LA FÉE AUX FLEURS: INVESTIGATION AND CONSERVATION OF A 19TH CENTURY OUTDOOR CAST IRON SCULPTURE

Jane C. Gillies*, Ingrid Seyb

Department of Conservation
Museum of Fine Arts
Houston
1001 Bissonnet St
Houston, Texas 77005
USA

*Corresponding author:jgillies@mfah.org

Abstract

A previously unattributed outdoor sculpture at the Rienzi House museum of European decorative arts in Houston required treatment for corrosion and lead paint mitigation. The sculpture was extremely corroded, with the base partially buried in soil, causing large pustules of iron corrosion and extensive failure of the oil-based top coats and red lead primer.

This piece was manufactured at the foundry of Val D'Osne, the premier cast iron sculpture foundry in France, in the second half of the 19th century. The artist, Mathurin Moreau, collaborated with the Val D'Osne foundry between 1849 and 1879.

Treatment involved the removal of multiple paint layers and experimentation with a range of non-caustic water-based paint removers to minimise exposure to both solvents and lead paint. The foundry mark was revealed during corrosion removal. Technical analysis included X-ray fluorescence and examination of paint cross sections. Reflectance transform imaging was used to enhance the visibility of the foundry mark and casting details. To minimise future build-up of paint layers, the sculpture was not repainted. Instead, a transparent thin layer of a commercial tannic-acid-based rust converter helped control corrosion and provided an even base layer. This was followed by a heated application of paste wax.

The interior surface had an insoluble layer of paint completely bound up with corrosion. Sand blasting to remove this was not an option, given the presence of lead. Future inspection and maintenance of the interior would be difficult in the garden environment, and action was needed to prevent staining of the planned granite base. The interior was therefore primed and painted with an industrial epoxy system designed to penetrate and bond together metal, corrosion and old paint layers, and which is tolerant of higher humidity levels.

The sculpture is now situated on a slightly domed granite base to allow for greater water run-off. It has been regularly inspected over the last year to monitor the stability of the surface coating. This revealed that the applied wax coating did not prevent corrosion initiation. A new wax coating containing the corrosion inhibitor benzotriazole proved effective on cast iron. With nearly a year of outdoor exposure the coating system has remained effective.

Keywords:
cast iron, Val D'Osne , French 19th century sculpture, tannic acid rust convertor, wax coating, outdoor sculpture, iron corrosion.

Introduction

The sculptures around the garden at Rienzi, a property of the Museum of Fine Arts, Houston, included an unattributed cast iron sculpture. It had been previously repainted multiple times (Fig. 1) and was in direct contact with soil which exacerbated corrosion. The paint, stained by the corrosion, was also flaking, exposing a red lead primer. The sculpture was taken out of the garden in 1996 and put in climate-controlled storage to prevent further deterioration. There it stayed until August 2011, when the decision was made to conserve it and put back in its original garden setting.

History

In correspondence with Eva Schwartz of Barbara Israel Antique Garden Ornament, an engraving of the sculpture was found in a catalogue of the Société Anonyme des Hauts Fourneaux du Val D'Osne, ca. 1867, with plates dated 1854 to 1867. The sculpture's title was ***La Fée aux Fleurs,*** and the sculptor was Mathurin Moreau (1822-1912). Two other surviving examples were located in Nice, France and Offida, Italy. The iconography is similar to other 19th century depictions of Flora and Zephyr.

Mathurin Moreau first studied at the École Nationale des Beaux Arts de Dijon in 1840 under Anatole Devosge (Mirollu, 1971), transferring to Paris in 1841 to study under Jules Ramey and Augustin Dumont. After winning a second place Prix de Rome prize in 1842, he finished his studies in 1848 with a Salon debut entitled ***The Elegy***. In 1852, ***La***

Figure 1 La Fée aux Fleurs, before treatment.

