Appendix O: Curatorial Care of Metal Objects

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APPENDIX O: CURATORIAL CARE OF METAL OBJECTS

A. Overview

1. *What information will I find in this appendix?*

This appendix discusses historic objects made primarily of metals and their long-term care and preservation. The main topics covered in this appendix are:

- the nature of metals
- agents of deterioration
- handling, storage, and exhibit of metal objects
- working with a conservator when treatment is needed
- specific emergency procedures for metal objects

Note: This appendix does not cover metals recovered from archeological sites. Care of archeological objects is discussed in Appendix I.

2. *Why is it important to practice preventive conservation with metal objects?*

Metals are very reactive and many factors contribute to their deterioration, but a metal object's rate of deterioration can be slowed significantly with proper preventive care. Practicing preventive conservation will also reduce the need for costly and time-consuming conservation treatment.

3. *How do I learn about preventive conservation?*

Read about the agents of deterioration that affect metal objects so that you can create a preventive conservation plan. See Chapter 3: Preservation: Getting Started, and Chapter 4: Museum Collections Environment, for discussions of the agents of deterioration. Refer to the *Museum Handbook* Part III, Chapter 7: Using Museum Collections in Exhibits, for additional information.

4. *Where can I find the latest information on care of metal objects?*

There are a variety of resources for up-to-date information on metal objects including:

- NPS *Conserve O Gram* series
- World Wide Web sources listed in Section J
- Selected references in Section K
- Regional/SO curator or collections manager of a large metals collection
- Objects conservators

B. The Nature of Metals and Metal Objects

1. *What are metals?*

Metallic elements compose the largest proportion of materials that make up our planet. Metallic ores are refined by the application of energy to produce metals. The physical properties of metal include:

- luster
- hardness
- strength
- malleability
- temperature sensitivity

Different metals exhibit different physical properties. Historically, these various properties have been exploited in the construction and fabrication of metal objects and structures. Metals are frequently selected for applications in architecture, decorative arts, fine arts, and functional objects.

2. *What are some of the metals found in park collections?*

Among the metals found in museum objects are gold, silver, copper, tin, iron, lead, zinc, nickel, and aluminum. Metals are frequently combined in order to modify their properties or to obtain a metal that is most suitable to a given application. The process of combining two or more metals is termed *alloying*.

3. *What is an alloy?*

An alloy is created by melting one metal and then adding another metal to it. An alloy is a solid solution since the metal elements remain distinct, one suspended in the other. Examples of common alloys are *brass* (a mixture of copper and zinc), *bronze* (a mixture of copper and tin and other metals), and *sterling silver* (a mixture of silver and copper). By varying the proportions of copper and zinc in brass alloys it is possible to obtain a range of brass alloys with differing properties including color, strength, corrosion resistance, or working properties.

4. *What are surface treatments of metals?*

Surface treatment can be an important characteristic of a metal object. Frequently metals are finished to enhance the appearance of the object, to improve the functional performance (for example, corrosion resistance), or a combination of both. Surface treatments include polishing, plating, patination, coatings, heat treatments, and chemical coloring treatments.

5. *Is it important to identify different metals?*

Yes. Proper identification of metals is important to housekeeping procedures, accurate interpretive program information, storage and exhibit techniques, climate control, handling methods, and the conservation treatment process.

6. *How do I identify different metals?*

You can identify metals by color, weight, function, magnetic properties, or hardness. If you are unsure of the metal object's identification, consult a conservator or your regional/SO curator. To identify a metal object properly, you need to have a basic knowledge of the properties of metals and have a few tools and supplies. If you can't identify a metal, it is better to use more generic terms to describe it. For example, describe a metal as a white metal instead of running the risk of misidentifying it as pewter, silver, or nickel.

