4a and 4b illustrates that there was no significant difference between cases measured at 0.12 and 0.38 ac day-1 to short term fluctuations in the ambient environment. Figure 5 shows the response of the same two cases to fluctuations in the gallery over a longer period. As expected, the better sealed case was more effective at buffering longer term RH changes (Figure 5a) and the relative humidity within this case remained lower than in the leakier case (Figure 5b). The temperature in the cases is consistently lower than in the gallery, because the datalogger in the gallery was placed at a higher level than those in cases, so the results reflect the temperature gradient within the room.

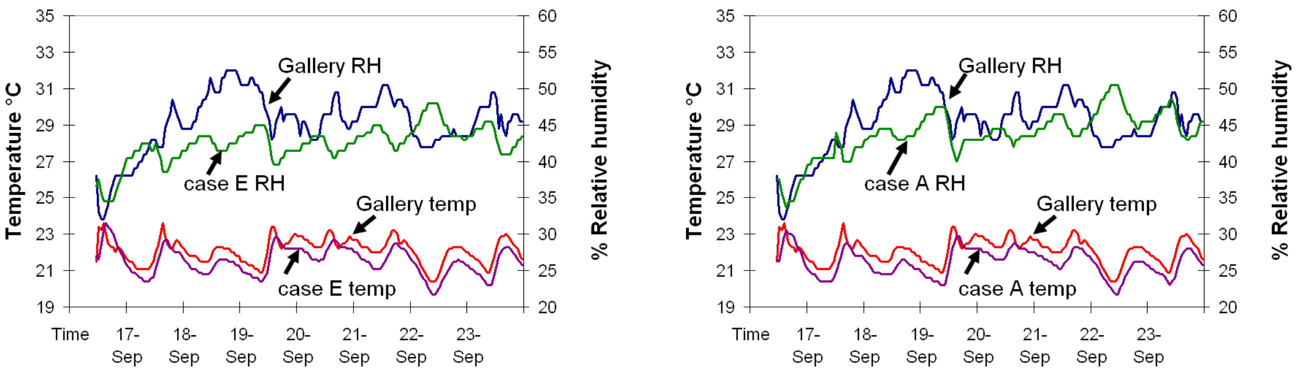
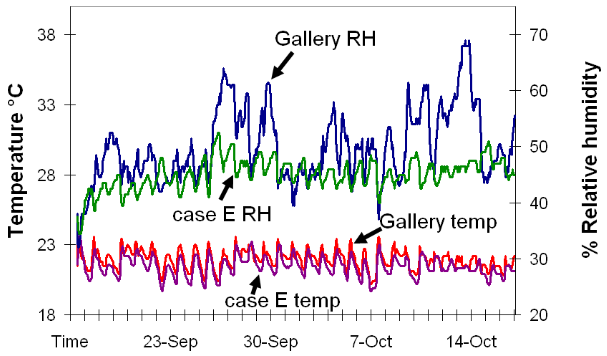


Figure 4. The response of cases with different air leakage rates to short term fluctuations in ambient gallery relative humidity and temperature.

a. RH and temperature in a display case measured at 0.12 ac day^{-1} over 1 week.

b. RH and temperature in a display case measure at 0.38 ac day^{-1} over 1 week



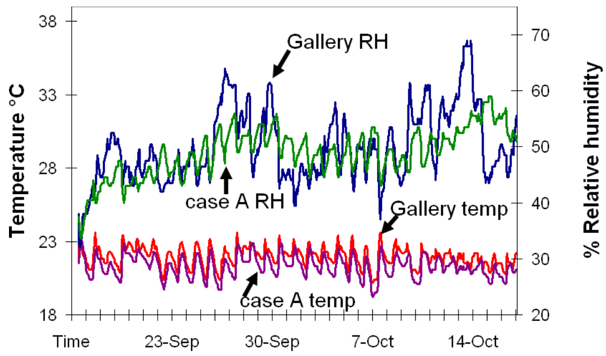


Figure 5. The response of cases with different air leakage rates to longer term fluctuations in ambient gallery relative humidity and temperature.

