Robert B. Faltermeier

An Easy Guide to Care for Sculpture and Antique Art Collections

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Foreword

Dr. Robert Faltermeier represents one of a dwindling number of conservator–restorers coming from a tradition of craftsmanship rather than following a purely academic route into the profession. As a third generation conservator–restorer Robert has an appreciation for the care and preservation of cultural heritage objects that comes only from years of experience, and of being surrounded by working restorers. At a time when many conservation training programs have had to scale back their practical component—focusing more on technical examination, documentation, and preventive conservation—professionals such as Dr. Faltermeier have become increasingly rare. Rather refreshingly, this is not an academic book. There are no references, and the text does not contain a single chemical equation. This sets it apart from most current conservative textbooks, which today tend to be heavy on theory but light on practical advice, in stark contrast to some of the earlier classic works such as that by Plenderleith and Werner. Nevertheless, I would unreservedly recommend this book to all students and practitioners in the field of conservation of museum objects. It reminds those of us working in the profession of what can be done by a conservator–restorer in possession of the appropriate skill sets. Perhaps more importantly, it emphasizes what should not be done in the restoration of objects that have suffered from poor environment, poor handling, or simply the passage of time, with minimum intervention and reversibility being strongly emphasized.

In many ways this is a beautiful book, full of fine photographs of intriguing objects. Robert has had the privilege of working on some very spectacular objects, and I am confident that his treatments will enhance their understanding and enjoyment for many years to come. I hope that this book will inspire and encourage young conservators and remind them that there is more to conservation than monitoring environments and writing reports. Interventive conservation is both rewarding and necessary, if undertaken within an appropriate ethical framework and executed by a pair of steady and caring hands.

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Acknowledgments

This book would not have been possible without my grandfather kick-starting this family into the subject of restoration, Karl Faltermeier a classical self-trained restorer from 1939–1971 at the Staatlichen Antikensammlung und Glyptothek in München in Germany. He was first hired as a janitor then advancing into a restorer position. My parents Karl and Corinna Faltermeier-Doer were conservators at the Antikenmuseum Basel und Sammlung Ludwig in Switzerland from 1962–1998 (Karl) and 1972–1999 (Corinna), respectively.

I also have to thank various restorers and conservators who encouraged me and trained me in the field of objects conservation and inspired me to follow a practical and academic approach to preserve and conserve cultural heritage; to name a few, Kurt Hunziger, a never-ending fountain of old traditional restoration techniques, Dr. John F. Merkel, lecturer and mentor at the University College London Institute of Archaeology, who put up with my academic endeavors in the field of corrosion inhibitors for ancient copper and copper alloys. Patricia Moncrieff, a dear personal friend and outstanding textile conservator with a humongous big heart, who had an ear for my eccentricities and led me with ease into the subject of textile conservation.

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Introduction

Among authorities in the art world, it is a well-known fact that you should buy art and antiques because you like them and not for a quick profit. Quite simply, for a novice, buying in the antique market can be risky business.

Investing in fine arts is done over a long time span and most new collectors start off by buying smaller less financially valuable pieces since they love them and feel an emotional attraction to the artwork. Over a period of time, they specialize in one segment of the fine art market or another and start growing more confident in spending larger amounts for more unique and valuable pieces.

After some time, the maturing and serious collector starts consolidating the collection by selling off pieces that are less appreciated or do not fit their tastes any longer. The pieces are mostly sold in groups and are often used as down payment for the purchase of more pricey items.

This slow growth of a collection allows for a more flexible investment and the gradual increase in understanding of the contemporary art and antiques collected. The layman will research the subject in question, talk to dealers and other collectors, and with time become a connoisseur of the genre. And as with all beautiful things in life that take time to mature, the love for the pieces adored grows exponentially.

Another important factor when investing large sums of money is the condition of the artwork. Very often the pieces have been damaged due to environmental causes, handling, or trafficking. Frequently the previous owner, to save money, got the damage fixed by an unqualified person. This often causes further damage, and will result in a decline of value. When buying a piece of fine art for thousands of dollars, it is important to obtain an independent consultant to assess the work in question.

Replicas and forgeries are widespread and bargain basement prices are often an indicator that something is fishy with the piece in question. To confirm the authenticity or age of an antique for example, a scientific test of age such as thermo luminescence dating or radiocarbon dating can clarify the issue. A laboratory that is

neutral to both seller and buyer should undertake these tests. In the case of modern pieces, it is best to contact the artist or his representative directly. Nevertheless, there have still been cases where copies and fakes have been authenticated as genuine.

With wars and political unrest ravaging countries, it is frequently possible that modern art and antiques are removed from private and public collections, and sold in the art market. Some art and antiques might have even been removed from museum stores, galleries, churches, and temples in peacetime. One church even had to label a Madonna a replica to ensure that it was not stolen again and again. To ensure that a piece has not been stolen or illegally exported, due diligence is of the essence, and any sales contract has to have a provision to protect the buyer.

This book is geared toward collectors and curators with little to no access to conservation or restoration specialists for immediate help and advice. The information in this book should be used with caution and common sense, and if in doubt, a professional should be consulted. The author cannot take any responsibility for actions taken following the reading of this book, since there is no control over the execution of procedures and recommendations.

It was decided to break away from the norm of most conservation and museum studies books that cover the subject of collections care. These will cover the subject according to environmental and other categories. This book has been kept short and divided into the major material groups to allow easy access into the subjects and the materials. Inevitably, there will be some repetition, especially in the fields of handling, storage, and display.

Should there be any need for further reading or clarification, contact your local museum. They should be able to recommend a competent conservator familiar with the object type and its materials, and with the local environment.

Ceramics

The oldest man made ceramic known today is thought to be about 25–29 thousand years old. It is the Venus of Dolni Vestonice displayed in Brno, Czech Republic. The term ceramics is a general term for artefacts made from fired clay. We divide ceramics into two main groups or types. The low fired ceramics, such as terracotta, earthenware or pottery and the high fired ceramics such as porcelain and stoneware.

Terracotta, earthenware, or pottery is usually fired at temperatures of 800–1,200 °C. The body of terracotta, is the most porous, softest and least compact of the fired clays. After firing, the body of terracotta is not fully vitrified and still contains pores where water and organic matter has been driven off. Frequently the clay used contains tempering material such as sand or crushed pottery, to avoid shrinkage and to alter the properties of the final product. The colours after firing can range widely from buff to red or black depending upon the clay used and the firing conditions. There are various finishes of the surface such as glazes, colour pigments and lime washes.

Stoneware is an impervious type of earthenware and is fired at temperatures of 1,200–1,350 °C. The body is hard and very compact. In comparison to terracotta, the material is non-porous and seems almost granite-like in texture. The colour is usually various shades of grey. Frequently the surface is salt-glazed.

Porcelain is made from kaolin and petuntse (from 白墩子, also known as china stone), white clay formed by the weathering of aluminosilicate minerals such as feldspar from granite sources. Porcelain is the most high-fired of the ceramics and is fired at temperatures of 1,300–1,450 °C. The body and surface are very hard, compact and vitreous. The colours range from white to bluish-white. Due to the vitreous nature of porcelain artefacts are easily chipped.

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Handling

It is imperative to understand the artwork that has to be moved or handled. The following points should be kept in mind. Before moving a work of art made of porcelain or terracotta, it has to be ensured that it is sturdy enough to be moved.

Wear cotton or nitrile gloves (non-latex synthetic gloves) when handling ceramics. However, porcelain or other glazed ceramics are best handled with nitrile gloves to minimise the risk of slipping (Fig. 1).

All parts need to be checked to see if they are detachable or loose. Old restorations are especially susceptible to new damage due to vibrations and handling. Artefacts should never be lifted by attached parts such as handles or spouts because these might be frail, brittle or loose. Failure could easily lead to breakage and complete loss of the object.

Before a ceramic is moved, it should be taken off the mount. Should it be permanently fastened to a mount, it needs to be secured adequately and care should be taken that no part should be abraded by the support itself.

Large and small pieces should only be moved by hand when this is absolutely unavoidable. Small pieces should be moved from shelf to padded cart whereby the cart is placed as close as feasible to the shelf. Large pieces should be lifted onto inert pallets and by portable lifting equipment whenever necessary.

Make sure that the mode of transport is in good working order and can take the weight and size of the object. If the trolley is height adjustable, the platform needs to be lowered to its lowest position.

Before moving an artwork, ensure that the path to the destination is clear, that no protruding wall fixtures or doors are blocking the path, and that there is sufficient illumination along the route.

It is always best to wear a lab coat and make sure that clothes cannot entangle with artworks or their mode of transport. Loose and open shoes have to be avoided. No rings, chains or buckles should come in contact with the surface since this could easily cause chipping.

Objects should be transported in inert, clean crates or boxes, whenever feasible. It is best to use polyethylene boxes that have a lid. It is not advisable to stack too many boxes on top of each other.

Display

Ceramic seems to be a resilient material; however there is a limit to it. Terracotta if not glazed has a porous surface and body. Frequently, terracotta is painted with mineral pigments that do not adhere well to the surface. Vigorous dusting will remove these pigments or rub the dust into the pores. Therefore if the surface of a ceramic is not glazed, the object should not be on open display. Pieces with glazed surfaces can be displayed, as long as the air-conditioning filters remove solids such as soot and major dust particles. Since fine particulates such as cigarette smoke can deposit within the flaws of a glaze.

Fig. 1 Peranakan lid; the old restoration had yellowed due to use of poor restoration materials and needed to be removed. A combination of both conservation and restoration techniques was then applied. The final treatment is completely reversible and the pigments lightfast (Faltermeier 2005a)

When displaying fine arts such as ceramics, it is always prudent to show the piece as intended. Hanging plates on walls always increases the risk of accidents. If a plate has to be propped up, it's best to use a purposely-made stand in a material such as acrylic or wood. The wood needs to be painted with an inert paint and the contact surface covered with polyethylene foam or another form of suitable cushioning.

Figurines are generally displayed by placing the piece on thin polyethylene foam. However, it is vital to ensure that the centre of gravity of the object is low

Fig. 2 Peranakan vases show extensive damage and old restorations. The adhesive used during the last restoration attempt on the larger vase has stained the edges and is smeared over the surface. All the fragments are also misaligned. The discolouration of the adhesive shows the poor aging qualities of commercially available household glues (Faltermeier 2005b)

enough to prevent the piece of falling over. Materials such as blue-tag are not suitable for securing art pieces. Most tagging materials on the market will loosen due to temperature fluctuations and can stain the surface.

Wherever possible, it is best to display ceramics in showcases or vitrines of one kind or another. This would minimise the risk of damage due to accidents and environmental damage such as soot, dust and humidity fluctuations.

It is important to check ceramics for old repairs, restorations and in case of archaeological material, soluble salts before displaying, storing or packing them in an environment that is not air-conditioned or light controlled (Figs. 2, 3).

Fig. 3 Terracotta Buddha image; the artefact was broken into 2 halves and showed severe cracking. The pieces were joined with a reversible resin and gap-filled with an acrylic filler. The fill was colour matched. The whole procedure is reversible [Faltermeier (2012) www.faltermeier.biz]

Maintenance

Dusting of ceramics seems to be straightforward; one way is to carefully dust the surface with a longhaired brush. It has to be ensured that the metal bracket around the stem of the brush is protected with a masking tape, so as to not scratch the surface of the ceramic. Hair of synthetic brushes can be rather sharp, due to the cutting and trimming of the tip of the brush. The edges of the hair can scratch a fragile terracotta surface.

It has been also recommended to use compressed air from an aerosol-can, however like the brushing, this has to be done with caution, since it can dislodge loose fragments and pigments or drive the dirt and dust further into pores, crevices and cracks.

Dusting with a cloth is not recommended. The cloth can interlock with parts of a damaged glaze or chips and further harm the surface.

Washing of porcelain should be left to an experienced conservator, since small cracks can absorb moisture and soap and water can drive dirt and dust between glaze and body or even further into the body of the ceramic. It is a well known fact that porcelain can take weeks to dry, which can result in corrosion stains, should there be iron particles or pins in the porcelain. Terracotta should never be washed if not absolutely unavoidable, such as in case of desalination of soluble salts.

Packing and Storage

Packaging for transit or storage is best done by a professional art-handler. The materials need to be inert to prevent damage due to off-gassing of harmful substances such as acids or caking of deteriorated foams onto the body of the artwork.

Fig. 4 The *top image* shows the terracotta sculpture with a fractured neck and deteriorated adhesive masking tape marks on *top* of the desk due to packaging. The *bottom image* shows the sculpture after the treatment [Faltermeier (2012) www.faltermeier.biz]

Ceramics are first condition checked, to ensure safe transport. Then acid-free paper is wrapped around the body. No tape is to be used in the first layer of wrapping (Fig. 4). Then a double layer of bubble wrap is to be wrapped around the body. The bubbles have to face each other, to minimize the pressure points.

The piece is then placed into a crate best made of inert plastic. The crate is to be padded with shock absorbent polyethylene foam.

Ceramics can be stored at a range of humidity levels, as long as the ceramic does not contain soluble salts, as can be found in pieces recovered from maritime sights such as shipwrecks or salty burial grounds. It is also pertinent to check for old restorations, since these are often susceptible to fluctuations in heat and humidity. Should the ceramic contain old restoration, it is best to keep the relative humidity around 55–65 % and the temperature should not exceed 20–25 °C. The higher the temperature the faster an old restoration deteriorates, especially those that use early synthetic materials.

Conservation and Restoration

Most museums all over the world practice conservation of terracotta, porcelain and other materials instead of restoration. This is based on the principle idea of minimal intervention with the artwork which means leaving as much of the original material intact and undisturbed for future generations of scholars to do their research. Many restoration techniques will remove or manipulate Porcelain or cover it.

Conservation work is almost completely reversible and does the least amount of alterations to the ceramic ware. But it has to be noted that there is no such thing as a 100 % reversible conservation technique. Once original dirt or deposits are removed, they cannot be added back at a later stage. Adhesives (glues) are rarely completely removable from ceramics since the structure contains fine pores that can trap the adhesive and fillers applied during conservation of an artefact.

Nowadays, many conservators use epoxy resins to join and replace missing pieces in porcelain. A good conservator will be able to match the colours very closely to the original. The draw back of this technique is that it is very time consuming. Epoxy is relatively hard and the application of epoxy is also not easily reversible. If not carefully executed, the adjacent ceramic might be scratched, and there is also a possibility that the fill colour is not well matched or the fill changes colour due to light and heat and its induced deterioration.

During past restoration practices, the broken or cracked ceramic is glued together and missing areas filled in most cases with unsuitable materials, and then the fills and cracks are covered with paint. In case of porcelain the new restorations and the adjacent porcelain are airbrushed with a solvent-based paint; this paint needs to be perfectly colour matched to the porcelain. Most restorations are done for the art market, private collectors and commercial art galleries. If a restoration is done well, it will be very difficult for a layperson to detect the cracks and missing parts.

In the past these restorations discoloured in a short time span, especially in a climate with high temperature, humidity and light intensity. This is due to accelerated ageing of the in-fills, paint and lacquer. Today there are synthetic paints in

the market that will age and discolour much slower, and when the ceramic is not exposed to extreme environmental conditions, it can last for a long time.