> ***DO NOT use chemical spot tests or spark tests to identify metals. This can damage or destroy the object.***

Metal	Color	Other Identifying Characteristics	Primary Alloys and Uses
Iron & Iron Alloys	Grey/silver, blue-black and red-brown color.	Some but not all iron alloys are magnetic.	**Cast Iron** (iron & carbon, 2% to 4%). Kettles, door hardware, fire-backs, stoves. **Wrought Iron** (pure iron & carbon, not more than .035%). Railings, nails, wagon hardware. **Steel** (iron & carbon, 0.15% to 2 %). Knives, tools, structural materials.
Copper & Copper Alloys	Yellow to rich browns. Surface may be patinated and vary in color from red, brown, black and blue to shades of green.		**Brass** (copper & zinc). Lighting devices, jewelry, scientific instruments, marine fixtures, cookware. **Bronze** (copper & tin). Bells, cannons, bearings. **Nickel Silver** (copper & nickel & zinc). Household decorative objects.
Lead	Pure lead and lead alloys where lead predominates, dull metallic blue in color.	Very heavy & very malleable.	Pipes, pump wells in ships, toys, roofs, bullets, and solder.
Silver & Silver alloys	White metallic appearance.	Sterling silver is usually hallmarked.	Numerous silver-copper alloys such as Sterling, coin silver, jewelry, and tableware.
Nickel	Gray to white appearance.	Metal is slightly magnetic.	**Nickel** is often used in its pure form as a plate for tableware, kitchenware, and decorative ornaments.
Tin & Tin Alloys	Dull gray.		**Pewter** (tin & antimony & copper). Kitchenware and plating for tin cans and toys

Figure O.1. Identification of Metals

7. *What is corrosion?*

Corrosion is the chemical or electrochemical reaction between a metal and its environment that produces deterioration of the material and its properties. It is the most commonly occurring problem of metal objects. Corrosion can take many forms depending on the metal(s) that compose the object, the manner in which they are fabricated, or the environment in which they are exhibited or stored. At times, the corrosion source may be from fabrication in the case of stress corrosion cracking in thin turned brass objects or contamination from solder flux in joined metals. In other instances, the conditions responsible for corrosion may be an integral part of the environment, such as a seacoast or polluted urban air.

8. *Is all metal corrosion harmful?*

No. The presence of a corrosion product on a metal object does not necessarily indicate active corrosion. Corrosion, tarnish, and patination are all examples of metal compounds, some of which are unintentional and considered disfiguring, while others are deliberately created for an aesthetic effect. While some forms of corrosion are more protective and stable than others, almost all are subject to failure at some critical relative humidity level or in the presence of certain pollutants. When metals are cleaned the surface can oxidize and be chemically stable.

9. *How can I identify active corrosion?*

Active corrosion can be identified visually by the following characteristics:

- color (wet or dry in appearance)
- powdery or flaky formations on the surface of the object and similar deposits around the base of the object
- loosely adhering formations, frequently appearing in patches on the surface as opposed to uniform, dense, well-adhered deposits
- continuing change or growth

10. *What are the characteristics of corrosion for different metals?*

Surface characteristics and colors of metals vary by alloy. Corrosion products also vary in color, depending on the alloy and cause of corrosion.

See Figure O.2 for additional information.

CAUTION! Lead acetate corrosion is a severe poison that can be fatal if swallowed, inhaled, or absorbed through the skin. If you see white, crystalline corrosion products on lead objects in your collection, assume that they are lead acetate and handle accordingly. Material Safety Data Sheets uniformly state that protective equipment for lead acetate should include goggles, lab coat, vent hood, and rubber or plastic gloves. This type of corrosion is often seen on lead bullets and toy soldiers.

