



# PREVENTIVE ART CONSERVATION WORKSHOP:

Storage and Environment Control  
Based on Context Found in Thailand

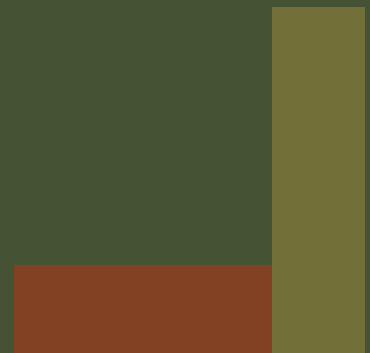




06

# Care, Handling, and Packaging

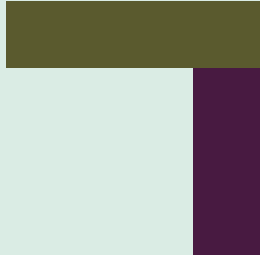
■ By Dr. Nicole Tse



# 06

## Care, Handling, and Packaging

By Dr. Nicole Tse




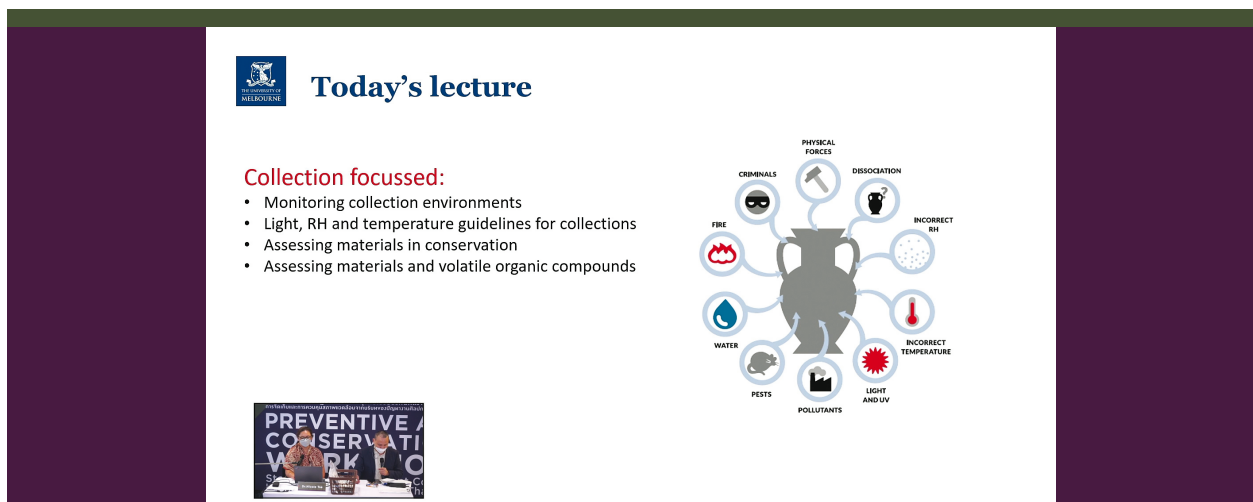
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21  
January  
2023

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The lecture Care, Handling, and Packaging will revise some of the content Aj. Chiraporn shared with the participants, and it's also a consolidation of the previous lecture on 'The Fundamentals of Painting Conservation and Decision Making'. For the practical session, we will be applying what we learn here to an assessment of museum environments and testing materials (Image 90).





**Today's lecture**

**Collection focussed:**

- Monitoring collection environments
- Light, RH and temperature guidelines for collections
- Assessing materials in conservation
- Assessing materials and volatile organic compounds

The diagram illustrates 10 agents of deterioration surrounding a central vase:

- CRIMINALS
- PHYSICAL FORCES
- DISSOCIATION
- INCORRECT RH
- INCORRECT TEMPERATURE
- LIGHT AND UV
- POLLUTANTS
- PESTS
- WATER
- FIRE

Below the list is a small image of a book cover titled 'PREVENTIVE CONSERVATION WORK'.

Figure 90: Lecture content & the 10 agents of deterioration from Michalski, SA, C & Pedersoli, JR 2016, 'Guide to risk management', Guide to risk management, viewed 9 May, 2018, ICCROM, Rome, from [https://www.iccrom.org/wp-content/uploads/Guide-to-Risk-Management\\_English.pdf](https://www.iccrom.org/wp-content/uploads/Guide-to-Risk-Management_English.pdf), p. 27

Our practical session will focus on an exhibition spaces within The Bangkok Art and Cultural Centre. As a public museums, conservation plays an important part. People access collections to create identity, explore their past, and access their works of art into the future, and conservators enable such access. Collections are not stored and locked up like silent, static objects. They are part of public collections and exhibitions to be accessed. As such, museums and conservation efforts are far more complex than they were in the 20<sup>th</sup> century when we would store things away with the goal to preserve collections forever. Our conservation challenge today is to support community access to collections while also managing the risks. It is a debate between preservation versus access.



Figure 91: 21<sup>st</sup> Century Museums, image: Robert Lazarus, from <https://arts.unimelb.edu.au/grimwade-centre-for-cultural-materials-conservation/ccc/cultural-conservation-channel#recollections>

When thinking about our globally-connected the world, how can collections travel from one location to another and what conservation standards support these? There are standard rules about museum climates, but many of these have emerged out of the global north, such as the United Kingdom, Europe, and America. A question for conservators working in Thailand is, how can these standards be applied to your situation and the transit of works of art? Looking at image 3 and Koppen climate map of the world, climates across the world are not the same, so how can the same standards and museum climates be universally applied?

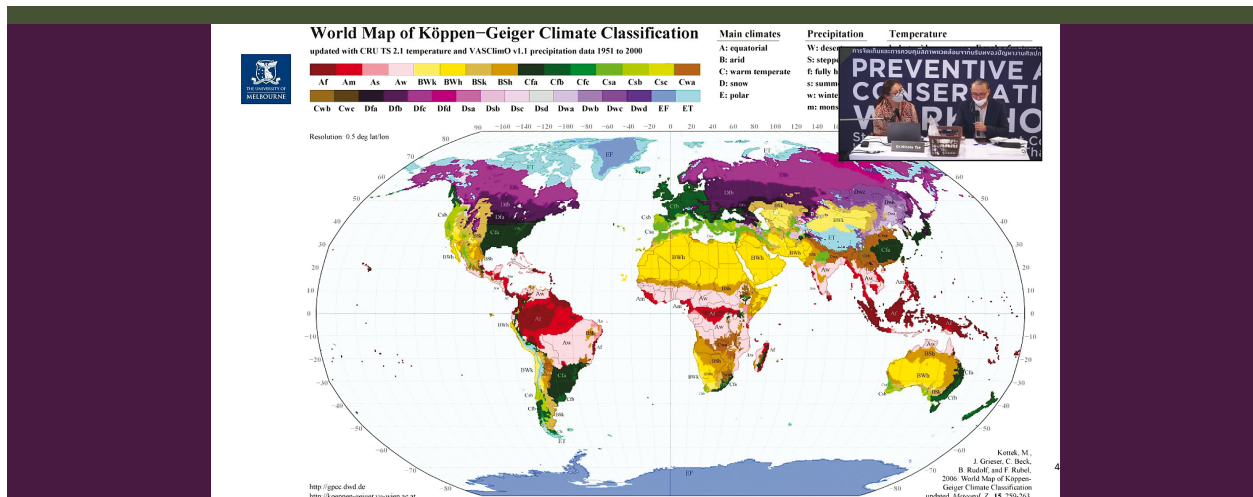
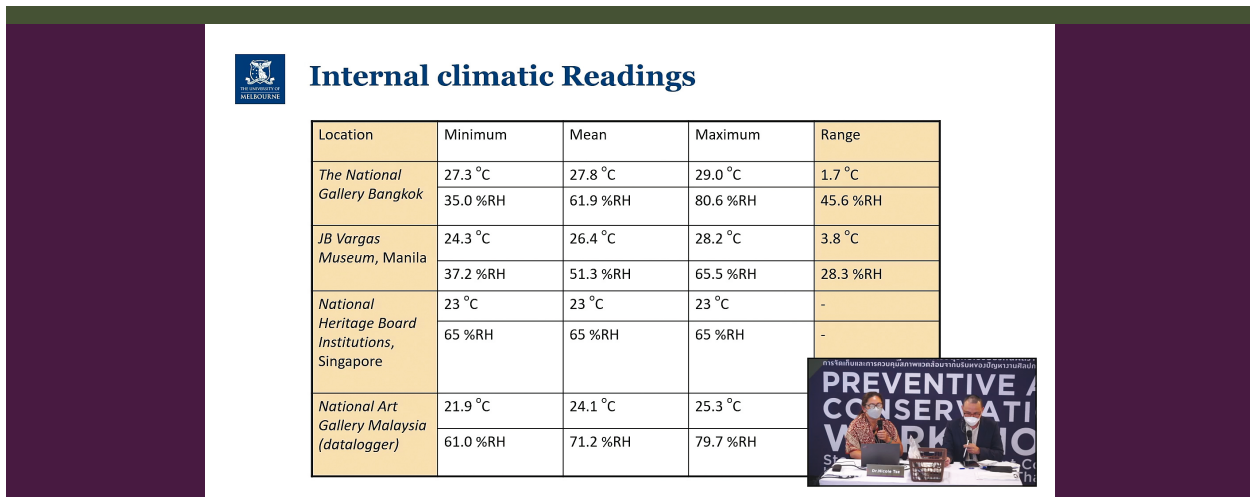


Figure 92: World Map of Köppen-Geiger Climate Classification, image <http://www.koppen-geiger.vu-wien.ac.at>

Currently, there are discussions on the repatriation of collections from Europe and America back to the to their former colonies and countries of origin. One argument for not returning objects to former colonies is that collections ca not be looked after and preserved. Although Thailand was not colonised, collections were removed by foreign countries like they were in Indonesia, the Philippines, Malaysia, and China. Significant collections and cultural material was removed from periods of colonisation and foreign intervention from the 16<sup>th</sup> Century to the 20<sup>th</sup> Century, and even today. Now it is a diplomatic and political issue. Conservation's role in this is demonstrating the in-country expertise and technical capability of collection care, should the discussions of repatriation take place.