Fée aux Fleurs was exhibited at the Salon in plaster, and was then commissioned by the State in bronze. The bronze is now in the collection of the Musée des Beaux Arts de Dijon. Moreau received state commissions for sculptures for the Paris Opera, the Tuileries, the Hôtel de Ville and the Gare du Nord. His figure of Oceania, shown at the Paris World's Fair of 1878, was cast at the Durenne foundry and now sits outside the Musée D'Orsay. He was given the Legion of Honour in 1865. From 1849 to 1879, Moreau collaborated with the art foundry of Val d'Osne, seeing a financial opportunity in mass production of his designs, later becoming a director and administrator of the foundry (Mirolli, 1971; Wasserman, 1975).

Val D'Osne was the largest of a group of foundries in the Haute-Marne region, 300 km to the east of Paris (Chevillot, 2004). Through their success, metalworking and casting became the principal industry of the region in the fourth quarter of the 19th century. The foundry began production in bronze in 1836 under Victor André. From 1837 the foundry began to produce cast iron in a cylindrical, vertically stacked cupola furnace where the melt materials were in direct contact with the coke fuel causing high temperature carburisation and a resultant carbon content of 2-3 wt % without the sulphur in unrefined coal which would result in a cast iron too brittle to use. Production quickly rose to over 900 tons with the expansion of steam engines and water wheels to produce hot air to fire the blast furnaces. Cast iron sculpture production increased with the growth of industrialisation, taking advantage of economies of mass production, technical advances in the casting process, and the mechanical assembly of components, which combined to make cast iron a much cheaper alternative to bronze. As well as development of secondary fusion, sand casting cost less and was quicker to produce than lost wax casting in bronze. Alphonse Mengy, a student mining engineer, wrote an account of a visit to Val D'Osne in 1840, recording that the moulds were made from fine sand mixed with coal dust and then dusted with coal dust specially ground by a wheel, which allowed for easier separation of the mould (Mengy, 1840). By 1860 Val D'Osne was entering a period of dominance in cast iron sculpture.

Val D'Osne was particularly successful in Latin America, where, in the mid-nineteenth century, French style was the very definition of fashion (Dasques, 2004). The foundry exhibited at the Great Exhibition of 1851, the International Exhibition of 1862 at the Crystal Palace in London, the Paris World's Fair of 1855 and the Chicago World's Fair of 1893. In 1851, cast iron sculpture was exhibited with general metalwork, but by 1855 its status had elevated to be displayed alongside the bronzes (Chevillot, 2004). Cast iron's meteoric rise was followed by a slow decline caused by changes in fashion away from the Academic style, a desire for uniqueness over the mass-produced, and eventually by the diversion of iron production for armaments during World War I. Cast iron memorials were made after the war, but the material never fully recovered its fashionable status. Val D'Osne closed in 1986 and was demolished in 2011.

Description of Structure

The sculpture is 135 x 90 x 91 cm, and the weight is estimated at 300 kg. The central portion of the sculpture, cast in a single mould, comprises the female figure (not including arms) with a male putto projecting outwards from one side on a mound of vegetation over a domed base.

The construction of the figure is similar to the Bartholdi fountain in Washington DC restored by Robinson Iron, which was cast in fine sand moulds using 'pick out' patterns. Using this method, back-drafted areas on complex shapes could be picked out of the mould by hand (Howell, personal communication, 2013). The smaller components are fitted onto the larger figure with mechanical joints (tenon, sleeve and lap joints) and connecting iron rivets and screws (Fig. 2). The wings of the fairy have tenons which are secured with two rivets into projecting slots. The wings of the putto are attached with lap joints and two flat head screws. The arms of the fairy were cast separately and are attached with a sleeve joint around the upper arms. Each arm was also cast with a portion of the flower garland, with a third section of garland in between, connected with lap joints and screws. The XRF analysis at one of the arm joints showed a higher zinc peak, possibly corresponding to an alloy of zinc and lead (pot metal) which has been found used in sealing the joints of sculptures from this period (Howell, personal communication, 2013).

