Museum Environment Control for Sustainable Collection Management

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1 Introduction

Museums not just in Japan but around the world are becoming more actively involved with their respective communities by opening up and allowing more access to their collections. With increasing demands for access to collections, museums need to provide a good balance between access and conservation. At the same time, the museum of the 21st century is required to pay consideration to its environmental impact.

Two environmental issues affecting museums are protection of the ozone layer and climate change. The former led to a comprehensive review in Japan of policies regarding the use of chemical fumigants to protect cultural properties, resulting in the implementation of Integrated Pest Management (IPM). The latter affects not only the outdoor environment, but also the museum environment. We therefore face a dilemma on how to reduce energy consumption without adversely affecting the control of temperature and humidity within the museum.

2 Pest control based on IPM

2.1 Protection of the ozone layer

The ozone layer is a part of the stratosphere and is situated about 50 kilometers above the earth's surface. It acts as a shield to prevent harmful ultraviolet radiation from reaching the surface. In 1974, an article published in *Nature* (Molina and Rowland 1974) pointed out that chemically inert halogenated aliphatic hydrocarbons are being added to the environment by human activities and they may remain in the atmosphere for 40 to 150 years. The concern was that once they reached the stratosphere, they would release ozone-depleting chlorine atoms which could then damage the earth's protective ozone layer. In the early 1980s, this concern became a real threat when it was discovered that the ozone layer over Antarctica was becoming thinner. Some examples of ozone-depleting substances are chlorofluorocarbons, used in almost all refrigeration and air conditioning systems; halons, used in fire extinguishers; and methyl bromide, used as a fumigant.

Since the 1970s, a mixture of methyl bromide and ethylene oxide has commonly been used in Japan as a fumigant for cultural properties. According to the "Montreal Protocol on Substances that Deplete the Ozone Layer"[1)], the phase-out schedule for methyl bromide was fixed by the end of 2004 for developed countries (Non-Article 5(1) Parties in Table 1) including Japan. Japanese museums

Table 1 Phase-out schedule for methyl bromide applicable to production and consumption, amounts used for quarantine and pre-shipment applications exempted. (Extracted from the United Nations Environment Programme – Ozone Secretariat).

Non-Article 5(1) Parties		Article 5(1) Parties	
Base level	1991	Base level	
Freeze	January 1, 1995	Freeze	January 1, 2002
25% reduction	January 1, 1999	20% reduction	January 1, 2005
50% reduction	January 1, 2001	100% reduction	January 1, 2015 (with possible critical use exemptions)
70% reduction	January 1, 2003		
100% reduction	January 1, 2005 (with possible critical use exemptions)		

were faced with revising their bio-deterioration control policies and given this background, it was decided to implement IPM for sustainable collection management.

2.2 Implementation of IPM

IPM was first introduced as a method for controlling pests on fruit trees and crops, and gradually became adapted for use in other fields including museums, libraries, and archives. IPM is based on a combination of common-sense practices, and has turned out to be the most economical approach. It is important to note that pest management options include, but are not limited to, the use of pesticides. With this approach, we opt for the method that poses the lowest possible risk to people, collections and the environment.

Several preventive measures are routinely employed in our museum and related surveys are conducted based on the principle of IPM (Sonoda and Hidaka 2008, 2011) (Sonoda 2012). Anyone entering the storage zone is required to change into clean shoes (Figure 1). Storage rooms are regularly cleaned and each room is dusted from top to bottom, starting from the air-conditioner ducts and light fittings on the ceiling before moving down to shelf tops and then to floors (Figure 2), and any dead insects or other signs of pest presence are photographed, collected and recorded.

Figure 1 Shoes removal prior to entering the storage zone.

Figure 2 Storage area cleaning.

Upon completion of cleaning of the storage zone, an inspection is performed to detect any possible signs of pest or fungal damage. In order to prevent pests from entering, doors and shutters are open only when it is necessary.