## Temperature and Relative Humidity



**Internal climatic Readings**

Location	Minimum	Mean	Maximum	Range
<i>The National Gallery Bangkok</i>	27.3 °C	27.8 °C	29.0 °C	1.7 °C
	35.0 %RH	61.9 %RH	80.6 %RH	45.6 %RH
<i>JB Vargas Museum, Manila</i>	24.3 °C	26.4 °C	28.2 °C	3.8 °C
	37.2 %RH	51.3 %RH	65.5 %RH	28.3 %RH
<i>National Heritage Board Institutions, Singapore</i>	23 °C	23 °C	23 °C	-
	65 %RH	65 %RH	65 %RH	-
<i>National Art Gallery Malaysia (datalogger)</i>	21.9 °C	24.1 °C	25.3 °C	
	61.0 %RH	71.2 %RH	79.7 %RH	

**PREVENTIVE CONSERVATION WORKSHOP**

Figure 93: Internal Climatic Readings recorded in 2003, from Tse, N 2010 'The Characterisation of Canvas Paintings in Tropical Southeast Asia; PhD thesis, The University of Melbourne, 2002- 2008

As seen in image 4, the collection climates in Bangkok, Manila, Singapore, and Malaysia are challenging with high temperatures, and high relative humidity, which all cause an increase in degradation. The challenges are immense, as is the realisation that nothing lasts forever. We can not keep collections forever because all materials eventually degrade, change is inevitable and the resourcing of collection care also comes at an environmental and economic cost. A collective discussion then is how long do you want a collection to last and what is their intended lifespan? This is a joint discussion on the value of collections, who they are for and how they will be accessed and used. Based on agreed decisions between stakeholders, communities and individuals, the role of conservation is to facilitate access and manage the risks.

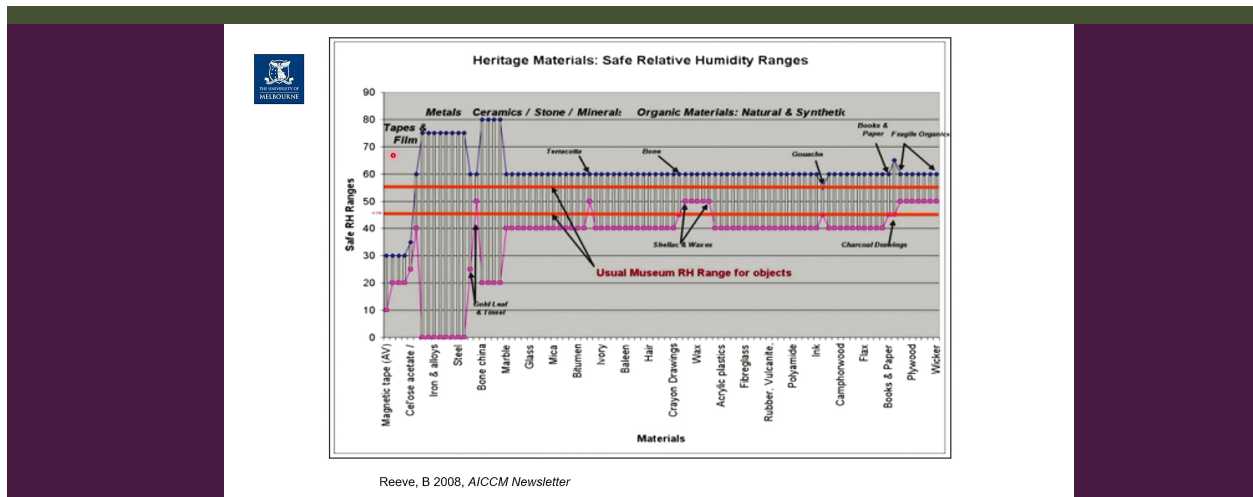


Figure 94: Heritage Materials: Safe Relative Humidity Ranges, Reeve, B 2008, AICCM Newsletter, no. 108, from <https://aiccm.org.au/publications/newsletter/>

RH (relative humidity) is one of the ten agents of deterioration and an issue in the tropical climates of Southeast Asia. The moisture in museums can be high, especially after the heavy rain during the wet season. For different objects there are safe material conditions at different relative humidity ranges. Image 5 sourced from the Australian conservator Barbara Reeve shows the tolerable limits for a range of materials: metals, ceramics, stones, organic materials, natural materials and synthetic materials. They provide the safe material ranges for RH from 0 to 100%RH; and most materials centre around 50%RH. From the graph, although the safe range of relative humidity for metals is between 0 to 70%RH, corrosion can occur at these higher RH% levels. For tapes and film, which will be important in the near future because many of our magnetic tape collections are very vulnerable in tropical climates. Their safe range is 20-30%RH but the relative humidity in Thailand is way above that. The role of conservation is manage these material tolerance ranges, and to assess the risk versus the benefits of access and use.

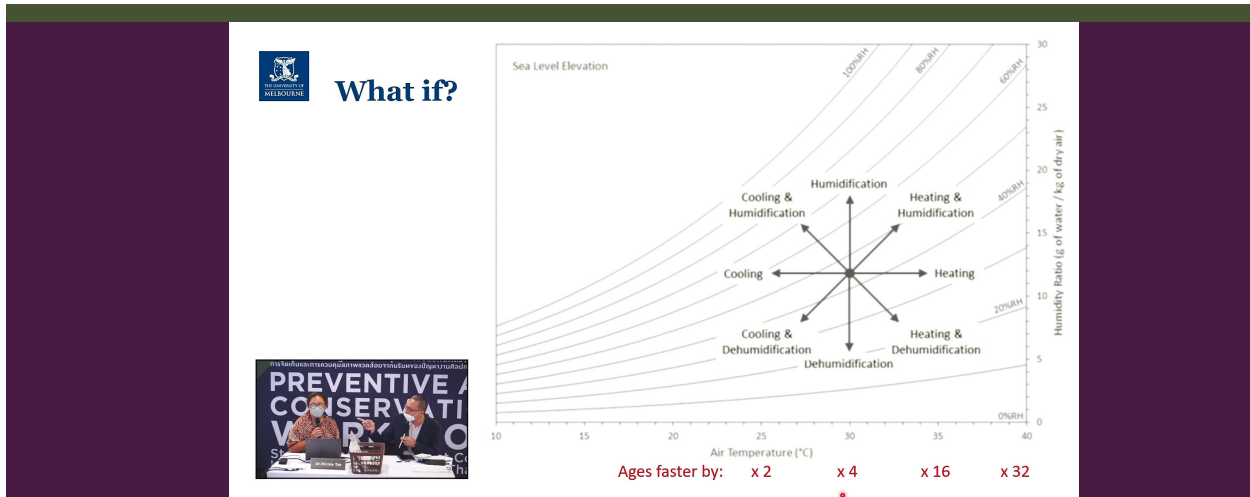


Figure 95: Psychrometry (Humidity ratio vs temperature) & what if we cool, humidify, heat, dehumidify internal climates, from Maekawa, S, Beltran, V & Henry, M 2015, 'Environmental Management for Collections- alternative Preservation Strategies for Hot and Humid Climates', Getty Conservation Institute, Los Angeles, p. 84; and ages x2 faster@25°C & x4 faster@30°C compared to 20°C.

The question is, how long will things last? Increasing the temperature from 20°C to 30°C means it will age four times faster or each 5°C drop in temperature will mean collections will last approximately twice as long. We can see this in image 6 with the psychrometric curved plots of %RH are shown with the temperature along the bottom and humidity ratio along the vertical. The arrows indicate how %RH can be managed through heating, cooling, humidification and de-humidification. Along the bottom chemical rates of reaction are increased with temperature changes (when taking 20°C as the reference point). If a museum director comes to you and says, we are going to install air conditioning to reduce the temperature for collections from 30°C to 25°C ; what will this mean for the collections in your care? Basically, every 5°C drop in temperature will double the chemical lifetime of collections. Image 7 shows how an object of high stability like a stone sculpture will last for 1,000 years at 20°C but at 30°C will last for 250 years, due to ageing four times faster. But this is for temperature only and does not account for RH. If the RH increases when the temperature drops, then there is more moisture available for other reactions to occur. Such RH induced reactions can increase reactions

rates too. So the way collections age will not be the result of one agent operating alone, but usually in combinations with the other 9 agents of deterioration (see Image 1).

