

Conservation and restoration of metals

For silver objects, see conservation and restoration of silver objects. For iron and steel objects, see Conservation and restoration of iron and steel objects. For copper-based objects, see Conservation and restoration of copper-based objects. For outdoor bronze objects, see Conservation and restoration of outdoor bronze objects.

Conservation and restoration of metals is the activ-



Derveni krater, bronze, 350 BC, height: 90.5 cm (35 1/2 in.), Inv. B1, Archaeological Museum of Thessaloniki, after cleaning and conservation.

ity devoted to the protection and preservation of historical (religious, artistic, technical and ethnographic) and archaeological objects made partly or entirely of metal. In it are included all activities aimed at preventing or slowing deterioration of items, as well as improving accessibility and readability of them as objects of cultural heritage. Despite the fact that metals are generally considered as the relatively permanent and stable materials, in contact with the environment they deteriorate gradually, some faster and some much slower. This applies especially to archaeological finds.

It is very important that a conservator of metals has knowledge of basic metalworking techniques, history of metalwork, history of art, archaeology, corrosion of metals, scientific research methods, theory and ethics of conservation-restoration.

1 Metals and alloys commonly used for cultural heritage objects



The bronze apoxyomenos, dated to between the 1st and 2nd century BC, found and recovered from Adriatic sea near the small island Vele Oryule, near island Loshiny, Croatia; example of archaeological metals conservation.

- Gold
- Silver
- Copper
- Bronze
- Brass
- Nickel
- Nickel silver
- Monel
- Chromium
- Iron and Steel
- Weathering steel (Corten)

- Stainless steel
- Titanium
- Tin and Pewter
- Lead
- Zinc
- Aluminium

2 Metals and alloys less commonly used for cultural heritage objects

- Antimony
- Magnesium
- Niobium
- Palladium
- Platinum
- Rhodium
- Mercury
- Electrum
- Tumbaga
- Shakudo
- Shibuichi
- Bidri
- Hepatizon

3 Metalworking techniques

3.1 Basic techniques

- Casting
- Forging
- Folding
- Sawing
- Cutting
- Bending
- Drilling
- Filing (metalworking)
- Piercing
- Sanding
- Polishing

3.2 Joining techniques

- Soldering
- Welding
- Mechanical joining
- Gluing/cementing

3.3 Some supplementary techniques

- Repousse
- Chasing
- Raising (metalwork)
- Metal spinning
- Annealing (metallurgy)

3.4 Surface decoration techniques

- Enamelling
- Niello
- Engraving
- Etching
- Granulation
- Filigree
- Inlay (Damascening)
- Mokume gane
- Pattern welding
- Plating
- Chemical coloring of metals (Patination)
- Heat coloring
- Combining metals and other materials

3.5 Some contemporary techniques

- Electroforming
- Reticulation
- Anodizing
- Photoetching



Perseus with the Head of Medusa in the Loggia dei Lanzi gallery on the edge of the Piazza della Signoria in Florence; picture taken after the statue's cleaning and restoration.

4 Deterioration of metals

An essential cause of deterioration is corrosion of metal objects or object deterioration by interaction with the environment. As the most influential factors of deterioration of historical objects should be pointed out as the relative humidity and air pollution while in archaeological objects a crucial role has composition, depth, humidity and amount of gasses in the soil. In cases of marine or fresh water finds the most important factors of decay are the amount and composition of soluble salts, water depth, amount of dissolved gases, the direction of water currents and the role of both microscopic and macroscopic living organisms.^[2]

5 Deterioration of materials associated with metals

Associated materials deteriorate depending on the origin whether they are organic or inorganic materials. Organic materials usually fail in a relatively short period of time, primarily due to biodegradation. With inorganic materials are these processes considerably longer and more complex. Amount of gases, humidity, depth and composition of soil are very important. In case of salty and sweet water finds essential are amount of gases dissolved in water, depth of water, direction of currents, and mi-

croscopic and macroscopic living organisms.