The sculpture is hollow, and would have been made with a central core requiring a support 'arbour'. There are square copper plugs which were brazed into the tops of both heads, filling holes left by the internal arbour for the core. There is a square section rod still fixed inside the cupid's body, corresponding to the dimensions of the hole in the head. Thin iron pins used as location marks for the inner and outer parts of the core were found attached to the interior. The only structural damage was a crack across the elbow to the proper left arm of the fairy.

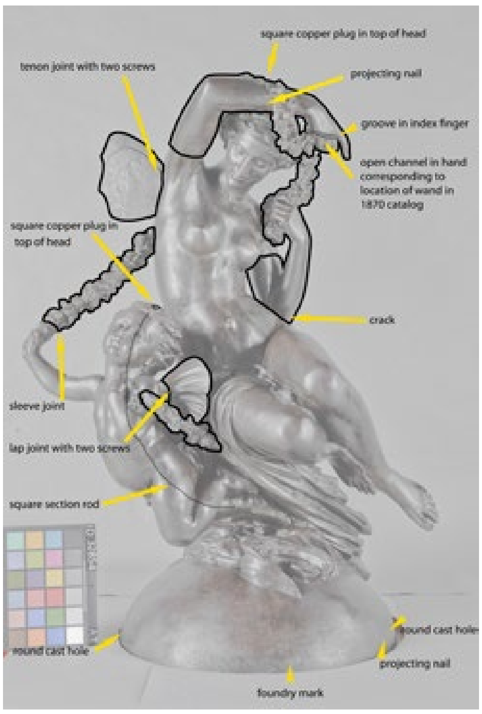

Figure 2
Details of the components.

The raised foundry mark 'VAL DOSNE' was found under the paint layers at the front edge of the domed pedestal (Fig. 3). There is a round hole through the proper right hand and cast depressions in the first finger which could have held the wand which is depicted in the catalogue engraving but has not been found in any of the surviving examples. The cylindrical hole on the hand passes through the thickness of the cast to the interior. On either side just above the bottom edge are two round holes, 1.7 cm in diameter, which pass through the thickness to the interior.

Figure 3
Two of the images of the foundry mark captured during RTI.

Treatment

Removal of Previous Coatings

Although conservation ethics generally prioritise the preservation of the surface of an object when some element of it may be original, the corrosion on ***La Fée aux Fleurs*** was too severe to consider such an approach in an outdoor installation. Clear coating of cast iron sculptures on top of failing paint has been suggested (Seiplet et al., 1998), but no such case studies were found during research. The corrosion under the paint layers would potentially reactivate as soon as the clear top coat began to fail, causing more rapid corrosion overall, and the poor adherence of any top coat to a failing and irregular paint layer would speed this inevitable process significantly. Some conservators prefer to leave a red lead primer on outdoor sculpture when removing a failing paint layer, as red lead often has better adhesion to the surface than modern primers (Lodge, 2013). In this case, the large areas of loss in the red lead and the impossibility of restoring those areas with a similar material made removal of the primer a necessity.

After mechanical removal of the large corrosion pustules on the base with a chisel (Fig. 4), a variety of options for coating removal were explored. The toxicity of lead severely limited the choices, as all cleaning by-products would have to be contained for proper disposal. Therefore air abrasives, dry ice blasting, power washing, dry scraping and vacuuming up of residues were all out of the question, leaving only chemical stripping. The following low-toxicity paint removers were tested: MasonRE S-301, S-303, S-305, PeelAway 6, PeelAway 7, and SmartStrip Pro. The most effective was MasonRE S-305, with benzyl alcohol, triethanolamine and hydrogen peroxide as the active ingredients. The product is designed to be sprayed; brush application was problematic, as the low viscosity resulted in the stripper sliding off vertical surfaces, and at least three applications were needed. The removal of the paint revealed fine detail in the modelling, most noticeable in the wings (Fig. 5). Filling in this detail again with thick paint layers was an unattractive proposition.