The advantage of conservation is the minimal interference with the actual body and surface of the ceramic in question. However, unsuitable materials like epoxy resins tend to be hard and difficult to remove. The colour matching of some synthetic resins is rarely satisfactory in the long run. Either the fill is off colour from the start or most resins in the market will change colour due to light and high temperatures.

The conservation and restoration of terracotta is fairly straight forward, since the body of the pieces is porous and will absorb adhesives much more readily, therefore the bonds are stable and strong. The missing pieces are usually filled with calcium carbonate containing fillers of one kind or another. The fills are then colour matched using reversible paint media. Today low-fired ceramics such as terracotta are mostly conserved rather then restored.

Conservation techniques are desirable, since in principal they are the least harmful to an art piece. But it is rare that the conservation work on porcelain and high-fired ceramics is visually or aesthetically pleasing, since it can be easily spotted when handling porcelain. In good conservation work, the fill will blend in well when the ceramic is viewed from a distance or through a display case. Should the colour matching or filling be poor, the ceramic will look cracked or broken, and this distracts from the original décor and the original craftsmanship. A conservator will always educate the owner of a damaged piece that it is of academic and ethical interest to not alter the surface appearance and keep as much of the original surface and history, including the damage as visible possible.

When restoring porcelain, it is often done by a person relying on the fact that some of the glaze adjacent to the damage, will be covered by airbrushing with paint. In case of a quick fix or an irresponsible restorer, scratching of the glaze when smoothing the fills is considered irrelevant since it is covered by paint and therefore not visible. In my experience most high-fired ceramics that went through restoration work of this kind, were heavily damaged by scratching of the glaze underneath the over-painted areas. This damage cannot be undone, and has to be colour matched with paint in future, since it will distract from the original décor.

A good restoration will combine the idea of minimal intervention as practised in conservation, with the inherent aesthetically pleasing nature of restoration. However, it is important that the restoration is always visible to an expert, and that the restoration is entirely reversible. Therefore Restorers need to adopt the practice of reversible materials and materials that do not age rapidly (Figs. 5, 6 and 7).

Testing and Analytical Methods

Microscopy:

It also can show inconsistencies in wear and tear, old and new damage.

Mineralogical Analysis:

Fig. 5 The terracotta horse has a fractured proper *front right leg*, the old restoration shows a dowel and tool marks, indicating that both sides of the fractured were manipulated to fit perfectly. No natural occurring break would be as flat and contain tool marks [Faltermeier (2012) www.faltermeier.biz]

This is used to determine the mineral composition in a cross-section and surface structure of glaze and colouring.

Ultraviolet Light (UV) and Infrared light (IR):

This can show up variations in materials old and modern additions, and in some cases traces of old decorations.

X-ray radiography or Magnetic Resonance Imaging (MRI):

Fig. 6 These tomb guardians were damaged due to poor packing during transport. Several of the protrusions fractured, due to a poor choice of adhesive old restorations opened and fractured again [Faltermeier (2012) www.faltermeier.biz]

This is a bit more complicated, but can for sure show up new additions and over-painting. If high radiation is used, it can interfere with Thermo luminescence Testing.

Chemical Spot Tests:

Small blotting paper pieces are soaked in a solvent and placed on the surface. The chemical reaction can suggest or indicate what materials are present.

Thermo luminescence Test (TL):

3 or more samples are taken by an independent party and send to a recognised laboratory. The samples will reflect the date when the piece was last fired (Fig. 8–10 and 11).

Fig. 7 The sculptures after conservation, the treatments are mostly reversible. The old restorations were not opened and conserved, since opening old restorations can often cause more damage than warranted by a new conservation treatment [Faltermeier (2012) www.faltermeier.biz]

Fig. 8 Han Dynasty terracotta Fig. (206 BC–220 AD) The figure is in one piece and covered in a *lime* wash and *red* pigments. The pigments are partially worn off and expose the *dark gray* terracotta. It is interesting to know that the figure is rather unstable due to a high center of gravity. There is also no major chipping or breakage [Faltermeier (2012) www.faltermeier.biz]

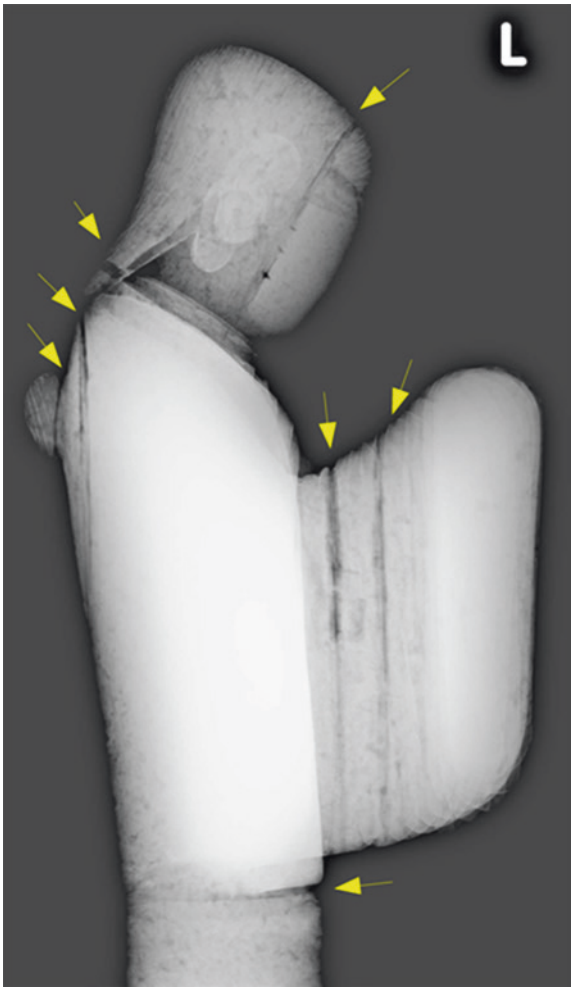

Fig. 9 The Han Dynasty figure was TL tested and was considered genuine by two laboratories. X-ray imaging however revealed that the figure was constructed from various ancient parts. The X-ray image shows the figure from its *right side* the arms and sleeves are made from 3 parts. The head is mounted onto the torso and the face is pinned to the main body of the head. The back of the shoulder and the hairpiece are also additions. The *bottom* part of this image shows *dark line*, where the torso is mounted onto the lower part of the figure (Faltermeier 2012)

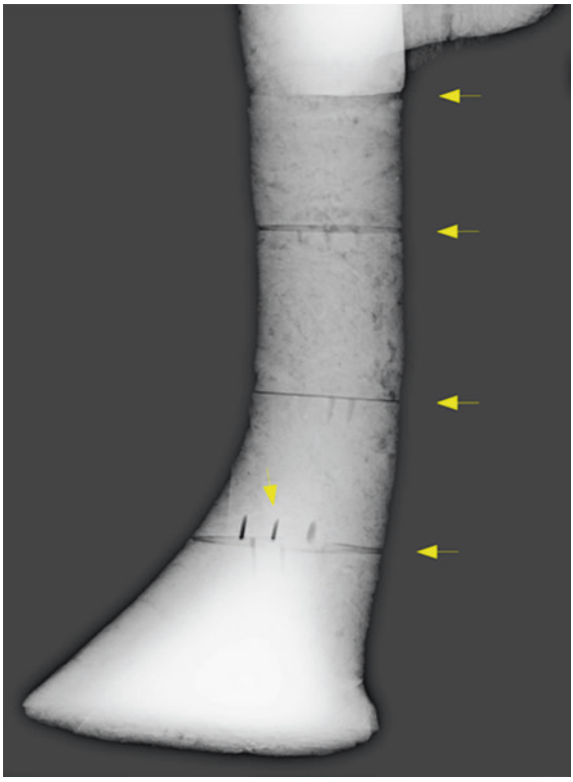

Fig. 10 The image shows the *bottom* part of the figure to be constructed of 4 separate pieces and pinned together with metal pins. Antique sculptures this size are generally not constructed like this and pinned and glued together and disguised with pigments and fillers in this manner. It shows that relying on Thermo luminescence testing is not sufficient to determine authenticity [Faltermeier (2012) www.faltermeier.biz]

Fig. 11 Kylix before, during and after conservation. The fragments were joined with an acrylic resin, gab-filled and colour matched using acrylic paint. The whole treatment is reversible [Faltermeier (2012) www.faltermeier.biz]

References

Faltermeier R (2005a) Peranakan Porcelain; Conservation versus Restoration. Heritage Asia, Kuala Lumpur, p 40 (June–August)
Faltermeier R (2005b) Peranakan Porcelain; Conservation versus Restoration. Heritage Asia, Kuala Lumpur, p 41 (June–August)

Glass

Mesopotamia is thought to be the cradle of glass making. A site approximately 3,500 years old has yielded the earliest glass fragments known. Glass is a silica based material with a amorphous structure. Ideally glass contains approximately sand or silica (SiO_2), alkali oxides soda (Na_2O) or potash (K_2O) (potassium carbonate in the past derived from wood ash) and a flux an alkaline earth such as lime (CaO). Soda-lime glass has been the most common glass throughout history. The higher the silica contents the higher the melting-point, therefore harder to work with, it is very hard and resists high temperatures (1,000–1,500 °C). An increase of soda or potash disrupts the silica network and lowers the working temperature.

Antique glass containing sodium or potassium can be susceptible to humidity. Sodium and potassium exposed on the surface can react with carbon dioxide from the atmosphere and turn into sodium carbonate and potassium carbonate, both of which are extremely hygroscopic. At a relative humidity of 40 % and above, drops of moisture appear on the glass (weeping glass) leaching out the sodium and potassium and leaving behind only the hydrated and porous silica. This can result in the glass having an iridescent, crazed, pitted or flaking surface. In glass produced after the 18th century, this effect is not commonly encountered.

Handling

Glass with an iridescent or fragile surface should not be handled with cotton gloves, since the fibres can entangle with the surface and cause more damage. It is best to handle this kind of glass with non-powdered nitrile gloves.

It is also pertinent to remove rings and watches, since the hard metal can chip, scratch or crack some ancient glass.

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As tempting as it is, do not handle objects by projecting elements such as spouts, handles or rims. These areas are very vulnerable and should there be a previous restoration, the likelihood of weak bonds failing catastrophically is high.

In cases of inappropriate handling, small faults such as hairline cracks can open further and cause disintegration of the artwork. Always use both hands, and then only hand-carry pieces over short distances, place them in padded boxes and use trolleys whenever possible.

Display

Effective illumination of glass objects is notoriously difficult. When lighting glass, the light source should not heat up the glass. Old restorations usually done with epoxy resins might discolour due to high light exposure.

The relative humidity of the showcase should not exceed 40 % when the glass shows signs of crazing (crizzling) or iridescence. Archaeological glass is best kept at a stable relative humidity 40–50 %.

Maintenance

The surface of modern glass can be dusted with a longhaired brush. It has to be ensured that the metal ferrule around the base of the bristles is protected with masking tape, so as not to risk scratching the surface of the glass.

It has sometimes been recommended to use compressed air from an aerosol-can; however, like the brushing; this has to be done with caution, since it can easily dislodge loose fragments on antique and damaged glass.

Dusting of antique glass with a cloth is not recommended. The cloth can catch on parts of damaged glass or chips and further harm the surface.

Washing of glass should be left to an experienced conservator. Since the acidity of some waters can cause problems with antique glass surfaces.

Packing and Storage

Packaging for transit or storage is best done by professional art-handlers. The packing materials need to be inert to prevent damage due to off-gassing of harmful substances such as acids. The acid can damage the alkaline in the surface of an antique glass.

To ensure safe transport, always check the condition of the glass in advance.

Then acid-free paper is wrapped around the body. No tape is to be used in the first layer of wrapping. Then a double layer of bubble wrap is to be wrapped

around the body. The bubbles have to face each other, to minimise the pressure points. The piece is then placed into a crate (one made of inert plastic is best). The crate is padded with shock absorbent polyethylene foam to secure the object against shock.

Old and antique glass is best stored in a relative humidity under 40 %. Modern glass can be stored at a relative humidity of 45–55 %. Temperature of storage should not exceed 20–25 °C. Higher temperatures will accelerate the ageing of old restorations.

Conservation and Restoration

Glass can be easily damaged during handling and transport. In the past cyanoacrylates and nitrocellulose adhesives have been used to repair the damage; however these adhesives do more damage then good. They can creep into cracks or cryzels and cannot be removed any more. Due to ageing, they diminish in coherence and yellow.

Today, a conservator will use specially developed epoxy resins to join the fragments or fill the missing areas. These epoxies are less susceptible to yellowing than earlier adhesives. The resins are usually colour matched with pigments and the resulting restoration is usually hardly visible. However, it has to be added that an adhesive such as an epoxy in a crack or in a porous or delaminating surface, cannot be reversed. Therefore acrylics are more suitable for archaeological materials. Surfaces that delaminate should never be impregnated with any kind of synthetic material by a non-specialist, since it is very difficult if not impossible to remove these materials (Figs. 1, 2 and 3).

Testing and Analytical Methods

Microscopy:

Low-power microscopic observation can show inconsistencies in wear and tear, plus any old or new damage.

Ultraviolet Light (UV) and Infrared light (IR):

This can show up variations in materials, as well as old and modern additions, and in some cases traces of old decorations.

Chemical Spot Tests:

Various chemicals are applied in small areas to detect inconsistencies in the surface materials and perhaps the application of modern coatings to improve the appearance of the object.

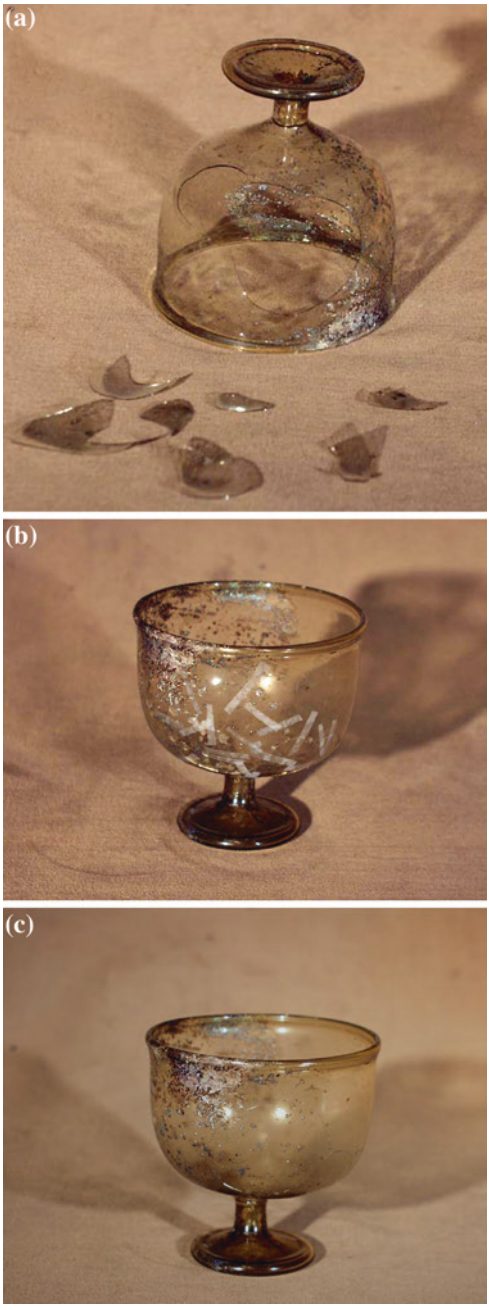

Fig. 1 **a** This Roman glass has a very interesting impact fracture that clearly shows that it is recent damage, since all the fragments are present and the edges are very sharply defined. **b** The fragments were taped into place using masking tape. Small strips allow the pieces to be placed and adjusted without damaging the surface of the glass. **c** The gaps and fractures were filled with an epoxy resin that was originally developed for the aircraft industry to join large glass panels in windscreens without leaving bubbles or visual traces in-between the panels. The fluidity and refractive index of the resin allows all the cracks in the glass to be filled and effectively disappear Faltermeier (2012) www.faltermeier.biz

Fig. 2 *Above* is a *dark green*, Roman glass dish before and after conservation. The fragments were joined with an acrylic resin. This procedure is almost completely reversible. Notice how in the calcareous deposit only a small hairline crack is visible

X-ray Fluorescence:

This technique looks at the surface composition of the glass and might indicate a modern reproduction. It is non-destructive.