5.1 Organic materials

- Leather
- Wood
- Paper
- Fur
- Feathers
- Textile
- Bone
- Horn
- Tortoiseshell
- Amber
- Plant fiber
- Shell
- Pearls
- Ivory
- Coral
- Jet (lignite)

5.2 Inorganic materials

- Precious and semiprecious stones (Gemstone)
- Glass
- Enamel
- Niello
- Ceramics
- Porcelain
- Plastics

6 Metals conservation planning

6.1 Basics

As with the conservation and restoration works on any other material, here are the basic tenets of conservation-restoration based on the quality of execution and the best possible preservation of cultural, historical and technological identity and integrity of objects. Minimal intervention, reversibility and repeatability of preferred treatment are essential, as well as the possibility of easy identification of restored parts.^[3] Recently non-toxic nature of

used materials and procedures becomes important too, both in relation to objects and conservator-restorer as a performer, but also in relation to the environment.

6.2 Research

Nowadays scientific research is an integral part of the metals conservation treatment, at least in highly developed countries.

6.2.1 Identification of metals and alloys

- Simple methods - visual examination, spot tests, specific gravity
- Scientific methods - X-ray fluorescence, XRD, Particle-induced X-ray emission, LIBS, SEM, electrochemical techniques, metallography

6.2.2 Identification of corrosion processes and products

- Simple method - visual examination, spot tests
- The Oddy test - for copper, silver, and lead
- Scientific methods - xrd, SEM, metallography

6.2.3 Identification of materials associated with metals

- Simple methods - visual examination, spot tests, specific gravity
- Scientific methods - xrf, chromatography,

Raman spectroscopy

6.2.4 Identification of technology used to produce objects

- Simple methods - visual examination
- Scientific methods - metallography, x-ray radiography, x-ray computed tomography

6.3 Decision making

In preparing the strategy of the metals conservation project interdisciplinary approach to the same is essential. It implies the participation of as many experts as is possible, as a minimum, we can take curator (archaeologist, historian, art historian), scientists specialized for corrosion of metallic objects of cultural heritage and the conservator - restorer.

6.4 Documentation

Systematic and well-managed documentation is today an essential prerequisite for quality executed conservation and restoration treatments, including documentation of the state of objects before, during and after treatment. Identification of materials and procedures used to produce object and the results of any scientific research must be part of documentation too. Last but not least- an integral part of the documentation must be a recommendation for further care of object.

6.5 Ethics and ethical problems in metals conservation

The ethical concept of conservation of metal objects in principle is the same as those in other fields of conservation-restoration of cultural heritage.

But there are several specific problems that can only be found in the conservation of metals - problem of heat treatment of archaeological objects, and the problem of radical restoration of historic, mostly technical, but also architectonic objects too.

While in the first case problem is primarily in the destruction of valuable scientific data, in case of the technical, the architectural, and somewhat less often, historical objects problem is that a radically restored items just simulate the original appearance of the object, and so in some ways that objects can be considered even as, more or less successful fakes, which only superficially simulate long-lost or never existing state of object.

According to the above-mentioned, whenever it is possible real historical substance must be preserved. Thoroughly documented and technically professionally executed restoration of objects, must be avoided because such objects must be seen only as freshly painted surrogates of authentic historic substance.

Ethical problems connected with conservation of sacred metallic heritage objects can be included too.^[4]

7 Conservation

7.1 Preventive conservation

Main article: Collections care

Metallic heritage objects are sensitive to environmental conditions such as temperature, humidity, air pollution and exposure to light and ultraviolet light. They must be protected in a controlled environment where such variables are maintained within a range of damage-limiting levels.

Preventive conservation, also known as collections care,

is an important element of museum policy. It is an essential responsibility of members of the museum profession to create and maintain a protective environment for the collections in their care, whether in store, on display, or in transit. A museum should carefully monitor the condition of collections to determine when an artifact requires conservation work and the services of a qualified conservator.

7.2 **Interventive conservation**

7.2.1 **Cleaning**



Conservation of gilt bronze Horses of Saint Mark, (Venice).

The most common procedure in conservation and restoration of metals is the cleaning process. This process can be distinguished between mechanical, chemical, electrochemical, ultrasonic, plasma and laser cleaning. In principle, it is aimed at removing dirt and corrosion products from the surface of a metal object. In many cases archaeology objects only can be cleaned mechanically.

7.2.2 **Structural consolidation**

Aimed at strengthening of the physical structure of the object, and correcting the shape of the object.

- Mechanical joining - riveting / tab and slot / overlapping / screws
- Soldering - soft / hard
- Welding - oxyacetylene / electric arc / TIG / tack / laser
- Gluing/Cementing
- Reconstructions -in original material - in polymers - *3D printing^[28]

7.2.3 **Reconstruction of missing parts or surface decoration**

In certain cases, metals conservator must re-create the lost parts of objects or restore original surface decoration. This approach is accurate only if we have an exact documentation or photographs of items in a complete, currently non-existent state that we want to return.