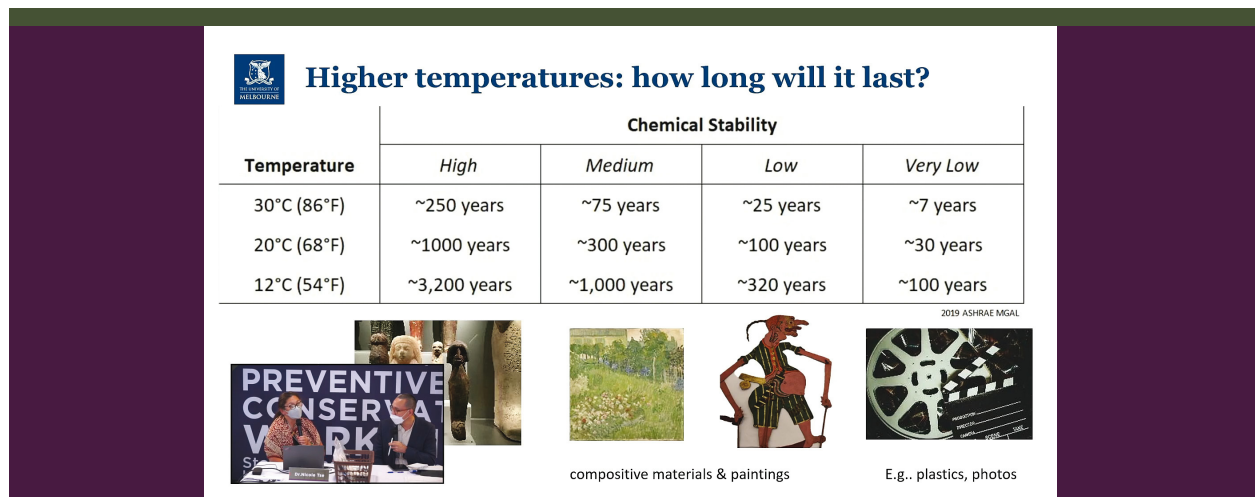


Figure 96: Higher Temperatures: How long different collection types of high, medium, low and very low stability will last? Adapted from Michalski, S 'Agent of Deterioration: Incorrect Temperature' from <https://www.canada.ca/en/conservation-institute/services/agents-deterioration/temperature.htm>

In cases when there is not any climate control and the hot air comes in from the outside and the humidity builds up, the goal is to stabilise the temperature and %RH as much as possible. Buildings with thick walls for example, will have a high thermal mass and will limit and buffer the amount of hot air coming inside a building. And for %RH when RH levels are high, it is important to keep the air circulating and reduce damp spots in a building where biodeterioration can occur. In summary, there is no correct %RH value for all collection types. The tolerance limits of materials will vary depending on whether it is wood, a layered structure or metal, for example, so the best one can do is to find a compromise and a %RH range that causes the least amount of damage to the collection.

These are the technical challenges, but by first agreeing on how long a collection should last for and jointly deciding on their intended lifetimes, collections can then be managed according to their material behaviour, known changes and tolerances.

The consequences of building operations like turning an air conditioning on and off, using a dehumidifier or deciding on passive environment, are then shared and more inclusive of how a collection is valued.

How long things last can vary for different object types. We also know that makers, creators, and artists use unique and different materials, all combined in different ways. So to precisely predict a collection's ageing profile, cannot be accurately determined but material tolerances are used in a general way. Image 7 shows different materials classified according to:

- High stability: stone and metal.
- Medium stability: composite materials like paintings.
- Low stability: more movable and organic objects like Wayang Kulit Puppets.
- Very low stability: magnetic tapes, early plastics, and film.

If we consider the very low stability materials like film and the Bangkok film festival at BACC; assume a film is produced by a very creative experimental filmmaker and it is stored at 30°C, the film will last for seven years. But sometimes, we do not realise a film's value until much later longer. It is tricky When it comes to film preservation in tropical climates then, it is tricky to know what is of value and worth preserving in the short time frame of 7 years. Film preservation is therefore a high-priority area in hot and humid climates, especially as so many artists are making films.

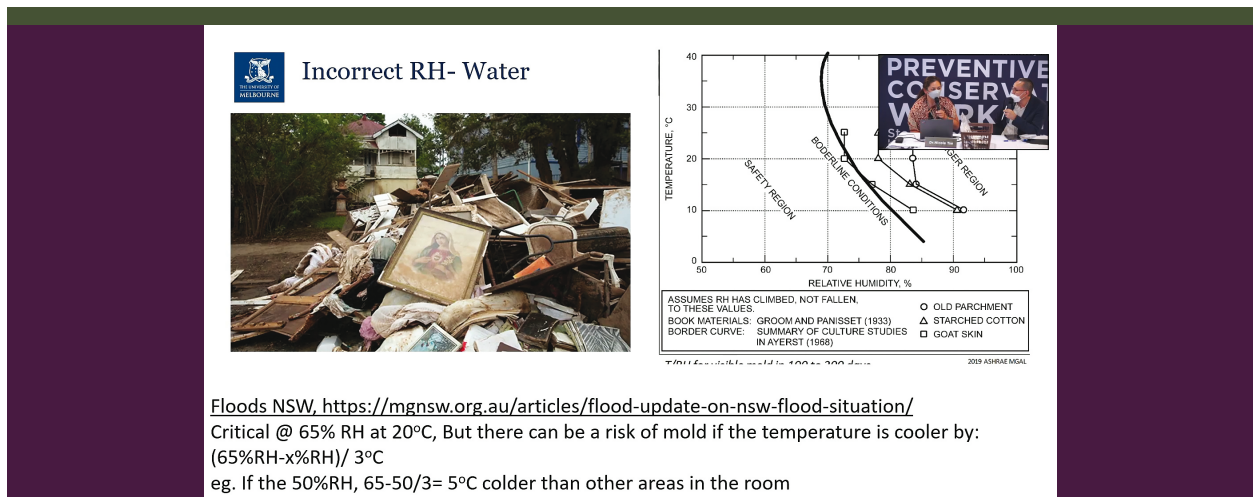




Figure 97: Incorrect RH – Water & incorrect %RH, a. from Floods NSW, <https://mgnsw.org.au/articles/flood-update-on-nsw-flood-situation/>, & b Borderline %RH conditions from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 2015, 23. Museums, Galleries, Archives, and Libraries, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), Figure 2, p. 24.8.

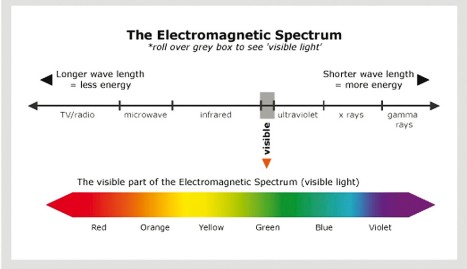
Another high risk is flooding. Currently, Australia has had unprecedented floods because of climate change (Image 97). Bangkok also faces annual flooding during the wet season, and maybe communities and people have become accustomed to floods and developed localised adaption strategies which can be applied to collection care too. Although it has become a part of people's lifestyles, flooding still has catastrophic effects and should be managed and mitigated. With floods, there is an immediate loss of heritage as a result. When it comes to water and a high %RH, there are material tolerance thresholds. The threshold is around 80%RH (Image 8), but this depends on the material types and temperature, as you can see plotted along the vertical and different %RH along the bottom of the image. For example, at 20°C, the threshold is about 75% for goats skin; above that becomes critical, moisture will be absorbed into the substrate and mold will develop.



## Chemical Degradation Photo-oxidation/ Photo-Degrada



Light induced  
Photons of energy  $\sim$  on  
the  $\lambda$   
Lower end of the  
spectrum (UV light) has  
more energy to break  
bonds



The Electromagnetic Spectrum  
\*roll over grey box to see 'visible light'

Longer wave length = less energy      Shorter wave length = more energy

TV/radio    microwave    infrared    **visible**    ultraviolet    x rays    gamma rays


The visible part of the Electromagnetic Spectrum (visible light)

Red    Orange    Yellow    Green    Blue    Violet

Figure 98: Chemical & Photo-Degradation.

*image: Nicole Tse*

Without light, we can not see collections so we need light to enjoy collections but it also needs to be managed. In terms of seeing collections, there are good and bad parts of light and the electromagnetic spectrum (Image 98). It is the ultraviolet region of electromagnetic spectrum from 200-400nm that is the most dangerous and damaging to collections (but the earth's atmosphere absorbs below 315nm). Windows exclude UV, with simple glass 300-325nm is excluded, and then the concern is only between 325-400nm. The use of filters on windows and light fittings; or glazing on paintings, can further exclude UV.

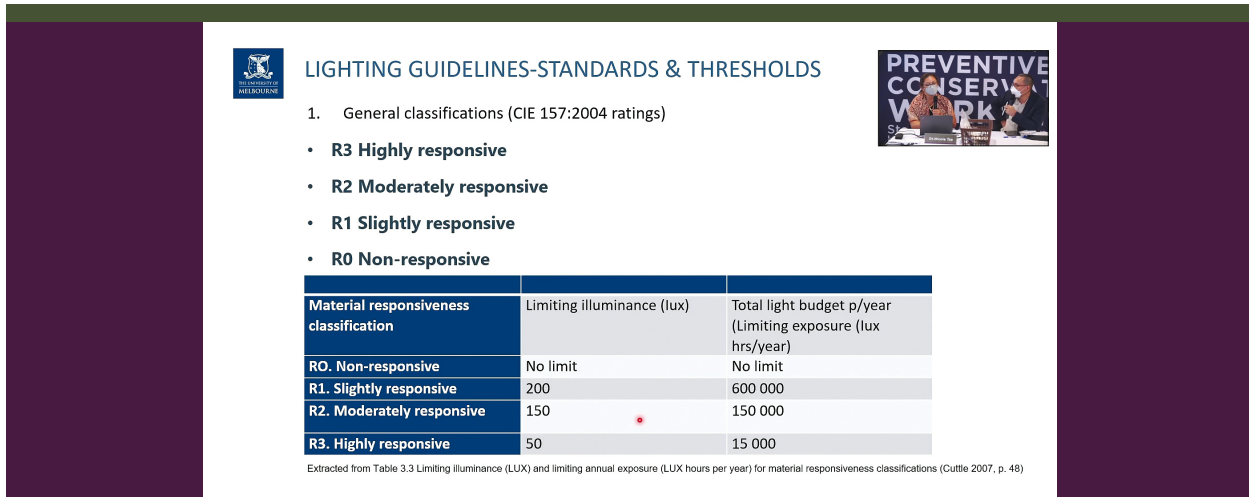


Material responsiveness classification	Material description
RO Non-responsive	The object is composed entirely of materials that are permanent, in that they have no response to light. Examples: most metals, stone, most glass, genuine ceramic, enamel, most minerals
R1. Slightly responsive	The object includes durable materials that are slightly light-responsive. Examples: oil and tempera painting, fresco, undyed leather and wood, horn, bone, ivory, lacquer, some plastics
R2. Moderately responsive	The object includes fugitive materials that are moderately light-responsive. Examples: costumes, watercolours, pastels, tapestries, prints and drawings, manuscripts, miniatures, paintings in distemper media, wallpaper, gouache, dyed leather and most natural history objects, including botanical specimens, fur and feathers
	The object includes highly light responsive materials. Examples: silk, colorants known to be highly fugitive, newspaper

Extracted from Table 3.1 Four category classification of materials according to responsiveness to visible light. (After CIE 157:2004) (Cuttle 2007, p. 46)

Figure 99: Lighting Guidelines-Standards and Thresholds, Four category classification of materials according to responsiveness to visible light, adapted from Cuttle, C 2007, 'Light-induced damage to object', *Light for Art's Sake: Lighting for Artworks and Museum Displays*, Butterworth-Heinemann, Oxford, p. 46 (After CIE 157:2004).