Fig. 3 This ancient aubergine coloured glass vase was covered in calcareous deposits that disfigured and obscured the white decoration flowing through the coloured glass matrix. The deposit was removed with a complexing agent that did not attack the fragile glass surface. At the end of the treatment the glass surface was smooth and reflective again. The deposit was *left* on the inside and near the rim

Stone

Since the Palaeolithic period, man has been able to shape and work stone. The oldest cultures still show their presence in the form of stone monuments and sculptures. Stone is resilient in most environments. However, weathering erodes the original worked surfaces.

Sandstone, marble, limestone and granite are only a few of the stones used to express the artisans' view of his surroundings. Each material has different properties and poses a challenge to the craftsman.

There are two types of sandstone used for buildings and sculptures: calcareous and siliceous sandstone. Calcareous sandstone tends to deteriorate faster since the calcium carbonate that binds the sand together is more readily dissolved by acid rain.

Marble and limestone are also calcareous stones and are easily attacked by acids. They are porous and soft and so scratch easily and are frequently stained due to environmental causes.

Granite is one of the most resilient stones used to produce sculptures and other ornamental features. It is fairly resilient to wear and tear and environmental impact in comparison to the other stones used. However, due to its brittle nature it chips easily. An interesting feature of some granite types is that when in contact with fire they can explode violently.

Handling

It is imperative to understand the artwork that has to be moved or handled. The following points should be kept in mind.

Before moving a work of art made of stone, it has to be ensured that it is sturdy enough to be moved.

R.B. Faltermeier, *An Easy Guide to Care for Sculpture and Antique Art Collections*, DOI 10.1007/978-3-319-08897-6_3

Cotton or nitrile gloves should be worn when handling artworks in stone or it has to be ensured that hands are very clean. A note of caution, cotton gloves can entangle with rough stone surfaces.

If a stone object is moved on a mount, it needs to be secured adequately and no part should be abraded by the support itself. Therefore, it is always advisable to remove all stones from their mounts prior to moving them. Large stones are best demounted using lifting equipment, to minimise the stresses exerted onto the mounting areas. Be sure that the attachment points for the lifting straps are strong enough and the straps secured properly.

All protruding parts, be they original or restored, need to be checked if they are detachable or loose, especially since old restorations are susceptible to new damage and need to be carefully checked along the original—restoration interface. Large and small pieces are only to be moved by hand a short distance. Small pieces should be moved from shelf to padded cart with the cart placed as close as feasible to the shelf. Large pieces should be lifted onto inert, padded pallets and whenever necessary by movable lifting equipment. They should be securely strapped to the pallet for the safety of both the object and personnel during movement (Fig. 1).

The mode of transport has to be in good working order and suitable for the artefact moved. Usually carts trolleys and forklift trucks are labeled with weight limits and under no circumstances should they be overloaded or used as ladders.

Before moving an artwork, ensure that the path to the destination is clear and that no protruding wall fixtures or doors are blocking the free movement of your object, and that there is sufficient illumination of the path.

Loose footwear or clothing that can entangle with the artwork are not suitable. No rings or buckles should come in contact with the stone surface since it may easily causes chipping or scratches. Artefacts should never be lifted at protruding parts; they might be frail, brittle or loose. Transport stone objects in crates or boxes, whenever feasible.

Display

Marble, limestone and sandstone sculptures should not be displayed outdoors, since air pollution in urban environments can cause the rapid deterioration of the surfaces. This often results in black streaks or crusts.

Granite can be displayed outdoors. However, it should be carefully monitored and maintained. Always raise stone slightly from the ground and use a water/moisture barrier between the object and the surface it is resting on. This prevents potentially contaminated water from the ground entering the stone and being transported through capillary action throughout the sculpture. Cyclic wetting and drying can cause damage to the body and especially the surface of a sculpture. Old sculptures can contain repairs with iron dowels, and humidity can result in corrosion of these iron rods with the resulting rust causing stains in the stonework or even cracking due to expansion of the rust (corrosion jacking).

Fig. 1 Egyptian limestone sculptor's model 305-30 BC; the edges on the proper *right side* are missing and disfigure the overall appearance of the model since the missing edges distract strongly from the original carving. By replacing the missing edges, the visual integrity of the piece is restored without altering the original figure

Frequently, antique stone artefacts have been drilled for mounting. In recent years, this has become unacceptable for most museums and collectors. Drilling can cause stresses within the stone, this can lead to micro-cracking and even result in fracturing of the stone. Modern mounting specialists will try to display objects by non-invasive techniques such as clamps and contoured armatures of the underside of the artwork. When displaying a sculpture, it is important that the object is

Fig. 2 This Gandara Buddha was mounted with brackets to a stainless steel base without the need to drill

mounted appropriately and that the centre of gravity (also called centre of mass) of an object is taken into account. Much of the damage caused to sculptures is due to accidental toppling (Fig. 2).

When exposing stones to strong light sources, it is important that previous restorations are identified and potential accelerated ageing is prevented. Frequently, excessive lighting can cause rapid deterioration of inappropriate glues, resulting in joint failure and further breakage.

Antique stone can also have remains of old colour decorations, these can fade when exposed to high light levels.

Maintenance

The surface of stone can be dusted with a longhaired brush. It has to be ensured that the metal ferrule around the stem of the brush is adequately protected with masking tape, so as to not scratch the surface of the stone.

Air from aerosol-cans can also be utilised in dust removal. However, as with brushing, this has to be done with caution, since it can dislodge loose fragments on antique and damaged stone or drive small dust particles into the capillaries.

Some antique stone sculptures have been found to have the remains of old painted decoration. These have to be dusted carefully so as not to damage the original pigmented areas. In come cases, the pigments might need consolidation treatment by a specialist conservator.

Fig. 3 Roman marble hand holding a Parazonium, 1st Century A.D., before, during and after conservation

Outdoor stone sculptures or architectural parts can be carefully rinsed with water.

However, the possibility of previous restorations has to be borne in mind. A professional conservator will know the best approach to maintaining the sculptures to ensure minimal deterioration due to their outdoor exposure (Figs. 3 and 4).

Packing and Storage

Before moving stone it is essential they be condition checked to prevent damage. The surface of the sculpture should be protected by a layer of acid free paper. No tape is to be used in the first layer of wrapping. Then a double layer of bubble wrap is to be wrapped around the body. The bubbles have to face each other to minimise the pressure points. In case of very heavy pieces, the bubble wrap can be substituted by several layers of clean thick blankets. However, this is only a

Fig. 4 Roman marble head of Doryphoros 2nd Century AD; the damaged nose was restored. However, the restoration is not stylistically correct and this will be immediately obvious to a connoisseur examining the head in future. Faltermeier (2012), www.faltermeier.biz

Table 1 Suitable and unsuitable packing materials

Appropriate	Inappropriate
Acid free paper	Newspaper
Acid free cardboard tubes	Toilet paper
Bubble wrap	Vinyl chloride, urethane foams, Styrofoam
Polyethylene foam, bags, tubes, boxes	Fabric fibres
Polyester film (Mylar Type D®)	Cotton wool
Aluminium foil (The above need to be specific archival quality or tested in advance)	Composite woods such as fibreboards and chip boards (only as outer casing)

temporary measure during transit, never for long-term storage. For long-term storage, polyethylene foam should be used. The common yellow foam or Styrofoam is not to be used, since this can deteriorate and stick to the artwork. The stone is then placed into a crate made of inert plastic. The crate is padded with shock absorbent polyethylene foam (Table 1).

Stone can be stored at various temperatures and humidity ranges. However, it is important to check for old repairs and restorations, since these can be susceptible to temperature and humidity changes. Generally it is thought that restored objects made of stone should be stored at a relative humidity of between 45 and 55 % and a temperature between 20 and 23 °C. Wet or humid stone artefacts cannot be stored in an environment likely to freeze; ice crystals can damage porous and frail surfaces due to an increase in pressure during crystallisation of water present.

Some excavated stones contain soluble salts. These objects should be desalinated by a professional before storage. A fluctuating humidity will most probably result in salt damage due to the re-crystallisation of soluble salts at low humidity levels. If desalination is not feasible, the stones need to be stored at a very stable relative humidity.

When storing heavy stones, it is often advised to take them off their mounts. It is best to place the object on clean, inert polyethylene foam. The weight should be

carried by the largest part closest to the centre of gravity of the artwork. Any protruding parts need to be protected and supported.

Since hardly any storage area is dust free, it is best to cover the stone with clean white cotton sheets.

Conservation and Restoration

In many cases, broken and damaged stones have been repaired using commonly available, rapid-curing epoxies or polyesters. These resins result in yellow staining and damage of the surface due to their poor ageing properties. It is very difficult if not impossible to remove these stains when the glues have been drawn into capillaries, in-between the grains or crystals of a stone matrix during the curing process. Accumulative effects due to temperature and light also cause these old repairs to fail, since the resins break down with age and lose their cohesive strength.

In the past, fractured protruding parts are often reinforced using iron or copper rods. These corrode rapidly in moist tropical climates or in outdoor stones and iron rods and their expanding corrosion will result in pressure, cracking and splitting of the adjacent stone. Iron, copper or copper alloy rods and their corrosion products, can in many cases, cause staining of the surrounding surface. A professional conservator will replace these with non-corroding stainless steel rods. When planning for outdoor exposure, it is warranted to use techniques such as ultrasound to detect old iron rods to prevent future damage due to their corrosion. This can be easily liaised by a local conservator and an engineering company (Fig. 5).

Fig. 5 The antique marble bust above was restored using an iron pin and plaster. The pin corroded and stained the original patina of the marble surface. It is fortunate that the drilled hole is much larger than the pin and that plaster was used, since the corroded and expanding pin only damaged the plaster and did not cause cracking of the original marble

Marble and limestone with black streaks should not be cleaned with commercially available cleaning solutions. These can have an adverse effect and can potentially dissolve the surface. Scrubbing the stone with heavy-duty sponges and brushes can abrade the surface and erode fine decorations. A conservator will use pH neutral soap and soft brushes to remove dust and grim while chemicals such as complexing agents, are used to remove stubborn stains.

Antique stone sculptures or architectural elements are frequently heavily restored. Many countries that are hosts to a thriving antique trade also have their own restorers; these restorers; re-carve missing pieces from similar stones. Since freshly excavated archaeological stone sculptures are frequently carved from regional stone, it can be difficult to distinguish old and new parts by colour or structure of a stone since the same or similar materials are still readily available.

The new additions can usually be distinguished by their deliberate wear of the surface, and the lack of natural staining and weathering. Frequently the joint of the original part and the re-carved part is filed down to allow a perfect surface appearance. This abrasion will have resulted in the damage of the original ancient surface. To mask the variation in colour and texture, the whole sculpture is then frequently soaked in chemicals and/or coated with waxes and pigments to resemble an ancient surface. In most instances, a mixture of solvents and chemicals easily removes the waxes and pigments. However, there are cases where damaged missing original features for example or worn decorations are re-carved out of the damaged surface material. This kind of treatment is much harder to detect and variations in surface weathering usually are a good indicator for a newly exposed surface in the recently carved areas (Figs. 6 and 7).

Testing and Analytical Methods

The simplest way determining which parts of a stone sculpture are antique or recent restoration is through test cleaning an inconspicuous area with water. (Caution: this should only be done with the permission of the owner. Additionally, any dirt, grime and other contaminating material can be driven into the surface of the stone.) Most restorations or synthetic additions will react differently to water. However, if the surface has been coated with a synthetic material or wax, this method will not work well (Fig. 8).

If a stone has fractured or chipped surfaces then a microscope or good magnifying glass (30× or larger) can be used to examine the stone fabric. Most stones, being porous) have a graduation in colour from the surface into the core of the piece. This colour change varies from stone to stone and depends upon the type of burial environment. I have seen cases in which shellac and other materials have been applied to imitate this gradual penetration of deterioration and discolouration. If this is suspected it should be followed up with careful surface testing to confirm if the material is soluble in organic solvents, indicating a synthetic resin has been used.

Fig. 6 Antique marble leopard from a palace in Bikaner Rajasthan. The detailed *insert* shows the previous restoration attempt. The aged and *yellowed* synthetic resin used to join the fragment has deteriorated. The resulting failure caused a new break visible as the clean broken edge. *Below* the Leopards paw restored and airbrushed. The new treatment is reversible. Faltermeier (2012), www.faltermeier.biz

Fig. 7 Gandara relief. The previously restored piece had various false heads. The heads were removed, the surface cleaned and gap-filled, and colour matched

Old restorations made of synthetic resins or synthetic fillers can be identified in most cases using infrared or ultraviolet lamps and/or by a simple heat test. A fine needle is heated to red-hot and then the suspicious surface is probed. If smoke and a hole with elevated rim develops the filler is most probably synthetic. This technique does not work with plaster and cement fillers. Plaster fillers tend to be softer than stone and much more homogenous than most stones. Cement fillers tend to have a clear boundary between stone and cement interface.

Microscopy:

Microscopy can show inconsistencies in wear and tear, distinguish between old and new damage and reveal modern additions. Binocular microscopy and oblique light is most useful (Fig. 9).

Ultraviolet Light (UV) and Infrared Light (IR):

This can show up variations in materials, revealing modern additions, and in some cases traces of old painted decorations.

Fig. 8 The Khmer gray stone sculpture of Narashima was analysed using solvent based Spot-Testing. The *yellow dashed lines* indicate the areas where the new carvings were added. The hips of the figure are the original area. The torso and the legs were newly carved and added. It is interesting to note the great difference in colour and structure. The hips are well aged and the deteriorated discolouration cannot be removed with solvents or a mixture of various chemicals. Faltermeier (2012), www.faltermeier.biz

Chemical Spot Tests:

Various chemicals are applied in small areas to detect inconsistencies in the surface materials and the application of modern coatings to improve the appearance.