New parts must be clearly and visibly marked and at least they must be minimally different from the original historic material.

If needed, those parts must be easily and completely removable from the object, and with methods which will not harm it.

Only cyanide or hexchromate free processes must be used.

Only worn-out spots can be replated.

Replating of entire object must be avoided.

7.2.4 **Stabilization**

Focused on slowing of deterioration of objects - in case of archaeology objects the thorough removal or blocking of chloride salts. In case of the historical objects it is focused on the use of corrosion inhibitors, conversion coatings, rust converters or eventually oxygen free storage.

- Chloride removal (chemical processes, electrochemical processes)
- Corrosion inhibitors (benzotriazole, tannin)
- Rust converters
- Conversion coatings (phosphate conversion coatings, phosphate/tannin, etc.)
- Oxygen free storage

7.2.5 **Protective Coatings**

Still mainly focused on use of clear coats and waxes, in case of technology objects oil coatings can be used too. In general it supports the stabilization process.^[55]

- Clear coats:

Paraloid B-72

For Additional information on Paraloid B-72, see Paraloid B-72.

durable and non yellowing acrylic resin, chemically an ethyl methacrylate copolymer. It can be used for conservation of metals. Soluble in acetone, toluene, xylene,

Shell Cyclo Sol® 100/Shell Cyclo Sol® 53, Arcosolv® PM/1-Methoxy-2-propanol.^[56]

Paraloid B 67

is acrylic resin, chemically it is an isobutyl methacrylate polymer. Soluble in toluene, xylene, acetone, Shell Cyclo Sol® 100/Shell Cyclo Sol® 53, Arcosolv® PM/1-Methoxy-2-propanol and white spirit acetone mixture (90 parts white spirit/10 parts acetone).^[57]

Paraloid B 44

is acrylic resin, chemically it is composed of methyl methacrylate and ethyl acrylate copolymer. Soluble in toluene, xylene, acetone. It is used for paints and clear coating for metals. It is ingredient in Inralac metal coating.^[58]

Paraloid B 48 N

is acrylic resin, chemically it is copolymer of methyl methacrylate and butyl acrylate. It is used as a clear coating for metals - copper, brass, bronze, and zinc. Soluble in toluene, xylene, methyl ethyl ketone, and acetone^[59]

Inralac

is special proprietary clear coat for copper and its alloys. It is based on Paraloid B 44 acrylic resin dissolved in toluene. It contains benzotriazole as copper corrosion inhibitor too.^[60]

Nitrocellulose lacquer

is solvent based lacquer that contain nitrocellulose, a resin obtained from the nitration of cotton and other cellulosic materials.^[61] Can be used on silver objects. Frigilene, Agateen No.27 and Perlitol RE 1260 are good brands.

ORMOCER

Organically modified ceramic, also known as ORMOCER (ORganically MODified CERamic) is a type of coating used in the conservation of metals. ORMOCER was originally developed by the Fraunhofer Society for the Advancement of Applied Research in Munich. While it is still in research phase, ORMOCER is essentially a heteropolysiloxane-based clear coat.^[62]

Other used varnishes or lacquers that would be worthwhile to examine:

Pantarol A (German product), the use of it is mentioned in German literature, according to manufacturer it is special acrylic coating for metal ^[63]

Everbrite ProtectaClear Coating, Everbrite Coating (USA products) - worthwhile to be tested, according to manufacturer product is easily removable from treated objects ^[64] ^[65]

- Waxes:

Renaissance Wax

Main article: Renaissance Wax

is a brand of microcrystalline wax polish that is widely encountered in antique restoration and museum curation. Although not appropriate for all materials, it is known to and used by almost every collection. It is also used as a primary finish for cabinetry and furniture. Renaissance wax is also used by reenactors of historic swordsmanship to protect armour and weapons. It is widely recognised that this substance is more protective and longer lasting than oil, especially for swords and helmets that are frequently touched by human hands.

To quote a typical commercial supplier of conservation materials, it is used, to revive and protect valuable furniture, leather, paintings, metals, marble, onyx, ivory etc. Freshens colours and imparts a soft sheen^[66]

Cosmolloid 80 H

is refined white microcrystalline wax. It can be used on historical and archaeological metals. Melting point 60–94 °C. Soluble in benzol, ether, chloroform, carbon disulfide, carbon tetrachloride, turpentine, petroleum distillates, and fixed oils; partially soluble in acetone, diacetone alcohol. Main ingredient in Renaissance Wax.