Figure 4
Detail of base before treatment (a) and after treatment (b).

The residues left by chemical stripping were reduced by such methods as spraying with water in hand-held spray bottles, wiping down with rags and collecting the runoff in rags for disposal. Nylon scrubbing pads, toothbrushes, bamboo skewers and scalpels were all used, keeping the surface wet while working to prevent lead dust becoming airborne, but the problem of residual lead trapped in the porous surface remained. A perfectly clean corrosion-free iron surface could not be achieved.

Selection and Application of New Coatings
The 2010 study of rust converters by the National Center for Preservation Technology and Training found that, in an accelerated weathering test, Rust-oleum's Rust Reformer™ product can be highly effective at protecting steel (Church, 2010). Rust Reformer™ contains less than 5 wt % tannic acid, under 15 wt % barium sulphate, an insoluble transparent filler and an acrylic vinylidene chloride copolymer barrier coating. The tannic acid converts the iron oxides to more stable ferrous tannate which oxidises to a strong, compact blue-black. The black colour can significantly improve the appearance of the surface. Undiluted, this resin gave the object an unattractive 'plastic' appearance and was prone to show brush marks. A better surface look was achieved by diluting the Rust Reformer™ by 50 % with distilled water. This solution was then brushed and sponged onto the cast iron, wiping the excess with a cotton rag, and repeating to slowly build-up a rich, even layer. Areas of remaining lead primer residues, notably the domed base where the rust and primer were interwoven, interfered with the tannic acid's blackening effect, leaving some patches noticeably red.

The standard treatment for outdoor cast iron is paint, often applied over a rust converter. Although black paint, to mimic patinated bronze, or white, to mimic marble, were the most common original coatings for 19th century cast iron, neither was found on the Moreau figure. Determining the original paint colour of the sculpture proved quite difficult, as most of the paint cross-sections showed only the light green-blue, used for all of the house's architectural ironwork, on top of the red lead primer. This suggests that the original paint had been stripped, but the primer left on. However, one of the samples from the interior of the base contained intermediate layers of a black material containing ground metal. It is possible that this is a so-called 'bronzed' finish mentioned in such primary source material as the catalogue of the 1851 Great Exhibition in London (Ellis, 1851).

Future maintenance was the primary consideration in choosing a new coating for the sculpture. An opaque coating on the sculpture would obscure formation of corrosion underneath and would be harder to remove. Given the imperfectly clean surface, re-treatability was a more desirable quality than absolute longevity under laboratory conditions. The prospect of painting the object and installing it in the garden, and then having the coating fail in a few years, requiring de-installation and re-treatment, did not appeal. A coating which could be reliably maintained for years without requiring removal was therefore preferred. Experience with the variety of coatings in the museum's sculpture garden (lacquers, waxes, and paints) led to a preference for wax. The waxes have been found to be much easier to maintain given the lack of a suitable location for the large-scale use of solvents for coating removal. The ability to heat the wax and reapply, incorporating the new layer into the old, is of significant help when all maintenance must be done ***in situ***. Conservation literature agrees that wax oxidises over time, resulting in an increasingly permeable coating (Considine et al., 2010), but the ease of use has meant in practice that the museum's waxed outdoor sculptures have been better protected than those without wax.

While paint is standard, there has been some research into wax coatings for iron and steel (Conrads, 2008; Hallam et al., 2004; Shashoua et al., 2007; Seipelt et al., 1998). Storch (2006) used a tannic acid-based rust converter, containing an ethylene vinyl acetate resin emulsion followed by a top coat of carnauba wax, on two cast iron bells belonging to the Lac Qui Parle Mission Historic Site in Montevideo, Minnesota. Although not a direct comparison – the bell tower provides a cover – the coating has survived with only one minor maintenance treatment since 2006 (Storch, personal communication, 2013).

Figure 5
Detail of female figure's proper right wing before (a) and after treatment (b) and RTI (c).