The guideline in Image 10 has been put together based on CIE international standards and categorised object types according to non-responsive, slightly responsive, moderately responsive, and highly responsive. In Image 99, the highly responsive materials are textiles, silk, colourants, and newspapers. Silk is very relevant in Thailand; many textile costumes are often not in very good condition because they are highly responsive to light and will be more quickly damaged if exposed to light.



The slide is titled "LIGHTING GUIDELINES-STANDARDS & THRESHOLDS" and features the logo of the International Commission on Illumination (CIE) on the left. It lists general classifications (CIE 157:2004 ratings) and includes a table of material responsiveness classifications. A small inset image on the right shows two people in a meeting with the text "PREVENTIVE CONSERVATION WORK".

1. General classifications (CIE 157:2004 ratings)

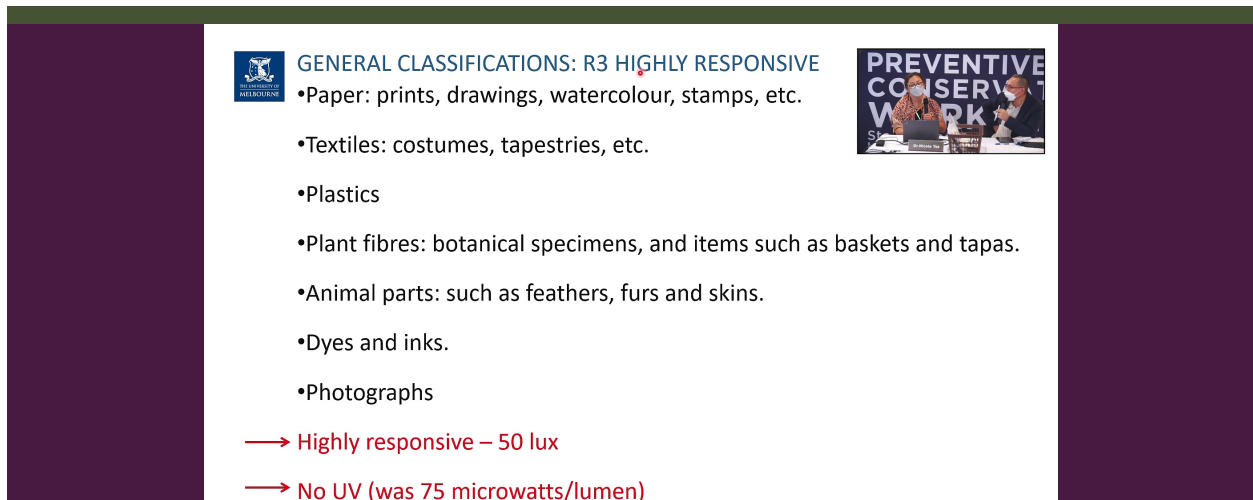
- **R3 Highly responsive**
- **R2 Moderately responsive**
- **R1 Slightly responsive**
- **R0 Non-responsive**

Material responsiveness classification	Limiting illuminance (lux)	Total light budget p/year (Limiting exposure (lux hrs/year))
<b>R0. Non-responsive</b>	No limit	No limit
<b>R1. Slightly responsive</b>	200	600 000
<b>R2. Moderately responsive</b>	150	150 000
<b>R3. Highly responsive</b>	50	15 000

Extracted from Table 3.3 Limiting illuminance (LUX) and limiting annual exposure (LUX hours per year) for material responsiveness classifications (Cuttle 2007, p. 48)

Figure 100: Lighting Guidelines-Standards and Thresholds, Limiting illuminance (LUX) and limiting annual exposure (LUX hours per year) for material responsiveness classifications, adapted from Cuttle, C 2007, 'Light-induced damage to object', Light for Art's Sake: Lighting for Artworks and Museum Displays, Butterworth-Heinemann, Oxford, p. 48 (After CIE 157:2004).

The idea is to first categorise collections and material types according to Image 10, and then to refer to Image 100 to work out the highest amount of LUX an object can endure, when illuminated or for the whole year known as the Total light budget. Slightly responsive materials are illuminated at 200 LUX, down to highly responsive materials, like textiles, at 50 LUX. Then there is the total light budget, which is how much illumination an object can have per year (Image 100). When you have something very sensitive, like textiles, once exposed to a total amount of 15 000 LUX in one year, you would then put it into storage in the dark to rest, until the following year. But something like a stone sculpture or ceramic that is not responsive; can remain on exhibition for a long time. It is with these known categories and values that conservators can negotiate with exhibition managers, curators and directors on how best to manage lighting conditions for collections. We can decide to use up all our light budget in a short period or a long period of time and distribute it over the year until all if the total light budget is consumed.



**GENERAL CLASSIFICATIONS: R3 HIGHLY RESPONSIVE**

- Paper: prints, drawings, watercolour, stamps, etc.
- Textiles: costumes, tapestries, etc.
- Plastics
- Plant fibres: botanical specimens, and items such as baskets and tapas.
- Animal parts: such as feathers, furs and skins.
- Dyes and inks.
- Photographs

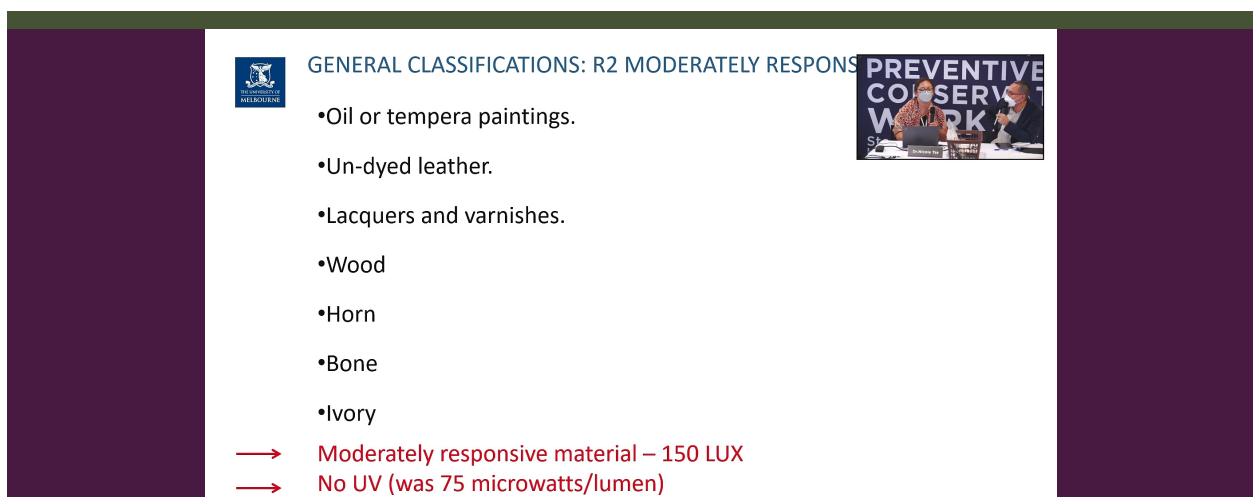
→ Highly responsive – 50 lux

→ No UV (was 75 microwatts/lumen)

Figure 101: General Classifications: R3 Highly Responsive.

*image: Nicole Tse*

Image 101 is a summary of material types for R3 highly responsive. The threshold is typically 50 LUX; try to exclude UV if possible as it is always manageable to exclude UV with filters and eliminate it completely. Image 101 lists all of the vulnerable materials. Most people would notice that 50 LUX is very low to the point that some vision impaired people can hardly see anything. There is a lot of debate about whether it is far too low. A way to increase illumination levels to say 100 LUX so collections can be enjoyed, is to limit exposure time and put it on display for a short period of time and then put it into dark storage (to make up for that extra high levels of illumination).



**GENERAL CLASSIFICATIONS: R2 MODERATELY RESPONSIVE**

- Oil or tempera paintings.
- Un-dyed leather.
- Lacquers and varnishes.
- Wood
- Horn
- Bone
- Ivory

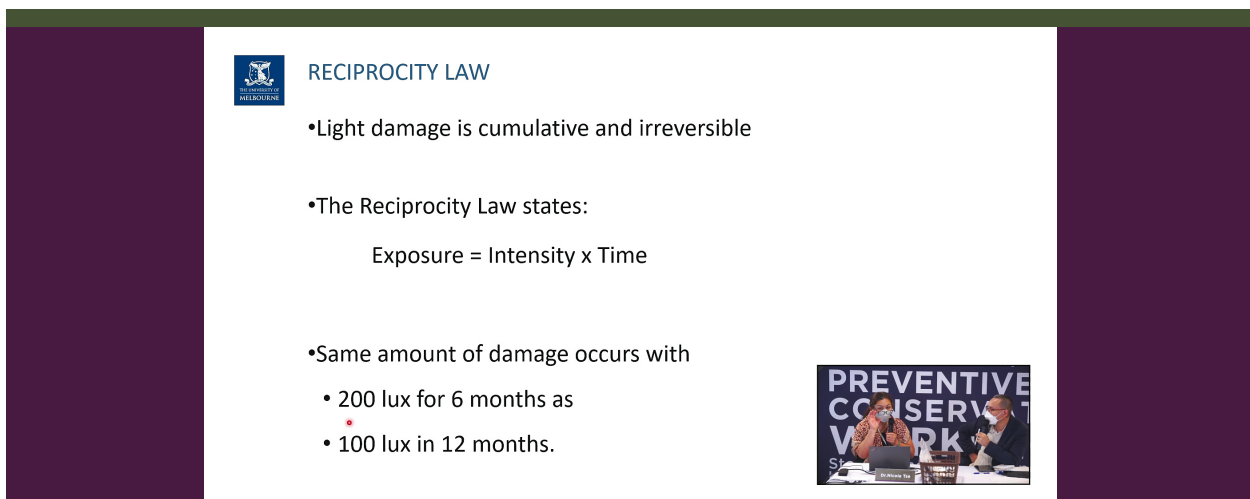
→ Moderately responsive material – 150 LUX

→ No UV (was 75 microwatts/lumen)

Figure 102: General Classification: R2 Moderately Responsive.