Dinitrol 4010

is a long-term engine protection proprietary product with heat resistance up to 200 °C. It leaves a firm transparent film with short drying time and good adhesion and flexibility on all metal surfaces, rubber and plastic parts. Dinitrol 4010 is resistant to alkali and acidic solutions. According to some research articles it can be used on metallic heritage objects too^[67]

Poligen ES 91 009

is patented wax emulsion (BASF), according to some sources better than Paraloid B 72^[68]

- Oils

-WD 40 / Ballistol / 80 parts white spirit+20 parts fish oil

- Combinations

-base coat Paraloid B 72 / topcoat Renaissance Wax etc.

7.3 Conservation of materials associated with metals

7.3.1 Precious and semi precious stones

In principle do not use any solvent, but only distilled water, or a 10% solution of soapwort plant (*Saponaria officinalis*). You must be Especially careful when working on porous gemstones like malachite, opal, chalcedony, chrysoptase, agate, carnelian, lapis lazuli, jade and turquoise. Special attention requires gemstones combined with colored metal foils, in this case, the liquid does not come into contact with the foil. Do not use ultrasonic cleaning.

7.3.2 Enamels

Main article: Conservation and restoration of glass objects

7.3.3 Niello

Nielloed items can be cleaned only mechanically, never try to use chemical cleaning. Black pigment mixed with Paraloid B 72 can be used for reconstruction of missing parts. Concentrated solution of Paraloid B 72 or B 67 (soluble in white spirit) can be used as reversible glue.

7.3.4 Amber

Do not clean with solvents, do not use ultrasound, you can use only distilled water, or a mixture of water and ethanol (add up to 0.5% crosslinker).^[69] Variety of waxy resin mixtures can be used as glue, depending on the color of amber. You can use 10% solution of Canada balsam in toluene.^[70] Archaeological material can be cleaned only mechanically. Soaking in liquid paraffin can be used to consolidate and improve color of amber.^[71] According to one Korean article for consolidation can be used Paraloid B 67 dissolved in xylene (proved more stable than white spirit, usual solvent for B 67)^[72] Artifacts must be Protected from strong light and high temperatures, low humidity and oscillations in humidity, in the case of metal/amber objects do not to use corrosion inhibitors.^[73]

7.3.5 Oriental lacquer - urushi

Requires a completely different approach than western lacquers. May be found on the Japanese arms and armour. The best approach – leave it to expert for oriental lacquer.^{[74][75][76]} Mixture of 6-8% polyvinyl alcohol and chalk can be used as filling material (Rhoplex WS 24 can be used too).^[77] Japanese conservators use traditional techniques, but as Urushi causes allergic reactions, these methods are not recommended. Clean it with an aliphatic hydrocarbon such as white or mineral spirits. Distilled water or saliva (moistened cottonwool swabs) can caused discoloration and should be avoided by the inexperienced: pH is crucial. Keep objects in rooms with controlled humidity and temperature, preferably about 50% RH, and protect them from UV radiation.

7.3.6 Coral

Can be cleaned with cotton wool swabs soaked in distilled water, or with a mixture of distilled water and ethanol.^[78] Do not use ultrasound. Avoid any contact with acids.

7.3.7 Pearls

Historical objects can be cleaned using a mixture of 70% ethanol and 30% weak ammonia water (1%). To remove the surface layer that has lost luster you can use 3-5% EDTA, after that step rinse with distilled water, and then with 80% ethanol, then with 90% ethanol, and finally with pure ethanol.^[79] Do not use ultrasound. Archaeological finds must be treated as soon as possible, preferably after excavation, you can clean them only mechanically, then consolidate with 2% Paraloid B 72, in the case of dry findings (first saturate with solvent in which it is dissolved), in case of damp or wet findings use Rhoplex WS 24 (acrylic dispersion).^[80] Somewhat More recent Russian literature recommends use of bleached beeswax dissolved in white spirit or medical benzine as protective coating. Fish glue mixed with water and alcohol (7/3), with addition of 1% katamine AB as biocide can be used as glue. Nonionogenic detergent 2-3% in a mixture of water and alcohol can be used for cleaning.^[81] Avoid prolonged contact with water, sudden changes in temperature and relative humidity, including strong light or contact with acidic or alkaline solutions (soap water too).