Most of the bronzes in the museum's sculpture garden have been coated since the 1980s with a mix of waxes formulated by Robert Pringle. This mixture of Minwax Paste Finishing Wax (a blend of natural waxes) with Renaissance Wax (containing microcrystalline and polyethylene wax) has proved reliable in Houston. This mixture was applied to the Moreau sculpture by brush, warming with a small propane torch and a heat gun to melt the wax into the surface. As it cooled, the wax was buffed to a shine with cotton cloths. The crack in the arm and openings to the interior were filled with 'sticky wax' which allows for expansion and contraction in the metal.

The interior of the sculpture had been primed and painted only in the domed base, and was unpainted above. The corrosion in both painted and unpainted areas was significant, and chemical stripping of the interior of the base had been unsuccessful. The corrosion was so intimately bound with the paint, primer and the core residue that the lead primer proved impossible to remove without first removing the corrosion. Most of the interior was not accessible for treatment and if left un-addressed, interior rusting would cause staining of the base very quickly after installation. A local coatings company, J.E. Titus & Co., was contracted to apply a penetrating primer and epoxy paint system, leaving the paint residues and corrosion in place. Firstly the sculpture was turned on its side, and the interior power washed. After drying, the interior and the bottom edge were brushed with Carboline Rustbond Penetrating Sealer™, a two-part thixotropic polymeric epoxy amine primer and tie coat used for marginally prepared surfaces, followed by two coats of Carboline Carbomastic 15™, an aluminum pigmented epoxy mastic paint. The following week, when the sculpture was righted and returned to the museum, it was found that moisture had been held against the surface where it was braced with Ethafoam while horizontal, and spots of corrosion had appeared. A reapplication of the wax mixture and carbon black pigment was made in some areas, particularly to the domed base, for aesthetic reasons (Fig. 6).

Installation and Maintenance

In August 2012 the sculpture was installed on its granite base with four Neoprene blocks to raise the sculpture slightly for drainage and air circulation. The quarter-inch Neoprene quickly compressed and was replaced with half-inch chemical-resistant polyethylene rubber. Returning to the site two weeks after installation, it was found that irrigation sprinkler heads were trained directly onto the sculpture and corrosion was reappearing, most noticeably on the fairy's lap and the domed base.

After requesting the sprinkler heads be adjusted and waiting for a dry day, a new layer of wax, formulated by Art Research and Technology and containing benzotriazole, was applied. Although benzotriazole is mostly used by conservators as a corrosion inhibitor for copper and its alloys, there is evidence that it can also be effective on iron and steel (Matheswaran and Ramasamy, 2010). The sculpture has been examined bi-monthly since the application of the ART sculpture wax. The only deterioration observed was in the form of faint silvery magnetite spots. These were easily treated with local reapplication of the ART wax.

Conclusion

The treatment requirements were low-cost, low-maintenance, ease of re-treatability, visual preservation of detail and aesthetic success. The treatment has been monitored over the course of a year, providing field test confirmation of Church's (2010) method when applied to a thin layer of rust. The heated application of paste wax helped mitigate the effects of residual lead primer. With nearly a year of outdoor exposure, a wax coating containing the corrosion inhibitor benzotriazole has remained effective.

Acknowledgements

The authors would like to thank colleagues Maureen Eck for imaging and Melissa Gardner for XRF analysis, Ken Whitmire (Rice University) and Cory Rogge (Buffalo State College).

Materials and equipment

Carboline Carbomastic 15: modified aluminium epoxy mastic Product data Mar 2007 Carbomastic Rustbond: polymeric epoxy amine primer Product Data Mar 2006 350 Hanley Industrial Court, St. Louis, MO 63144, USA. Tel: +0(314)64- 1000 Fax:+01(314)644-4617 website: www.carboline.com

Chemical –resistant polyethylene rubber, McMaster-Carr, 6100 Fulyton Industrial Blvd SW, Atlanta GA 30336, USA. Tel: +01(404)346-7000. email:atl.sales@mcmaster.com