Metal	Active Corrosion	Stable Surfaces	Causes of Corrosion
Iron & Steel	Orange to reddish-brown. Wet or glossy appearance. A surface that is scaling, flaking or pitting.	Compact blue-black and red-brown color.	High relative humidity, surface moisture.
Lead	Loose white powder in tiny spots or overall.	Smooth gray surface.	Weak organic acid vapors, from sources such as wood, cardboard, and vinegar.
Copper & Copper Alloys	Corrosion forms in small spots overall. Powdery green, blue, and white corrosion products that are generally over the entire surface.	Wide variety of colors: solid blue, green, red, brown, or black. Surfaces are smooth and tightly adherent.	High relative humidity, surface moisture, air pollution, salts from inappropriate cleaning and handling.
Silver and Silver Alloys	Slight gray dullness through blue/purple that deepens to brown/black as corrosion becomes thicker.	Smooth white metallic. A blue/purple surface can be stable if it occurs overall and the object is removed from the source of corrosion.	High humidity, sulfur compounds, etching from fingerprints, organic vapors.
Nickel	Nickel corrosion is reddish brown and is similar in appearance to rust. Green copper corrosion products indicate preferential corrosion from a copper alloy.	Smooth gray appearance.	High humidity and sulfur compounds.
Tin & Tin Alloys	White gray, dark gray to black. Nodules of white to gray corrosion that form under the surface layer in nodules that erupt through the surface exposing a light gray or white corrosion product.	Smooth gray surfaces.	High relative humidity, atmospheric pollutants, low temperatures.

Figure O.2. Identifying Active Corrosion

C. Factors That Contribute to Metal Object Deterioration

1. *What agents of deterioration affect metal objects?*

The primary causes of metal object deterioration in the museum or historic furnished house are:

- relative humidity
- temperature extremes
- atmospheric pollutants

- improper care and handling

2. *What is the best relative humidity and temperature for my metal objects?*

Keep relative humidity in metal collections as low as possible. Steels will not rust and brass will not tarnish below 15% RH. This is not a practical solution for metal objects in the historic furnished structure, but it may be for objects in storage cabinets or exhibit cases. Ambient temperatures between 60° and 75°F are appropriate for most metals. To inhibit active corrosion in salt air environments, metals should be housed in spaces with relative humidity levels no greater than 35%.

It is generally a good idea to avoid low temperatures for most metal objects. Low temperatures usually result in higher levels of relative humidity and the possibility of condensation on metal surfaces.

3. *Should I be concerned about atmospheric pollution?*

Yes, many forms of air pollution are corrosive. Polluted urban air and coastal environments are among the more severe areas. Dirt and dust may contain chemical compounds that will react with metals or trap moisture close to the metal surface. Sulfur and sulfur compounds are probably the strongest tarnishing agents. Sulfur is present in the air from burning of fossil fuels and is generated from products such as foam rubber, carpet padding, paints, wool, and felt.

4. *Does cleaning contribute to deterioration?*

Cleaning and polishing remove original metal. Over-cleaning often results from a desire to have metals bright and shiny, especially brass and silver objects on display in a historic furnished structure. Intense treatment often results in the loss of information from the object. In addition, metal cleaners may leave harmful chemical residues that can generate further corrosion.

D. Proper Handling and Storage of Metal Objects

1. *What do I need to know about handling metal objects?*

All of the general rules for safe handling of three dimensional museum objects apply to metal objects. Refer to Chapter 6: Handling, Packing, and Shipping, for general guidance on handling museum objects. Two special concerns for metals are the weight of the object and skin contact with bare metal surfaces.

- Metal objects can be heavy. The inadvertent placement of a heavy metal object on another object or on a period piece of furniture may result in dents, scratches, or staining.

- Transport heavy metal objects on carts or dollies.

- Most metal objects should not be handled with bare hands. Salts and oils from your skin can etch metals and may even cause permanent damage.

- Always wear clean cotton, latex, or synthetic rubber gloves when handling metal objects. Avoid cotton gloves if the decorative surface is friable. Avoid cotton gloves with polyvinyl chloride (PVC) nubs when handling metal objects. PVC residues from the nubs may cause oxidation or tarnish. Synthetic rubber gloves are not recommended for handling silver or copper alloys because some brands contain high proportions of sulfur and chlorides.

See caution in B10 on handling corroded lead objects

2. *Can I use a jeweler's cloth after handling uncoated metal objects?*

Yes. A jeweler's cloth can be used to wipe or buff away fingerprints on uncoated gold, silver, copper alloys, and highly polished steels, if an uncoated metal object is inadvertently touched. Select cloths that contain no abrasive, and rely instead, on the stiffness of the weave for their polishing effect. Any clean, soft cloth may be used to buff an object after handling.