Pest monitoring using insect traps has been ongoing since 1992. Two kinds of insect traps (302 sheet traps and 180 pheromone traps for cigarette beetles) are set at fixed points, left for two weeks and then collected. The pests captured in each trap are counted and identified. In order to analyze the problems by identifying the sources of abnormalities and then taking appropriate measures, a customized computer program has been developed as well as an original mapping system.

The results of over 20 years' investigation (Figure 3) show that, the most frequently captured pests in the storage zone are booklice, beetles, and moths. In Osaka, where the summer tends to be hot and humid, special attention is required for booklice. From around 2001 onwards, early pest detection efforts combined with improved organization and better IPM awareness among the museum staff have resulted in a dramatic decline in the number of insects captured - a trend continuing to this day.

Since 2004, we have adopted the following pest control policies. Artifacts collected outside Japan are systematically treated with ethylene oxide while artifacts infested after arrival in Japan are treated using non-chemical methods, generally by carbon dioxide treatment, and supplementary methods using heat treatment or freezing. As a preventive measure, all the items removed from the storage zone for exhibition or for loan to other museums are systematically treated with one of these

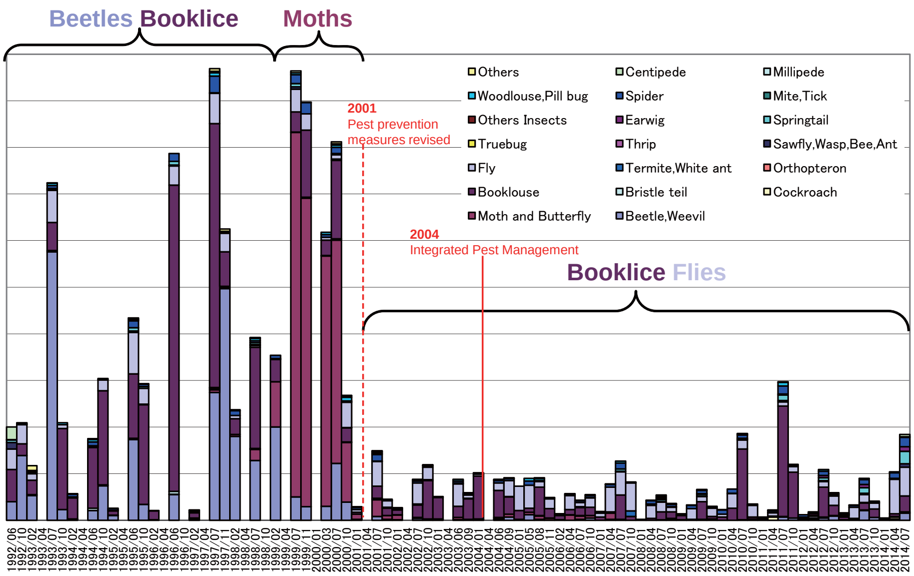

Figure 3 Relative changes in the numbers of pests trapped in the storage zone.

non-toxic methods prior to being put back into storage. Carbon dioxide treatment is currently used for ethnographic artifacts because it can be performed easily within airtight enclosures. However, certain species of beetles may survive the treatment. In such cases, heat treatment is considered the method of choice: An in situ heat treatment system has been developed for large ethnographic objects, composed of a thermal isolation container, a heat generator and connecting pipes; the first real application of the system was conducted on a wooden Indian boat in the South Asia gallery in March 2003. For textiles, carpets and fur, a commercially available freezer is also used. In March 2007, a special chamber was constructed with a capacity of approximately 19 m^3, satisfying operational conditions both for heat treatment and freezing. In July 2007, the existing fumigation chamber was developed into a multi-function chamber that enables non-toxic methods to be used, i.e. anoxia with nitrogen, carbon dioxide treatment, both with eventual use of heat to maintain temperature higher than room temperature (up to 30 ℃).

