The use of glass boxes to protect modern paintings in warm humid museums

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Abstract

This paper considers the advantages and disadvantages of an enclosure for the display of unvarnished easel paintings, both modern and contemporary, for use in warm, humid museums. Microclimate analyses of a display box's performance in five museums are presented and correlated with material damage to paintings. The results are presented of a research project, carried out between 2000 and 2002, to test a sealed glass box at five Brazilian, naturally ventilated museums and to verify its efficacy in protecting paintings, not only to avoid soiling and consequent cleaning of their surfaces but also to reduce biological attack, particularly that caused by fungi.

Introduction

This research resulted from a discussion among Brazilian conservators on the efficacy of using glass boxes for the exhibition and conservation of modern paintings in Brazilian museums, during a workshop conducted by Stephen Hackney (Tate, London), supported by Fundação Vitae, a Brazilian private sponsoring body, in 1999. It aimed at testing a simplified type of box and evaluating its performance as a protective device for unvarnished paintings. The box was tested in five museums in Brazil, all naturally ventilated, in three regions of the country with distinct climates: Northeast, Southeast and South of Brazil. The host museums were the following: Museu de Arte Contemporânea de Pernambuco (MAC-PE), in Olinda, Museu de Arte Contemporânea da Universidade de São Paulo (MAC-USP), in São Paulo, Museu de Arte Moderna (MAM-RIO), in Rio de Janeiro, Museu de Arte da Pampulha (MAP-BH), in Belo Horizonte, and Pinacoteca Barão de Santo Ângelo (PINA-POA), in Porto Alegre, Rio Grande do Sul.

Physical protection and stability of museum objects is achieved by enclosures of many types. However, it is common knowledge that, in warm and humid climates, each and every thing that is kept in cabinets, drawers and boxes grows mold. In fact, biodeterioration, fungal outbreaks in particular, is one of the major conservation problems faced by Brazilian museums' staff. During the workshop, conservators reported that unvarnished paintings aged quickly, particularly if exhibited in naturally ventilated museums. Surfaces darken with dust, losing colour saturation, and potentially hazardous surface cleaning becomes necessary.

The argument put forward by Stephen Hackney at the workshop was that in temperate climates protection of modern paintings by enclosure behind glass brings benefits, preventing them from dust accumulation, soiling, premature aging [1] and large daily climate fluctuations [2] and the debate was whether this protection could be extended to museums with high temperatures and humidity and consequent tendency for mould growth.

Some researchers state that fungal outbreaks are due to sporadic rises of air temperature and relative humidity [3]; others relate them to constantly high levels of relative humidity, corresponding to a high 'water activity number' [4] [5]. Other researchers anecdotally correlate mould growth with a combination of moist and dirty surfaces [6]. During the development of its ten-year program in Sub-Saharan African countries – Prevention in Museums in Africa, the International Centre for the Study of the Preservation and Restoration of Cultural Property – ICCROM staff observed that fungal spores would not germinate on clean surfaces. In some African museums, both objects and shelves, after being thoroughly cleaned, were enclosed by polyethene sheets fixed with *Velcro* to the furniture structure. Most of them have remained free of biodeterioration.

It is interesting to note that while easel paintings are directly exposed to indoor environmental conditions, works of art on paper, due to their apparent fragility, have their fronts protected by glass, and their backs by cardboard or other inadequate, porous, normally acidic materials. This type of protection allows humidity from the walls to penetrate those back supports and cause mould to appear, first on the inner glass surface, where condensation may occur, then on the *passe-partout* (the card mount), and finally on the art work itself. Therefore the experience of framing visual art in warm humid museums had failed in Brazil in the past.

