# ADVICE SHEET

## Caring for metal collections in museums

Museums Galleries Scotland

### Introduction

'Metals' is a broad term used to cover a group of materials that have a 'metallic' lustre, are *ductile**, have a high density and are good conductors of heat and electricity. Metal items are very common in museum collections in categories such as social history, archaeology, militaria, numismatics and in scientific and industrial collections. This factsheet cannot cover all metals that might be found in museum collections, but the most common ones are listed below.

**Gold** is a soft metal with a distinctive colour. It is frequently *alloyed* with a small proportion of silver to make it harder and more durable.

**Silver** is a soft, bright 'white' metal, the surface of which *oxidises* to give a greyish white colour. It is often alloyed with copper to harden it.

**Pure copper** is characterised by the pinkish colour revealed by scratching or polishing the surface. *Oxidation* of the surface leads to the rapid formation of a protective brown surface layer or *patina*. Copper is frequently alloyed with other metals. **Bronze** is an alloy of copper with about 10% tin. It is harder than copper, but has a lower melting point for casting purposes. **Brass** is an alloy of copper with zinc, which gives hard, *corrosion* resistant alloys with a range of colours, depending on the ratio of the components.

**Lead** is a very soft, bright silver-coloured metal that rapidly forms a dull grey surface layer of lead oxide in normal atmospheres. Lead is an important component of leaded bronze and is added to reduce the melting point and increase the pourability of the molten metal.
The most important historical alloy of lead is pewter, a hard alloy frequently used for vessels, plates, buttons, and so forth (see under **Tin**). While metallic lead is safe to handle, lead corrosion products are toxic and should be handled and disposed of with care.

**Tin** is a soft, bright silver-coloured metal with a very low melting point. Tin rapidly forms a thin protective layer of tin oxide, which can give the metal a bright appearance for many years, even in corrosive environments, but eventually tin may form a dull grey or black surface. Tin is resistant to corrosion and has often been used as a coating for other metals, notably iron, steel and copper alloys.

* For words printed in *italic,* refer to glossary on last page.

**Pewter** is an alloy of tin with lead, of value because pewter is much harder than either pure lead or pure tin. Historic pewter, such as that used in Roman and medieval times for the manufacture of vessels and flatware, contains 10-20% lead. Modern pewter is quite different, being an alloy of tin with antimony and copper.

**Mercury** is the only metal found in the liquid state. It is bright silver in colour and feels extremely heavy because of its high density. It is mainly used in scientific instruments particularly thermometers and it was used in fire-gilding and mirror-making in the past. Mercury is toxic by inhalation and ingestion and it should be handled with care.

**Iron** is a hard, bright silver-coloured metal with a high melting point. The melting of iron was not achieved until the 19th century, and early iron had to be *smelted* and worked in the solid state to make wrought iron, a hard, *ductile* material. Adding a small amount of carbon to iron makes **steel**, a harder but more brittle material. If even more carbon is added, the alloy **cast iron** is made. New objects made of iron and steel are usually shiny and metallic, especially if they have been polished. The surface is initially protected with a thin transparent layer of iron oxides, but iron and its alloys are the metals that are most vulnerable to damage by corrosion.

**Aluminium** is a soft, bright silver-coloured metal that is highly chemically reactive. It is protected by the rapid formation of a thin coat of aluminium oxide, a very hard unreactive material. For this reason, aluminium cannot take a high polish and is often given a matt or anodised finish. It is too soft and weak for use as a pure metal and it is frequently alloyed with copper and/or magnesium, manganese, silicon and zinc, giving a wide range of properties for different uses.

**Zinc** has a low melting point and is very resistant to corrosion because of the rapid formation of protective zinc oxide. It is used to make the copper alloy **brass**. The corrosion resistance of zinc has led to the wide use of galvanising processes in which it is coated onto iron and steel.

## Deterioration processes

While metals are often considered to be hard and durable materials, a close examination reveals that even the hardest metals can be physically damaged by inappropriate treatment. Metals are also very vulnerable to corrosion processes, which can cause great harm to museum collections. Whether a metal corrodes depends on the nature of the metal or alloy, any protective coatings or patinas that are present, and the environmental conditions to which it is exposed.

All the common metals develop a coating of metal oxide called the *patina.* The patina, which starts as a transparent layer but often becomes visible as it thickens, protects metals from corroding under normal circumstances and should not be routinely removed.