3 Energy efficient climate control

3.1 Climate change – global warming

Climate change is another serious environmental issue for museums. Global warming, one of the aspects of climate change, refers to the ongoing rise in global average temperature near the earth's surface. This warming is attributed to the release of large amounts of carbon dioxide and other greenhouse gases into the atmosphere through the use of fossil fuels over the last 100 or so years. In order to mitigate climate change, it is necessary to make fundamental and continuous efforts to reduce greenhouse gas emissions at the global level. For example, following the introduction of the Act on the Rational Use of Energy by the Japanese government, our museum is required to achieve an average energy use reduction of over 1% per annum and to make a systematic effort to reduce energy consumption.

In Japan, the circumstances surrounding energy changed drastically in March 2011 after the Great East Japan Earthquake and the accident at Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant, which led to an energy shortage.

3.2 Towards energy-efficient air-conditioning control

The storage rooms in our museum can be divided into two types: General storage rooms and special storage rooms (Table 2).

- Most of the items in our collections are made of mixed materials and are placed in general storage rooms under collection classifications, without any sorting by material. The air conditioning in the general storage rooms is normally run daily during working hours. Different temperature settings are used in summer and in winter, with adjustments made in increments of 0.5℃ per week during the

Table 2 Temperature and RH settings for a storage room under the standard regime.

	General storage rooms	Special storage rooms				
Rooms	Rooms 1-7	A. Weapons	B. Carpets	C. Lacquer wares	D. Fur, skin, feather	F. Textiles
Air conditioning operating hours	8:30-17:30	24 hours				
Temperature settings	Summer 26±2℃	22±1℃	20±1℃	22±1℃	22±1℃	22±1℃
	Winter 20±2℃					
Relative Humidity settings	52±5%RH	50±2%RH	50±5%RH	60±2%RH	50±2%RH	55±2%RH

transitional seasons of spring and autumn. The relative humidity (RH) setting is constant throughout the year.

- Special storage rooms house artifacts made of sensitive materials requiring finely tuned air-conditioning control, as well as items that require special security arrangements. The temperature and RH settings in the special storage rooms are optimized for the materials from which the items stored in each room have been made, with 24-hour air conditioning.

Following the Great East Japan Earthquake and the subsequent power shortages, we adopted the following power-saving measures. The air conditioning in the general storage rooms was turned off during the transitional seasons (autumn 2011 and spring 2012). During the winter of 2012, air conditioning was run only at night during the off-peak period, with the humidity in the storage rooms controlled within a pre-defined range. In summer 2012, in response to requests to reduce electricity usage to 15% (later 10%) below 2010 levels, the air conditioning was only run for 24 hours on Wednesdays (when the museum was closed and power usage was low) and Sundays (when fewer members of staff were at work) and was turned off completely on all other days. However, storage room 5, which is situated upstairs and not surrounded by other rooms, and is thus directly exposed to the effects of outside air, was exempted from these power-saving measures. To prevent any inconvenience and to detect abnormalities at an early stage, environment monitoring and control has been strengthened. For the special storage rooms, 24-hour air conditioning was maintained during the power-saving initiatives.

Temperature and humidity control under the standard air conditioning regime and the power-saving regime are compared, based on actual readings (Sonoda and Hidaka 2013).

- Temperature: Average temperature tends to drop below the control range under the power-saving regime; the maximum daily difference is less than 4℃ (even less than 2℃ in several rooms) under both regimes, except for storage room 5; and the average daily difference is around 2℃ or less (even less than 0.5℃ in several rooms) under both regimes, except for storage room 5. It is noteworthy that, after a period of no air conditioning in spring 2012, the temperatures in the storage rooms were lower than the temperature set for the air conditioning on the day the air conditioning was scheduled to be switched on. It is hoped that the suspension of air conditioning in spring may allow the use of air conditioning to be delayed.

- RH: Average RH values are slightly higher during the summer period under the power-saving regime (around 60%RH) but otherwise remained largely within the control range; the maximum daily difference is 10%RH or less under both regimes in most storerooms, but in some storerooms this value can exceed 10%RH during spring and summer; and the average daily difference is less than 5%RH under both regimes except for the summer period under the standard regime where it exceeds this value.

