Canadian Conservation Institute
Institut canadien de conservation

CCI Notes 9/2

Storage of Metals

Introduction

Most metals corrode: iron rusts, copper turns green, silver turns black, and lead disintegrates into a white powder. Stored improperly, most of the metals in a museum collection will slowly transform into oxides, sulphides, carbonates, or other compounds. The corrosion processes are faster on metal surfaces contaminated by salts, volatile organic acids (such as those from wooden storage cabinets), ammonia from cleaning fluids, or dust. The rate of corrosion can also be increased through galvanic corrosion, a process that occurs when objects made of different metals are in contact with each other in high relative humidity (RH) conditions. (For more detailed information, see Selwyn 2004.)

For best protection of metal artifacts, museum storage areas must be clean and well-organized, have controlled RH, and have as clean air as possible.

This Note describes general guidelines for the proper storage of metals. It explains the role of RH, recommends general storage conditions and handling procedures, and discusses a few specific metals: aluminum, copper, iron, lead, plated objects, and silver. (For more detailed information, see Drayman-Weisser 1992.)

Relative Humidity

Relative humidity is a key factor in metal corrosion because most metals corrode more quickly in moist conditions. (For more information on RH, see Thomson 1994 and Tétreault 2003.) For ideal storage of metals, the RH should be as low as possible. However, this is rarely practical, especially for mixed collections.

It is reasonable to store stable metal artifacts — that is, metals that do not exhibit signs of active corrosion — with the rest of the collection in controlled storage conditions. The RH should be between 35% and 55%, the range generally recommended for storing and displaying mixed collections. If the RH exceeds 55%, consideration should be given to moving metal artifacts to proper humidity-controlled storage facilities.

Storage of Actively Corroding (Unstable) Metal

When examining a collection, look for metals that exhibit signs of active corrosion (see CCI Notes 9/1 *Recognizing Active Corrosion*). Because actively corroding pieces create dust, chloride, or staining problems by scattering corrosion products, they should be removed from the main collection and stored in a separate area with an RH below 35%. The drier conditions will reduce the corrosion rate, but the source of the corrosion will still need to be addressed. Seek advice from a qualified conservator on the care and treatment of such objects.

Small, important pieces can be stored in desiccators containing silica gel that has been dried completely or conditioned to a low RH. (For more information on how to use silica gel, see Lafontaine 1984 and Tétreault 2003.)

Large numbers of unstable metal objects can be stored together in a small room or in a cabinet where RH can be kept low with a dehumidifier. Small silica gel dehumidifiers are suitable for this purpose. Domestic dehumidifiers are not as effective as silica gel dehumidifiers because they cannot reduce the RH below 40%, but they are better than no dehumidifier at all. Lithium chloride dehumidifiers are not recommended because of the risk of contaminating artifacts with lithium chloride, which could make the corrosion worse. (For information on a low-cost unit for controlling RH, see Michalski 1982.)

Humidity control systems require regular maintenance. Empty the water pans of dehumidifers often, and check and recondition silica gel regularly.

Organizing Storage

Although not necessary, it can be useful to store artifacts composed of similar metals together. This makes examination and retrieval easy and systematic. If objects such as silver trophies, medals, coins, tools, etc. are stored in groups, shelving systems and storage containers can be standardized to some extent. However, the final decision on organizing storage depends on the collection and should be made by curatorial staff.

Whether storing metal artifacts in a separate room or with the main collection, select an area situated away from windows, doors, vents, and heating units. If windows cannot be avoided, ensure that they are tightly sealed to prevent leaks and condensation.

The storage area should have sufficient air circulation to maintain an even temperature and humidity and to prevent build-up of corrosive gases, such as volatile acidic or alkaline vapours. It is almost impossible to eliminate volatile substances from a museum collection. However, local high concentrations that will damage metal can be prevented if the room is adequately ventilated. Fans in the storage area will help to maintain airflow.

Storage of Stable Metals

Dust that settles on metal retains moisture. In urban areas, dust may contain pollutants, such as sulphur compounds, that tarnish silver. Any chlorides absorbed in the dust on metal objects will accelerate the corrosion of the metal. Storage areas should, therefore, be kept clean and dust-free. Seal concrete walls and floors to reduce dust levels.