a. RH and temperature in a display case measured at 0.12 ac day^{-1} over 1 month.

b. RH and temperature in a display case measured at 0.38 ac day^{-1} over 1 month

When specifying the air-tightness of a case, consideration needs to be given to the ambient environment – a very air-tight case may not be suitable for a gallery with diurnal fluctuations in temperature but little seasonal drift. The specification of 0.1 ac day-1 for the Into the Future galleries was informed by dynamic thermal modelling of the galleries in which the showcases were to be installed, and as a consequence adjustments were made to the control strategies for the comfort cooling systems to reduce the short term temperature fluctuations in the galleries.

IMPACT OF LIGHTING SYSTEMS ON CASE PERFORMANCE

Our showcase specifications originally stated that the case lighting systems should not result in any heat gain within the case, and requested that drivers for fibre optic projectors should be be placed remotely, or above the case rather than below the case volume. Experience has shown us that this is unrealistic, and the case lighting frequently has a significant effect on the case microclimate. The impact on air exchange rate has been noted by others [7], and is clearly illustrated by this example of the diurnal effect of the case lighting system (Figure 6). The air exchange rate varies from 0.4 ac day-1 at night when the lights are off, and nearly 3 ac day-1 during the day. This pattern of extreme and sudden variation between the air exchange rates measured in the day and night was observed for a large proportion of the cases in the Reveal Gallery. More detailed tests were carried out on one case (Reveal case S), to investigate whether this variation resulted exclusively from the case lighting system. This case (Figure 7) has a lighting system of both fluorescent lighting and fibre optics, with the projector for the fibre optics located in a light box above the main volume of the case. The external dimensions of the case are 1350 x 1550 x 340 mm, with a hinged door on one side that opens the full width and height of the case enclosure.

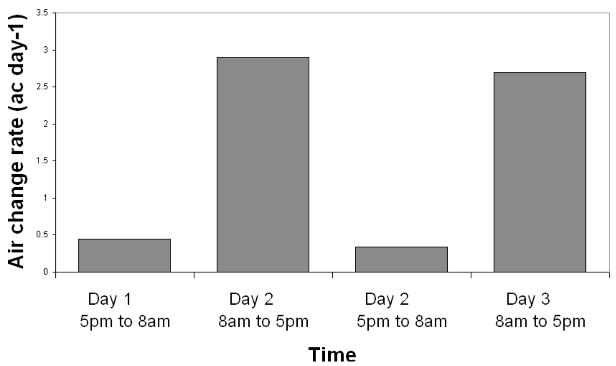


Figure 6. Diurnal changes in the air exchange rate of Case M in the Reveal Gallery.

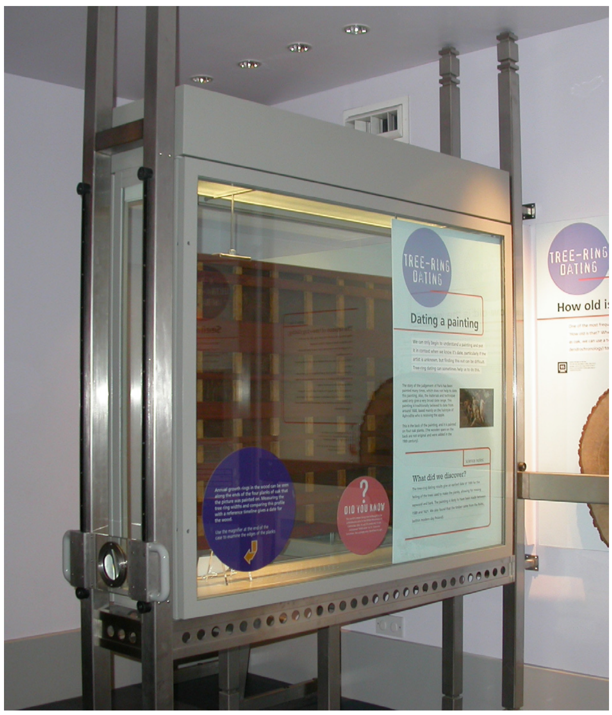


Figure 7. Case S in the Reveal Gallery.