Figure 4 shows weekly transitions in temperature and RH for each season from 2010 to 2012 for one of the general storage rooms. An ellipse is tentatively drawn for each week to include 90 percent of the data, with temperature on the x-axis and RH on the y-axis. In spring, groups of ellipses can be seen to move from low temperature/low RH to high temperature/high RH as a result of an increase in temperature and relative humidity, whereas in autumn, the opposite tendency is observed. The size of each ellipse reflects the fluctuation; the greater the size, the greater the fluctuation in temperature and/or relative humidity. For spring and autumn, the seasonal transition in temperature and RH may be greater under the power-saving regime (spring 2012) (autumn 2011, 2012) than under the standard regime (spring 2010, 2011) (autumn 2010). However, weekly changes are comparable to other seasons as shown by the small size of the ellipses, indicating that transitions in temperature and RH were gradual and there were no sudden changes in temperature and RH. Overall, we can conclude that temperature and humidity control results under the power-saving regime did not differ greatly from those under the normal regime, with the exception of summer 2012 under the power-saving regime (the largest ellipses), showing that the power-saving measures adopted for the summer 2012 need to be revised.

Based on these findings, energy-efficient air-conditioning control has been in place since fiscal year 2014. During the transitional seasons, the air conditioning is switched off to allow natural transitions in temperature and RH. This results in a cost reduction of 3 million JPY (approximately 27,500 USD) per annum. Note that in the special case of storage room 6, located underground (therefore largely unaffected by outside temperature), it was not necessary to use air conditioning in summer as the temperature remained lower than the temperature set for summer air conditioning. This resulted in the air conditioning being switched off for three consecutive seasons, spring, summer and autumn of 2013[2)].

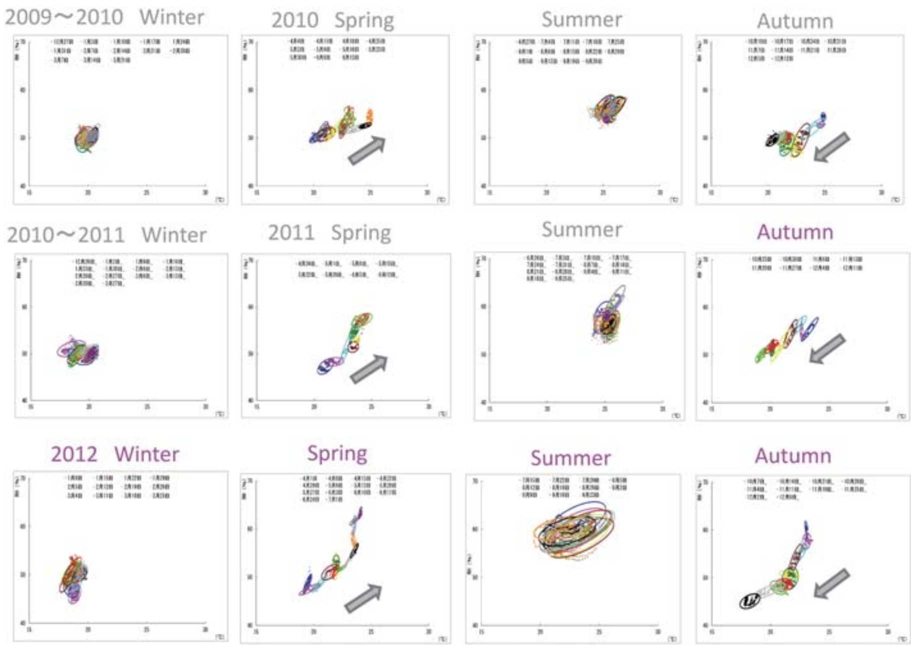

Figure 4 Weekly transitions in temperature and RH for each season from 2010 to 2012.
(Gray: normal regime Pink: power-saving regime)

Under the new regime, if power conservation is required, we will opt for reducing the duration of air conditioning rather than alternating between no air-conditioning days and 24-hour operation days as in the summer of 2012. The air conditioning is run for just a short period every day in order to minimize fluctuations in temperature and RH.