*image: Nicole Tse*

Image 102 shows the R2 moderately responsive collections applicable to tempera paintings and watercolours for example, at 150 LUX with no UV. The reason we can play around with time is because of the Law of Reciprocity (Image 102). It means exposure is equal to intensity multiplied by time. You can measure the intensity or illumination light levels with different instruments, and then multiply this by time, ie. How many hours in the day a collection item will be exposed to light (Exposure = Intensity x Time) (Image 14 below).



The slide features a purple header and footer. The main content is white with a blue logo on the left. The text is as follows:

- Light damage is cumulative and irreversible
- The Reciprocity Law states:  
$$\text{Exposure} = \text{Intensity} \times \text{Time}$$
- Same amount of damage occurs with
  - 200 lux for 6 months as
  - 100 lux in 12 months.

An inset image on the right shows two people at a table with a sign that reads 'PREVENTIVE CONSERVATION WORK'.

Figure 103: Law of Reciprocity or Reciprocity Law

*image: Nicole Tse*

For example, if you want something with higher light levels, you could illuminate the collection at 200 LUX for six months, which would be the same as 100 LUX at 12 months. The total of both is 12 000 LUX per year.



### Sight impaired: High light levels needed


Same amount of damage occurs:

- 1000 lux for 1.5 months
- 500 lux for 3 months
- 250 lux for 6 months
- ~4,000 lux for an old person looking for subtle patterns in fine detail in a dark object.




Figure 104: Sight Impaired: High light levels needed & audio tours, image National Gallery of Victoria, <https://www.ngv.vic.gov.au/plan-your-visit/access/information-for-visitors-who-are-blind-or-have-low-vision/>

Now, we are much more inclusive of all communities, including the elderly who are sight challenged and sight impaired people (Image 104). How can we permit access and enjoyment of collections for sight-impaired people who cannot necessarily see and also manage tactile interactions with cultural material? Conservation is part of this discussion to determine protocols and access for sight impaired and provide assistance for tactile interactions as another way to enjoy collections.



### Types of lights



- Efficient-Costly
- Bright
- Some problems with colour consistency
- Low UV
- Low heat due to use of deflectors
- Environmental rating




Figure 105: Types of light.

image: Nicole Tse

When we visit galleries, we see many different types of lights being used. For a long time, conservators have been working with incandescent and fluorescent lights, but these are less sustainable, and there is a transition to LED lights. The incandescent lights seen above use a lot of energy and are environmentally not worth investing in anymore. With LEDs there are a lot of upfront costs at the beginning but the energy savings have long term benefits.



Figure 106: Object Handling.

Next is object handling and how to move collections safely with different types of materials, crates and solutions to protect artworks and objects. In the practical session, participants handled collections. The goal with when handling collections is to avoid haphazard movements like we see in Image 106. It is all about planning, talking with your team members about the planned move to ensure you think through the process and avoid any risks. This is much like a risk assessment that we regularly do in conservation and in everyday life. Typically, a conservation team will do a walkthrough first to determine where the start and end points are. Pathways will be cleared along the way and space prepared with supporting props like cushions and foam blocks at the other end. It is never rushed and always well-planned. As you can see in Image 106, it is a disaster waiting to happen.



Figure 107: Crates: Storage or Transport, Orange touring crate from <https://podservices.com.au/museum-fine-art-services/>, Sustainable Turtle Crates from <https://masterpieceintl.com/industry-solutions/fine-art/turtle-crates/>

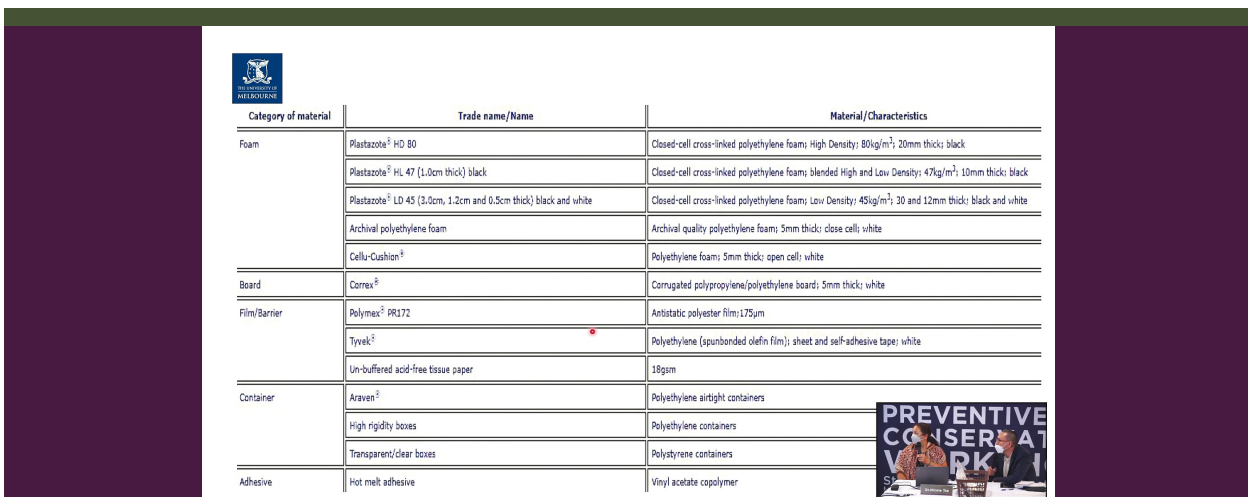


Figure 108: turtle crate. available from [https://turtlebox.com/media/fluxfile\\_files/TURTLE\\_NRC.pdf](https://turtlebox.com/media/fluxfile_files/TURTLE_NRC.pdf)

Specialised crates are often made for transporting collections, and if also used for storing collections (provided the materials used are chemically stable). Both have different needs; when a crate is used for transit or transport, the internal fittings are constructed of foams for short term use. The crate will also be fitted with thermal resistance materials for

when collections are transported from one climate to another. Thermal resistance foams are U-foam, Esterfoam, and Polystyrene, but we do not want to use these for long term storage because they emit pollutant gases. They are good for transport because of their thermal capacity. In transit, we also have to think about vibrations and buffering; and for this purpose, we use Ethafoam and Volara foam. They can also be used for long-term storage but are more expensive. Image 109 shows some other materials that are used as internal fittings for crates.

There are also different types of crates made of wood and now plastics. A new types of crate made from recycled plastics,, called turtle crates (Image 108), are marketed as sustainable crates. Rather than constructing a crate for one specific object, these can be rented out and then re-used and fitted out for another object. Many cultural institutions make crates for single use and throw them out because they have limited storage space adding to wastage.



Category of material	Trade name/Name	Material/Characteristics
Foam	Plastazote <sup>®</sup> HD 80	Closed-cell cross-linked polyethylene foams; High Density; 80kg/m <sup>3</sup> ; 20mm thick; black
	Plastazote <sup>®</sup> HL 47 (1.0cm thick) black	Closed-cell cross-linked polyethylene foams; blended High and Low Density; 47kg/m <sup>3</sup> ; 10mm thick; black
	Plastazote <sup>®</sup> LD 45 (3.0cm, 1.2cm and 0.5cm thick) black and white	Closed-cell cross-linked polyethylene foams; Low Density; 45kg/m <sup>3</sup> ; 30 and 12mm thick; black and white
	Archival polyethylene foam	Archival quality polyethylene foams; 5mm thick; close cell; white
	Cellu-Cushion <sup>®</sup>	Polyethylene foams; 5mm thick; open cell; white
Board	Correx <sup>®</sup>	Corrugated polypropylene/polyethylene boards; 5mm thick; white
Film/Barrier	Polymex <sup>®</sup> PR172	Antistatic polyester film; 175µm
	Tyvek <sup>®</sup>	Polyethylene (spunbonded olefin film); sheet and self-adhesive tape; white
	Un-buffered acid-free tissue paper	18gsm
Container	Araven <sup>®</sup>	Polyethylene airtight containers
	High rigidity boxes	Polyethylene containers
	Transparent/clear boxes	Polystyrene containers
Adhesive	Hot melt adhesive	Vinyl acetate copolymer

Figure 109: Internal fittings and foams for packaging and transport

The table (Image 109) shows the many materials used for different transport and storage purposes. There are different foams, with varying trade names and different material characteristics. Some of them have low and high density. If they have higher density, they can offer more support against vibrations. Take care however with the trade names. It can be confusing especially when each country has a different name for the same product, or suppliers use other names. In the practical session, the participants will look at some materials and work out what the materials are and match their qualities and characteristics.