Using chemically stable materials (e.g. shelving, cupboards, padding, wrapping) in storage areas will help to prevent problems because these materials last longer than unstable materials and will not damage the collection. Although expensive, metal storage cabinets and shelves with powder coatings are ideal. Other safe materials include polyethylene or clear food-grade polystyrene boxes, and acid-free unbuffered papers. Avoid wood and wood-pulp products because they release sulphur compounds and organic acid vapours (acetic and formic acid). Also avoid oil-based and alkyd paints because they release volatile materials for long periods. Rooms that have been freshly painted with oil or alkyd paints should be aired for at least four months before metals are stored in them. (For more information on coatings and on storage and display materials, see Miles 1986; Padfield 1982; Tétreault 1994, 1999.) If there is doubt regarding the suitability of a material, contact Client Services at CCI for advice.

Ideally, metal objects should be stored in closed systems, such as cabinets with well-sealed doors or drawers. Closed systems will protect metals from dust, pollutants, and, to a degree, changes in RH. Dry silica gel can be placed in the drawers to maintain a low RH; the silica gel should be checked and reconditioned regularly. One hazard associated with closed storage is the tendency for volatile materials to build up slowly over time. To prevent this problem, choose storage systems made of inert materials, such as metal.

If open shelving is to be used for storing metals, the objects must be protected from dust and pollutants. Wrap artifacts in acid-free unbuffered paper or place them in acid-free boxes or in polyethylene bags. (For more information on constructing boxes, see CCI Notes 11/1 *Protective Enclosures for Books and Paper Artifacts*.) As a further precaution, polyethylene or washed cotton dust covers can be draped over shelving units.

Never place metal objects directly on a storage shelf or drawer. Line shelves and drawers with closed-cell polyethylene foam such as Ethafoam, PolyPlank, Volara, Plastazote, or Nalgene. The foam lining also helps to protect the objects from shock or abrasion. Avoid urethane foams because they degrade easily.

Arrange each metal artifact on a shelf or in a drawer so that its weight is evenly supported and so that it can be retrieved without damaging neighbouring artifacts. For metals housed in drawers, place wads of acid-free unbuffered paper or strips of polyethylene foam between the individual objects to keep artifacts from moving when drawers are opened or closed. Alternatively, individual supports for metal artifacts can be carved from thick polyethylene foam (see CCI Schlichting 1994). Metal objects can also be stored in clear plastic food-grade polystyrene boxes, polyolefin freezer containers (e.g. Tupperware), or polyethylene bags. Boxes and bags may need to be perforated to prevent the build-up of condensation on the inside in the event that the storage area is not well controlled for fluctuations in RH. Polyethylene bags can be punctured several times with a small sharp awl or punch although this will leave rough plastic projections on the inside of the bag that could catch on the artifact. Alternatively, the bag can be slit along the side with very small diagonal cuts. All holes must be small enough to prevent the artifact from falling out of the bag. Soft polyolefin boxes can be drilled through the sides (beneath the handles). Avoid Saran Wrap because it contains poly(vinylidene chloride). This slowly

degrades to form hydrogen chloride (HCl) gas, which can damage metals. (For an excellent source of ideas and practical solutions to storage problems, see Rose and de Torres 1992.)

Handling

When removing metals from storage, ensure that they are supported well. Transport fragile pieces in padded trays, boxes, or the artifact's own storage support.

Wear well-fitting plastic or clean cotton gloves when handling metals. (Cotton gloves absorb sweat and accumulate salts during use, so be sure to clean them regularly.) Highly polished metals, such as silver and copper, are particularly sensitive to the oils and salts in skin. Avoid handling silver with latex rubber gloves because the sulphur compounds from the rubber may tarnish the silver over the long term. Also, many pure metals and some alloys are soft and are therefore easily scratched or dented.

Storage and Care of Specific Metals

Aluminum

Aluminum resists corrosion because of the protective oxide layer that forms rapidly when aluminum is exposed to air. Normally, if the oxide layer is damaged by an abrasive action like scratching, it re-forms rapidly. Chloride ions prevent the oxide from re-forming and so cause pitting of the aluminum surface. Following the guidelines in this Note will help to prevent the accumulation of surface contaminants that lead to this problem.