Sometimes the patina improves the appearance and increases the value of the object.
The presence of finger marks, with their complex mixture of acids, salts, and oils, may have a considerable impact on the way a patina is formed, and this is one reason gloves should be worn when handling metal objects in museums.

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Corrosion processes are electrochemical, that is, they are based on chemical processes that rely on the flow of electric currents through the metal. Favourable conditions for the preservation of metals are those that tend to prevent the flow of currents. Corrosion requires moisture and salts to help conduct electric currents: the best way to prevent it is by providing dry, clean conditions.

In general, dry conditions are those where the relative humidity is less than 65% RH. Dust and dirt will often contain salts and efforts should be made to ensure that museum objects are not heavily soiled as this can stimulate corrosion. Of course, there are other factors that may cause corrosion problems with particular metals, and these are mentioned in the following section.

Archaeological metals form a separate category for preventive care because burial in the soil leads to extensive corrosion due to the constant presence of water and salts of all kinds over many years or centuries. In particular, very dry conditions are required for the preservation of untreated archaeological iron objects, and the humidity must be maintained at 10 to 15% RH with dry silica gel and sealed enclosures both in storage and on display.

**Gold** and gilding is generally stable, but can tarnish or discolour, especially if it contains or overlies silver and has been exposed to damp and polluted conditions. The tarnish will be made of silver sulphide (see below) but the layers are often very thin.

**Silver** tarnishes easily in the presence of **sulphide** pollutant gases, though it is fairly resistant to more extensive corrosion in most circumstances. When a layer of black sulphide tarnish builds up, it can protect the metal beneath. When silver has been buried in the ground, more extensive corrosion can occur and silver chloride (horn silver) can form.

**Copper** objects that are exposed to corrosive environments over long periods of time (such as in tombs, on rooftops, or in a slightly damp museum cupboard) develop a patina that may be dark brown, black, green, blue or a combination of colours. The patina can be smooth and lustrous, or it can be uneven and lumpy. Copper also reacts with oils and fats, and a soft waxy green copper compound, copper stearate, can often be seen where the metal is in contact with an oily material such as leather.

For archaeological copper alloy objects, **chlorides** are the principal threat, combining with moisture to cause "bronze disease". This is characterised by the rapid growth of a soft bright green copper corrosion product from one or more spots on the surface of the object.

**Lead** is stable in dry and unpolluted conditions, but is extremely vulnerable to the presence of volatile organic acids, especially **acetic** and **formic acid**. These acid pollutants, which are released from wood and wood products, attack the protective patina and start corrosion, which can be recognised by the fine loose white crystals on the surface. The lead is particularly vulnerable if ventilation is poor, and the concentration of pollutants becomes very high. Once started, active lead corrosion is progressive and can lead to the total destruction of the object, unless treatment takes place. Lead corrosion products are toxic by ingestion and should be handled and disposed of with care.

Fortunately, tin and pewter are less vulnerable to corrosion caused by these common pollutants.

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The surface of **iron** and **steel** objects is usually protected with a thin transparent layer of iron oxides. This oxide layer is easily broken by the presence of **moisture** and **salts** - especially chlorides - and the formation of a soft, bright reddish-brown corrosion product (rust) can quickly occur. Iron initially corrodes in small points on the surface. As the process continues, pits form all over the surface, producing ever thicker layers of rust. If the process occurs slowly and evenly, the layer of rust can be compact and hard, mimicking the appearance of the uncorroded object. Many historic objects in museums are covered with compact layers of rust of this type.

However, if the iron object is in a corrosive environment, with plenty of water and salts, the rust layer grows so quickly that it detaches from the surface, revealing bare metal that then corrodes again. Salts and moisture can penetrate deeply into the object, depending on the structure. Wrought iron is particularly vulnerable to this because it contains small amounts of impurities that can act as channels through the metal. The stability of iron objects can be ascertained by examination of the surface: if flakes of rust are continuously detaching, or if cracking and weeping are observed, the object is probably unstable.

**Aluminium** and its alloys are generally corrosion resistant, but problems can occur with certain alloys in very corrosive environments. The deterioration of the high-strength aluminium/copper alloys used in aircraft is an example: they are normally stable but, when exposed to the salts in seawater, the copper component starts to corrode, creating conditions that encourage the corrosion of the aluminium. This problem, which is characterised by the appearance of blue-green and white crystals, can be treated but laboratory facilities are required.