X-ray Diffraction (XRD):

This technology is used to identify the minerals present in a stone.

Fig. 9 Vishnu sandstone sculpture, Cambodia; the legs of this figure are replacements. The *infrared image* clearly shows the difference in surface and the great variations in tool marks and the original weathering of the antique areas above the legs

Cross-sections:

Mounted thin sections of the stone viewed in an analytical microscope can highlight erosion and deterioration patterns and type of minerals present. This is necessarily a destructive technique unless there are loose fragments that may be sacrificed.

Metals

Since the Bronze Age, man has used metallic ores and converted them into metals for utilitarian and decorative purposes. However, the earliest remains of such industrial activities, have been lost due to the natural effects of weathering and subsequent mining operations.

Bronze usually develops a beautiful green, red, or blue patina in a non-polluted environment. This patina is just another form of corrosion. However, prolonged corrosion will result in the complete mineralisation of the metallic bronze making the object highly brittle and easily breakable. Chlorides in the environment induce the most harmful type of corrosion to any kind of bronze or copper alloy. In archaeological bronzes they can cause very rapid deterioration and result in total loss of an artefact if exposed to a moist environment, even in a museum store.

Iron is one of the metals in collections that are most susceptible to moisture and humidity. In most cases, rust is non-protective and therefore will not slow down the corrosion to an acceptable level, as is the case in a bronze patina. One of the few iron artworks that shows little corrosion in the outdoors is the Delhi Iron Pillar thought to be 1,600 years old (presumed to be due to a high amount of phosphorous in the iron—in addition to the accumulation of grease from thousands of hands) (Fig. 1).

Silver, a precious metal frequently used for highly priced decorative objects, tarnishes rapidly in a polluted urban environment. Both chloride and sulphur in the environment will cause rapid blackening of the surface. This tarnish can usually not be reversed back into a solid stable metallic surface, only chemically or mechanically removed.

Gold in its pure form is a very soft and malleable metal and hardly suitable for regular wear, however, in a non-alloyed form it will hardly deteriorate in any practical environmental conditions. Only when gold is debased and alloyed with other metals such as copper, will it tarnish or corrode. We often find antique gold pieces

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Fig. 1 Delhi iron pillar

covered in green corrosion. This is the result of copper in the debased gold corroding and migrating to the surface of object.

Handling

When coming into contact with metals it is always advisable to wear gloves, since moisture and secretions from the skin can tarnish and corrode bronze, iron and silver (Fig. 2). Frequently, clean white cotton gloves are recommended. However, these are permeable to humidity and can catch on a rough, corroded metal surface or on decorative elements. In most museums, disposable non-powdered latex (or better still, nitrile) gloves are used today.

Copper and its alloys can exhibit a light green powdery corrosion. In most cases this corrosion is copper hydroxychloride corrosion (also known under

Fig. 2 Chinese bronze Hu; the copper alloy has become completely mineralized. Due to an accident, the Hu fractured into numerous pieces. Here, a synthetic resin has been used to join the pieces and fill the missing areas. Acrylic paint was applied to cover the retouched areas. This process is almost completely reversible. Faltermeier (2012), www.faltermeier.biz

Fig. 3 During handling, this "antique" oil lamp was damaged. Closer inspection revealed that the piece is a pastiche

Fig. 4 This export silver teapot was found crushed and was subsequently reshaped. This procedure removed the original silver oxide corrosion. The surface was later chemically patinated to restore the antique appearance. (Faltermeier 2004)

the mineral terms atacamite and paratacamite) and it is advised not to breathe in, or touch, this corrosion with bare hands since it might be carcinogenic (Fig. 3).

Silver tarnishes rapidly when handled without gloves since sweat and salts can react rapidly with polished silver surfaces (Figs. 4 and 5).

Always remove jewelry when handling metals, since some especially soft metals such as gold and silver can be easily dented and scratched.

Fig. 5 This export silver tray tarnished within weeks of being exposed in a tropical urban and coastal climate. (Faltermeier 2012), www.faltermeier.biz

Display

Not all metals have the same display requirements. Corrosion involves three principal components: humidity, temperature and air. The most practical form of corrosion control for metals is the removal of moisture from the surrounding air (since excluding oxygen is difficult and expensive). This can be done by either removing excess humidity by the use of electric dehumidifiers or desiccants such as SilicaGel©. Its main ingredient is silicon dioxide therefore it is safe to use on a daily basis and in a home, although the fine dust may be a health hazard. Artsorb© is another moisture-absorbing material (a combination of silica gel and lithium chloride), which adsorbs and desorbs moisture in order to compensate for changes in relative humidity. It is very important not to use the calcium chloride-containing humidity absorbers that are available in hardware shops, since the chlorides can be volatile and deposit on metal surfaces in showcases. To monitor the tarnish or corrosion rate, it is always a good idea to place a small polished silver strip near the artwork on display or in storage.

Bronzes are ideally kept at a relative humidity of 35–45 %. This relative humidity level will minimise the risk of any copper chlorides present in the object becoming active and corroding the metal further. This is especially pertinent when collecting antique and archaeological bronzes that were recovered from a chloride containing burial environment—especially those coming from hot dry countries. These are safest if kept in a humidity below than 35 %.

Unprotected or un-coated historical ironwork should be kept at a relative humidity below 35 %. In a private collection, it is therefore strongly suggested to preventatively treat the surface of iron artefacts to allow them to be stored or displayed at higher ambient humidity levels. All iron or steel artworks should be

Table 1 Recommended humidity levels for display and storage of various material types

Relative humidity levels	
Material:	Relative humidity
Iron containing iron chlorides	Under 15 %
Bronze (with copper chlorides)	Under 35 % (ideally lower)
Iron, bronze, silver and other metals with stable patina	45–55 % (ideally lower)
Paper, book, furniture textiles, modern materials, plastics, paintings, photographs	45–55 %
Glass containing potassium or sodium	Under 40 % (ideally not much lower)
Ivory, bone, teeth	45–55% (needs to be very stable)
Collection type	
Mixed collections (to high for some metals)	45–55 %
Metal only collections	40–45 % (ideally lower)
International loan agreements usually stipulate	45–55 %

inspected regularly to ensure that no corrosion is present, and no remedial treatment is required. Archaeological iron objects of all kinds are notoriously prone to post-excavation corrosion. This corrosion can completely destroy even large objects. Archaeological iron requires specialist conservation and very stringent storage/display environments.

Polished and uncoated silver should be displayed at an RH between 40 and 45 %. This level of humidity will minimise the risk of corrosion arising from pollutants in the atmosphere. Display materials in contact with, or in the vicinity of silver artworks should be free of acids and other harmful gasses. Display materials such as paints, textiles, wood and the sealants used to hold the glass need to be tested prior to use, especially in confined spaces such as showcases.

In tropical and coastal climates, works of art and antiques made of metal or containing metal, especially composite metal structures, have to be monitored constantly and a condition check by a trained person is required.

When mounting metal artworks, a suitable mounting material needs to be chosen. Not all materials are compatible. It is best to avoid direct contact with iron or copper based mounts. If a strong material is needed stainless steel, stone or inert plastics are preferred. There should be always an isolating layer such as foam or inert plastic between the artwork and the mount (Table 1).

Maintenance

Metals should never be washed or cleaned by unqualified persons since water and most commercial cleaners will damage metals and leave residues that promote further corrosion. It is best to just dust the surface with a soft brush and leave in-depth cleaning to a professional.

Bronze and other copper alloys can corrode when in contact with water, especially chlorinated tap water. Outdoor sculptures can be rinsed with tap water where the surface of the bronze has been previously coated with synthetic resins or/and waxed. However, this rinsing with water should only be done as part of a maintenance plan of an outdoor bronze or metalwork in general.

Cleaning blackened and tarnished silver is not as simple as it may seem. On a microscopic level, commercial silver pastes can actually do more damage than good, since their compositions vary greatly. They usually scratch and/or change the silver surface composition. The most common brands contain ammonia; this chemical will dissolve the copper in the silver alloy, and make the surface porous. After polishing, the surface will contain mainly silver. This silver surface is even more reactive than the silver-copper alloy of the main body, and due to the high purity of the silver surface the silver will re-tarnish even more rapidly than before.

Gold and gold alloys tend to need little maintenance, but are best not polished, since the use of commercial cleaners can scratch the surface and cause a change in surface composition. Such a change in composition can raise questions of authenticity, especially in antique gold and silver pieces. Coins and medals should only be cleaned by professionally trained conservator.

Polishing with motor driven machines and commercial polishing pastes should be completely avoided since the polishing will remove any original wear and tear and will make it impossible to differentiate a modern from an antique piece, since the surface finish will be identical in each case.

Packing and Storage

All materials used need to be of conservation or archival grade. Newspapers and other wood based materials can result in a low pH environment or even worse in case of newspaper; the printing ink can rub onto an artwork. Tapes of any kind should only be used on the outermost layer, never near the artwork itself.

Any plastic packing, be it film or boxes, needs to be inert and not off-gas any aggressive pollutants, since tight and confined spaces can result in a build up of pollutants around the object.

To prevent corrosion of fine metals such as silver and debased gold by pollutants such as acid vapours, it is advisable to place metals such as silver and debased gold into airtight boxes containing activated charcoal or to use materials such as Intercept©. Intercept© has solid state reactive materials incorporated into a polymer matrix such as film or foam. These materials react with and neutralise all corrosive gases in an enclosed environment.

Smaller bronzes and iron works of art are best packed in padded airtight polyethylene boxes containing a moisture absorbent material and an humidity indicator strip that is placed on the inside of the see-through box, so as to be able to read it when the absorbent is not desiccating sufficiently. It is imperative that all these materials need to be checked regularly.

To test plastic boxes for their suitability: place a dish of water, together with polished silver, copper and lead wire or strip into the box. Make sure the different metals do not touch and are not in direct contact with the water. Close the box tightly and place it in an oven at 50–60 °C (check in advance that the box does not melt at this temperature). As a precaution, place a metal tray beneath the box. Monitor the results, initially every 10 min and then in half an hour and then hourly intervals for at least one day. If there is any corrosion or tarnishing of the metal samples the box is not suitable.

Conservation and Restoration

Metal conservation is a specialist endeavour, since each metal can pose a variety of problems.

Bronze is easily corroded under high humidity and pollution levels. The main cause of corrosion for modern and antique metals is copper chloride corrosion. Chlorides from the environment, be it due to handling, aerosol or burial will interact with copper present in the bronze and will start a cyclic corrosion process. In coastal tropical regions, chloride corrosion is a huge problem. This deterioration process will convert copper into the various copper chloride minerals such as nantokite and atacamite/paratacamite. These minerals tend to be of grey to light green colour and mostly powdery in nature. It has been suggested that these copper chlorides are carcinogenic. A conservator will remove these corrosion products or will try to stabilise them with various treatments such as a corrosion inhibitor or coating. Frequently the chlorides are within the artwork or antique and can only be stabilised superficially and not removed. It is best to keep bronzes with chloride corrosion at a relative humidity below 35 %. Outdoor bronzes should have a maintenance plan. This plan will include regular surface cleaning, including removal and re-application of various protective coatings. In tropical climates with high temperatures and strong sunlight the surface temperature of outdoor bronzes can be very high, causing coatings to deteriorate prematurely. Low molecular wax can evaporate due to the heat and/or become sticky and collect environmental pollutants—further increasing the risk of damaging the surface. Most susceptible are modern chemically patinated bronzes (Figs. 6 and 7).

Iron corrodes readily, especially when not coated with a protective film such as paint or lacquer. During conservation treatments the surface will be cleaned and in case of archaeological iron, the soluble salts will be removed. A coating of one kind or another will follow this cleaning process. The coating will significantly slow down the corrosion rate; but will not stop corrosion indefinitely. Iron needs to be kept as dry as possible at all times, inspected on a regular basis and have coatings reapplied. The only exception to this is Corten (COR-TEN) steel, a special alloy that produces a self-renewing corrosion retarding layer.

Silver polishing is the most invasive way of maintaining a shiny silver surface. A conservator will use either mixtures of abrasives and lubricant to remove silver oxidation selectively, or an electrochemical method. This will result in a minimal damage to the underlying silver and controlled removal of the black tarnished

Fig. 6 The bronze wine jug above has some sand from its burial environment bound up in its corrosion. There is also a corrosion hole in the bottom half that has been previously restored. The old restoration was removed and the gap filled with a synthetic filler and then colour matched

layer, this work is mostly done under magnification for maximum control. All treated silver should be then coated with a reversible lacquer, to retard future oxidation and tarnishing of the silver surface.

Gold rarely needs conservation, only in case of debased archaeological gold is a treatment warranted. The most obvious corrosion products on archaeological gold tend to be copper oxides, due to the alloying constituents in the debased gold. These corrosion products should not be polished off, since the soft gold will be easily damaged and the signs of original wear and tear removed. A conservation treatment will usually selectively tackle the corroded areas containing copper corrosion products, by applying a complexing agent. These chemicals selectively dissolve the corrosion products and do not attack the gold.

Fig. 7 This praying monk had copper chloride corrosion. In the tropical climate of South East Asia, the humidity can be as high as 95 % during the rainy season. The *light green* corrosion was mechanically removed and stabilized. The back of the head above shows on the *left hand side* the head before treatment and in the *right hand image* the head after it was stabilised

Testing and Analytical Methods

There is a wide array of testing equipment to analyse metal artefacts. However, it is best to start with the least complicated tests first.

Microscopy:

An inexpensive method to check for damage such as corrosion, cracks and other flaws. It also can show inconsistencies in wear and tear, of major importance to detect fakes (Fig. 8).

Ultraviolet Light (UV) and Infrared light (IR):

This can show up variations in materials, old and modern additions, and in some cases traces of old decorations and inlays covered in part by corrosion. Especially new paints and plastics especially glow differently under different light wavelengths.

Fig. 8 This Chinese archaic bronze Jei was brought in for conservation and during cleaning, it was discovered that various parts were new additions. One leg and a knob (see insert images on the *right side*) had a clean, straight edge, cut to fit the original antique. Faltermeier (2012), www.faltermeier.biz

Chemical Spot-Tests:

These are used to determine the chemical composition of a polished metal, or can be used to determine modern additions and fakes; the chemicals might result in discolouration of the surface area tested.

X-ray radiography:

This is a little more complicated, but can, with certainty, show up new additions and over-restorations, both techniques are ideal to look at the inner construction and joints of an artwork. If high radiation is used, it might interfere with thermo luminescence testing of any clay mould residues inside a hollow object. There is no need to take samples and thus this method is non-destructive.

Metal Cross-Sections:

A small sample is taken from an inconspicuous area, mounted in a synthetic resin and polished. Under high magnification, the corrosion pattern from the surface into the metal is observed and can give information about likely authenticity.

Energy Dispersive X-ray Analysis (EDX), or Electron Probe Micro Analysis:

These analytical techniques are used to determine the composition of a metal especially bronzes. It can determine if the alloy contains elements that are indicative of fakes.