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The use of glass boxes to protect modern, unvarnished paintings also raises aesthetic problems. Artists, curators and ordinary museum-goers seem not to appreciate observing works of art through glazing. Light reflects on the glass surface, producing glare and preventing the observer from identifying and enjoying artistic materials and techniques. In this research, the aesthetic drawbacks of glazing modern and contemporary paintings are not discussed, and the performance of the glass boxes is analysed simply on their ability to stabilize indoor climate daily fluctuations and prevent surface mould growth. Therefore an attempt was made to correlate both sporadic climatic extremes and also long periods of constantly high temperature and relative humidity with mould growth on painting replicas.

Methodology

Because it was a national project, involving five institutions in five states of Brazil, some logistical issues were addressed prior to the design concept and construction of the glass box. Aiming at a smooth development of the research project, the authors undertook the following: 1) theoretical and conceptual discussions; 2) definition of the design and materials to be used in the glass box; 3) definition of the materials to be used in the painting replicas; 4) selection of the monitoring equipment; 5) microbiological analysis to be carried out, before and after the boxes were exhibited in the five museums, to be undertaken by the Instituto de Pesquisas Tecnológicas – IPT in São Paulo; and 6) data analysis, correlation and conclusions on glass enclosures in warm humid museums.

The box was intended to be sent to the museums and be exposed there for one year, completely unattended, without any type of maintenance. The box design and construction were very simple: two 4mm glass panes on its front and back, held together by a wood frame, a sliding plywood (10mm) stretcher with the six painting samples, sealed together with caulk. Holes were drilled around the stretcher to facilitate air mixing between front and back of the box. The relationship between air moisture content and that of the organic buffering materials inside the box was calculated [7][8] based on the space necessary to insert the small NOVUS datalogger. A set of six unprotected painting replicas was exhibited next to the set protected by the glass box.

The most popular and vulnerable painting materials, particularly to microbial attack, were selected for the mock-ups. Six different painting techniques were tested, with and without ground or preparation layer: 1) oil, 2) acrylic emulsion, 3) vinyl emulsion, 4) egg tempera, 5) mixed media (oil, acrylic and paper glued on canvas), and 6) mixed media (acrylic on paper glued on *Eucatex*). The paintings were simple stripes of primary and black and white colours. A set of replicas was kept in the laboratory, in controlled conditions, for later comparison purposes. Ready-made acrylic paints *Acrilex* were utilized, being available in many colours, of good colour rendering, cheap and easily found in the local market. However, for the other painting techniques to be tested, some imported pigments (*Prisma*) had to be purchased. The most popular supports were also chosen: cotton canvas (that could be tensioned on a stretcher, plywood or wall); *papier collé* (*Kraft* paper glued on textile); and *Eucatex* (a hard and lightweight wooden panel that accepts various painting techniques). For the preparation layer, white *Suvinil* ground paste was used. Twelve prototypes were made: six were exhibited inside a well sealed glass box and the other six were exhibited without protection.

Before sealing the box, its interior glass panels were cleaned and sterilized with alcohol (ethanol). Painting surfaces were sampled for fungi by IPT staff, at three points: egg tempera, vinyl emulsion and the plywood stretcher. Under laboratory conditions, mould grew on the vinyl emulsion of the MAC-USP and MAM-RIO, and on the egg tempera of the MAC-PE and the PINA-POA. The potential for mould growth was observed in all egg tempera samples exhibited without glass protection. 7 types of fungi were isolated.

Two dataloggers were attached to the box: one inside and the other outside it. The monitoring of air temperature and relative humidity values lasted one year, from April 2001 through March 2002. The dataloggers had to be wireless, operating by battery, be resistant, accurate, and the data downloaded without opening the box (by infra-red emission)1. The equipment was manufactured by and purchased from NOVUS Produtos Eletrônicos, a Brazilian company that uses the English technology of Tiny Tags. They were programmed to register an average of 5 readings, taken every 15 minutes, with just 19 daily readings, with the hours coinciding each 5 days. The averaging, meant to save memory, in fact smoothed the curve, missing some extreme climate values.