3. *How should I store my metal objects?*

Follow these guidelines:

- To the extent possible, house metal objects indoors to reduce exposure to rain and temperature extremes.
- If possible, keep all metal objects together. Further isolation can be made according to metal type, object size, and object type.
- Never store metal objects directly on the floor or in close proximity to exterior walls. Avoid storing metal objects in attics and basements.
- Metals are normally immune to biological attack; however, the droppings of pigeons, mice, and even insects will cause pitting and corroding of a metal object's surface.
- Keep metals away from hygroscopic materials such as paper, textiles, and wood.

4. *What kind of shelving and cabinetry should I use?*

Follow these guidelines:

- Steel shelving is preferred over wood shelving because it is stronger and it does not emit harmful vapors. Line shelves with an inert, nonabsorbent material such as expanded polyethylene.
- The standard museum specimen cabinet provides excellent storage for metal objects. Depending on degree of seal, some of the newer museum storage cabinets can be used to create microenvironments using silica gel to control RH.
- For heavy metal objects such as cannon tubes and sculpture, polyethylene plastic pallets are available to prevent contact with the ground or floor.
- Loosely drape clear polyethylene over shelves to protect metal objects from water leaks and dust.

5. *What additional protection do metals need in storage?*

You may need to use microclimates to protect some collections. Consult with a conservator to determine which collections are most vulnerable. A conservator may recommend:

- ***Activated charcoal paper:*** Activated charcoal absorbs air pollutants.
- ***Silica gel:*** Silica gel can be used to reduce and to buffer the relative humidity of an enclosed space. The bags must be monitored and reconditioned as necessary. See *COG* 1/8, "Using Silica Gel in Microenvironments."
- ***Vapor phase inhibitors***: These materials release a vapor that inhibits corrosion. **Note**: Many vapor phase inhibitors are toxic.
- ***Clear plastic boxes & bags:*** Various plastic boxes and bags can be used to create microenvironments and allow conditions to be monitored inside.

E. Exhibiting Metal Objects

1. *What do I need to consider when planning an exhibit?*

Conditions within the exhibit space are usually more subject to change than those in the storage space. This is especially true for historic furnished structures. The goal is to create an exhibit environment that is just as safe and controlled as possible. All of the general rules for safe display of three-dimensional objects apply to metal objects. Refer to the *Museum Handbook,* Part III, Chapter 7: Using Collections in Exhibits, and NPS *Exhibit Conservation Guidelines*, available from the Harpers Ferry Center.

2. *Are there any particular concerns for exhibiting metal objects?*

Consider the following:

- Cast and wrought iron objects are often exhibited in hearths, on mantles, or hung on the fireplace. Rainwater may enter through the flue, and brick and mortar will trap the moisture. In addition, chimneys are usually cold. All of these conditions promote condensation and corrosion.
- During seasonal transition periods, fluctuations of temperature and relative humidity can promote condensation and corrosion on metal objects.
- Frequent cleaning of exhibit areas may add moisture and potentially harmful vapors to the environment.
- Ensure that exhibit mounts are padded to prevent scratching

3. *Are there any specific situations that should be avoided when exhibiting metal objects?*

Follow these guidelines:

- Avoid leaving doors and windows open as gaseous and particulate pollutants can enter the exhibit area causing corrosion. This is a particular concern in urban areas.

- Avoid lighting fixtures such as fluorescent light ballasts or transformers that may generate ozone. Ozone will cause corrosion on metal surfaces.

- Avoid using hardwoods, such as oak, in exhibit cases because they can emit acidic vapors that corrode lead and silver.

- Avoid the use of adhesives, paints, woods, and textiles in exhibition cases and exhibition spaces unless they have been tested for off-gassing. See Chapter 4: Museum Collections Environment, for information on gaseous air pollutants and safe construction materials for exhibitions.

4. *What should I know about cleaning metal objects?*

Be aware that many proprietary cleaning products contain ammonia, weak acids or bases, solvents, waxes, and fats that may have an adverse effect on metal objects. Refer to Chapter 13: Museum Housekeeping, for additional information.