Lead Isotope Test (Pb210):

This is a recently developed technique to test small samples of copper and copper alloys if they were produced in the past 100 years. If high radiation is used, it might interfere with Thermo luminescence Testing.

Thermo luminescence dating (TL):

Some bronzes contain sand or clay cores that can be tested for their age. This is a partially destructive method since a sample needs to be drilled out of the body of the artwork.

X-ray powder diffraction (XRD):

This technique uses small samples of corrosion products from the surface of a metal artwork and can determine the composition of the minerals present. This can indicate fake or artificial patination.

Infrared Spectroscopy/Fourier Transform Infrared Spectroscopy:

These techniques can be used on small samples of corrosion products from the surface of a metal artwork and can determine the composition of the minerals and/or binder present. This can indicate fake or artificial patination.

Reference

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Textiles

Since prehistoric times, textiles and fabrics have played an important role in people's lives. Most antique textiles are made from wool, silk, cotton and linen, although other fibres have been used. Often, other materials such as beads, quills, metals, bones, paints and leather are incorporated within a textile object. Synthetic fibres were introduced only in recent history and pose specific challenge for preservation, conservation and restoration. They should only be dealt with by appropriate specialists.

The deterioration of textiles is physical and chemical in nature. The problems encountered are multi-faceted and are mainly due to poor environmental conditions, rough handling and inappropriate display or storage.

Handling

Proper handling of textiles is imperative. Nitrile gloves should be worn when handling textiles since cotton gloves leave fibres on the textile. Jewellery such as rings, bracelets and dangling chains cannot be worn. Even buttons on shirts or belt buckles could entangle with fabrics and be a cause of damage. Never keep food, drinks or ink containing writing equipment near textile artefacts.

To measure the size of textiles always use a flexible textile-measuring tape and ensure that the metallic endings are covered in a soft material. Textiles incorporating metal-wound threads are best handled with clean nitrile gloves, since cotton gloves are likely to entangle with the sharp edges of the metal threads and could cause considerable damage the fabric.

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Fig. 1 This Indonesian fabric, most likely from Sumatra; the Songket is woven with supplemental weft gold threads. It probably dates from the early 20th century and was probably worn during ceremonial occasions. The technique most likely originates from Arabia or India

Most textiles are more fragile than they appear at first glance. Before handling a piece, familiarise yourself with the problematic areas. When lifting or moving textiles, make sure that the weight is evenly distributed and no area is unnecessarily stressed by the weight of the fabric itself. Delicate areas can be supported by sliding acid free cardboard or paper underneath before attempting to lift a textile. Heavier and larger pieces can be transported on acid-free rollers or tubes or carried on fabric slings (Fig. 1).

Display

Light is a form of electromagnetic energy and is one of the main causes of photochemical degradation, since organic materials such as textiles will absorb light energy and deteriorate. The absorbed energy will cause the textiles to fade and cause structural damage. Natural and artificial light sources contain visible and ultraviolet light. Both will damage a textile. Ultraviolet (UV) light is not visible to the human eye, but will cause the greatest amount of damage in the shortest period of time. UV is present in almost all light sources, but can be filtered out by the use of UV inhibiting acrylic sheeting or special UV foils applied to window panels or showcases. It is not enough to just filter out UV light since the rest of the visible spectrum of light will also do damage over a period of time. This damage is dose-dependent, so it is a combination of light intensity and exposure time (Table 1).

It is best to select light sources such as bulbs according to their UV output. Textiles should always be kept at low light levels and are best displayed at 50–100 Lux and in most collections, fabrics are only displayed for a short period of time since damage through light is cumulative. Visible light can be measured by a common camera light meter but for UV light, a specialised UV measuring device is needed.

Humidity and temperature are interrelated. Various deterioration processes are influenced by relative humidity and these can severely damage textiles and other organic materials:

1. Changes in size and shape (expansion and contraction of organic materials)
2. Biological deterioration (fungi, mould, insects etc. are all increased with water content)
3. Catalysing chemical reaction (both organic materials and some metals)

A fluctuation in humidity causes fibres to expand and contract creating stress, resulting in their physical and chemical degradation. High humidity levels will increase the rate of chemical reactions and can cause running and fading of dyes. Low humidity levels will desiccate fibres resulting in brittleness. Fluctuations must be minimised since they cause uneven dimensional changes and jeopardise the resilience of a fabric. Textiles are best kept at a relative humidity between 55–65 %.

Table 1 Recommended light levels for displaying works of art and antiques

Exhibit	Maximum illumination
Metal, stone, ceramic, glass, jewellery, enamel (not containing substances like pigments that can be changed by photochemical reactions)	200 lux and above (usually not more than 300 lux is necessary to see objects clearly)
Oil, tempera, horn, bone, ivory, leather, lacquer (not containing substances like pigments that can be changed by photochemical reactions)	200 lux or less
Textiles, watercolours, photographs, tapestry, carpets, prints, wallpapers, some oils, drawings, gouache, botanical specimens, fur, feathers and dyed leather	50–100 lux

Fig. 2 This textile is damaged due to wear and tear and the gilded parts are abraded along the folds and creases. Storing this fabric on conservation grade tubing would have prevented the damage

Pollution such as smog, ozone (never display fragile textiles near a photocopier since they are a source of ozone) and car exhaust are also a cause of chemical degradation. Household cleaners such as bleach and ammonia are well known hidden air born pollutants in a domestic environment. Dust and gritty particles can result in physical abrasion of fibres as the textile is manipulated.

All materials used to exhibit a textile such as frames, cases and storage containers have to be carefully checked and selected. Most woods, cardboards and plastics are not sufficiently chemically stable to store fabrics safely. They may release volatile acids and other damaging gases. Airtight cases and plastic bags can trap these released vapours, together with adsorbed water causing high humidity and further damage. Poor packing materials should be avoided.

Textiles such as banners or tapestry are frequently displayed vertically by hand stitching a support fabric on the back of a fragile artwork. A VelcroTM loop is then stitched to the back of the support fabric and corresponding VelcroTM hook is mounted onto a suitable background, for example a sealed wooden baton. Alternatively, a flat fabric is mounted onto a stretcher and then the textile in question is carefully sewn onto the clean backing. This work should always be done by a trained conservator that has specialised in textile conservation and mounting.

Maintenance

Vacuum cleaning is usually the main means of cleaning a fabric and keeping it dust free. This is done by brushing the surface of the fabric with a soft bristle brush into the nozzle of a vacuum cleaner. It is important that the nozzle is covered with gauze that can trap larger particulates and prevent the accidental entering of the fabric into the nozzle. The suction of the vacuum cleaner needs to be

regulated and the vacuum cleaner needs to be fitted with a micro filter, to trap mould spores and finer dust particles. HEPA (high-efficiency particulate air) filters are claimed to remove 99 % of airborne particles. It is important to note here that not all fabrics are suitable for vacuum cleaning. Never attempt to wash a textile, since degraded textiles are far more prone to shrinkage, colour bleeding and damage. Degraded linen will invariably develop an brown line on drying and may even partially disssolve. Always contact a specialised conservator to assess the needs of heavily soiled and stained fabrics.

Packing and Storage

All materials used for packing and storing textiles should be of archival quality; such as barrier films, acid free tissue and cardboards used in rolling tubes and storage boxes. They are all available through conservation suppliers. Good housekeeping is the best way to prevent damage to textiles. The fabrics need to be kept in a clean environment and routinely checked and maintained. Adequate housekeeping will prevent damage due to insects, other pests and micro-organisms such as mould and fungi.

Never store your textiles in attics, lofts or basements, since it is very difficult to control the environment in these areas. They are often readily accessible to insects and other pests. It is best to store textiles in a cool (20–25 Centigrade), dry (55–65 %RH) room and when storing textiles in cupboards and chests ensure that they are well ventilated to prevent mould and fungal growth.

Whenever possible, store your textiles flat between sheets of acid free paper in archival boxes. It is best to avoid folding textiles to prevent sharp creases. Larger pieces are best supported by rolling them on to archival quality tubes, making sure that the tube has a large enough circumference to avoid damage to the fabric. The textiles should face outwards and be interleaved with acid free paper when rolling them onto the tube. Special attention should be given to textiles that are beaded, heavily embroidered or embellished with metallic threads. Finally, the roll is covered with a clean washed cotton sheet that will act as a dust cover. Secure the dust cover by tying cotton tape gently around the roll and tucking the ends of the sheet into the ends of the roll (Figs. 2, 3 and 4).

Garments can be hung for storage. However, the hangers should be specially selected to have the correct shoulder angle and must be padded sufficiently with archival quality material to avoid straining the fabric. Be sure when hanging the garment that it will not be damaged by its own weight. Finally protect the garment with a cotton dust cover. Do not use plastic bags, since these can emit harmful gases or cause micro-climates within the bag and their static electricity attracts dust and dirt. TyvekTM sheets are excellent for protecting stored textiles and garments. If the garments or textiles cannot be hung or rolled and must be folded, they are carefully placed between layers of acid free tissue and the folds are supported with crumpled acid free paper, avoiding creasing of the fold, which in the

Fig. 3 This jacket has been stored flat. This has caused strong creases in the sleeves, sides and shoulders of the fabric. Long-term, this will weaken the threads and cause severe damage. It is far better to stuff the textile with acid free tissue to avoid sharp creases and distribute the weight

long term, results in the fracture and permanent breaking of fibres. Masking tapes and other tapes for packaging should never be near textiles, and when wrapping textiles, it has to be ensured that the tape never touches the fabric.

Insect infestations have the most devastating effects on textiles and other organic materials. Insects such as termites, silverfish, beetles, cockroaches and moths will eat all kinds of organic matter. The three main indicators for insect infestations are damaged sections in the textile such as eaten away parts, insect droppings and dead insects. It is best to place insect traps, for example sticky blunder traps or pheromone traps around the display and storage areas. Traps should be inspected every 1–2 months and the number of trapped insects carefully documented. This will indicate the extent and nature of the insect problem. Note: some experts suggest that the pheromone traps can actually attract insects from outside of the storage area (Table 2).

Table 2 Some insects damaging organic materials

Insect	Damage	Prevention
Carpet beetle	Larvae do the most damage on silk, wool and fur, horn and tortoiseshel	Keep textile clean and use insect traps
Clothes moth	The larvae feed on proteins derived from wool, silk and fur	Inspection of new acquisitions, keep the textile clean. Screen windows and air ducts to prevent the entering of moths
Silverfish	They usually do not attack textiles but are attracted to sizing on textiles and can damage fine fabrics such as silk and cotton. Usually they are more of a problem for paper, e.g. museum labels	Silverfish love humidity. It is best to keep the area humidity controlled and wrap fine gauze or netting around the packing

Fig. 4 Painted Indonesian textile. The fabric should be stored on a conservation grade tubing, reducing the stresses on the fibers and paint

Conservation and Restoration

Old textiles that have been collected over decades or centuries have been mended at one point or another. Often they have been stitched or washed in the past and it seems to be a natural thing to do, since we are accustomed to undertake these tasks on a regular basis. However, for aged textiles, these treatments are not always appropriate or beneficial to their preservation. When faced with a valuable old fabric, it is best to approach a specialised textile conservator. The treatment recommended will be based on their experience with similar pieces, together with careful study and research on each individual artefact prior to conservation. It is always best to get a second opinion. Should there be a large discrepancy between the recommended treatments, seek further expert advice and try to see if there is a general consensus in approach and conservation treatment.

Cleaning of textiles is mostly done by carefully vacuum cleaning. Only when absolutely necessary, will a conservator wash a textile by immersion treatment and the textile will be then dried in a controlled environment. In the past, restorers not only backed and reinforced a fabric by stitching, but also using synthetic materials such as glues and waxes. This approach is not acceptable today, since most synthetic materials such as glues and synthetic resins are non-reversible, often changing the handle and aesthetics of the textile and can do more damage than good. A conservator today will try to approach a problem under the professional guidelines of minimal intervention and maximum reversibility. In the case of frail and damaged textiles, this will involve carefully stitching of the old fabric onto a supportive backing which will stabilise but not interfere with the original and can be removed without a trace. Insect infestations can be eradicated by extended freezing of smaller or larger items. Another approach is an anoxic treatment in which all the oxygen in a closed environment is removed for several months. These have shown to be effective ways to kill off insect infestations without using toxic chemicals. When handling frozen materials, the fibres and organic matter will become brittle. Condensation can also pose risks such as corrosion on metal threads, or damage to other inorganic materials (such a beads and pearls) incorporated into the textile.

Testing and Analytical Methods

Microscopy:

An inexpensive method to check for damage and other flaws. It also can show inconsistencies in wear and tear, of major importance in detection of fakes.

Ultraviolet light (UV) and infrared light (IR):

This can show up variations in materials, old and modern additions, and in some cases traces of old decorations. Especially variations in pigments and plastics glow differently under different light wavelengths.

Fourier transform infrared spectroscopy (FTIR):

This is a non-destructive or minimally destructive analytical method to determine the composition of a fabric and possibly dyes.

Radiocarbon dating:

Small samples can be used to determine the age of a textile. Usually a sample size of 50–100 mg is required. This technique is considered destructive.

Ivory, Bone, Horn and Teeth

These organic materials, derived from body parts of animals, are largely composed of calcium phosphate. It is often difficult to distinguish between ivory and bone without a magnifying glass or microscope. Generally, ivory has a much lower visible porosity than bone. Ivory is made of dentin and refers to the tusks of elephants and mammoths, although the term is also used for walrus, hippopotamus and various whales' teeth. Both ivory and bone are easily distorted or warped when exposed to fluctuating humidity and/or temperature.

Elephant ivory has wavy, longitudinal lines and in cross-section exhibits a cross-hatched pattern (Schreger lines). When holding the object under a light source, these characteristic lines will be more visible but they may gradually disappear when turning the ivory. In fake ivory, these lines are too regular and will not disappear when turning the artwork. Walrus ivory has a characteristic core of cloudy secondary dentine, whereas sperm whale teeth have simple concentric rings.

Bones are supplied with blood in a living animal and therefore will contain small channels or pores that are usually seen as small brown or black spots on the object. They are more easily seen under a simple magnifying glass. Bone objects also tend to be much more coarse looking and not as shiny and polished as ivory, however buyer beware; the bone might have been coated with waxes or resins.

Horns, especially rhino horn are especially prized. Many cultures make objects of mythological belief, magical and medicinal powers from horn. Many animals such as goats, sheep, cows and antelope have horns. The horns of most animals have an inner bony core made of calcium phosphate which supports a thin sheath of keratin—the same material that makes up hair and fingernails. Rhino horn does not contain a bone core as in other horns but grows directly from within the skin as a cemented mass of fibrous tissue. All horn is very susceptible to elevated temperatures since it is a natural thermoplastic polymer. At around 100 °C, it is thermoplastic and can be reshaped. At about 200 °C it starts to melt and two pieces of horn can be joined or welded together.

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How to distinguish fakes? A simple test would be a temperature check. When placing an ivory piece on the upper lip or cheek, ivory will feel much cooler. Synthetics will tend to warm up much faster than bone or ivory which contains a large proportion of heat absorbing mineral.