Because of the long monitoring interval established by the conservators in the first year, as well as the

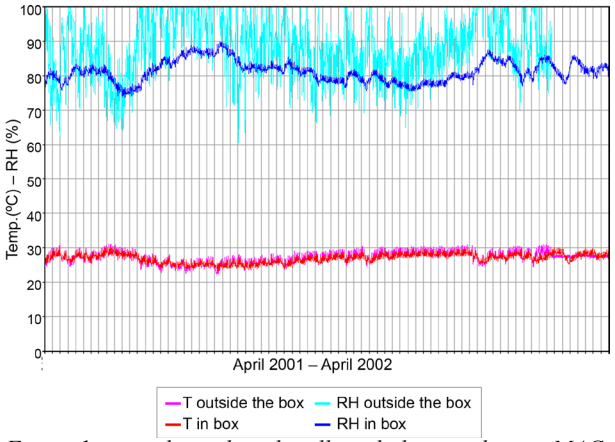

Figure 1. annual graph with collected climatic data at MAC-PE, a massive building, showing the high indoor RH. There is frequent condensation on the wall of the upper exhibition room where the glass box was hung.

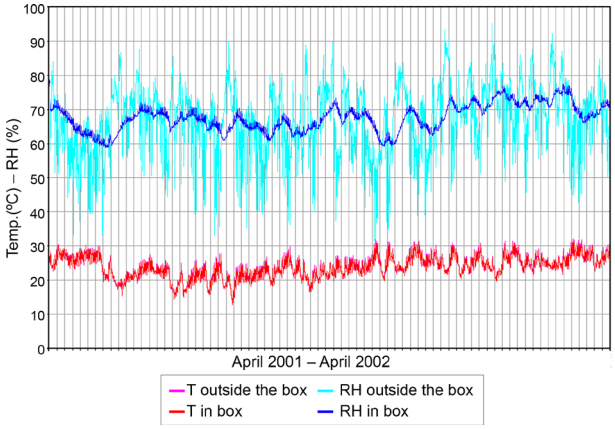

Figure 2. annual graph of the collected climatic data in the MAC-USP museum corridor, showing five-day large fluctuations both of temperature and RH values.

large number of painting replicas (and therefore variables to take into account), the experiment was considerably simplified, according to recommendations made by Stephen Hackney, in September 2002, when all the authors met in Rio de Janeiro, and since September 2006 it has been repeated in Recife, by Franciza Toledo. The box is in her living room, sitting next to an interior wall perpendicular to the glazed east facade, and daily exposed to the morning sun. The dataloggers were then programmed for hourly readings. The painting replicas of the first experiment were replaced by a piece of cotton canvas, stretched and partially coated with animal (rabbit-skin) glue, with and without fungicide. The results of this research in progress will be the subject of another article.

Results

Out of the five experiments carried out between 2001 and 2002, three failed in data collection because three exterior dataloggers became faulty. Therefore only data from experiments undertaken at MAC-PE, in Olinda, northeast Brazil, and MAC-USP, in São Paulo, southeast Brazil, are discussed in depth. The experiments conducted at MAP-BH, in Belo Horizonte, MAM-RIO, in Rio de Janeiro, and PINA-POA, in Porto Alegre, are discussed in a general way. Summer and winter climatic data were processed, to determine the average values of temperature, relative (RH) and absolute humidity (AH) of air, inside and outside the boxes, and to evaluate its performance.

The Museu de Arte Contemporânea de Pernambuco – MAC-PE occupies an 18th century two-storey massive building in Olinda, a world heritage site. It was originally built to house a religious prison and still maintains its original features: the windows do not have shutters, just rails, being permanently cross-ventilated, and the upper rooms do not have ceilings. The boxes were exhibited on the upper, first, back room. Being a constantly open museum, the MAC-PE presented a large daily climate variation of ± 7%RH and ± 1.3°C. The box reduced the variation to ± 1%RH, while interior temperature variation values approached those of the exterior (± 1°C). Next to the wall there was frequent air saturation and condensation, while the RH inside the box remained high, around 81%. The RH near the wall varied between 90% and 100%, while inside the box it varied between 85% and 90%. In the rainy winter the average climate values inside the box were 83%RH and 25.6°C and in the dry summer, 80%RH and 27.8°C. The absolute humidity next to the wall was 19g/kg in winter and 21g/kg in summer. Inside the box, it ranged from 16.5g/kg to 18.5g/kg in winter, while in summer it increased, ranging from 18g/kg to 20.3g/kg (fig. 1).