F. Conservation Treatment

1. *Why should I contact a conservator?*

All interventive treatment must be undertaken by a conservator trained to examine, analyze, stabilize, and treat objects. Conservators are trained in the treatment of specific materials. See Chapter 3: Preservation: Getting Started, and Chapter 8: Conservation Treatment, for information on choosing and contracting with a conservator. Be sure you check references and question the experience and background of any conservator you choose. Discuss any recommended treatments and be sure you understand what is planned and why it is necessary.

Only experienced conservators who agree to follow the AIC Code of Ethics and Guidelines for Practice should be allowed to treat NPS museum objects.

2. *What might a conservator be able to tell me about my metal object upon examination?*

When conservators examine metal objects they can tell you a number of things, including:

- the type of metal

- the type and source of any corrosion product

- the range of possible conservation treatments

3. *Should protective coatings be applied to metals?*

Protective coatings are often applied to metal objects to prevent or reduce the possibility of corrosion from high humidity, frequent handling, atmospheric pollution, and to reduce the need for aggressive cleaning such as polishing.

4. *Who should clean and apply coatings to metal objects?*

All metal objects are best left **untreated** until an objects conservator has had an opportunity to examine them. Cleaning involves the risk of over-cleaning, exposure to hazardous solvents and chemicals, and the consequence of higher corrosion rates on freshly exposed metal surfaces.

A conservator should specify the most appropriate coating for an object and determine who best can apply the coating. With appropriate training by a conservator, collections management staff can be trained to coat metals with wax. The scope of treatment may be expanded to include other barrier coatings or corrosion inhibitors. This type of treatment is especially good for objects stored or exhibited outdoors.

5. *What are some common metal coatings?*

The most common metal coatings are:

- waxes
- lacquers
- corrosion inhibitors

Some preventive conservation measures for metal objects require hands-on methods. Preventive measures should mitigate frequent handling of the object, be easy to apply and to remove, and be safe for both the object and the person applying the material. Wax is an example of such a material.

Before applying any surface coating it is very important to properly identify the metal surface. Ask an objects conservator to conduct a Collection Condition Survey that includes current condition and provides information about routine maintenance.

- **Waxes.** Waxes are easy to apply, relatively safe and easy to remove, and provide reasonably long-term protection to the metal surface.

  – Waxes may be natural or synthetic.

  – The metal object should be polished, washed, thoroughly dried, and buffed before waxing.

  – Most waxes suitable for use in an exhibit space can be applied at room temperature.

  – Be aware that waxes will collect dust, are a food source for some molds and fungi, and may blanche or turn white.

  – Avoid natural waxes such as bees wax, which may be acidic. Use instead manufactured microcrystalline waxes as specified by a conservator.

- **Lacquers.** Lacquers, like waxes, can be natural or synthetic. Generally, synthetic lacquers and waxes are considered to be more stable than those derived from natural products. The objections to protective lacquer coatings are not well founded. A common objection is that lacquers make a metal object look "plastic." Matting agents are available if necessary. Considering the difference in wear caused by frequent polishing or less frequent waxing, the lacquer finish provides the toughest and the longest lasting protection.

  – Lacquers are more difficult to apply and to remove than waxes.

- Lacquers are harder than waxes and will usually last for five to ten years before reapplication is necessary.

- Certain solvents used in lacquers, such as toluene or xylene, pose health hazards. An objects conservator should be consulted and asked to apply the lacquer coating or to train the staff in the use of these materials.

- Lacquers when properly applied will not adversely affect the appearance of an object.

• **Corrosion Inhibitors.** Corrosion inhibitors react with the surface of a metal object to prevent corrosion. Some corrosion inhibitors are available commercially and others can be obtained from chemical supply houses. They also may be incorporated into waxes and resins. This provides an additional degree of protection should the wax or resin be scratched. Most corrosion inhibitors are metal specific.

  Keep in mind that corrosion inhibitors are not fool proof. Any metal treated with an inhibitor is still subject to corrosion at or above the critical relative humidity for that metal. For that reason, coatings, inhibitors and environmental quality should be considered an integrated system requiring ongoing maintenance.