When looking at the surface of plastic resin fakes these tend to be much more uniform in visual appearance than ivory. When poking a fake ivory artwork with a red hot needle a resin copy will smell of burned plastic. This test is not recommended for valuable pieces and should only be attempted in inconspicuous places such as the un-worked underside.

Handling

Ivory and bone are easily stained due to their micro-porous surfaces. Oils and moisture from hands are easily absorbed into the surface. When handling this kind of artefact it is best to wear gloves. Clean white cotton gloves are acceptable on smooth surfaces. However it is advisable to use un-powdered nitrile gloves on rougher surfaces, especially on bones or bone artefacts. It is very important that the surfaces on which artefacts rest or are worked upon are spotless.

No food, ink or other potentially contaminating matter should be in the vicinity, since stains are inherently difficult to remove.

Objects made from bone, ivory and other hard tissues should always be moved in polyethylene boxes that are padded with conservation grade materials and covered with a lid. It is advisable not to stack too many boxes on top of each other and should the boxes also be used as a storage container, humidity buffers must be added to protect against changes in temperature causing fluctuating humidity.

Display

Ivory and Bone are fragile materials that are very susceptible to elevated levels of humidity, temperature and light. They rapidly distort when exposed to fluctuating or very high humidity and temperature levels. They are prone to crack if they are allowed to desiccate. Excessive amounts of light will rapidly bleach the surface or may cause yellowing (Note bones that are exposed in the open desert sun).

These organic materials are best displayed in an airtight showcase containing a humidity buffer. The light sources should be placed outside of the showcase to reduce the buildup of heat in the showcase.

The display temperature should be in 20–25 °C and humidity in the range 35–55 % but in tropical climates it will be difficult to achieve such relative humidities and therefore ivory is frequently stored at a relative humidity of 55–65 %. This puts the ivory at high risk if it is moved to a dryer climate. Fluctuations

Fig. 1 This carved Batack ivory tusk was mounted on a clear acrylic stand. The edges were rounded and polished to prevent scratching. The clear acrylic does not obscure the ivory carving and cradles the tusk effectively

should be avoided since ivory and bone will react quite rapidly to these changes. Since exposure to light has an accumulative effect—meaning that the more light energy that is absorbed the more the surface will deteriorate and change colour—it is best to exhibit ivory at 50 lux and store it in a dark place (Fig. 1).

Maintenance and Conservation

Ivory and bone objects are at best only dusted with a fine brush and a low powered vacuum cleaner containing a micro-filter. The metal ferrules of brushes should be covered with masking tape to prevent potential scratching of soft surfaces.

Because this group of material is very moisture sensitive an untrained individual should never clean ivory or bone, since the cleaning can do more damage than good. Water and other solvents penetrate readily the surface and can stain irreversibly.

When documenting ivory and bones make sure that photo lamps do not heat up and desiccate these materials. This can happen very rapidly. It is best to use fluorescent lighting when photographing these materials and exposure to light should be kept to a minimum.

Packing and Storage

Humidity (35–55 % Rh) and temperature (20–25 °C). Levels have to be stable and should not rise 70 % RH since this might cause mould growth.

When transporting fragile ivory and bone by air. It has to be noted that sudden changes in air pressure can cause damage to the material. This includes micro-vibration because fragile ivory has fissures and cracks along its growth lines (Fig. 2). Both of these calcified tissue grow by the deposition of successive layers on top of each other. These can swell and separate due to changes in humidity and temperature.

Fragile ivory and bone are also sensitive to sulphur, such that any material (such as display materials or even other objects) containing keratin or adhesives emitting sulphur might yellow or discolour the surface. Keratin is contained in tortoiseshell, hair, hooves, nails and claws but also woolen fibres (such as felt). It is best to store valuable and sensitive pieces with activated charcoal to absorb airborne pollutants. For control measures, a highly polished strip of silver can be added (if the strip tarnishes rapidly then the object is at risk).

Ivory and bone are best stored in airtight inert boxes containing a humidity buffering material. Only acid free paper should be used.

Old labels are best removed by a conservator, and reapplied after coating the specific area with a protective acrylic layer. This is done to avoid the adhesive on the back of the label penetrating into the surface and causing staining. Many

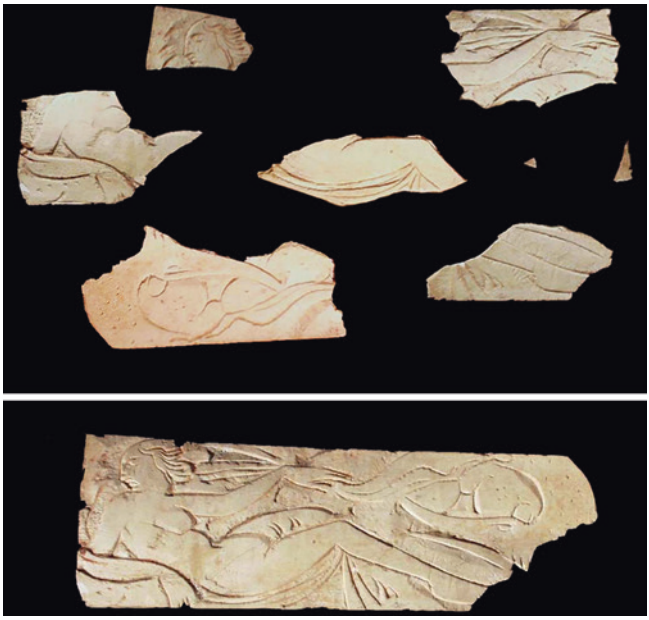

Fig. 2 Ancient bone plaque; the fragments were cleaned and joined using an acrylic adhesive. The gaps were filled with an acrylic filler and colour matched with acrylic paint

auction house labels, especially the older ones, contain adhesives that deteriorate and cause damage to the surfaces they are applied to.

Testing and Analytical Methods

Microscopy:

An inexpensive method to check for damage and other flaws. It also can show inconsistencies in wear and tear, of major importance to detect fakes. Bone, ivory and antler have different structures.

Ultraviolet light and infrared light:

In addition to revealing both historic and modern additions, ultraviolet light can also be used to distinguish real horn and tortoiseshell from synthetic substitutes. In UV light horn and tortoiseshell fluoresce a yellow-green. This is readily seen in the blond horn and tortoiseshell but is much harder to see in the brown regions of tortoiseshell.

Radio carbon dating:

Small samples can be used to determine the age of a textile, as in the famous test of the Turin Shroud. Usually a sample size of 50–100 mg is required. Samples taken to date bone or ivory have to be larger because of the lower organic content. Although this technique is considered destructive it is less damaging to objects than used to be the case.

Paper

The name paper derives from the Greek word “papure” which originates from the earliest Egyptian form of paper papyrus made from the inner bark of the stem of the papyrus plant. Strips of the papyrus plants were layered and pounded together. The Egyptians have used this as writing material 5000 years ago. However, it is not true paper as we know it today.

According to Chinese legend, a Chinese named Tsai Lun invented paper. He tried to find a use for scrap woven fabrics; these were beaten till they were a mass of loose fibres. The fibres were mixed with water and then poured onto a cloth or bamboo screen and left to dry. He presented the paper to the Chinese emperor He Di of the Eastern Han Dynasty in 105 CE (CE = Common Era).

Archaeological evidence, however, has shown that the oldest piece of paper known was found in a tomb near Xian. This paper made from hemp fibres and is dated to around 140 CE. The oldest paper covered in Chinese characters is dated to 110 CE and was also found in China. The earliest papers were made of silk fibres, the inner berk (bast) of mulberry and, most commonly, bamboo fibres.

The inherent long-term stability of artworks made of paper is mainly governed by the manufacturing method and materials used, such as paper components, inks and paints. There are many types of papers that are meant to be short-lived such as those used in newspapers or paperback books. Nevertheless, modern prints and artists’ works on paper should be executed on acid-free papers if the artists want their work to survive.

Handling

Books and works on papers should only be handled with clean hands and gloves. They should be handled with both hands as this will reduce the risk of creasing or tearing the work. Whenever possible, the paper should be supported by an inert material such as acid free cardboard.

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No food or drink should be consumed near artworks, since they can contaminate the area and accidental transfer of food remains is possible.

When prints or works on paper are stacked, they should have a clean acid-free separation layer.

It is best to store pieces matted or in acid-free storage boxes or folders.

Matted works of art on paper or documents should never be opened through the window, since inserting a finger can scratch the artwork. Always lift the window by the outer edges.

Never use masking tape or ballpoint pens near any work on paper, since residues of adhesive or ink can easily be transferred onto the work surface, packing materials or gloves. This may then find its way onto the artwork itself, causing smuges. Always write with a pencil.

It is important to not drag anything over works of art since they are vulnerable to scratching and other forms of damage.

Display

Art collectors should ensure that only archival grade material such as acid-free paper and board is used for mounting and display.

Lighting should be monitored carefully and UV filters applied wherever possible. Artworks on paper should not be exposed to light if not necessary and the light levels should be kept under 50–100 Lux. It is never sufficient to just filter out UV light.

It is imperative to monitor humidity and temperature since foxing and staining are mostly due to elevated humidity. It is best to display paper documents at 45–50 % RH. The lower the temperature and humidity, the slower the chemical processes that cause deterioration. So inadvertent heating through illumination or placement above a fireplace will speed up damage. In the tropics, it is best to not hang an artwork on an exterior facing wall that is bathed in sunlight and never store or hang artworks on paper in the kitchen, the bathroom or the basement.

When framing paper, it is important that the covering glass has a UV absorbent layer or preferably, a non reflective acrylic sheet is used (acrylic sheet should never be used for artworks with powder pigments, such as pastel drawings, due to the risk of electrostatic charge lifting of loose pigment). An adequate spacing between paper and glass ensures that the surface of the paper does not get damaged by sticking to the glass cover.

Packing and Storage

Never roll or fold works on paper, since this can cause damage to the paper fibres and result in creases or tears. If paper is excessively large, it can be rolled onto acid-free tubing with a sufficiently large diameter. It is best to seek advice from a specialised paper conservator when attempting to unfold or unroll a frail or fragile piece of paper.

Objects made of paper are best stored in acid-free materials such as buffer containing archival cardboard or polyester folders. When using polyester folders, it is important to take into account that polyester film can acquire an electrostatic charge, damaging materials such as charcoal and pastel drawings. Being impermiable they can also trap moisture. The alkaline buffer in cardboard folders and boxes is added to neutralise acids released from the cardboard. When storing materials that are highly acidic such as newspapers and magazines, it is best to keep them separate to prevent acid migration to other parts of the collection. Storage boxes or folders have to be sturdy enough to allow the support of the artefact during transport or handling.

Pest and insect infestations in paper are as problematic as with textiles. The main culprits for book and paper damage are silverfish, termites, cockroaches, book- lice, moths and various beetles.

Conservation and Restoration

It is always best to seek professional advice on conservation or restoration. If a picture, document or a book is damaged it is best to get a trained individual to assess the damage and produce a condition report. This report should contain advice on how to store and display the artefact and minimise future damage. There are limitations to restoration treatments and this need to be addressed prior to commencement of any treatment (Fig. 1).

Fig. 1 This Peranakan wedding photo has been heavily damaged and there has been an attempt of retouching the damage. The photo was scanned and digitally restored. Faltermeier (2012) www.faltermeier.biz

Testing and Analytical Methods

Microscopy:

An inexpensive method to check for damage and other flaws. It also can show inconsistencies in wear and tear, of major importance to detect fakes.

Ultraviolet Light (UV) and Infrared light (IR):

Ultraviolet and infrared photography are both used to reveal differences in inks and paints used in works of art on paper. Both are useful in the detection of later additions and restorations, etc. They are widely used in forensic investigations of drawings and prints.

Fourier transform infrared spectroscopy (FTIR):

This is a potential non-destructive analytical method to determine the surface composition of a paper.

Radio carbon dating:

Small samples can be used to determine the age of a piece of paper. Usually a sample size of 50-100 mg is required. This technique is considered destructive and rarely undertaken.

Wooden Materials

Wooden materials are a broad subject and in this chapter only the basics are covered. Wood artefacts can be furniture, sculptures and others and are either utilitarian or decorative in their purpose. Wood may seem to be a solid material but only a small percentage of living wood is actually made of wood substance (cellulose, hemicellulose and lignin). The bulk of a living tree is made of water. Dry wood mainly consists of carbon, oxygen, hydrogen and traces of inorganic materials. By volume, 60–80 % of dry wood normally consists of air filled cells and this makes wood de facto a very porous material with a high surface area.

Wood can be divided into two main groups, hardwoods and softwoods. Softwood such as coniferous species (for example pine, fir and cedar) has a higher cellulose and lignin content than the hardwood species (for example birch, cherry, ebony and teak).

Millions of years ago, nature's evolution created wood for a wet/humid environment, this resulted in a microstructure made from cells that allow wood to absorb water. In living trees the moisture content varies from species to species. This gives the wood its elasticity to withstand the harsh windy outdoor environment and the strains placed on its structure. Humans cut down wood and dry it, to shape it in accordance to their needs. However, wood still retains its hygroscopic nature. Wood is also anisotropic, meaning its structure and growth direction governs its expansion and contraction and its physical properties, all of which depend on its moisture context. The more moisture present within the wood the higher its elasticity. When wood dries, it shrinks differently due to its anisotropic nature, meaning it shrinks differently in all three growth direction. This explains why wood cut from the same tree can distort differently as it dries, depending upon the orientation of the piece when it was sawn from the trunk. This distortion can result in warped and cracked planks or future artefacts.

Wood is degraded in various ways. Bacteria, single cell organisms, thrive on wood immersed in freshwater and seawater. This is one reason why archaeological wooden artefacts rarely survive in a wet and moist environment where oxygen is present. Moisture and humidity allow mould and fungi to flourish, which causes surface staining. This staining comes in various colours from black to brown and

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various light colours. Fungus however can come in red, yellow and other colours and can penetrate deep into to the wood, mainly along the cell walls. The fungi live on the cellulose and lignin and destroy the woody material by punching holes into the cell walls and softening the wood structure.

Another agent that severely damages works of art in wood is light. It has a bleaching effect on wood. Lignin in the surface of wood is deteriorated by ultraviolet light and cause embrittlement on the surface. Although this is generally shallow it can lead to loss of surface details when handled inappropriately or abraded by other means of transport. Insects are another major problem for art collections containing wooden materials. They live and breed inside wooden artefacts and are thus hidden from sight. Insects reproduce and spread rapidly since many adult species have wings. Look for the telltale signs of fine powder or frass (insect droppings), dead insects (near the object or under the nearest window) or exit holes in the surface.

Handling

It is imperative to understand the artwork that has to be moved or handled. The following points should be kept in mind.

Before moving an artwork or furniture made of wood, it has to be ensured that it is sturdy enough to be moved.

A sufficient number of people should be employed to lift and move items, without the risk of damaging large wooden items or individuals.

All parts need to be checked if they are detachable or loose. These parts should be removed and transported separately and/or fastened with cotton tape to prevent damage or loss.