The Museu de Arte Contemporânea da Universidade de São Paulo – MAC-USP is housed in a modern, modular concrete building at the university campus. The box was hung in a corridor between the museum administration and exhibition rooms, characterized by a large movement of people and climatic instability. The RH daily fluctuation next to the wall at the MAC-USP was about ± 8.5%, while temperature varied about ± 2.2°C. The box reduced the RH fluctuation to ± 1%, while temperature variation was similar (± 2°C). Both average temperature and RH values, inside and outside the box were similar, around 24°C and 67%RH. Inside the box, the RH average value in the dry winter was 66% and in the rainy summer 71%. Temperature inside the box, in winter, was 22.5°C and in summer, 25.6°C. Still in summer, the absolute humidity next to the wall was 14g/kg to 15g/kg, while inside the

box it varied from 13.5g/kg to 15.5g/kg. In winter, the absolute humidity reduced, the inside values ranging from 10 to 13g/kg, and the outside ones from 11 to 12g/kg (fig. 2).

At the Museu de Arte Moderna do Rio de Janeiro – MAM-RIO, a modern concrete building from the 1950s, designed by architect Afonso Eduardo Reidy, in Flamengo Beach, exterior temperature readings were corrupted in winter time, and remained high, while the inside temperature reduced by about 4°C (in September and October 2001, the average temperature inside the box was 24.6°C and that of the outside, 28.6°C). The interior RH average value was 72%, while the exterior RH varied between 62% and 83%. Towards the rainy summer, exterior RH readings decrease instead of increasing, confirming the inaccuracy of the equipment. Next to the wall, the microclimate varied just ± 3%RH, and the box contributed to enhance this stability, presenting interior daily fluctuations of ± 0.75°C and ± 0.75%RH. In February and March 2002, the RH inside the box was about 76%, while the exterior ranged from 53% and 81%. The average temperature inside the box was 28.3 °C, but reached 32.4°C (on 03.20.02 at 17:45). The glass box was exhibited in the museum entrance hall.

At the Museu de Arte da Pampulha – MAP-BH, in Belo Horizonte, a concrete and glass building, designed by Oscar Niemeyer in the 1940s, the exterior climate data were corrupted after July 5, 2001. However, the climate conditions inside the box, hung on an exterior wall of the museum's mezzanine, showed a constantly hot environment, which led to a gradual air drying process, with the interior RH values being reduced from 72% to 55% at the end of the year. In the first three months of the dataloggers simultaneous operation, both inside and outside temperatures dropped 2.5 °C and while the outside RH raised to 78%, the inside one remained stable at about 72%. In this short period, the outside temperature and RH variations were ± 0.25°C and ± 2%RH, and the inside ones, ± 0.3°C and ± 0.4%RH. The inside temperature values were slightly higher (0.7°C) than that of the outside, the average value being 28.7°C, reaching 32.6°C in various occasions. In the dry winter, the absolute humidity inside the box varied from 17.5g/kg to 15.2g/kg, and in the rainy summer, it was about 13.7g/kg.

At the Pinacoteca Barão de Santo Ângelo, which is housed in an ordinary building from the 1940s, in the center of Porto Alegre, the exterior climate data were also corrupted. The box was hung on an internal wall of one of the exhibition rooms on the second floor. The average temperature inside the box was 22.5°C and the RH, 78%. Between September and October 2001, the average RH was about 85% and temperature, 21°C. In January and February 2002, the RH was 73%, and the temperature, 26.4°C, reaching 29°C (on 01.30.02 at 20:00). Interior temperature and RH daily fluctuations were ± 0.6°C and ± 0,5%RH. The lowest absolute humidity value occurred in the rainy winter, with an average of 11.5g/kg, and the highest, in the dry summer, with an average of 15g/kg.