Copper

Copper alloys are susceptible to corrosion by ammonia, acids, strong alkalis, chlorides, and sulphide gases. It is best to store small copper artifacts in clear plastic boxes padded with acid-free unbuffered paper, or in boxes made from acid-free or neutral board. Larger artifacts can be wrapped in acid-free unbuffered paper, stored in carved Ethafoam supports, or placed on foam shelf-liners. (More information on brass and copper can be found in CCI Notes 9/3 *The Cleaning, Polishing, and Protective Waxing of Brass and Copper* and 9/4 *Basic Care of Coins and Medals*.)

Bronze disease is a form of active corrosion that affects archaeological copper alloys. It is characterized by the eruption of a light-green powder in spots over the surface. Objects displaying bronze disease should be stored separately to keep the corrosion products away from other artifacts. The RH of the storage environment for these objects should be below 35%.

Iron

All iron rusts when the RH is over about 65%. Uncontaminated iron is stable at 50% RH, but iron contaminated with salts continues to corrode. Actively corroding iron should be separated from the rest of the collection, and stored in conditions where the RH is below 35%. (For more information on caring for iron objects, see CCI Notes 9/6 *Care and Cleaning of Iron*.)

Many of the general storage methods discussed here are not practical for large iron artifacts. Their storage is often dictated more by the availability of space than by environmental considerations. However, maintaining a clean storage environment and providing adequate storage supports for these artifacts contribute to their long-term preservation. (Details on the storage of large iron artifacts are given in CCI Notes 15/2 *Care of Machinery Artifacts Displayed or Stored Outside*.)

Lead

Stable lead surfaces are generally dark grey, while actively corroding lead is usually covered with a loosely adherent white powder. Lead is particularly difficult to store safely because it is easily corroded by very small amounts of volatile organic acids, such as acetic or formic acid. These acids can act rapidly, destroying surface detail and weakening the object. Formaldehyde, a source of formic acid, is released from the adhesives used in certain plywoods and particle boards. (For more information, see Tétreault 2003.)

Inspect lead objects regularly for active corrosion because lead is particularly susceptible to damage in poorly ventilated areas. If an object is actively corroding, isolate it and store it at a low RH. At the same time, identify and, if possible, remove the corrosion source (often wood, paint, or adhesives) or provide better storage conditions.

To protect lead artifacts from harmful acids, wrap the objects with neutral and acid-free materials and store them in suitable containers. Envelopes made for the archival storage of coins are suitable for small lead objects or fragments. Polyethylene and food-grade polystyrene boxes are also safe for lead.

Plated objects

Collections often contain numerous plated objects such as steel cans plated with tin, copper-based objects plated with silver, chrome-plated automobile parts, or iron buckets galvanized with zinc.

These objects may be prone to galvanic corrosion because the two metals are in contact with each other. Such corrosion can be stimulated if there are salts, foods, or other organic residues in the cans or buckets, or if there is polish residue on a silver-plated object. If there is a concern about the stability of plated objects, keep them in as low RH as possible.

Silver

Tarnishing of silver is caused by sulphur-containing gases, such as hydrogen sulphide. In museums, these tarnishing gases may come from air pollutants, certain foods, sulphur-contaminated water, or materials commonly found in storage areas such as natural or synthetic rubber (in stoppers, O-rings, and latex gloves), certain paints, and some textiles (e.g. wool or felt). Because the source of tarnishing may be difficult to isolate or control, the use of closed and, if possible, sealed storage containers is recommended. (For more information on the storage of silver, see CCI Notes 9/7 *Silver — Care and Tarnish Removal*.)

Conclusion

Proper storage conditions and good housekeeping are essential for the long-term preservation of metal artifacts. Environmental controls are important. No corrosion should occur on most stable metal objects in a mixed collection if the RH is maintained at or below 55% (although certain pollutants in the air will still cause silver to tarnish or lead to corrode). Serious damage can be minimized by inspecting the collection regularly and by removing any objects suspected of actively corroding. Isolate these objects and keep them at an RH below 35% until a conservator can be consulted.