J.E.Titus Co., Industrial and Commercial painting contractors, 10425 Moers St., Houston TX 77075, USA. Tel: +01(713)991-1100. Fax: +01(713)991-1104. email:jetco@cyberbay.net

MasonRE S-301: Benzyl alcohol, water, thickening agent methyl cellulose General purpose paint stripper; MasonRE S-303: Light duty paint stripper plus triethanolamine; MasonRE S-305 Heavy duty paint stripper plus hydrogen peroxide, Cathedral Stone Products, Inc. 7266 Park Circle Drive, Hanover MD, 21076, USA. Tel: +01(410)782-915 Fax: +01(410)782-9155 website: www.cathedralstone.com

Figure 6 After treatment.

Minwax Finishing Wax, Sherwin Williams, Upper Saddle River, NJ 07458, USA Tel: 800-523-9299 website:www.minwax.com

Peelaway 6,7 and Smart Strip PRO , Dumond Chemicals, Inc. Corporate office, 83 General Warren Blvd., Suite 190 Malvern, PA 19355, USA. Phone: +01(609)655-7700 Fax: +01(609)655-7725 email: info@dumondglobal.com

Renaissance microcrystalline wax polish, Picreator Enterprises Ltd. 44 Park View Gardens, London NW4 2PN, UK. Tel: +44(0)20 8202 8972. Fax: +44(0)8202 3435. email: info@picreator.co.uk

Rust reformer, Rust-Oleum Corporation, 11 Hawthorn Parkway, Vernon Hills, IL 60061 USA. Tel: +01-847-367-7700 website: www.rustoleum.com

Scotchbrite: 7447 General purpose hand pad Maroon Non-woven nylon/polyester, aluminum oxide spun polypropylene, 7445 White light duty hand pad aluminum silicate 3M, 3M Center, St. Paul, MN 55144, USA. Tel :+1(800)364-3577

Sculpture wax, Art Research and Technology, 3050 Industry Drive, Lancaster, PA 17603, USA. Tel: +01(717)290-1303 Fax: +01(717)290-1309 email: email@thinksculpture.com

References

Argyropoulos, V., Charalambous, D., Kaminari, A., Karabotsos, A., et al., 2007. Testing of a new wax coating Poligen ES 91009R and corrosion inhibitor additives used for improving coatings for historic iron alloys. In: C. Degrigny, R. van Langh, I. Joosten, B. Ankersmit, eds. ***Metal 07: Interim Meeting of the ICOM-CC Metal Working Group, 17-21 September 2007,*** Rijksmuseum, ***Amsterdam.*** Volume I5: ***Protection of Metal Artefacts***, pp.10-15.

Binnie, N.E., Selwyn, L.S., Schlichting, C. and Rennie-Bisaillion, D.A., 1995. Corrosion protection of outdoor iron artifacts using commercial rust converters. ***Journal of the International Institute for Conservation, Canadian Group,*** 20, pp.26-40.

Chevillot, C., 2004. Cast-Iron Sculpture in Nineteenth-Century France. ***Artes de México***, 72, pp.10-21.

Church, J., Muto, A. and Striegal, M., 2010. Comparative Study of Commercially Available Rust Converters. ***Architecture Session, American Institute of Conservation 39th Annual Meeting***. Philadelphia, June 3 2010, unpublished.

Conrads, M., 2008. Transparente Beschichtungsstoffe zum Schutz von Kulturgütern. ***Materials and Corrosion,*** 59(3), pp.232-238.

Considine, B., Wolfe, J., Posner, K. and Bouchard, M., 2010. ***Conserving Outdoor Sculpture: The Stark Collection at the Getty Center.*** Los Angeles: The Getty Conservation Institute.

Dasques, F., 2004. Laboratory of Echoes: Decorative Metal Arts in France and Mexico. ***Artes de México***, 72, pp.24-49.

Ellis, R., 1851. ***Official Catalogue of the Great Exhibition of the Works of Industry of All Nations, 1851.*** London: Spicer Brothers.