Concerning the annual RH average values inside the boxes, it was observed that the MAC-PE presented the highest (81%), followed by the PINA-POA (78%), MAM-RIO (73%), MAC-USP (67,5%) and MAP-BH (63%). The latter presented the highest temperature average value (28.7°C), followed by MAC-PE (27°C), MAM-RIO (26.9°C), MAC-USP (23.8°C) and lastly, PINA-POA (22.5°C). The most stable microclimate was found at the MAP-BH, followed by the PINA-POA. The most unstable

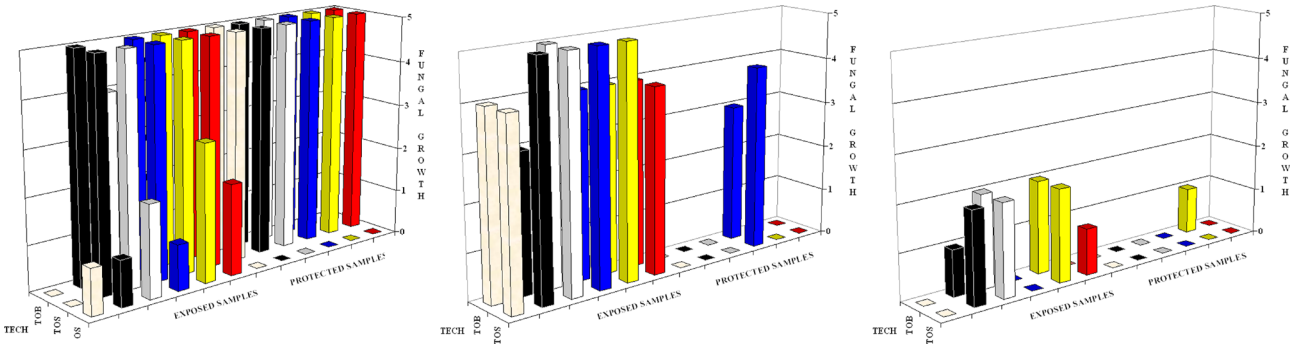

Figure 3. microbiological analysis of the egg tempera painting replicas exhibited at the MAC-PE (left), PINA-POA (center), and MAM-RIO (right). The colours in the graphs represent the stripes and the beige represents the canvas without paint. Axis X shows the two sets of replicas without and with the protection of the glass box. Axis Y shows the degree of mould growth: 0 - no growth, 1 - signs of growth, 2 - 1 to 10% of growth of the total area of the colour stripe, 3 – over 10% up to 30% of growth, 4 – over 30 % up to 70% of growth, and 5 - more than 70% of growth. Axis Z shows the egg tempera replicas with (TOB) and without (TOS) the preparation layer; at the MAC-PE (left graph), the oil on canvas painting replica, without preparation layer (OS), in the third row, also grew mould. Source: IPT report n° 63.058.

climate conditions were registered at the MAC-USP and MAC-PE. The highest absolute humidity values were registered at the MAC-PE (18.3g/kg), followed by the MAM-RIO (16.5g/kg), MAP-BH (15.5g/kg), PINA-POA (13.4g/kg) and MAC-USP (12.6g/kg).

The boxes were collected at the IPT, on April 11 to 18, 2002, for microbial examinations: quantification and identification of fungi. The painting replicas displayed without the protection of the glass box were visibly soiled and presented, aside from the stains caused by fungal attack, wall or ceiling paint drops, bats and insects' excrements, surface darkening and dust accumulation, as well as structural damages such as undulations, fissures and paint losses. Such decay was considerably attenuated in the samples displayed in the glass boxes. The technique most susceptible to decay was the egg tempera, followed by the two mixed media: acrylic paint on Kraft paper glued to Eucatex, and oil and acrylic paint on Kraft paper glued to canvas.