Because many natural and synthetic products emit gases that can cause metal to corrode, use safe storage materials and proper air ventilation to minimize the build-up of these corrosive gases. Many metal objects are constructed of soft metals that are easily scratched or of brittle ones that are easily broken. Careful handling of and proper support for metals objects will also ensure their protection.

Suppliers

Note: The following information is provided only to assist the reader. Inclusion of a company in this list does not in any way imply endorsement by the Canadian Conservation Institute.

Cotton gloves:
conservation suppliers

Metal shelves and cabinets with powder coatings:
shelving suppliers such as:

Montel
225 4th Avenue, P.O. Box 130
Montmagny QC G5V 3S5
Canada
tel.: 877-935-0236
www.montel.com

or

Delta Designs Ltd.
P.O. Box 1733
Topeka KS 66601
USA
tel.: 785-234-2244 or 1-800-656-7426
www.deltadesignsltd.com

Neutral, acid-free paper products (non-buffered or unbuffered):
conservation suppliers such as:

Carr McLean
461 Horner Avenue
Toronto ON M8W 4X2
Canada
tel.: 416-252-3371 or 1-800-268-2123
www.carrmclean.ca

or

Conservation Resources International Inc.
8000-H Forbes Place
Springfield VA 22151
USA
tel.: 703-321-7730 or 1-800-634-6932
www.conservationsources.com

Plastic boxes (food-grade polystyrene):
distributors of plastic supplies

Polyethylene bags:
grocery stores, chemical suppliers

Polyethylene foam (closed-cell) such as Ethafoam, PolyPlank, Volara, Plastazote, or Nalgene:
suppliers of packing materials

Polyethylene sheeting:
hardware stores, building suppliers

Silica gel:
laboratory equipment and chemical suppliers

Bibliography

Drayman-Weisser, T. "Metal Objects." pp. 108–121 in *Caring for Your Collections* (edited by H. Whelchel). New York, NY: Harry N. Abrams, Inc., 1992.

Lafontaine, R.H. *Silica Gel*. Technical Bulletin No. 10. Ottawa, ON: Canadian Conservation Institute, 1984.

Michalski, S. "A Control Module for Relative Humidity in Display Cases." pp. 28–31 in *Science and Technology in the Service of Conservation* (edited by N.S. Brommelle and G. Thomson). London, UK: International Institute for Conservation of Historic and Artistic Works, 1982.

Miles, C.E. "Wood Coatings for Display and Storage Cases." *Studies in Conservation* 31, 2 (1986), pp. 114–124.

Padfield T., D. Erhardt, and W. Hopwood. "Trouble in Store." pp. 24–28 in *Science & Technology in the Service of Conservation*. IIC Preprints of the Contributions to the Washington Congress, 3–9 September 1982.

Rose, C.L., and A.R. de Torres (eds.). *Storage of Natural History Collections: Ideas and Practical Solutions*. Pittsburgh, PA: Society for the Preservation of Natural History Collections, 1992.

Schlichting, C. *Working with Polyethylene Foams and Fluted Plastic Sheet*. CCI Technical Bulletin No. 14. Ottawa, ON: Canadian Conservation Institute, 1994.

Selwyn, L. *Metals and Corrosion: A Handbook for the Conservation Professional*. Ottawa, ON: Canadian Conservation Institute, 2004.

Tétreault, J. "Display Materials: The Good, The Bad and The Ugly." pp. 79–87 in *Exhibitions and Conservation*. Edinburgh, UK: Scottish Society for Conservation and Restoration, 1994.

Tétreault, J. *Coatings for Display and Storage in Museums*. CCI Technical Bulletin No. 21. Ottawa, ON: Canadian Conservation Institute, 1999.

Tétreault, J. *Airborne Pollutants in Museums, Galleries, and Archives: Risk Assessment and Control Strategies*. Ottawa, ON: Canadian Conservation Institute, 2003.

Thomson, G. *The Museum Environment, 2nd edition*. Oxford, UK: Butterworth-Heinemann, 1994.

by Judy Logan
revised by Lyndsie Selwyn

Originally published 1988
Revised 1994, 1995, 2007

Copies are also available in French.
Texte également publié en version française.

Cat. No. NM95-57/9-2-2007E
ISSN 0714-6221

Printed in Canada