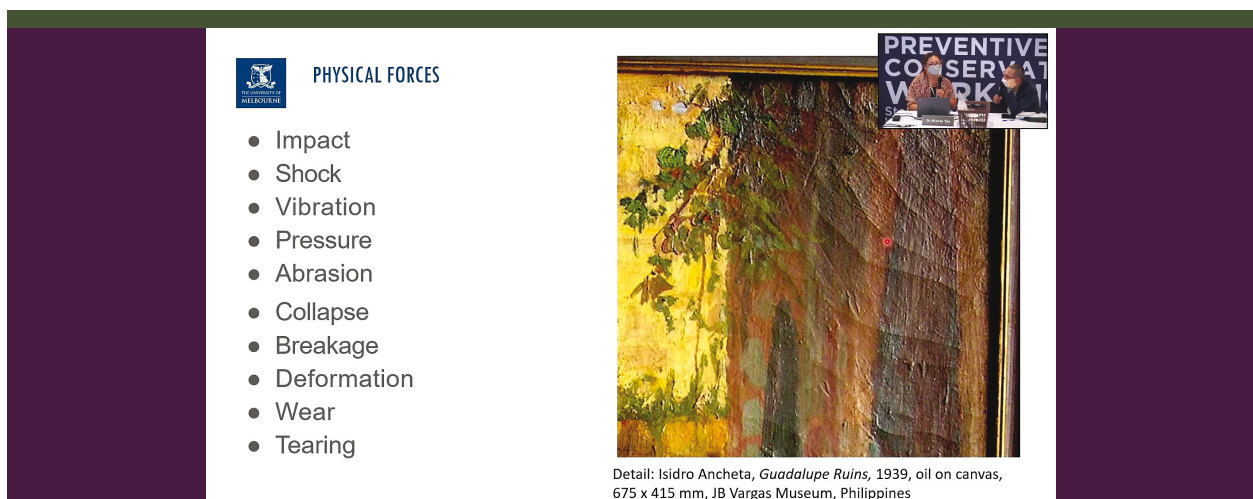


Figure 110: Physical Forces

*image: Nicole Tse*


Regarding transport, consider vibrations and how to buffer the objects in the crates by selecting different foams. Otherwise, cyclic damage can occur such as this type of paint cracking we see in Image 110, where there is damage across the corners.



Figure 111: Paintings: Storage or transport: Travelling frames.

*image: Nicole Tse*

If however, you do not have a crate, soft packing methods and traveling crates can be used (Image 111). On the right are travelling frames; they support and protect a painting along the edge by attaching an external frame with a locking Oz-Clip mechanism (Image 111, top-right). The travelling frame sits outward which means nothing is in direct contact with the surface or edge of the painting. Within the travelling frame, there is also a pocket of air which allows for air circulation around the painting and less of a likelihood for moisture condensation from occurring and bubble wrap sticking to the surface of an artwork. This can occur when soft packing works of art in bubble wrap, the plastic does not allow moisture to transfer through it, so condensation can occur inside the packaging if moisture is trapped. Condensation will create water droplets on the internal wrapping and could transfer to the surface of an artwork. So, what can you do? Either wrap your things when the relative humidity is low in the afternoon or wrap your items with an interleaving absorbing material like a cellulose based paper or include silica gels, ProSorb or something similar, inside the soft packing.




**Rolling paintings**

**5.4. Rolling/packing up painting**

- When rolling up the painting, the painted surface should be on the outside to prevent it from compressing or developing creases.
- Place the interleaving layer on top of the surface prior to rolling.
- Following the same procedure as unrolling, an appropriate number of people must be present to assist and supervise.

Large works require four people: one at either end and two spaced in between to keep the painting under tension.

- Rolling should be undertaken low to the ground/surface to prevent the work from flopping or distorting. However, the painting should also be slightly above the ground/surface to prevent the work from dragging and damaging the paint surface.






Figure 1. Unrolling large scale painting onto ground.




Figure 2. Painting rolled on ground with plastic sheet and cardboard to cover as earth.




Figure 3. Carrying/rolling rolled painting.




Figure 4. Rolling painting onto cover using hardware using the second pipe to roll the opposite end.

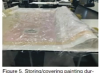


Figure 5. Rolling painting onto painting treatment using plastic sheet to cover and proper storage.





Figure 6. Rolling painting onto painting to for storage after treatment.


Figure 112: Rolling Paintings and a standard protocol.

image: Nicole Tse

Another challenge is with large-sized works which are often hard to store. In the case of large paintings on canvas or textiles, we often have to roll them. To do that, it is the more flexible side of the work that faces outwards. With a painting, the paint layer is more flexible and can stretch and cover the extra distance when it faces outward and is rolled.



**Packing trays**




Top loading, front loading trays




Figure 113: Packing Trays

Another way to pack works is to use packing trays (Image 113). They are similar to a travelling tray but are made from cardboard and foam is placed around the outer edge to secure the artwork and to handle it. The outer foam is higher than the painting, and then you can place another board on top. This means that the surface of the artwork is not in direct contact with any packaging materials.



Figure 114: Flat pack works of art: folders, boxes, shadow boxed

Another option is a shadow box (Image 114). They are not very sophisticated but a useful adaption and better than direct soft packaging with bubble wrap. You can use a found box and put a painting on the bottom. But to stop anything from falling on the painting, place a piece of foam on the end of a bamboo stick to protect the surface (Image 113, right). After that, wrap it in bubble wrap

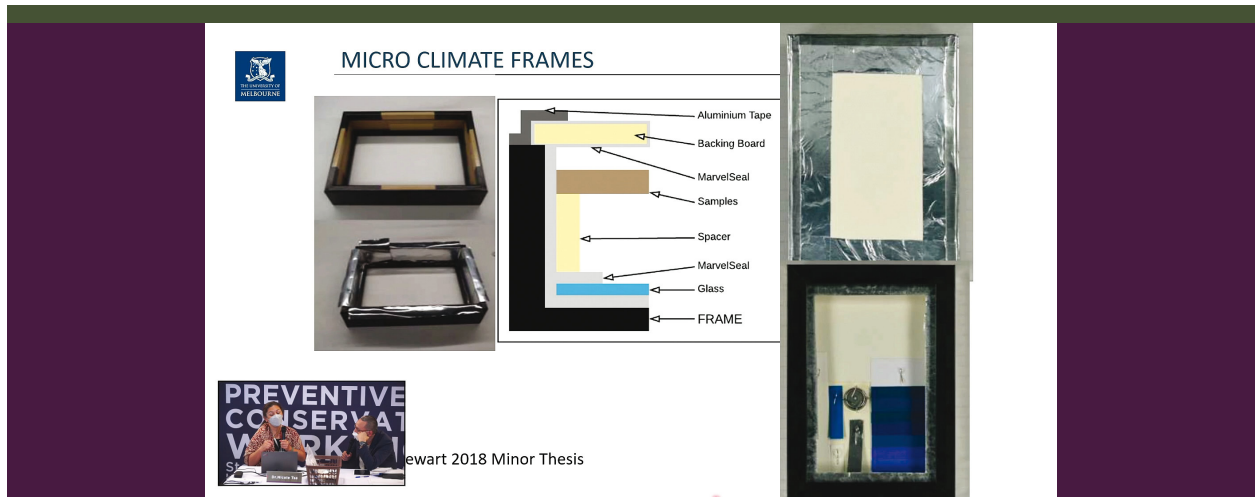


Figure 115: MicroClimate Frames.

*image: Nicole Tse*

Earlier the build-up of moisture was mentioned. To control moisture build up inside a framed artwork, display case or crate, moisture levels can be stabilised to create a microclimates. A microclimate frame like we see in Image 115 completely seals the whole frame and includes materials that will absorb the extra moisture (Image 115).



Figure 116: Dr. Tse demonstrating the assembly of a microclimate frame

To enclose the box, there is a moisture barrier aluminium material called Marvelseal which covers the surfaces within the frame rebate and on the reverse (Image 116, left). Marvelseal will reduce the movement of moisture in and outside the frame if properly sealed

and also reduce the movement of volatile organics components from the wood effecting the artwork. As the microclimate frame will be totally enclosed, it is important that stable materials and those that do not off gas volatile organics components are used. Then we will place an acid free backing board on the reverse and tape around the outside to seal it (Image 26, right). It is also possible to also include cloths impregnated with activated charcoal or silica gel inside the frame and the inner side of the backing board. The cloth will absorb the volatile organic components and moisture respectively, that may build up inside the enclosed frame . Another type of cloth is ProSorb cloth which will absorb excess relative humidity.

For more information on microclimates, there was a European Union supported research project called Propaint ; which produced a 300-page document. Propaint undertook a study of micro climate frames in Europe and Mexico, which produced very different results in Mexico's climate compared to Europe climates. It might be interesting to read that and compare it to Thailand.

**MICRO CLIMATES: BOXES & FRAMES**

Desiccant conditioned to desired RH  
 <a href="http://www.smallcorp.com/silica-gel-calculator"></a>  
 Silica gel: self-indicating: blue to pink below 40% RH

ProSorb Reconditioning Packs/Silica gel desiccant sachet/Pro Sorb Humidity Control Cassettes  
 ProSorb (ideal at 30-60% RH @ 25 °C)  
 <a href="https://www.preservationequipment.com/Catalogue/Conservation-Materials/Moisture-and-Humidity-Control">https://www.preservationequipment.com/Catalogue/Conservation-Materials/Moisture-and-Humidity-Control</a>  
 Other absorbing materials: silica gel E (ideal 0-30% RH), artsorb (ideal 60-80% RH)

Figure 117: ProSorb, Silica Gel and Artsorb desiccants to absorb moisture, from <a href="https://www.preservationequipment.com/Catalogue/Conservation-Materials/Moisture-and-Humidity-Control"></a>, & <a href="http://www.smallcorp.com/silica-gel-calculator"></a>

If you do not have activated charcoal cloths to use with objects you want to store, there are different types of desiccants. Some of them are more appropriate for different relative humidities. For example, ProSorb desiccant (Image 117, left), is ideal

for 30-60%RH, and it is made of clay particles. Whilst silica gel E, it is good for 0-30% RH. It is easy to buy silica gel in small bags and the gel is wrapped in Tyvek and are calibrated and ready to use when purchased. There are also ways to re-condition the silica bags at a desired %RH. Another dessiccant is Artsorb, which is ideal for 60-80 %RH. See the links in Image 117 for further information on these products.