After one year, the fungal contamination increased, with 21 new fungi being identified. Yeasts and bacteria were also identified. Three out of the five pairs of boxes developed mould, but microbial contamination was higher on the replicas exhibited without protection. The following was observed: a) canvas, plywood and paper favoured microbial deterioration; b) the ground used was less susceptible to fungi; c) egg tempera and oil painting (without ground), particularly on the black and white colours, were the most vulnerable to fungal attack. The replicas from MAC-USP and from MAP-BH were clean, while those of MAC-PE, PINA-POA, and MAM-RIO presented microbial contamination, in an incipient manner on the third, and widespread on the first and second sets of replicas (fig. 3).

Conclusion

The results showed that, in warm humid museums, a glass box, if well built, is efficient in creating a safe microclimate and protecting exhibited paintings from microbial deterioration. The glass boxes presented many advantages: 1) climatic stability due to a good sealing and a certain amount of buffering materials; 2) microbial control; 3) dust control; 4) extra protection for works on loan; and 5) UV radiation control, if UV filters is applied to the glass. The disadvantages were: 1) visual interference; and 2) its incompatibility with some conceptual works of art.

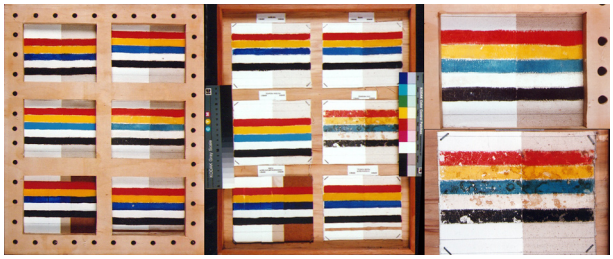

Figure 4. painting replicas exhibited with (left) and without (center) the protection of the glass box at the MAC-PE, and details (right) of the egg tempera samples protected by the glass (above) and unprotected (below).

Figure 5. painting replicas exhibited with (left) and without (center) the protection of the glass at the MAC-USP, and details (right) of the mixed media - acrylic, oil and Kraft paper on canvas samples, protected by the glass box (above) and unprotected (below), showing the paper undulations.

The glass box may be recommended for: a) works of art with thin painting layers sensitive to daily climate fluctuations and prone to mechanical damages; b) works with rich, porous painting layers, such as temperas; c) monochromed works, on which any type of surface cleaning is problematic; d) old, fragile or heavily soiled works; e) works that are constantly handled and/or on loan.

It should not be used on: a) works of art composed of slow drying materials (such as oil, paraffin, vaseline, etc.); b) varnished works; c) works with thick impasto paint or reliefs; d) conceptual works that require exhibition as they are; and e) works of large dimensions due to risk of glass breakage.

To work properly the glass box requires: a) minimal sealing, with tape, silicone or caulk; b) minimal sterilization; c) the use of dry organic buffering materials in the enclosure; d) interior air absolute humidity lower than that in equilibrium with the moisture content of the enclosed materials; e) the use of chemically inert materials. However, more investigation is needed on: a) the use of thermal insulation materials as backings; b) the use of lighter materials; c) painting surfaces changes (colour and texture); d) air diffusion rate and hygrometric half-time of the glass box; and e) smaller and more reliable monitoring equipment.

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9 The boxes at the MAC-PE presented the highest level of microbial deterioration (fig. 4) followed by the ones exhibited at the PINA-POA. At the MAC-USP (fig. 5) and MAM-RIO, the mixed medias, with paper strips glued as collages, presented fissures and undulations. In sum, within a year, the painting replicas exhibited in constantly high air relative humidity developed mould while the ones that underwent daily large fluctuations suffered mechanical damages