The deterioration of **mercury** itself is not considered a problem, but spills cause a health and safety problem in the museum. Mercury, which is toxic, will evaporate slowly into the atmosphere and can affect people through inhalation. If thermometers are broken, or mercury barometers are accidentally inverted, a spillage must be dealt with in accordance with health and safety regulations. Mercury does not wet non-metallic objects and small spills can be swept up with a paintbrush or a synthetic sponge, and placed in a non-metal (glass or plastic) container. It must then be disposed of carefully, preferably to a certified waste contractor or possibly via the local pharmacist. If large spills of mercury occur, health and safety advice should be obtained from an appropriate professional, and the use of a mercury spill kit, available from chemical suppliers, may be advisable.

## Display

As can be seen above, humidity and pollutants are the two main threats and these should therefore both be addressed when displaying metal items. It is also wise to avoid unnecessary contact with other materials, as dissimilar metals in contact can promote corrosion, while contact with organic materials such as paper, leather, and textiles can provide sufficient moisture where the materials touch for corrosion to occur. Where composite objects are concerned, of course, such problems cannot be avoided.

The **humidity** level can be controlled either by controlling the conditions within the display area or by using display cases to create an 'environment within the environment' *(a microclimate).*

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It is often easier and more effective to control a small quantity of air such as the contents of a display case, especially if the case is sealed effectively. Even inside a display case that is not sealed, the fluctuations in temperature and humidity are usually less extreme than in the surrounding area. The stability and the level of the humidity inside a case can be further controlled by using moisture-absorbing or buffering material such as silica gel or Art Sorb™. The use of display cases has the added benefits of protecting the items against unnecessary touching and improving security.

Adverse effects of **pollutants** can be reduced by using inert materials for the construction of the display - including carpets, paints, display cases, mount-boards, plinths, supports, text labels, case lining and backing fabrics. Lead objects in particular must be protected from poor quality (acidic) materials.

Materials that are safe to use for display are

- metal, either uncoated, or with an enamel or painted finish
- glass
- plastics such as polythene, polyester, and Perspex (acrylic)
- neoprene rubber seals
- museum-quality (acid-free) silicone sealants
- inert foam materials such as Plastazote™
- acid-free paper products
- unbleached, undyed cotton and polyester fabrics, provided they have been scoured before use by putting them through a machine wash at 60°C without detergent
- materials that have passed the standard tests for museum use.

Many of these products can be obtained from conservation suppliers or other specialist firms that serve museums and art galleries.

Materials that can affect objects by contact, or that give off harmful vapours, and should therefore be avoided, are

- wood and wood products (unless entirely sealed with a *barrier foil*)
- acidic paper products
- textiles, especially those made of wool
- products containing non-inert polymer foams, including carpets
- most paints and varnishes, especially when freshly applied.

Fabrics intended for long term display should always be tested for harmful emissions before use, as dyes and finishes may be different with each batch. Some manufacturers now offer pre-tested fabrics for use in museums. If there is any doubt whether a display material is safe to use near metal objects, it is best to have it tested first. The British Museum offers a commercial testing service.

Paints routinely fail museum tests, and if they must be used in cases, a long "curing" time of several weeks should be allowed to ensure that the bulk of any solvents and other pollutants are given off before the cases are closed.

When metal objects and organic objects are displayed in one case, deteriorating organic material can sometimes give off harmful vapours that may affect the metal items. Ideally, such materials should not be placed in the same showcase as metal objects; if this cannot be

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avoided, an absorbent material such as Charcoal Cloth™ or sulphide-absorbing textile can be placed in the case.

Alternatively, some metals such as silver may be protected by a vapour-phase inhibitor, for example Carosil™, which reduces corrosion rates in such situations. Silver may also be protected against slow tarnishing while on display by coating it with a protective lacquer, but this is not suitable for all silver objects. Because of health and safety considerations, lacquering should be undertaken by a conservator.

If there is general concern about pollutant levels in a museum (whether in galleries, cases, or storage areas), it is possible to undertake tests to detect the presence and concentration of pollutants.

**Archaeological iron** objects require well-sealed display cases, in which a stable and low humidity level of 15% RH or less can be maintained. These cases should be able to contain ample amounts of silica gel (10 to 20 kg per $m^3$ of enclosed space), preferably in drawers to allow swift changing. In some situations, dehumidifiers are connected to display cases in order to keep the humidity at the recommended low level but this approach is rarely taken due to its cost.