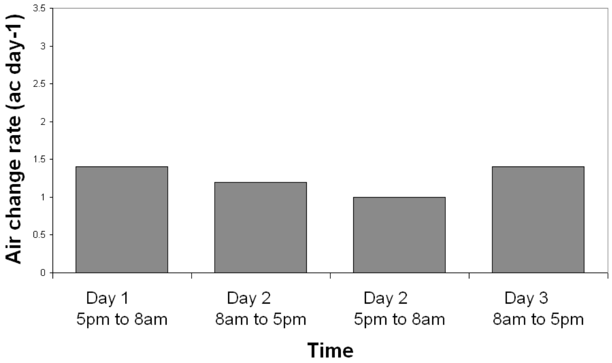


Figure 8. Air exchange rate measured in Reveal case S over a 48 hour period, with the case lighting off and gallery ventilation on for the duration of the testing period.

Measurement conditions	AER – night	AER – day	AER 24 hours
Case lights on 7:30 – 17:00 gallery ventilation on 24 hrs	1.1	4.9	2.5
Case lights on 7:30 – 17:00 gallery ventilation off	0.8	4.4	2.3
Case lights off Gallery ventilation on 24 hrs	1.4	1.2	1.3
Case lights off Gallery ventilation off	1.0	1.0	1.0

Table 1. Variation in the air exchange rate of Case S in the Reveal gallery. All measurements are air changes per day (ac day^{-1}).

As well as the impact of case lighting systems, we also investigated the effect of the gallery ventilation system, given the large reduction in the air exchange rate noted above for one of the Into the Future test cases following the sealing of air vents in the gallery where the case was tested. Case S is located directly below two of the main air inlets for the gallery ventilation system. Table 1 summarises the results of the air exchange rate measurements under differing conditions, with case lights on during the day, or switched off completely for the duration of the test, and with the gallery ventilation on for the duration of the measurements or switched off. The results demonstrate clearly that the case lighting system is responsible for the variation in air exchange rate of the case. When the case lighting was switched off, the air exchange rate of the case remained constant (Figure 8). When the gallery ventilation was switched off but the case lights turned on as usual during the day, the same diurnal effect on the air exchange rate was observed. There was a slight reduction in the air exchange rate when the ventilation was off, but this is within the error of 20% for the measurement method estimated by Thickett et al. [7], so would need further measurements to determine whether this apparent contribution is significant.

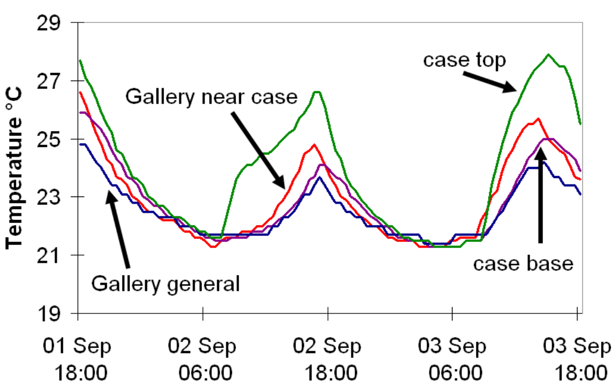


Figure 9. Variation in temperature inside Reveal case S at the top and base, and between gallery locations in the vicinity of case S, and remote from the case.

Temperature inside the case and in the ambient gallery environment was recorded during the air exchange rate measurements. Dataloggers were placed inside the case at the top and bottom to measure the temperature gradient within the case during the first test, when case lighting and ventilation systems were operating normally. These measurements showed that when the case lighting was on, the temperature at the top of the case was 2.5-3ºC warmer than the temperature at the base of the case (Figure 9). At the top of the case, diurnal fluctuations of 5-6ºC were measured during the air exchange rate tests. The temperature differential between the top of the case and the ambient gallery environment in the vicinity of the case varied from less than 0.5ºC at night when the lights were off, to 2ºC with the case lighting switched on.