CAUTION! Many corrosion inhibitors are toxic.

G. Emergency Procedures For Metal Objects

Metals are very reactive materials. In an emergency situation, corrosion can cause irreversible damage to inorganic materials, complicating their salvage. If the metal object has survived a fire and the deluge of water, a flood, or a storm, the first course of action is to isolate it from other materials.

Be sure to:

• Implement security precautions for precious metals and objects of intrinsic value such as metal sculpture.

• Provide a secure dry storage area for all metal objects.

• Have an objects conservator prepare a Collection Condition Survey that documents each object’s condition, recommends needed conservation treatment, and outlines remedial preventive conservation procedures.

• Rinse, sponge, and blot metal objects. Air dry.

• If the object has an applied finish, do not clean it. Air dry. Keep flaking surfaces horizontal.

Refer to Chapter 10: Emergency Planning, for information about planning for emergencies and minimizing damage.

In an emergency situation, do not attempt to perform interventive treatments on metal objects.

H. Special Considerations for Archeological Metal Objects

Considerations for the care and conservation of archeological metals are considerably different than for historic metals. Care of archeological metals is discussed in Appendix I.

I. Glossary

Abrasion: the wearing, grinding, or rubbing away of surface material by friction, usually through the action of particulate matter (e.g., sand) or as a result of rubbing by people, animals, or plants

Accretion: the accumulation of extraneous materials on the surface of an artifact, sculpture, or monument. It may include core materials, deposition of insoluble salts, or even the heavy accumulation of dirt, grime, pollutants, or bird droppings.

Acid deposition: the deposition of acidic constituents onto a surface. This occurs not only by precipitation, but also by the deposition of atmospheric particulate matter and the incorporation of soluble gases.

Acid precipitation: rain, snowfall, or atmospheric moisture below pH 7

Alloy: metallic material composed of two or more elements intimately mixed

Amalgam gilding: a process for applying gold to the surface of another metal, usually a copper or silver alloy, by forming a paste of mercury and gold

Annealing: a process of heating and cooling sheet metal, which has become work-hardened by hammering, spinning, or stamping, in order to relieve stress and to return the metal to a malleable state

Anode: the positive electrode of an electrolytic cell at which oxidation is the principal reaction. Electrons flow away from the anode. Usually the anode is where corrosion occurs and metal ions enter solution.

Bimetallic corrosion: corrosion resulting from dissimilar metal contact; galvanic corrosion

Brazing: a method of joining nonferrous metals using a nonferrous alloy that melts at a lower temperature than that of the metals to be joined. Brazing is similar to soldering; the distinction being that soldering is accomplished at temperatures below 800°F, and brazing is done above 800°F.

Bronze: an alloy of copper and tin and sometimes other elements

Bronze disease: copper corrosion in which chloride is the primary corrosive agent. It is rare, but may develop on archeological specimens or objects that have been recovered from the sea.

Burnish: a method to smooth rough surfaces of a metal by rubbing a hard stone or highly polished, harder metal over the surface

Casting: an object created by pouring molten metal into a mold

Cathode: the negative electrode of an electrolytic cell. Electrons flow toward the cathode in the external circuit. Corrosion does not occur at the cathode (see Anode).

Chasing: a metal finishing technique intended to sharpen or add detail on an object. For sculpture, the term is expanded to include all finishing techniques.

Checking: surface cracking in a checkerboard-like pattern often associated with the degradation of a protective coating

Chemical conversion coating: a protective or decorative nonmetallic coating created by treating the metal with an acidic or basic compound. Examples are coatings on iron produced by tannic or phosphoric acid.

Coating: a protective barrier, usually a synthetic resin or a wax, applied to a metal surface

Corrosion: the electrochemical degradation of a metal, due primarily to the loss of electrons and the recombination of metal ions with other electro-negative elements such as oxygen, carbon, sulfur, chloride, and nitrogen

Critical humidity: the relative humidity above which atmospheric corrosion rates of some metals increase sharply

Electrolytic cleaning (electrolytic reduction, electrolysis): a powerful method of cleaning metals used particularly if they are heavily corroded or salt contaminated. An object is wired to a low voltage direct current and is suspended between metal plates in a conductive solution.