Hallam, D., Thurrowgood, D., Archer, E., Otieno-Alego, V., et al., 2004. Studies of commercial protective coatings on ferrous surface of historical and museum objects. In: I.D. MacLeod, J.M. Theile, C. Degrigny, eds. ***Metal 2001: Proceedings of the International Conference on Metals Conservation, Santiago, Chile 2-6 April 2001.*** Perth: Western Australian Museum, pp.297-303.

Howell, J.S. (2013) 'VP General Manager, Robinson Iron, Alexander City Alabama'. ***Discussion of sand casting methods.*** (Personal communication, March 2013).

Howell, J.S., 2004. Bringing back the magic: restoring Giuseppe Moretti's ***Vulcan*** in Birmingham, Alabama. ***APT bulletin***, 35(2-3), pp.27-31.

Lodge, R., 2013. ***A history of "Calder Red" color and its paints in the United States in relation to the recoatings of Alexander Calder's Flamingo (1973) and La Grande Vitesse (1969) and other Calder stabiles.*** (Personal communication, 11 January 2013).

Matheswaran, P. and Ramasamy, A.K., 2010. Influence of Benzotriazole on Corrosion Inhibition of Mild Steel in Citric Acid Medium. ***E-Journal of Chemistry***, 7(3), [online] Available at: < http://www.hindawi.com/journals/chem/2010/598025/abs/> [Accessed 1 March 2013].

Mengy, A., 1840. ***Memoir on the cast moulding plant Osne Val (Haute-Marne), followed by a notice on a recent change in the treatment of iron ore in blast furnaces***. No.264, Library of the School of Mines, Paris. Available at: < http://www.fontesdart.org/ressources-documentaires/bibliotheque-en-ligne/de-la-metallurgie-ancienne/306-memoire-de-visite-au-val-dosne-en-1840-par-mengy> [Accessed 1 March 2013].

Mirolli, R., 1971. ***Nineteenth century French sculpture: Monuments for the middle class***. Louisville: J.B.Speed Art Museum.

Mottner, P., Roemich, H., Pilz, M., Brueggerhoff, S. and Kiesenberg, J., 2004. Investigations of transparent coatings for the conservation of iron and steel outdoor industrial monuments. In: I.D. MacLeod, J.M. Theile, C. Degrigny, eds. ***Metal 2001: Proceedings of the International Conference on Metals Conservation, Santiago, Chile 2-6 April 2001.*** Perth: Western Australian Museum, pp.279-288.

Société Anonyme des Hauts-Forneaux, Fonderies et Aciéries du Val d'Osne, ca.1867. ***Hauts fourneaux & fonderies du Val d'Osne: Ornements en fonte de fer.*** Paris: Fourment, Houille & Cie.

Scott, D.A. and Eggert, G., 2009. ***Iron and Steel in Art: Corrosion, Colorants, Conservation.*** London: Archetype Publications.

Seipelt, B., Pilz, M. and Kiessenberg, J., 1998. Transparent coatings - suitable corrosion protection for industrial heritage made of iron?' In: W. Mourey, L. Robbiola, eds. ***Metal 98: proceedings of the International Conference on Metals Conservation, Draguignan-Figanières, France, 27-29 May 1998***. London: James & James, pp.291-296.

Shashoua, Y., Taube, M., Holst, T., Modewegsvej, I.C. and Lyngby, B.K., 2007. Protection of iron and steel in industrial heritage objects. ***Corrosion Engineering Science and Technology***, 59(5), pp.357-361.

Storch, P., 2006. The Conservation of Two Cast Iron Bells at the Lac Qui Parle Mission Historic Site. ***Minnesota Historical Society,*** [online] Available at: <http://www.mnhs.org/preserve/conservation/reports/iron_bells.pdf> [Accessed January 25 2013].

Wasserman, J.L., 1975. ***Metamorphoses in Nineteenth-Century Sculpture***. Cambridge: Fogg Art Museum.