In a gallery development project, case air exchange rate measurements are frequently carried out before the case lighting systems are operating normally, so such measurements are of doubtful usefulness. Since an idea of the air exchange rate of a case is important for calculating the quantity of buffering material needed, it is helpful to have a realistic measurement of the air exchange rate of a case within a normal gallery environment, rather than a measurement made in unrealistic conditions with no ventilation or lighting. It is clear that the air exchange rate of these cases, once the impact of lighting systems is taken into account, is even further from the specification than indicated in Figure 3.

One action that has been agreed for the cases is to place additional insulation materials between the fibre optic projector and the base of the light box, to minimise the heat radiated into the case volume. The impact of fibre optic lighting systems on case leakage is not limited to the problems of heat generation: even if the projectors are located remotely and are well insulated, the tails for fibre optics will invariably puncture the microclimate, with a potential increase in the air-exchange rate. The point where the tails enter the case volume can be well-sealed initially, but there is the risk that the sealant will deteriorate over time, and the leakage rate of the case will increase [7].

Specification of materials for showcases

The requirement to specify inert construction materials to reduce the emission of reactive volatile components causing collections to deteriorate is well understood. There are clear guidelines and a standard testing procedure for materials [10] is routinely used to screen case construction and dressing materials before they are approved for used.

However, in practice the choice of materials is not straightforward. To begin with, the main inert materials used in case construction (metal, glass, Perspex) offer comparatively little buffering capacity, so there is already a compromise between an inert environment and a well-buffered environment. Powder-coated steel as a case lining is less likely to produce harmful organic acids than MDF or other wood products, but it is much more difficult to fix to, and therefore not popular with designers wishing to display objects fixed to the back or sides of a case.

National Museums Liverpool's case specifications list our required curing and off-gassing periods for coatings and sealants. However, even when all materials have been tested and approved, the cases invariably have a strong solvent smell when they are installed – perhaps because curing times are difficult to police when plinths and case linings are manufactured off site. The original programme had an allowance of two weeks for the cases to ventilate, with the doors open, once constructed. This became very difficult to enforce with so many other activities taking place on the gallery.

Concentrations of organic acids were measured in the Into the Future sample cases, and in some of the final cases before the plinths and objects were installed, and were found to be well within the "no observable adverse effect level" suggested by Tétrault et al for the corrosion of lead and copper in the presence of organic acids [11]. However, when concentrations were measured again two to three years later, some cases had high levels of acetic and formic acids. Possible sources include the objects themselves, or the plinths and stands which were constructed from MDF sealed with a two part polyurethane coating.

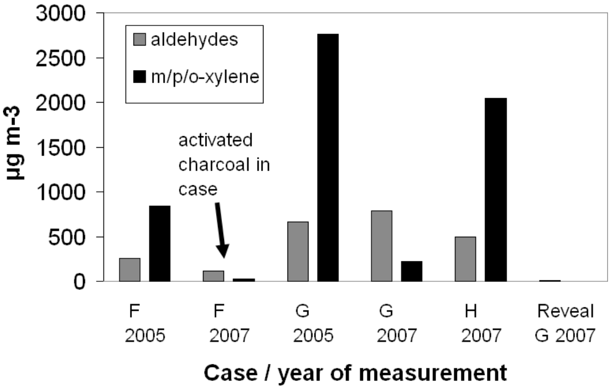


Figure 10. Concentrations of aldehydes (formaldehyde and acetaldehyde) and xylene (total m/p/o-xylene) in showcases. Cases F and G were monitored soon after installation (2005), and two years later (2007). Case H was monitored 2 years after installation. The Into the Future cases were specified to have an air exchange rate of 0.1 ac day^{-1}, although this was not confirmed through testing these cases. Reveal case G had a measured air exchange rate of 1.5 ac day^{-1}, and the aldehyde and VOC concentrations were monitored 9 months after installation.