Very fragile metal objects should be supported adequately with inert materials. If necessary, a special mount that can be used for both display and storage purposes should be made for the item and kept with it at all times.

In situations where it is not possible to use display cases (perhaps because the items are too large, such as industrial machinery), it is important that other physical barriers are used to prevent the public from touching the items. In these situations, the control of the ambient environmental conditions is very important for the preservation of the objects.

## Storage

The (polished) surface of metal items can easily be scratched by dust, dirt or other metal objects, especially when they are stored unprotected on open shelving. It is important that items are protected adequately by using boxes with lids, trays and dust covers. Boxes can be stacked easily, thus economising available storage space. Large or awkwardly shaped items that cannot be stored in boxes or on shelves should be stored off the floor (on pallets) and covered with a calico or Tyvek™ dust sheet. Write or print the museum number - and if necessary a description - on the dust sheet for ease of access.

As with display areas, humidity should be controlled to within desired levels by the use of dehumidifiers and heating for larger spaces, and silica gel in air-tight boxes for material such as archaeological iron.

The control of air pollution is less easy as it is difficult to monitor, and the best approach is to use well-sealed buildings with inert storage furniture and packing materials. A recent development in the control of pollution has been the development of special plastics such as Corrosion Intercept™ that absorb pollutant gases before they can react with the object. Further advice on pollution and its control can be found in other Museums Galleries Scotland factsheets.

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**Silver** items can be stored in sulphide-absorbing Tarnprufe™ or Corrosion Intercept™ bags to prevent tarnishing. The use of other recommended storage materials such as acid-free tissue and cardboard can also provide protection.

**Lead** objects should be isolated from any materials that might release acidic pollutants such as acetic acid, including all types of wood; wood products such as ply, MDF, and hardboard; and most paper products. The best way to store lead items is to use inert plastics such as polythene and polypropylene. Stewart Sealfresh™ boxes, polythene bags, polystyrene "crystal" boxes, Plastazote™ polythene foam and Jiffy™ polythene foam are all recommended. The use of archival quality acid-free tissue and acid-free cardboard is possible, as tests have shown that these materials are unlikely to affect lead objects.

For historic **iron and steel** objects, storage conditions are very important: the humidity should be kept stable and low, not exceeding 65% RH for objects in good condition. Contact with materials that naturally retain moisture, acids or salts should be avoided. As these can include leather and textiles, it may be advisable in some cases (for instance, if damp conditions cannot be avoided) to remove swords from sheaths, pistols from holsters and medals from presentation boxes. However, do make sure that sheaths, boxes and so forth are carefully packed, supported and labelled to prevent damage and loss.

Only inert materials should be chosen to store iron objects: enamelled metal shelving units; acid-free paper and boxes; and polythene-based packaging materials.

Severe soiling on iron and steel objects makes them difficult to handle and access, and can encourage corrosion. Contact a conservator for advice on cleaning objects in such condition.

Iron objects that are covered with a loose, flaky, weeping or otherwise unstable layer of rust should be placed into stable dry storage with dry silica gel until treatment can take place. Their condition indicates that they have been exposed to corrosive environments in the past and that deterioration will continue even in normal museum environments. Below 10-15% RH, the objects will dry out and corrosion will cease. Where providing a protective micro-climate like this is difficult (for instance, with large objects), a conservator should be consulted and a programme of treatment devised.

**Archaeological iron** presents an extreme aspect of the problems with iron and steel described above. The structure of the metal may be completely penetrated by salts, and the surface may be totally obscured by corrosion products and soil. Archaeological iron should **always** be stored in very dry stable conditions at 15% RH or less, using dry silica gel and airtight plastic boxes, and displayed in dry display cases as described elsewhere in this factsheet.

**Marine archaeological iron** objects are in much the same position, but they tend to contain even more salts and can corrode so rapidly on exposure to air that objects can fall apart in a few days. Looking after archaeological or marine material requires specialist attention and therefore a conservator should always be contacted for this.

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## Handling and maintenance

Metal objects range from extremely fragile to very heavy. Care must be taken that handling techniques are appropriate to the item and available staff. Wherever possible, use a box, tray or other container to move items from one room to another. Heavy items can be placed on a trolley. If necessary, complete a risk assessment and method statement to ensure that objects are transported safely and without risk to staff.