Make sure that large and small pieces are only moved by hand as short a distance as possible. Small pieces should be moved from shelf to padded cart, whereby the cart is placed as close as feasible to the shelf. Large pieces should be lifted onto inert pallets and, whenever necessary, by movable lifting equipment.

Certain categories of furniture or other items have specific handling requirements:

Chairs should never be lifted or handled from the back support or arm rests. They should be handled from the supporting frame under the seat. This will minimise the risk of damaging joints.

Tables have to be handled and supported at the frame under the table top to minimize the stress on joinery and frames.

Chests of drawers, cupboards and bookcases should be disassembled wherever possible without damaging the piece. The individual pieces should be transported separately.

Make sure that the mode of transport is in good working order.

Before moving an artwork, ensure that the path to the destination is clear and that no protruding wall fixtures or doors are blocking the move, and that there is sufficient illumination of the path.

Loose foot wear or clothing that might entangle with the artwork are not suitable. No rings or buckles should come in contact with the wooden surface

since it easily causes scratching or bruising of the surface. Artefacts should never be lifted at protruding parts, since they might be frail, brittle or loose.

When moving a large piece it is best to not wear cotton gloves, since a lacquered finish is very slippery, un-powdered nitrile gloves are more suitable or clean washed hands.

Maintenance

Wooden works of art should never be cleaned using liquids or solvents, this is only to be done by a trained conservator, since it can cause severe staining or damage to previously applied coatings. Smooth surfaces are best dusted with a lint free cloth, and/or by dusting the surface with a soft brush and a vacuum cleaner with adjustable suction and micro-filter.

It is unacceptable for laymen to apply wax coatings to ancient wooden artefacts or furniture, since most waxes are dissolved in chemicals and solvents which can harm the artwork. Many waxes also contain materials that are not reversible such as polyethylene (only soluble in hot solvents) or silicone waxes, or waxes that have low pH value that might damage the surface. In many cases, it is very difficult if not impossible to remove the damaging waxes from within porous wooden surfaces if the object requires retreatment.

Commercially available polishing sprays and other cleaning products contain an assortment of chemical ingredients for example emulsifiers, perfumes etc. These will migrate underneath coatings such as lacquers and cause blanching (whitening of varnishes) or block cells within the wood, disrupting the absorption and release of moisture and resulting in internal stress and damage.

Packing, Storage and Display

The deterioration of wood is mainly governed by:

- Humidity and moisture level
- Bio-deterioration
- Temperature
- Oxygen level
- Excessive light exposure

Humidity will distort wood and excessive drying will cause distortion and cracking. Wood is best kept at an RH between 55–65 %. Relative humidity fluctuations should not be more than plus and minus 5–10 %. In dry environments such as centrally heated homes during the dry winter period, it is important to keep a stable environment to minimise damage to the wood. Temperature seems to play a less direct role in the deterioration. However, temperature is closely linked to humidity and rapid fluctuations are to be avoided. Freezing temperatures can cause embrittlement and desiccation, as can elevate temperature. A reduction in oxygen will

Fig. 1 This sarcophagus was originally in only two pieces (back and cover). The front and back were later cut into halves. The cut can clearly be seen in the first image. The central image shows it was heavily worn and the proper right bottom side near the feet is completely missing and shows the ancient wood additions. The four pieces were joined using a reversible technology. This will allow the disassembly of the Sarcophagus. The saw cut at the center front was gap filled and colour matched. The gap in the back was left open. Faltermeier (2012), www.faltermeier.biz

minimise bio-deterioration such as insect infestations. Excess light levels and high UV exposure will bleach wood and deteriorate any coatings on its surface.

Wooden artefacts displayed outdoors deteriorate much more rapidly than artworks displayed indoors. This is due to the combined effects of direct sun exposure and

weathering by rain, and large temperature fluctuations. This photo-oxidative effect, causing the wood to tyrn grey or silvery, is very obvious on beached driftwood and tree trunks exposed to the sun and rain. However, one has to bear in mind that these are the combined environmental effects of an extreme environment. Light and environmental exposure has also a detrimental effect on coatings such as lacquers and waxes as it will cause dimensional changes and movements of the wood substrate (Fig. 1).

Smaller objects are best backed in conservation grade materials. Larger items in storage are placed on plastic pallets off the ground and covered with a breathable synthetic fabric. If lint-free white cotton sheets are used, they need to be checked on a regular basis for insect damage and mould growth, since in humid climates these will retain moisture.

Polyethylene dust covers can also be used. However, they should not be wrapped tightly around an artwork since they easily produce a microclimate facilitating biodeterioration. Good housekeeping of storage area is of paramount importance to reduce risks of further damage and deterioration. The storage area needs to have a pest management system to ensure the regular inspection of items for insect infestation.

When openly displaying wooden pieces, good housekeeping and pest control should become a priority since the artworks are readily accessible to insects and exposed to fluctuating humidity and temperature.

Larger wooden objects should never be placed directly on the floor. Raising them slightly will minimise damage due to water when the floors are cleaned or by groundwater capillary action should the floor not be insulated.

Wooden artworks in display cases should always be monitored with a thermo-hygrograph. This is a device that records both temperature and humidity within the showcase. Ideally, an insect trap should be included in the case and inspected regularly. When illuminating wooden objects, either inside or outside of a showcase, it is important that there is no heat transfer from the light source. Uneven heating may cause irreversible damage (Figs. 2 and 3).

Fig. 2 The two wooden hands from a painted Buddha were heavily damaged in transit. It is interesting to note that the hands were assembled from various pieces

Fig. 3 The fractured hands shown on the previous page were restored and re-joined to the Buddha using reinforcing with wooden pegs

Conservation and Restoration

This chapter will only scratch the surface of this vast topic and is not meant to be comprehensive.

Wooden artefacts when hydrating and dehydrating in unsuitable environments develop cracks and voids. These should not be filled with dense materials that do not allow for movement and dimensional changes within the wood. Inflexible materials such as tough synthetic resins will only aggravate the problem and cause more damage.

Wooden artefacts should never be coated with synthetic resins that do not allow the wood to breath or hinder dimensional changes due to fluctuations in humidity

and temperature. Coatings frequently used on antique furniture, especially antique Chinese furniture, such as polyurethane are not acceptable and are very difficult to remove completely.

How are insect infestations recognised? Normally, frass (wood debris in powdered form) from active insects is found around the boreholes and under the wooden artefact. To ensure it is an active infestation, it is a good idea to place a black matt paper or cardboard underneath the borehole and see if new frass is being created. Old boreholes tend to be filled with dust and dirt. If an object is identified as being infested with insects, it must be immediately isolated from the rest of the collection and packed into sealed polyethylene bags. It should be dealt with as swiftly as possible since packing in polyethylene plastic bags can cause micro environments that are not beneficial for the wood.

As a small note: it has been suggested that furniture is faked and boreholes are intentionally made to suggest age. A common method is to drill the exit holes of emerging adult woodborers by using a small drill bit; it will create a straight and thus detectable hole. A more dramatic and random procedure is achieved by shooting a shotgun at the surface of the artwork so producing many holes of similar size. However when pushing a small needle into these holes, they turn out to bore straight into the wood. A natural insect borehole is usually bent and curved since the insect will follow the softest parts of the wood structure and follow the grain.

Insect infestations in wooden artworks are best dealt with by removing oxygen from the environment (anoxic treatments). Anoxic treatments are the best and least damaging method of eradicating insect infestations today. Another suggested method is freezing. However, this requires a large enough freezer and can cause Embrittlement and damage to woods that contain excessive of water can result in drying and cracking. Coated wooden objects or materials that incorporate pigments should never be frozen.

The use of chemical sprays should be avoided by all means since it might discolour wood or its finishes and in many cases is toxic to humans (Fig. 4).

Fig. 4 A modern icon that broke during shipment. It has to be joined, gap filled and colour matched

Testing and Analytical Methodologies

Hand Lens:

A simple hand lens ($\times 10$) is a useful magnification aid for preliminary wood identification.

Microscopy:

A microscope with approximately $\times 10$–100 magnifications is used for the identification of wood and its agents of deterioration. This is a non-destructive method.

Scanning Electron Microscopy:

A small sample is taken and mounted into a synthetic resin and coated with a conducting material. It allows high resolution imaging of the microstructure of the wood; this is a partially destructive method.

Dendrochronology:

Cross-sections of wood are compared to known and dated tree ring samples of the same species of tree. Unless the rings are visible on the cut end of a board this can be a partially destructive method.

Radiocarbon Dating (C14):

C14 is a dating method using small amount of wood samples to determine the age of an artefact; this is a partially destructive method.

Ultraviolet and infrared examination:

This is to determine additions and restorations, a non-destructive method.

Modern Materials and Sculptures

This is a very broad subject and I can only touch briefly on the various issues involved. I personally consider "Modern materials" includes artworks made during the beginning of the 20th Century and later. They can be for example bronzes, stone or plastics or artworks made of composite materials.

These artefacts have various fundamental differences, which have to be taken into account when collecting and preserving them. For example, if their copyright is still valid or existent, they can not be treated like archaeological material or other antiques (see the chapter "Copyright and Law in Conservation and Restoration").

With modern materials the conservation, restoration and preservation approach has take into consideration what the artist's original intent is or was, meaning it has to be understood what the artist had in mind when he produced the artwork and his wishes and ideas for its future existence. This can but must not include deterioration of the artwork to a point where it is completely altered from its original appearance. Therefore conservation procedures might fundamentally differ from the artist's objective and might not be appropriate, or even possibly be an infringement of copyright which could potentially result in a legal battle.

The preservation of modern materials is also more difficult in tropical climates. The deterioration of materials in these environments is generally much more rapid and advanced. Therefore, the artist's intent is much more radically altered. So, when collecting in regions with elevated temperature, humidity, light and pollution the preservation and conservation is a much more intricate problem than in moderate climates.

For many years now private and corporate investors have realised that investing in modern art can be very profitable and enjoyable. Buying modern art can also immediately enhance your living and working environment. Having an artwork on display, at home or in the office, can demonstrate taste, style and power.

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Collecting contemporary art is also a great way to start collecting or to bring new life into an established collection. When buying modern sculptures, it is important to see if the artist has understood the material he or she is working in—be it stone, bronze or modern materials. Stone is one of the most resilient materials; the re-occurring maintenance costs such as cleaning and conservation are low. When buying a bronze for indoor or outdoor display, the patina has to be in pristine condition and the sculpture needs regular attention, since bronze corrodes easily in an urban environment.

Modern materials such as plastics are generally a difficult genre. Since many modern resins can deteriorate rapidly when exposed to high light and temperature levels, as they are typically in tropical regions. It is always an excellent idea when investing in contemporary art to have the assistance and advice of an independent, experienced conservator familiar with the material and the subject.

Handling

It is imperative to understand the artwork that has to be moved or handled. The following points should be kept in mind.

Before moving a work of art, it has to be ensured that it is sturdy enough to be moved.

Cotton or nitrile gloves should be worn when handling artworks, but keep in mind that some surfaces might catch with cotton gloves, or may be too slippery to be lifted with synthetic gloves.

If an artwork is moved on a mount, it needs to be secured adequately and no part should be abraded by the support itself.

All parts need to be checked if they are detachable or loose, especially since previous restorations are susceptible to new damage. If extensions, additions or protruding parts are not detachable but loose, they are best secured with a cotton ribbon to the main part of the sculpture.

Make sure that large and small pieces are only moved by hand as short a distance as possible. Small pieces should be moved from shelf to a padded cart where the cart is placed as close as feasible to the shelf. Large pieces should be lifted onto inert pallets and whenever necessary by movable lifting equipment.

Make sure that the mode of transport is in good working order and that height adjustable trolleys are lowered to the lowest position when moved.

Before moving an artwork, ensure that the path to the destination is clear and that no protruding wall fixtures or doors are blocking the move, and that there is sufficient illumination of the path.

Loose footwear or clothing that can entangle with the artwork are not suitable. No rings or buckles should come in contact with the surface since it easily causes damage. Artefacts should never be lifted at protruding parts as they might be frail, brittle or loose.

Transport objects in crates or boxes whenever feasible.

Display

The exhibition to an indoor or outdoor environment results in a greatly different level of deterioration of modern sculptures. The highest rates of deterioration are observed in urban, coastal, tropical climates. The combination of humidity, temperature, light and air pollution, deteriorates and destroys the surfaces of sculptures very rapidly and can be visually detectable within weeks. It is therefore of fundamental importance to understand the outdoor environment the artwork is placed into.

In urban environments such as the South East Asian region, humidity ranges from 75–90 % and the temperatures range from 20 to 34 °C. Industrial pollution and salt aerosols in coastal regions, in combination with humidity and increased temperature, will speed up the corrosion processes on almost all surfaces. The air surrounding urban sculptures contain a cocktail of particles in an aqueous solution, which will react with the surface constantly. The higher the daily temperature and humidity, the faster the reaction processes occur and the more rapidly the surfaces deteriorate.

Most particles in urban air are organic chemicals. These are molecules containing carbon, hydrogen, and other elements. Most of these compounds are volatile organic compounds (VOCs) which are of organic nature and readily evaporate. VOCs are a by-product when burning fossil fuels, such as oil and coal, resulting in hydrocarbons, partially oxidized hydrocarbons, and organic compounds containing chlorine, sulphur, or nitrogen. It will also catalyse reactions with other pollutants dissolved in a wet film or airbourne droplets. These substances are very aggressive and readily eats into wooden, metal, stone and plastic surfaces.

Sculptures made of synthetic materials such as polyester-glass-fibre, epoxy-glass-fibre, polyurethane and acrylics, are best kept in a controlled environment. The temperature should be around 20–25 Centigrade and the humidity at best 50–65 %RH. Depending on the coatings, the light levels should be moderate and not exceeding 200 lux for long term exposure since the exposure and deterioration due to temperature and light is cumulative (Fig. 1). Some early synthetic resins should be kept in a cold environment and not exposed to light if not absolutely necessary. Polyester sculptures even when coated with polyurethane car paints, are best not displayed outdoors, since they are very vulnerable to heat, light and pollutants.

For public safety and prevention of theft, all but the heaviest sculptures are secured to their bases. It is important to recognise the potential damage, when planning for the display sight and how the sculpture is fastened to the base or ground (Fig. 2).

It is often not a good idea to place sculptures outdoors on the greens. Grass cutting with a trimmer or a lawnmower can cause damage to the base of the artwork. Often, fertilisers are used. Fertilisers are obtained from ammonia and contain nitrogen, phosphorus, sulphur and potassium. These chemicals can cause discolouration of surfaces. Depending on the techniques used to produce the sculpture, the underside might be open and can be a humidity trap from wet ground, or used by animals as shelters or nesting grounds. To prevent such damage, it is well advised

Fig. 1 This Yu Minjun sculpture is painted glass fiber reinforced resin (GRP). There were various old restorations and abrasions due to poor handling and inadequate hardening of the joints. The old oil restoration had to be removed and acrylic was used to retouch the damage (The sculpture belongs to Dr Woffles WU and is in the permanent collection of the Museum of Contemporary Art in Singapore.)