Concentrations of aldehydes and total volatile organic compounds (VOC's) of the Into the Future Cases were measured shortly after the cases were constructed, but before the objects were installed. Relatively high levels of VOCs, especially xylene and aldehydes were found in the cases (Figure 10). The concentrations were measured again two years later. Activated charcoal had been placed in one of the cases, (case F), as a scavenger for pollutants, and this appears to be successful in reducing concentrations. In cases without any pollutant scavenger, concentrations remain relatively high two years after installation. Case H had not been part of the initial study immediately after construction, but was included because curators had noted that it had a very strong solvent smell, and two years after installation, xylene concentrations were still over 2000 µg m^{-3}.

By contrast, the concentrations of VOCs measured in the comparatively leakier Reveal cases were very low one year after installation, even though the initial perception was that there was a strong solvent smell when they were installed. One advantage of the cases failing to meet the air tightness specification is that they allow any volatile products emitted by sealants and finishes to disperse. The dilemma that we now face is how to undertake remedial works to improve the air-tightness of the cases, which may mean applying sealant to cases with collections in situ. This is a problem that is sometimes encountered in the run-up to a gallery opening. When air-tightness testing finds gaps in the case days before object installation is due to take place and additional sealant needs to be applied, do you prioritise an air-tight case over one where all the volatile components have dispersed?

The comparative risk to a collection from a leaky case and pollutants needs to be assessed. For some internally generated pollutants, such as the VOCs measured in the Into the Future cases, these risks are difficult to assess when little is known about the likelihood of damage to collections at particular concentrations. Metal coupons exposed in Into the Future case G for 32 months showed some tarnishing of the silver coupon, and darkening of the lead coupon, compared to control coupons kept in the laboratory for the same duration. A survey of metal objects in the Into the Future cases 24-32 months after installation showed no significant effect from the high levels of VOCs.

Project management and communication

The examples given above illustrate that the way a project is managed affects the ability to procure a product that meets the specified requirements. Stanley et al [12] discuss the benefits of having a conservator in a key role in the project team, and the importance of ensuring that all parties accept the technical specifications and understand their implications for the programme. National Museums Liverpool's specifications were developed by a cross-functional team with input from all departments, and following widespread consultation with external colleagues. One of the factors that may have contributed to the problems we encountered is that the project team changed completely part way through the Into the Future project, and the new team had not been involved in the development of the original showcase specifications or the original tender process.

Programmes drawn up at the beginning of a project usually have a generous allocation for commissioning and ventilation of cases and off-gassing of sealants. However, since the off-gassing time is towards the end of the programme, it is very vulnerable to compression when a fixed opening date is looming, with dignitaries booked. Frequently this period ends up being used to absorb the slippage of other elements, which may be incompatible with the dust-free environment needed to allow cases to vent with doors open. We now avoid the use of solvent-based paint finishes in showcases, even if accelerated corrosion tests indicate that the cured finish is relatively inert. If the finishes are applied off-site, it is very difficult to ensure that they have been cured for the recommended time in a well-ventilated environment.

The specifications have been updated and revised following the Reveal project, and the appointment process for a showcase contractor now includes a detailed session to examine the technical specifications and discuss difficulties and queries. Over the next 3 to 4 years, National Museums Liverpool is undertaking a further series of major development projects, and one of the challenges will be communicating the lessons learned to the different external consultants appointed to each project.

Conclusions

This paper highlights some of the practical problems encountered when applying knowledge of microclimates to specifying museum showcases, and the compromises needed to satisfy different aspects of the microclimate. The development of a method for testing air-exchange rates that can be used in-house to test every case installed in a new gallery doesn't necessarily result in more air-tight cases. More important is the management of the project, to ensure that the specifications and their implications are understood, and to allow time for testing and development at an early stage of the project. Programmes for testing cases and measuring air exchange rates need to take account of factors such as the case lighting systems and gallery ventilation, to predict the air-exchange rates that will actually be achieved once the cases are in an operating gallery.

There are certain risks associated with specifying air-tight cases that need to be communicated and understood. An understanding of the comparative risks to objects from a leaky case or from internally generated gaseous pollutants is important. Ongoing research on the interaction of these pollutants with museum objects [13] has a significant contribution to make to the specification and procurement of museum showcases.

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