**Always wear gloves when handling metal objects.** Finger marks can cause an uneven, disfiguring tarnish on the surface, which can become difficult to remove. Accidental fresh finger marks can be removed with a clean cloth moistened with a little white spirit. Never attempt to remove patinas but buff them with a clean soft cloth if appropriate.

**Dusting** of metal objects should be kept to a minimum, because dust particles can be very sharp and can easily scratch the (polished) surfaces. If dusting is required, use a clean, soft, cotton cloth or a soft brush.

**Excessive oil or grease** on the surface of metals can be problematic. Initially protective, such coatings can deteriorate and become soiled, and this can encourage corrosion in the longer term. Excess oil and grease also makes metal objects difficult to handle and can pose a threat to other museum objects. Consult a conservator for advice on removing such coatings.

The thin **plated** layer of gold on gilded objects can be extremely vulnerable to damage and should not be polished, as this will quickly wear away the gilding until the ground material below is revealed.

Many metal surfaces benefit from a thin protective **coating** of Renaissance™ wax, while others can be protected by a coat of lacquer. Items with working parts may require a little oil or grease, lightly applied with a clean soft cloth. The suitability of coatings varies from one situation to another and it is recommended that a conservator should be consulted for more detailed advice.

## Transport

It is important that metal items are securely packed in well-padded containers. In many cases, the containers used for the storage of the items will be suitable for this. Make sure that any container used is safe to carry with secure handles, straps, and so forth.

In some cases, special transport containers are used. These may have been made with poorer quality materials such as plywood and are therefore only suitable for temporary use. It is very important that items are removed from transport cases upon arrival.

Temporary transport containers should not be used for storage purposes without conservation advice.

To protect archaeological metal items from high humidity levels during transport, airtight containers with enclosed dry silica gel should be used.

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## Treatments

Sometimes it is considered necessary to remove or stabilise patinas or corrosion layers. Common examples are the polishing of silver to keep it bright, or the conversion of rust on iron and steel to create a more stable and attractive patina. The discussion of these and other treatments is beyond the scope of this factsheet. **It is strongly recommended that a conservator be consulted before any treatment is carried out.**

## Further information and advice

This is one of a series of advice sheets produced by Museums Galleries Scotland on common collections care and preventive conservation issues. For more details, signposting to further sources of advice or information on how to contact a conservator, see our website at: www.museumsgalleriesscotland.org.uk

## Selected reading

**The National Trust Manual of Housekeeping**
Butterworth-Heinemann, 2006
ISBN 0750655291
An excellent general guide to the care of collections including a variety of metals.

Selwyn, L
**Metals and Corrosion: A Handbook for the Conservation Professional**
CCI (Canadian Conservation Institute), 2006
ISBN 0662379845
A comprehensive manual for those requiring a deeper insight into metals conservation.

* For words printed in *italic*, refer to glossary on last page.

## Glossary

| | |
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| alloy | a material made of two or more metals mixed together |
| barrier foil | a special composite of polymer-coated aluminium foil that prevents movement of water vapour and pollutant gases through the material to which it is attached; useful for protecting objects in wooden cases |
| corrosion | an electrochemical process that changes and eats away the surfaces of metals; it is stimulated by the presence of moisture and salts; a destructive result of oxidation |
| corrosion intercept™ | a polymer that reacts with pollutants, preventing damage to museum objects; can be used to bag or otherwise protect metal objects |
| ductile | able to be hammered into sheets or drawn out into wires without breaking; characteristic of many metals |
| micro-climate | the environmental conditions found in an enclosed area, which differ from the conditions in the surroundings |
| oxidation | a chemical reaction with oxygen or other oxidising agents, causing the formation of (metal) oxide, or other compounds such as sulphide, chloride, carbonate and so forth on the surface of a metal |
| patina | a film of oxide formed on the surface of a metal or the sheen on a surface that is caused by long handling; a protective result of oxidation |
| smelting | extraction of metal from ore by chemical reduction, in most cases by the use of heat and charcoal |
| tarnish | loss of metallic lustre and formation of darker surface layers, caused by surface oxidation; also, the dark patina formed on silver |


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**Museums Galleries Scotland**
1 Papermill Wynd, McDonald Road, Edinburgh EH7 4QL

**Tel** (Switchboard) 0131 550 4100
**Fax** 01315504139
**Email** inform@museumsgalleriesscotland.org.uk
**Website** www.museumsgalleriesscotland.org.uk



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