4 Sustainable collection management

At the beginning, I said that the museum of the 21st century is obligated to consider its impact on the environment. This fact affects what measures we decide to take to ensure the collection is managed properly. This paper described examples of pest control and climate control measures implemented at our museum.

Collection management is not, however, confined to what happens under normal circumstances, but comprises measures to address all eventualities that may affect the collection including emergencies. In 2005, an introductory workshop to the Museum Emergency Programme[3)] (organized by ICOM, the Getty Conservation, and ICCROM) was held in Bangkok. The practical application of the concept of “Integrated Emergency Management” was presented as a series of cyclical activities: The pre-disaster phase consisting of “risk determination & analysis”, “risk evaluation” and “risk mitigation”; the disaster phase comprising “emergency preparedness” and “response procedures”; and the post-disaster phase consisting of “damage assessment / loss estimation”, “treatment”, “recovery, rehabilitation”; and then returning again to the pre-disaster phase in an ongoing cycle.

Here, I would like to discuss an Integrated Emergency Management scheme from the perspective of collection management. The pre-disaster phase, together with “recovery, rehabilitation” and “emergency preparedness” can be incorporated into preventive conservation activities under the standard regime, while the disaster and post-disaster phases corresponding to the rescue/treatment activities in the event of an emergency can be assimilated as curative conservation activities. Preventive conservation activities and curative conservation activities complement each other to form Integrated Collection Management (Figure 5).

We cannot eliminate all the risks to our collection. However, we can mitigate effects on the collection by controlling the museum environment and taking appropriate measures before and after a natural disaster, and we can reduce the risk of damage or loss to our collections through sustainable collection management.

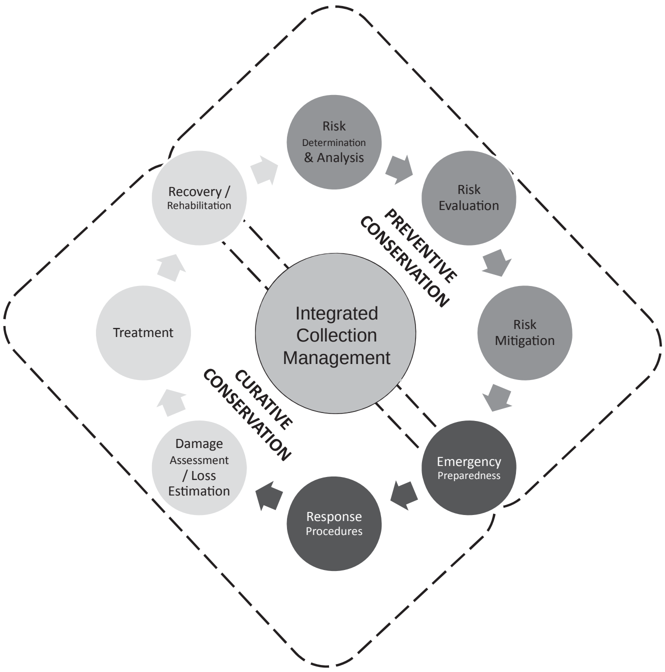

Figure 5 Integrated Collection Management.
(Based on the concept of Integrated Emergency Management proposed at a workshop on the Museum Emergency Programme, organized by ICOM, the Getty Conservation and ICCROM, Bangkok, 2005).

Notes

1) The “Montreal Protocol on Substances that Deplete the Ozone Layer” was adopted in 1987, and amended in 1990, 1992, 1997, and 1999.
2) However, as storage room 6 (approximately 5600 m^3) is located underground and tends to have high RH, nine dehumidifiers continued to operate even during the period when the air conditioning was switched off.
3) http://www.iccrom.org/ifrcdn/eng/news_en/2006_en/events_en/06_19meetingMEPSeoul_en.shtml

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