Fig. 2 This cloisonné tripod container, probably created in the late 19th or early 20th century was heavily damaged. The cloisonné was missing in several areas. In the *lower right* photos above, an old restoration is depicted. The missing area was restored using plaster and oil paint. The plaster did not adhere well to the substrate, cracked and fell off. The oil paint discoloured over the years. The old restorations were all removed. The missing cloisonné was replaced with acrylic filler and the missing areas colour matched with an air-brush. The missing decorations were not painted (Faltermeier 2012) www.faltermeier.biz

to place the artwork on a dense material such stone, with a protective plastic between the sculpture and the stone base. Water is sucked by capillary action into the stone base and keeps the stone-artwork interface moist.

Sculptures are also frequently harmed by nature. This can be due to insects nesting in their recesses, or mammals and birds and their excretory habits. Metabolic waste contains an array of chemicals potentially damaging to an artwork. Urea, ammonia and inorganic salts, to name only the main culprits, react readily with copper. They cause streaking of the surfaces, actively eating into the

surface and cause irreversible damage. Frequently in parks and public spaces, urine corrosion on the lower parts of bronze sculptures is due to dogs lifting their legs. Bird droppings on horizontal surfaces also react with the patina, and therefore need to be removed as soon as discovered.

Trees and shrubs may also damage the surface. Branches could break off and scratch the surface. Tree sap and other organic matter will leave resinous deposits and cause a spotty appearance of the finish on the artwork. It is therefore best to keep a sculpture in an open well-aerated space away from any trees or shrubs.

Maintenance

To keep a modern artwork in good health it is important to ensure a maintenance plan right from the start of exhibiting it. Initially, whenever possible, it is important to find out the case history of the sculpture. How it was made and what form of patina and/or coating the surface received after or during production or by their previous owners. When initially studying the sculpture, a qualified person has to seek out flaws in the body and surface, such as hairline cracks or pitting, since these are future trouble spots and can and should be repaired before displaying especially in the outdoors (Fig. 3).

Most modern bronze sculptures are produced by the lost wax casting process and in this process a sand-core is used at one point to support the modelled wax

Fig. 3 This female bronze bust by Joseph-Maria-Thomas Lambeaux (1852–1908). The *left* photograph prior to conservation shows the typical light green chloride corrosion. The chloride corrosion was removed mechanically and then stabilised with a corrosion inhibitor. Finally a thin protective wax coating was applied

layer which, in the final sculpture, is replaced by bronze. This sand-core is in many cases a source of future problems and corrosion. The sand used for the core is hardly ever clean or pure and will also be able to retain water from the ground or rain. The water can enter through cracks and crevices in the bronze or due to an opening in the base. The trapped humidity will evaporate through the same cracks and soluble salts from the sand-core will be carried through to the surface and deposit around the cracks. Thus, whenever possible, all the sand-core should be removed when displaying in the outdoor to avoid future complications.

It is advised that sculptures with protective synthetic coatings such as polyester, epoxy and polyurethane, are not exposed to high temperatures or sunlight, since these coatings age, crack and become insoluble. Any non-protected cracks, holes or voids will suffer accelerated corrosion—a mechanism known as crevice corrosion, causing deep pits in the surface. These sculptures can be better preserved in indoors since the temperatures and humidity are more readily controllable and the deterioration of the plastic coatings is slowed down.

Packing and Storage

Packaging for transit or storage is best done by a professional art-handler. The materials need to be inert to prevent damage due to off-gassing of harmful substances such as acids, or caking of deteriorated foams onto the body of the artwork (see Table 1).

Sculptures are first condition checked, to ensure safe transport. Then acid-free paper is wrapped around the body. No tape is to be used in the first layer of wrapping. Then a double layer of bubble wrap is to be wrapped around the body. The bubbles have to face each other to minimise the pressure points. The piece is then placed into a crate best made of inert plastic. The crate is to be padded with shock absorbent polyethylene foam.

It is pertinent to check for old restorations, since these are often susceptible to fluctuations in heat and humidity. Should the sculpture contain old restorations, it is best to keep the relative humidity around 55–65 % and the temperature should not exceed 20–25 °C. The higher the temperature the faster an old restoration deteriorates, specially those that use early synthetic materials. Keep sculptures made of synthetic materials or with paint coatings in dark storage; this will slow down deterioration.

Conservation and Restoration

It is advised that any maintenance plan for sculptures indoors and outdoors should be developed by a trained conservator with experience in the preservation of sculptures. Frequently, untrained employees use highly acidic or alkaline commercial

cleaning solutions. These cleaning agents are often the only readily available, off the shelf solutions that can remove persistent stains. One of the worst examples is grout or tile cleaner; they tend to contain either hydrochloric acid or hydrofluoric acid, both highly aggressive and remove all forms of corrosion and concretions and eat into the metal and stone causing irreparable damage.

A normal maintenance plan would include the monthly rinsing of an outdoor sculpture using a hose. The water pressure should not be high, since it can force water into the inside of a plastic, stone and bronze sculpture through cracks, voids and pores in the surface. It can also lift damaged paint layers along cracks and fissures. Any rubbing or brushing, to remove dirt and grim, should be done with a soft brush or clean flannel since the surface is easily scratched. At least once a year, a trained conservator should wash the sculpture, using a tested museum grade surfactant. Since any protective coating such as natural waxes, will attract dirt and in most cases will be sublimated over prolonged outdoor exposure. This is extremely important in a tropical climate where heat and light rapidly deteriorate coatings of any kind. Remains of these sacrificial wax coatings need to be removed. The reapplication of these sacrificial coatings should only be done by a qualified person and with tested materials, since the wrong procedure can do irreparable damage. During these maintenance works, the conservator with his trained eye will locate areas that need special attention and identify with his trained eye future trouble spots.

The first indictor of an outdoor sculpture deteriorating is a loss of gloss on shiny sculptures and the appearance of patchy, matt areas on surfaces. This can be due to several factors. Most surfaces were originally waxed or lacquered by the foundry or artist. It is most likely that the wax or coating has started to deteriorate due to temperature, humidity and pollution. In circumstances where the painted surface or patina has not been attacked, the damage can be easily reversed by a regular maintenance plan, including regular washing of the surface, removal and reapplication of protective coating with museum grade materials by a trained professional.

In case of a sculpture that has been in the outdoors for several years, it is most likely that the original protective layer is completely gone. Initially, the inadequate coatings tend to get sticky in hot temperatures. This sticky surface traps dirt and if a museum grade coating was not used it might acidify, turning from a protective layer to a harmful substance. Constant urban rain with generally low pH will remove most of the remaining coating, exposing an already damaged, usually pitted surface. Further rain and humidity together with pollutants will result in further damage by washing off the recently formed corrosion/deterioration products eating further and further into the metal, stone or synthetic resin leaving behind a variation in surface appearance. Rain leaches out various components in exposed surface areas and will attack recesses that are not in direct contact with rain to a lesser extent. Dirt and dust will also accumulate in recesses, resulting in a thick black layer.

Graffiti is one of the oldest form of vandalism, defacing public buildings and sculptures. Already during classical antiquity, visitors have left their markings on

Egyptian and Roman monuments for posterity. These scribblings already included names, poetry or rude caricatures. Today, vandals frequently use water resistant markers and spray paint. These can be removed with the appropriate solvents. It is not advisable to apply commercial paint or stain removers as this may contain chemicals which will cause further corrosion or deterioration and discolouration.

Other forms of defacement are the use of stickers, either plastic or paper based. The adhesives on the back can be of varying composition and some of them can be very difficult to remove. The decomposition of most of these glues will cause a discolouration of many surfaces.

The most damaging forms of vandalism are scratches. These scratches penetrate through any protective coating and patina, exposing the core material. These scratches have to be treated by a trained conservator to minimise the damage to the surrounding and underlying areas.

Humans are very tactile creatures in nature, and a sculpture's surface is a very inviting target for strokes and caresses. The abrasive and corrosive nature of human touch is usually visible as metallic bronze patches on easily accessible parts of a patinated sculpture. Sweat contains salts and amino acids and these will attack and dissolve the surface of stone, metals and plastic coatings.

Showcases

Fragile works of art and antiques are best displayed in a protective environment that allows the control of humidity, temperature, light and airborne pollutants.

The following list of recommendations specifies preferred methods of showcase design and/or manufacture. The exact design and construction of the showcase will vary according to the financial constraints and the type and size of the object displayed. It is imperative that all showcases are build solidly and with attention to details.

All materials that are in contact or exposed to the space within the showcase need to be made from inert materials. This means none of the materials can emit pollutants such as harmful gasses. For example, it is known that many synthetic fabricated wood substitutes produce volatile acids. These volatile acids can and will degrade artworks. Whenever a composite piece of wood is used such as ply-wood or medium-density fibreboard (MDF), three coats of a protective paint should be applied to the surface to seal it and prevent off-gassing of harmful gasses. These paints have to go through vigorous tests to ensure their insulating properties. Preferred building or construction materials for showcases are glass, metal, stone, and acrylics.

Showcases have to be constructed in a manner that vibrations due to road or human traffic is minimised. Vibrations can cause slow movement and creep of artworks to the edges of shelves and can result in opening of micro cracks and fractures. To prevent humidity, dust, and harmful gasses entering the showcase, it should be as airtight as possible. As a rule of thumb, the air-exchange from outside to the inside of the showcase should not be more than one time the air volume of the showcase per day. This is especially important in urban, tropical and coastal environments containing pollutants that can readily react with the artefacts and cause further deterioration.

Laminated glass is usually used for showcases; toughened or tempered glass should not be used, since it shatters into small fragments when it breaks.

Float glass, the same glass that is used for domestic window panels may be used for shelving within a case. However I personally would refrain from its use

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Fig. 1 This antique bronze ladle from Indonesia was fractured and needed mounting and a showcase

since it tends to have sharp edges when it breaks. When using glass shelving, the loading strength needs to be checked and a suitable thickness of glass be used.

Another option for shelving, pedestals and mounts within the showcase are acrylic materials. They are easily fabricated and tend to be inexpensive. Static electrical charges are however an issue and this form of display might not be suitable for textiles and paper. Acrylics also scratch easily and attract dust.

When choosing a showcase, the size of the artwork has to be taken into account. There should be easy access for the placement of objects. There should be a large enough opening to be able to dust and clean the inside with ease (Fig. 1).

Frequently, security of showcases is underrated. Strong locks and hinges are quintessential part of a safe showcase. The locks should be placed in a manner to allow a high level of security and ease of operation.

Appropriate lighting of artworks has frequently been neglected in the past. Fluorescent tubing and halogen lighting are still frequently used and are rarely suitable for showcases. Generally no lighting compartments should be within the showcase. The actual lighting can be housed outside of the showcase to allow the emitted heat to disperse and not heat up the inside of the showcase and the artworks. Adequate ventilation and insulation is imperative to prevent heat transfer into the showcase. UV emission should be kept to a minimum and absorbed with filters as much as possible. It is best to direct the light from the source for example glass fibre to the object. This glass fibre optics should be securely attached to the showcase and the light output adjustable with a dimmer.

If the artworks are humidity sensitive, one form or another of humidity control should be installed. Dehumidifiers are the easiest to install, however, water drainage needs to be provided to dispose of the excess water that is removed from within the showcase. Another option is passive humidity buffers such as silica gel. These are normally placed in a drawer or compartment under or within the showcase. The quantity of buffer needs to be enough to account for the volume and air exchange within the showcase.

Copyright and Law in Conservation and Restoration

When collecting works of art and antiques, it is inevitable to take into account conservation or restoration. Over millennia, works of art have been maintained and restored by their custodians and owners. Not all of these treatments were particularly successful. Some of them resulted in damage due to the techniques and materials applied.

Ownership of a work of art and ownership of the copyright are not the same. If an artwork is purchased the buyer, in the absence of an agreement to the contrary, only buys certain rights to the physical artwork and not the underlying artistic copyright. This means the owner of the artwork might not necessarily do with the artwork as he or she pleases. The buyer only buys the right to physically posses, publicly display and sell the artwork. Should he wish to exploit or reproduce the artwork he needs the permission of the artist or the copyright holder in case the copyright has not expired.

Copyright refers to a bundle of legal and property rights that include the exclusive rights to reproduce and distribute the art work and to make derivative copies. The duration of copyright varies from country to country (Table 1).

Table 1 Variations in expiration of copyright

Country	Term in years
United States of America	70
Europe generally	70
Hong Kong	50
Singapore	70

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Conservation–Restoration

What are some of the legal implications when buying art or antiques? It has to be understood that artworks will need maintenance but they cannot be altered or reproduced freely. Frequently in the past, owners, conservators and restorers applied remedial treatments without considering the legal implications.

In light of the growing emphasis given to ethical rights it is best to have a written contract between owner of the antique and conservator—restorer. The contract should clearly stipulate the techniques used and the possible consequences of their application to the antique or work of art.

Artworks should have a maintenance plan, especially when they are part of a larger private or public collection and displayed indoor or outdoor to the public.

The maintenance will include regular check-ups and cleaning of the surface of the artwork. As long as the maintenance does not materially alter the artwork, no claim in breach of ethical rights may be raised. However, should the artwork be altered due to handling or weathering in the outdoors, the surface or nature of the artwork can change. This alters the intention of the artist and therefore a claim in breach may be commenced by a copyright holder.

Restoration work undertaken on an artwork can result in claims for damages by the artist or the copyright holder. Such restorations might be well-intentioned. However, due to the alterations induced by the materials or techniques, the surface or the body of the artwork might not be as intended by the artist. Conservation work and its techniques are based on the principal of minimal intervention with the artwork, therefore resulting in little to no alteration of the artwork and the artist's intent. The rights of the artist are hence respected. Owners, conservators and restorers of artworks that intend to maintain, conserve or restore a piece, are best advised to acquire the written permission from the copyright holder that the techniques applied are in line with that artist's intention for the artwork.

Photography and Publications

When taking pictures of artworks in which copyright still exists for catalogues, reports and publications, the artist's permission needs to be sought. Claims for damages could potentially be filed, should there be an infringement of copyright arising from unauthorised reproductions of the artwork. In most cases, publications for educational or non-commercial activities, such as reviews do not need the authorisation of the artist or copyright holder under the exceptions of fair use in most countries. However these exceptions vary from country to country.

Damage and Disposal of Artworks

Damage to artworks arising from inappropriate handling, packing and shipping could result in a claim by the artist, due to the resulting devaluation of the artwork. The choice of professional art handlers and movers is therefore very important, as packaging can result in damage due to movements and environmental conditions during transit and storage.

Vandalism is a deliberate act of damage. The culprit will not only be held liable for the damage to the artwork and the loss in monetary value to the present owner, it is also possible for the artist to claim damages due to the alteration of the artwork and the artist's intention.

There have been cases in which artists have claimed damages due to infringement of copyright to their 2- and 3-dimensional artworks. It is therefore important to consider first, before taking any actions involving a work of art, where the creator or his representative still has copyright. Such actions can involve an artwork includes transport, conservation, restoration, photography and publication.