When selecting dessiccants products that can be re-conditioned and reused are preferred. Single-use ones are not good for the environment. The reusable ones are the best if you know how to recondition them. To recondition them, you must know how much moisture to add to the silica bags. This can be calculated via an online website<sup>1</sup> and inserting the desired %RH and volume of air, number of bags or quantity of silica gel. For example, if you have a dry desiccant bag and your current RH is 30%RH, but the desired RH is 50%RH, the website will calculate it for you. Then the desiccant is placed into a glass container alongside a beaker of water with the calculated volume of water. The desiccant will absorb the water moisture released from the beaker to recondition the silica bag to your desired %RH.



Figure 118: Micro Climate boxes: Objects

For objects, you could use the same concept as microclimate framing. Use a plastic container and construct supports within the box to hold your collections in place

<sup>1</sup> Silica Gel Calculator Website - <http://www.smallcorp.com/silica-gel-calculator>

(left, Image 118). Alongside your collection items, securely place your desiccants inside the box (provided you have conditioned them according to your desired %RH beforehand).



Figure 119: High risks: Hazards and natural history collections.

*image: Nicole Tse*

Then there are riskier environments, which are often natural history collections, particularly taxidermy specimens. Historically specimens were preserved with heavy metals such as arsenic, asbestos, DDT and mercury (Image 119). If you are ever working with these collections, always wear gloves and masks, and undertake a risk assessment as the potential risk with these collections is very high.



Figure 120: High Risks: Biodeterioration

*image: Nicole Tse*

Biodeterioration is also big risk as you know. In the third practical session, participants will work on how to minimise biodeterioration and remedial treatment methods.



Figure 121: High Risk: Insects.

*image: Nicole Tse*

Insects are also high risk. For cellulose materials, silverfish and cockroaches are damaging. They eat fabrics to get to nourishment- such as starch sizing, cotton or paper. While cockroaches will consume almost anything. Lastly, there is less insect attack when RH is below 40%RH, but this level can leave textile fibres dry and brittle. The third practical session will look at low-oxygen environments to treat insect infestations.

## PRACTICAL SESSION

The role of the environment and the importance of proper display, and storage will be presented. Particular emphasis will be given to environmental conditions in Thailand and ways to minimise damage. What collection climates cause more damage and how to measure these? What materials, storage systems and packaging solutions can be used and what technical assessment methods can be used?

## Instructions:

Three workstations will be set up. The groups will have 30 minutes at each station and rotate between workstations.

1. Monitoring collection climates
  - Measure light, temperature and RH with spot and datalogger hand-held instruments
  - Provide recommendations/ solutions within the parameters of the light, RH and temperature measurements taken.
  - Apply your knowledge to light scenarios using the law of reciprocity
2. Assess materials used in conservation
3. Assessing materials for conservation: volatile organic component

## Part 1: Monitoring collection climates

Part one will be measuring the museum environment using this type of equipment (Image 122).



Figure 122: Measuring museum environments with HOB0 dataloggers, an Elsec Environmental monitor and PocketLab.

image: Nicole Tse

## Materials-Consumables

1. Handling gloves, paper triangles, Foam blocks, Post-it notes, Large sheet of paper, Folding table
2. A HOBO data logger, which measures RH and temperature, it has Bluetooth so you can read the data on your phone. (Image 32, bottom left)
3. PocketLab, which can measure RH temperature, light, and different gases. Nearly all aspects. (Image 32, green device)
4. Elsec, which are used to measure light levels in LUX (Image 32, black device)

**Practical Part 1: Measuring museum environments**

Total Exposure = Intensity (in LUX- measure this) x Total Time (when exposed to light- gallery opening hours)

Let's take some measurements, Let's calculate how long the works of art are exposed, Let's work out the total light budget

Is it too high, too low?

What if?

Material responsiveness classification	Limiting illuminance (lux)	Total light budget p/year (Limiting exposure (lux hrs/year)
R0. Non-responsive	No limit	No limit
R1. Slightly responsive	200	600 000
R2. Moderately responsive	150	150 000
R3. Highly responsive	50	15 000

**PREVENTIVE CONSERVATION WORK**

Figure 123: Practical Part 1: Measuring museum environment, Property of Dr. Nicole Tse Lighting Guidelines-Standards and Thresholds, Limiting illuminance (LUX) and limiting annual exposure (LUX hours per year) for material responsiveness classifications, adapted from Cuttle, C 2007, 'Light-induced damage to object', Light for Art's Sake: Lighting for Artworks and Museum Displays, Butterworth-Heinemann, Oxford, p. 48 (After CIE 157:2004).

The exercise is to work out the total amount of exposure per year. Participants will measure some illumination levels in LUX in the gallery space and determine the possible exposure length for those particular objects.

## Steps

1. Light Object categories: R3 Highly responsive/R2 Moderately responsive/ R1 Slightly responsive/ R0 Non-responsive (Table 3.3, Cuttle 2007). Categorise your objects according to the criteria R0-R3. Discuss your classifications.

2. Environmental measurements. Take some temperature, RH, and light measurements. We will need to share sensors and results. Record your results in a table and measurement locations

3. To calculate the Annual light budget, remember;  
 Total Exposure = Intensity (in LUX) x Total Time (for how long is the collection on display in light-gallery calculate the opening hours

Material responsiveness classification	Limiting illuminance (lux)	Total light budget p/year limiting exposure (lux hrs/year)
R0. Non-responsive	No limit	No limit
R1. Slightly responsive	200	600,000
R2. Moderately responsive	150	150,000
R3. Highly responsive	50	15,000

Extracted from Table 3.3 Limiting illuminance (LUX) and limiting annual exposure (LUX hours per year) for material responsiveness classifications (Cuttle 2007, p. 48)



## Part 3: : Assessing materials for conservation: volatile organic components



Figure 123: Practical Part 2: Materials testing for conservation.

*image: Nicole Tse*

The third practical you will be running through a test called the Oddy test, basically it looks at the effects of different gases from the materials onto different coupons: lead, copper and silver coupons.

We will now look at ways to detect and measure VOC's from materials in close proximity to objects and particulate pollutants from external and internal sources.

We will assess VOCS and consider these three approaches as proposed by Jean Tetreault from the Canadian Conservation Institute presented at the International Symposium on the Testing of Materials for Storage and Display of Cultural Heritage (MET 2019). We will be doing the tests marked with \*. See these other resources

Method	Uncertainty	Cost
1. List of approved materials, technical data*	High to low	Non to low
2. Spot Tests- qualitative tests Oddy Test* Acidity test: pH strips, A-D strips Other tests: PAT (Photographic Activity Tests) PocketLabAir +	Medium to low	Low to medium
3. Quantitative tests, full investigation: GC	Low	High

## WORKSTATION 1: Testing VOCs of materials

1. Select one material to test.
2. We will investigate this material via lists of approved materials, technical data and MSDS.
3. Approved lists (select 2 sources only):
  - Conservation and Art Materials Encyclopedia Online (CAMEO) 1997, [http://cameo.mfa.org/wiki/Main\\_Page](http://cameo.mfa.org/wiki/Main_Page)
  - AIC 2021 'Choosing Materials for Storage, Exhibition & Transport' and 'Materials Testing)', AIC WIKI Materials Working Group, viewed 20 January 2021, <[http://www.conservation-wiki.com/wiki/Choosing\\_Materials\\_for\\_Storage,\\_Exhibition\\_%26\\_Transport](http://www.conservation-wiki.com/wiki/Choosing_Materials_for_Storage,_Exhibition_%26_Transport)>
  - NAA 2019 'About the Photographic Activity Test' National Archives Australia, viewed 20 November 2019,

<<https://www.naa.gov.au/information-management/store-and-preserve-information/preserving-information/preserving-photographs/about-photographic-activity-test>>

- STASHc (Storage Techniques for Art, Science & History Collections). Foundation of the American Institute for Conservation. viewed 1 February 2022, <<https://stashc.com/>>
- Tétreault, J 2017, 'Products used in Preventive Conservation', CCI Technical Bulletin, no. 32, <https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/technical-bulletins/products-used-preventive-conservation.html>

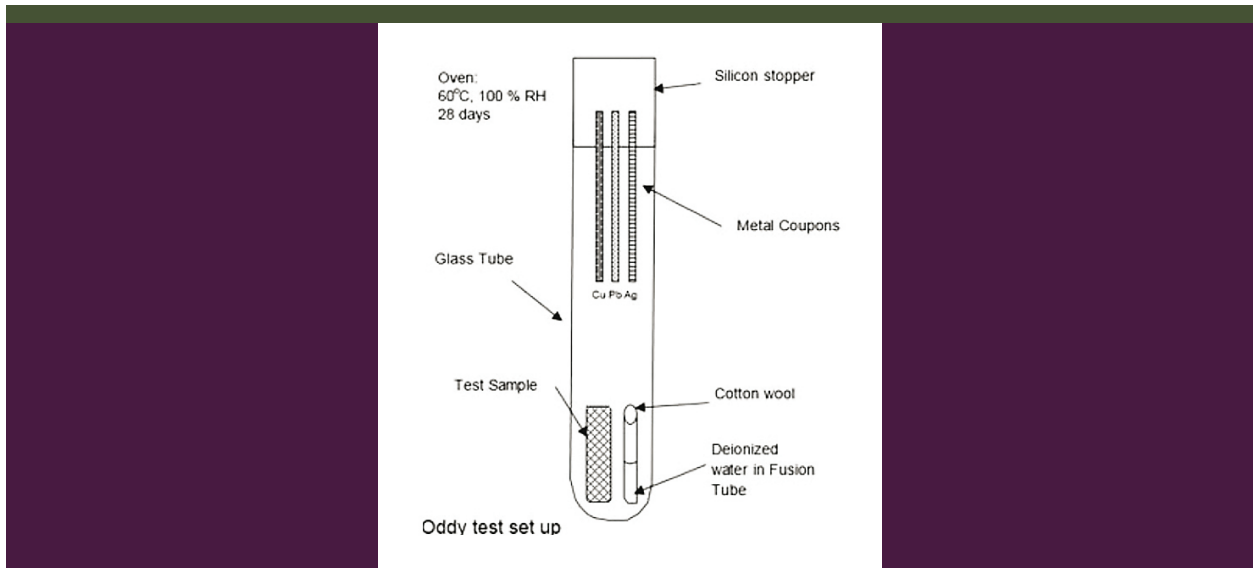
4. Technical and MSDS data: search what MSDS or any technical data that you can find on the tape. Remove any materials that contain sulfur compounds:

- SO<sub>2</sub> (sulfur dioxide)
- SO<sub>x</sub> (sulfur oxides)
- H<sub>2</sub>SO<sub>4</sub> (sulphuric acid)
- H<sub>2</sub>S (hydrogen sulphide)
- COS (carbonyl sulfide)

## **WORKSTATION 2: Testing VOCs of materials**

### **Materials**

1. Test materials used in exhibitions (tapes, papers, boards, paint outs, plastic tubing, carpet, fabrics, foams, plastics-any samples)
2. White tiles, tweezers, cotton wool, water, alcohol for cleaning, acetone for cleaning, detergent for cleaning (usually Decon Neutracon), petri dish (or covered dish), glass jars x 10 (all the same size), sand paper/ micro mesh 1800 grit, glass tubes (x 4), metal coupons (Cu, Ag, Pb), washing buckets, measuring cylinder, tissue paper (lint free), metal trays for preparation.



CC Oddy Test, < [https://www.conservation-wiki.com/wiki/Oddy\\_Test\\_Protocols#MMA](https://www.conservation-wiki.com/wiki/Oddy_Test_Protocols#MMA)>  
Video Oddy test demo: <https://www.youtube.com/watch?v=xcnFSKUxn5s>

Oddy Test: There are a few different versions and the AIC WIKI lists different approaches institutions used and provides some useful tips including videos. One of the first was: Thickett, D & Lee, R 2003, 'Selection of materials for storage or display of museum objects', British Museum Occasional Papers, Number 111, British Museum, London. <[https://www.conservation-wiki.com/wiki/Oddy\\_Test\\_Protocols#MMA](https://www.conservation-wiki.com/wiki/Oddy_Test_Protocols#MMA)>

We will follow the Heritage Conservation Centre's protocol accessible via [https://www.conservation-wiki.com/wiki/Oddy\\_Test\\_Protocols#MMA](https://www.conservation-wiki.com/wiki/Oddy_Test_Protocols#MMA) and as pasted below.

The Heritage Conservation Centre (HCC), Singapore, carries out the "3-in-1" Oddy test, adapted from published protocols used at the British Museum (BM occasional paper number 111 2004). The first protocol undertaken at the HCC between 2009 and 2016 used a heat shrink tubing and ground glass stopper with nylon monofilament (Thickett and Lee 1995) and silver, lead and copper coupons were separated with glass beads. Since 2017, the second protocol uses a silicon stopper with cut slots to separate the coupons (Robinet and Thickett 2003). According to needs and experiences, HCC adopts two notable variations from the British museum protocol, which are triplicate testing and

glassware cleaning procedure. In triplicate testing, three tubes containing the same sample are tested and an overall pass is indicated for the sample if two or more tubes pass the test. In the glassware cleaning procedure, an additional step in evaluating the glassware suitability of use is employed.

## Sample preparation

The thumb of rule is to prepare the material as they are used in exhibition or storage.

- For paints, adhesives and sealants, apply coating on a piece of cleaned Mylar and allow it to cure according to exhibition / storage use. After drying, scrape off 2 g of coating or roll the painted Mylar into the glass vessel.

- For fabric, cut, roll and secure it with a cotton thread. Washed fabric: For organic fabric, the fabric is boiled repeatedly until water runs clear. For synthetic fabric, the fibres are washed at 60° C until water runs clear.

- For foams, which are less dense, it may not be possible to squeeze 2 g into the tube. It is acceptable as long as the tube is sufficiently filled with the sample material, without touching the metal coupons.

- For glass cleaning agents, use a paper towel immersed with cleaning agent to clean the interior of the glass vessel.

## Glassware cleaning procedure

- Fill glass tubes with a cleaning solution in deionised water and soak for 2 hours (2% Decon Neutracon). Ensure no air bubble is trapped in glass tubes.

- After soaking, rinse the glass tubes with deionised water several times to remove any soap.

- Perform the 'water test'. 'Water test' is carried out by overturning the deionised water filled tube. The glassware is considered clean when water flows smoothly down the glass surface, without water droplets clinging onto the glass surface within 10 sec.

- For glassware that failed the water test, repeat soaking in cleaning solution for 2 hours. Then perform the 'water test' again. If persistent residue is left in glass tubes,

ultrasonicate these glass tubes for about 6 min in cleaning solution. If residues cannot be removed, avoid using the tube.

- For those tubes that passed the 'water test', dry the glass tubes in the oven until use.

## Preparation of coupons

- Prepare metal coupons in a fume cupboard or extractor.
- Wipe all metal trays and tools with acetone and cotton wool. A separate metal tray is designated for each metal type to prevent cross-contamination.
- Measure and cut out a metal sheet.
- Place metal sheet over a glass block in its respective metal tray and use micro mesh (polishing cloth 'Micro-Mesh®' (AO grade 1800 grit) to abrade one side of the metal sheet in two perpendicular directions.
  - Continue the abrasion until the surface of the metal appears evenly polished.
  - Turn the metal sheet to the other side and repeat the abrasion in two perpendicular directions.
- When the abrasion is satisfactory, wipe the metal surface with a clean and dry cotton wool to remove remnant metal particles. If particles remain, clean the remnants with 99,9 % purity acetone.
  - Keep the metal coupons as flat as possible.
  - Clean all tools with acetone after use.
  - Using a scalpel, make three parallel slices at the bottom centre of the silicon stopper.
    - With one hand, pinch the silicon stopper to open the cut and insert the metal coupon with tweezers.
    - Start with inserting the lead coupon at the middle cut, followed by the silver and copper coupon at the auxiliary cuts.

## Loading of samples

### HCC Oddy Test Set Up

- Add deionised water into the fusion tubes (mini-glass tubes) and close the opening with a small plug of cotton wool. The size and porosity of the cotton wool plug shall be as uniform as possible according to past practices. Ensure that the cotton wool plug is dry and not wet with water.

- For highly absorbent materials like fabrics, add 0.6 ml deionised water. For low absorbent materials like paint, add 0.4 ml deionised water.

- Place the sample, fusion tube and metal coupons assembly into the glass tubes.

- Load three tubes without sample materials as negative controls.

- Ensure that the sample is not in contact with the metal coupons. Ensure the metal coupons are flat. Ensure that the metal coupons are neither touching the inner walls of the boiling tube nor each other.

- For each test, include a control sample with no test material.

- Leave the glass tubes in the oven at 60°C for 28 days.

## Metal coupon evaluation




- When removing the “Oddy test vessels” from the oven, check that the temperature is at 60° C. Check for any condensation of water vapour in the tubes upon cooling and whether the coupons are freely suspended.

- Remove the coupons from the tubes and place them on a white sheet of paper.

- Rate the metal coupons with P (pass), T (temporary) or U (unusable) relative to the control coupons.

- A pass is indicated if all coupons are rated P or T and a fail is indicated if any one coupon is rated U. Rate this for all triplicate tubes for each sample. Rate the sample pass if more than two tubes are rated pass.

- Photo-document the results.

Lead	Copper	Silver
 <p><b>Left:</b> acceptable amount of minimal corrosion for control.</p> <p><b>Right:</b> too much corrosion, observed as darkening, for control.</p>	 <p><b>Left:</b> acceptable amount of minimal corrosion for control.</p> <p><b>Right:</b> too much corrosion, observed as reddening, for control.</p>	 <p><b>Left:</b> acceptable amount of minimal corrosion for control.</p> <p><b>Right:</b> too much corrosion, observed as yellowing, for control.</p> <p>Note: silver control coupons rarely show corrosion.</p>

*Image: Buscarino, I. C., Bone, A. C., Stephens, C. H., and Breitung, E. M. 2021 'Metropolitan Museum of Art (MMA) Protocol', Current Version: 20211201\_OT 11 May 2022 <[https://www.conservation-wiki.com/wiki/Oddy\\_Test\\_Protocols#MMA](https://www.conservation-wiki.com/wiki/Oddy_Test_Protocols#MMA)>*

## Risk Assessment

### Nature of chemical hazard

- Corrosive / Irritant / Toxic / Oxidising / Flammable / Carcinogenic / Mutagenic / Cytotoxic / Reacts violently with water.

### Procedural hazards

- Sharp objects / Hot apparatus / Reaction in sealed tubes / Containers under high vacuum / Radioactivity / Ultra-violet light / Potentially explosive reactions.

### Special precautions

- Safety glasses or goggles / Special clothing / Gloves / Safety shield / Face-mask / Help necessary during the process.

### Special location

- Fume cupboard / Other.

### Waste disposal

- Sharps / Bio-waste / Water soluble waste / Water insoluble waste / Appropriate waste.

### Category of risk:

- |                                  |                                     |
|----------------------------------|-------------------------------------|
| 1a - significant (chemical)      | 1b - significant (special location) |
| 2a - low (fume hood recommended) | 2b - low (fume hood essential)      |
| 3 - minimal                      |                                     |

# PREVENTIVE ART CONSERVATION: Storage and Environment Control Based on Context Found in Thailand

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