Electroplating: the deposition of a metal from a solution of one of its salts onto a metal surface using an electrical current

Electrotyping: a process identical to electroplating. Electrotyping is used to build up thick metallic deposits on the interior of nonmetallic molds. It might be thought of as an electrolytic form of casting.

Embossing: raising a design in relief on a surface

Engraving: a decorative technique in which metal is removed by cutting into the surface with gravers

Etching**:** the production of patterns on a surface by the use of a corrosive chemical agent

Ferrous metals: composed of iron as the dominant metal

Filigree: decoration by means of thin, twisted wire soldered together into an openwork structure

Finishing: cleaning, polishing, patinating, and coating metal

Flux: a substance applied to metals being welded, soldered, or brazed to improve flow

Forging: shaping metal, usually steel and iron, by hammering while the metal is hot

Galvanic corrosion: accelerated corrosion of a metal because of an electrical contact with a more noble metal

Gild: to overlay with a thin covering of gold

Glass bead peening: dry blasting of a surface with glass microspheres

Graver: a chisel-like tool used for engraving metal surfaces

Inclusions: particles of impurities, such as mold materials, ferrous metal, or slag

Incralac: synthetic resin that contains the copper corrosion inhibitor, benzotriazole

Intergranular corrosion: preferential corrosion at, or adjacent to the grain boundaries of a metal or alloy

Inhibitor: a chemical substance that prevents or reduces metallic corrosion

Lacquer: an organic resin coating. The resin may contain matting agents or corrosion inhibitors. Some historic resins were pigmented.

Lost wax casting: a casting technique that utilizes a wax model or pattern. A refractory mold material is used to cover the wax pattern. The mold is later heated, the wax melts, and molten metal is poured into the resulting hollow.

Machining: shaping of metal with machines such as the lathe, planer, milling machine, drill press, and grinder

Metals: elements or mixtures of elements that possess high electrical conductivity and a lustrous appearance in the solid state

Mold**:** a form containing a refractory void (mold cavity) into which molten metal is poured during casting

Nonferrous metals: not composed of iron

Passive: the state of a metal surface characterized by low corrosion rates

Patina: a colored layer on the surface of a metal. This term is usually, but not always applied to copper alloys. The layer may be naturally occurring or artificially produced.

Planishing: a forming technique utilizing stakes and highly polished hammers to shape sheet metal

Plating: a thin layer of metal deposited on the surface of another metal

Raising: forming a hollow shape in metal by hammering on the outside surface over a dome headed stake or anvil

Repoussé: a technique whereby hammering from the inside produces raised areas on the outside of a sheet metal object

Rust**:** a corrosion product consisting of hydrated iron oxide. This term is properly applied only to ferrous alloys.

Sand casting**:** a casting technique that uses sand or sandstone as the refractory mold material

Sandstone casting: a casting technique that uses sandstone as the refractory mold material

Soldering: the use of alloys that flow at low temperatures to join two or more metal parts having higher melting points

Spinning: a metal forming technique in which sheet metal is rolled over a form on a lathe

Stamping: impressing a design into sheet metal with a metal die

Steel: an alloy of iron and carbon, with a carbon content between 0.15 and 2.0%

Stress-corrosion cracking: a cracking process that requires the simultaneous action of a corrosive agent and sustained tensile stress

Tarnish: discoloration of a bright metal surface by a thin film of corrosion products

***Tinning*:** covering a metal surface with tin

Tin Pest, Tin Disease: deterioration of tin caused by changes in the crystal structure at low temperatures (below 56°F)

Welding: joining two pieces of metal at a temperature close to their fusion point

J. Web Resources

American Institute for Conservation Disaster Recovery Page: <http://palimpsest. stanford.edu/aic/disaster/>.

Conservation OnLine, Resources for Conservation Professionals: <http://palimpsest.stanford.edu>.

Conserve O Gram Leaflets: <http://www.cr.nps.gov/museum/publications/index.htm>.

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