7.3.8 Mother of pearl

7.3.9 Ivory, bone and antler

Main article: Conservation and restoration of ivory objects

7.3.10 Tortoiseshell

7.3.11 Jet

You can clean it with cottonwool swabs soaked in distilled water or soapwort extract (*Saponaria officinalis*, 100 grams of dried root per 1 liter of boiling water). Archaeological material can be cleaned only mechanically. Wax/resin mixtures or concentrated solution of Paraloid B 72 (or B 67) can used as glue for archaeology objects.^[82]

7.3.12 Wood

7.3.13 Textile

Main article: Textile preservation

7.3.14 Paper

7.3.15 Glass

Main article Conservation and restoration of glass objects

7.3.16 Ceramics and porcelain

Main article: Conservation and restoration of ceramic objects

7.3.17 Leather

7.3.18 Plastics

Main article: Conservation and restoration of objects made from plastics

7.3.19 Wax

7.3.20 Plaster

Unsealed plaster can be cleaned with soft brush only; never try to use water or water-based cleaning solutions. Sealed plaster can be cleaned with a swab dampened with water or white spirit.^[83]

8 Replicas and Copies

- molding (process)
- casting
- electroforming
- 3D printing^[84]

9 Storage of metallic heritage objects

The items should be stored in rooms that are protected from polluted air, dust, ultraviolet radiation, and excessive relative humidity - ideal values are temperature of 16-20 °C and up to 40% (35-55% according to recent Canadian Conservation Institute recommendations) relative humidity, noting that if metal is combined with organic materials, relative humidity should not be below 45%. Archaeological objects must be stored in rooms (or plastic boxes) with very low relative humidity, or in the case of particularly valuable items in the chambers with nitrogen or argon. Copper or copper alloy objects with active corrosion up to 35% RH. Iron objects with active corrosion 12-15% RH. Shelves in the storerooms must be of stainless steel or chlorine and acetate free plastic or powder coated steel. Wood and wood based products (Particle board, plywood) must be avoided. Also do not use rubber, felt or wool. When you are handling metal objects, always wear clean cotton gloves. Lighting levels

must be kept below 300 lux (up to 150 lux in case of lacquered or painted objects, up to 50 lux in case of objects with light sensitive materials)^[85]

10 History of metals conservation

10.1 Important persons

- Gustav Rosenberg
- William Matthew Flinders Petrie
- Friedrich Rathgen
- Alexander Scott
- Harold Plenderleith
- Mstislav Vladimirovich Farmakovskiy
- Albert France-Lanord
- Robert M. Organ
- Hanna Jedrzejewska
- Joachim Szvetnik

11 Specializations within the profession

- Conservation of Historical Metal Objects
- Conservation of Archaeological Metal Objects
- Conservation of Technological Metal Objects
- Conservation of Ethnographic Metal Objects
- Conservation of Architectural Metal Objects
- Conservation of Metal Sculpture
- Conservation of Gold and Silversmiths Works
- Conservation of Arms and Armour

12 Training

Main article: conservation-restoration training

12.1 USA

- Buffalo State College, Art Conservation Department, objects specialization
- UCLA/Getty Masters Program - Conservation of Archaeological and Ethnographic Materials
- Winterthur/University of Delaware Program in Art Conservation, objects specialization

12.2 Canada

- Queens University, Art Conservation, objects specialization
- Fleming College, Collections Conservation and Management

12.3 Mexico

- Escuela nacional de conservacion, restauracion y museografia, Ciudad de Mexico, Diplomado de Especialización en Patrimonio Metálico

12.4 South America

- Chile

Centro Nacional de Conservacion y Restauracion, Santiago de Chile, objetos arqueológicos, etnográficos e históricos

- Perú

Universidad Nacional Mayor de San Marcos, Escuela academico profesional de Conservación y Restauración

- Brasil

Universidade Federal de Pelotas, Instituto de Ciências Humanas, Laboratório Multidisciplinar de Investigação Arqueológica (LÂMINA)

12.5 Africa

- Egypt

Conservation Department, Faculty of Archaeology, Cairo University

- South Africa

The South African Institute for Objects Conservation, Joubertina, Eastern Cape, metals conservation

12.6 Australia

The University of Melbourne, Centre for Cultural Materials Conservation

12.7 Europe

- Austria

Universitaet fuer Angewandte Kunst, Wien, Konservierung/Restaurierung von Objekten

- Belgium

Koninklijke Academie voor schone kunsten, Antwerpen, metalen conservatie

- Croatia

1. Sveučilište u Dubrovniku, konzervacija restauracija metala (BA+MA)

2. Umjetnička akademija u Splitu, Konzervacija restauracija metala (BA+MA)

- Denmark

The Royal Danish Academy of Fine Arts, School of Conservation

- Czech Republic

Konzervování-restaurování uměleckořemeslných děl z kovů, Turnov

- France

1. Université Panthéon-Sorbonne Paris I, Paris, Conservation and restoration department

2. Institut de Formation des Restaurateurs d'Oeuvres d'Art ,Institut National du Patrimoine, Saint-Denis-la-Plaine, Metals conservation

- Finland

Metropolia University of Applied Sciences, Helsinki, objects conservation

- Germany

1. Roemisch Germanisches Zentralmuseum, Mainz, Ausbildung zum Restaurator des Fachbereichs Archeologie

2. Hochschule fuer Technik und Wirtschaft, Berlin, schwerpunkt Archaeologisch-Historisches Kulturgut

3. Staatliche Akademie der Bildende Kuenste, Stuttgart, Objekt Restaurierung

4. Fachhochschule Potsdam, Metallkonservierung

5. University of Applied Sciences Erfurt, Archäologisches Kulturgut und kunsthandwerkliche Objekte

- Greece

Technological Educational Institution (TEI), Athens

- Hungary

Hungarian Academy of Fine Arts, Budapest, conservation of metalwork and goldsmiths works

- Italy

1. Istituto Superiore per la Conservazione e il Restauro, Roma

2. Opificio delle Pietre Dure, Firenze

- Netherlands

Universiteit van Amsterdam, Amsterdam, MA metaal-restauratie

- Poland

Nicolaus Copernicus University in Torun, Institute of Fine Art, Department of Conservation and Restoration of Historic and Artistic Works, graduate program, metal conservation

- Portugal

Faculdade de Ciências e Tecnologia da Universidade Nova, Lisboa

- United Kingdom

1. West Dean College, metalwork conservation
2. University of Sussex, metalwork conservation

- Spain

1. Universidad de Granada, Grado en conservación y restauración de bienes culturales
2. Escuela Superior de Conservación y Restauración de Bienes Culturales, Madrid, Especialidad de bienes arqueológicos
3. Escuela Superior de Conservación y Restauración de Bienes Culturales, Barcelona, Especialidad de bienes arqueológicos
4. Escuela Superior de Conservación y Restauración de Bienes Culturales, Pontevedra, Especialidad de bienes arqueológicos

- Switzerland

La Chaux de Fonds, Haute Ecole de Conservation-restauration Arc, objects conservation

12.8 Ukraine

Lvov Academy of Arts, metals conservation

12.9 Russian Federation

- Факультет искусства реставрации Московской государственной художественно-промышленной академии им.С. Г. Строганова, Moscow-katedra"Restavraciya hudozhestvennogo metalla" (Conservation of artistic metalwork)

12.10 India

NATIONAL MUSEUM INSTITUTE of History of Art, Conservation and Museology (Deemed to be University) Ministry of Culture, Government of India, New Delhi

12.11 Iran

1. Art University of Isfahan, Faculty of Conservation, Department for Conservation of Art Objects
2. Tabriz Islamic Art University, Conservation Department

12.12 Pakistan

Hazara University, Mansehra

12.13 Qatar

University College London, in partnership with Qatar Foundation and Qatar Museums Authority, Doha, objects conservation

12.14 Turkey

Gazi University, Faculty of Fine Arts, Ankara, conservation department

13 Further reading

13.1 Essential literature

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13.2 Some important books on metal conservation in languages other than English

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14 Online magazines

- BROMECA Bulletin of Research on Metal Conservation

15 Metals conservation blogs

1. Armas protohistóricas con magnetita, by Jesús Alonso López
2. Conservation of metals - by Catia Viegas-Wesolowska
3. Staffordshire Hoard Blog

16 Free software that can be used for metals conservation

1. The Use of Expert Systems in Conservation
2. The Modular Cleaning Program
3. Download free conservators documentation software
4. Freecorp-simple corrosion prediction software
5. Online Cellular Automata based corrosion simulation

17 See also

- Conservation and restoration of outdoor bronze artworks
- Conservation and restoration of copper-based objects
- Conservation and restoration of ferrous objects
- Conservation and restoration of glass objects
- Conservation and restoration of ivory objects
- Conservation and restoration of ceramic objects
- Conservation and restoration of silver objects

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19 External links

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3. METALConsinfo (Metals Conservation Catalog subpage - including big collection of links //300 links!!!/)
4. Коррозионные разрушения археологического железа и методы его стабилизации
5. MEDAL project
6. UCLA metals course-archived presentations
7. Society for Historical Archaeology-Conservation FAQ and facts
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9. Development and Testing of Organic Coatings for the Protection of Outdoor Bronze Sculpture from Air-Pollutant Enhanced Corrosion — Year (2001-09)
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41. CCI Notes 9/3 The Cleaning, Polishing and Protective Waxing of Brass and Copper
42. CCI Silver Care and Tarnish removal
43. CCI Notes 9/8 Mechanical Removal of Rust from Machined Ferrous Surfaces
44. CCI Notes 9/5 Tannic Acid Treatment
45. Care and Conservation of Pewter
46. Conservation of lead sculpture
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79. Funcionalidad vs conservacion en piezas de orfebreria...
80. METAL 2010. proceedings
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82. Identifying Archaeological Metal
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84. Conservation Case Studies: A medieval tabernacle from Cologne
85. Cleaning treatment of a tarnished Daguerreotype by using the reducing afterglow of an atmospheric plasma
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90. Серебряный кратир из Новгорода отреставрируют лазером
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92. Metals in America's Historic Buildings - Uses and Preservation Treatments
93. Guidelines for the Storage and Display of Archaeological Metalwork
94. NHIG Conservation Principles for Heritage Forged and Cast Ironwork

20 Metals conservation video files

1. Conserving Bronze: The Lamp with Eros from Vani
2. Caring for Metals - Housekeeping for Historic Sites
3. USS Monitor Engine Removed from Water
4. Laser Cleaning of Bronze Eagle in Oak Park
5. Re-Constructing Silver Objects from the Staffordshire Hoard
6. Erik Risser Describes the Conservation of the Apollo Saettante at the Getty Villa
7. CoinScubber - Cleaning Ancient Coins
8. Cleaning an Outdoor Sculpture Part I
9. Parlament Wien, Quadriga, Restaurierung, Bronze
10. Dorure au mercure
11. Repatination of a Bronze WWII Memorial Plaque
12. how to care for bronze sculptures
13. Restoring an Artifact at the SCCRRMM
14. Clemson Conservation Center: H.L. Hunley submarine - Part 1/3
15. NCPTT Iron Fence Repair - Cemetery Monument Conservation
16. Restoration of the USS Monitor
17. Apoxyomenos de Croacia 5
18. Bronze Age Fibula
19. Masterclass -silverplating
20. Patina & corrosion surfaces on ancient bronzes
21. Campanas medievales limpieza criogenica
22. Restauro David Donatello
23. Cruz Parroquial de la iglesia de Santa María de la Asunción de Estepa (Sevilla)
24. Il nuovo intervento di restauro sui Bronzi di Riace
25. Il restauro della base originale del Cinghiale in Firenze
26. Restauración y conservación de los cañones de La Sabana
27. Conservation of iron artefacts at Jamestown
28. Cleaning the Staffordshire Hoard - K551 and K1775

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21.1 Text

- **Conservation and restoration of metals** *Source:* <http://en.wikipedia.org/wiki/Conservation%20and%20restoration%20of%20metals?oldid=646637769> *Contributors:* William Avery, Icairns, Tabletop, BD2412, Kolbasz, Bgwhite, Edgar181, Gilliam, Chris the speller, Paul venter, Cydebot, Magioladitis, Rivertorch, RichardMcCoy, Squids and Chips, Billinghamurst, Lamro, Bentogoa, Arjayay, SchreiberBike, ChrisHodgesUK, Heironymous Rowe, XLinkBot, Good Olfactory, Addbot, Ronschmidting, Yobot, Rose Daly, Bility, LilHelpa, Mathonius, Eugene-elgato, FrescoBot, John of Reading, Dewritech, ZéroBot, Rocketrod1960, Whoop whoop pull up, ClueBot NG, Gb777, DPL bot, Tovalu, Morning Sunshine, YFdyh-bot, AngelKelley, Mogism, Lliberopoulou, Argarico, Esteb83 and Anonymous: 247

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