

# A TALE OF TWO CRANES

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The Sydney Harbour Bridge is an internationally recognised Australian landmark. The distinctive 'coat hangers' of the bridge also served as rails for four cranes to traverse the structure. These cranes were used for construction of the arches between 1928 and 1932, and then for maintenance of the bridge until they were decommissioned in 1997. Heritage approval for their removal from the bridge was conditional on the conservation of two representative examples, with at least one to be put on permanent public display. The remaining two cranes were scrapped.

In recognition of the national significance of the bridge, the history and folklore surrounding its construction and maintenance, including its never-ending painting, the National Museum of Australia (NMA) acquired one of the remaining cranes from the NSW Roads and Traffic Authority (RTA) in 2007. This example was 'conserved' for the RTA by International Conservation Services (ICS) according to a treatment plan designed by the NMA and ICS to retain as much of the original fabric as possible, including its many layers of lead paint. By contrast, the second remaining crane, intended for outdoor display in a public park below the bridge, was 'restored'. The works, which included sandblasting and repainting with a modern non-lead paint, were undertaken to allow the materials to withstand permanent outdoor exposure.

In mid-2011, despite already owning one of the two remaining cranes, the NMA received the second on loan from the RTA in order to display it in the external forecourt of the Museum. The decision was taken not to display the Museum's own minimally conserved crane because the need for further treatment to comply with health and safety regulations associated with lead paint and other parts of the structure would have seriously compromised important aspects of the historic and technical significance for which it had been acquired and conserved.

This paper is an account of both treatment approaches and the rationale underlying them.

## THE SYDNEY HARBOUR BRIDGE CRANES: HISTORY AND SIGNIFICANCE

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The Sydney Harbour Bridge, a single-arch steel bridge that connects Sydney to North Sydney, was constructed between 1924 and 1932. The state, national and international significance of the bridge's construction in Depression-era Sydney, the drama of its opening and its importance as an iconic Australian structure have been thoroughly established through major historical studies (Spearritt 2007, Mackaness 2006). The cranes have also been the subjects of

several heritage reports and these formed the basis of the NMA's significance assessment. The cranes have had many names, including 'travelling maintenance cranes', 'gantry cranes', 'painting cranes', 'arch cranes', 'travelling cranes', 'arch maintenance units', 'travelling jib cranes'. In this paper we will use the term 'travelling maintenance cranes' as applied in the "Sydney Harbour Bridge Travelling Maintenance Cranes Assessment of Cultural Significance" (Travis *et al* 1989). Our approach to the treatment of the cranes was informed by this significance, as well as the particular histories of the travelling maintenance cranes (Department of Public Works and Services 1997, RTA Operations Environmental Technology Branch 2003, RTA 1997).

Four ‘travelling maintenance cranes’ were installed on the bridge in mid-1930. The cranes moved up and down the arches of the bridge, enabling workers suspended on maintenance stages, or gantries, to construct and then paint and maintain the structure. The cranes were in service until 1997 when they were removed from the bridge and replaced by modern cranes that met higher OH&S standards. The cranes were a familiar part of the Sydney skyline for 67 years, as Sydneysiders tracked their progress over the bridge that was, according to legend, painted continuously (Figure 1 – from State Records NSW [http://investigator.records.nsw.gov.au/asp/photosearch/photo.asp?12685\\_a007\\_a007\\_04\\_8733000077r](http://investigator.records.nsw.gov.au/asp/photosearch/photo.asp?12685_a007_a007_04_8733000077r)).



**Figure 1 |** Painting Crane on East Top Chord [during construction of the Bridge, 11 Dec 1931].

According to Mackaness (2007):

*‘The steelwork was thoroughly painted during fabrication and erection with a number of coats of lead primer being applied to all surfaces of the members. Two further top coats of ‘bridge’ grey paint, also with a high lead content, were applied on site. Strategies of spot repair and overall painting have continued ever since, although health and safety standards have promoted different working methods and paint compositions more recently.’*

Heritage approval to remove the cranes from the bridge in 1997 was conditional on two “representative examples” being “conserved” and “one being placed on public display” (Department of Public Works and Services 1997). The RTA approached the Powerhouse Museum in 1997 and 2007 but it declined to acquire a crane. The National Museum of Australia agreed to add a conserved crane to its national historic collection in 2007. Another was sandblasted and repainted in preparation for possible

outdoor display in a park below the bridge. The other two cranes were scrapped.

When the cranes were removed from the bridge, the crane arms were cut off and the chains, cabling and other associated gear placed on top of the platforms. They were then taken to the RTA’s Rockdale depot where they remained for 11 years. After sitting out in the weather for this time they showed signs of rust, paint flaking and water-affected wood.

Nevertheless, senior NMA Conservation staff advised, on initial inspection, that the objects were not unstable. Whilst the cranes appeared in a disordered state, they were largely complete.

The NMA selected the most intact crane along with a complete set of gantries, engines, cabling, tools and other associated equipment, as well as documentary collections including oral histories of former crane workers.

## THE CASE FOR ACQUISITION BY NMA

At the time of the offer it was not envisaged that one of these cranes would be on public display in the current NMA museum building. It was possible that it might be shown in a display store or in a large technology display facility – taking into consideration the challenge of orienting visitors to an object designed to travel along an arch.

While its immediate display potential was limited, the curatorial team argued that the crane offered the opportunity to give visitors a sense of the scale and character of the Sydney Harbour Bridge otherwise only available by being on the bridge itself. In this

sense, the crane is unlike any other object associated with the Sydney Harbour Bridge in a museum collection anywhere in Australia. It represents part of the intact, original fabric of the structure yet structurally distinct enough and small enough to be removed. It was doubtful that any other object with this kind of presence and long association with working life on the bridge would ever become available, so finding a way to preserve the crane's visual integrity and evidence of its long working history became paramount.

In addition to its historical significance, the research potential of the crane was high. Analysis of the surface of the object could allow the museum to identify the major changes in paint technology and application over the twentieth century, including broader issues associated with safety and environmental impacts. Given that in 2006 the bridge was completely repainted, a process that included the removal of previous layers of lead-based paint, the cranes may represent one of the few places where this paint record remains. Close investigation of the object would also reveal aspects of 1920s and 1930s engineering and construction in both Australia and Britain, and working conditions for Australian maintenance workers from the 1930s to the 1990s.

The acquisition process included vigorous discussion within the NMA of the practical issues and costs associated with the crane's exhibition potential, storage requirements and potential safety risks.

## Safety concerns: Lead-based paint and its management

While the lead-based paint applied to the cranes, and by bridge workers using the cranes, was central to the story and significance, it also presented a challenge for the cranes' preservation, storage and display.

Lead in the form of its various oxides has been used as a key ingredient in industrial paint primers for more than 100 years due to its excellent ability to protect steel from corrosion.

These primers were found to be particularly tolerant to minimal surface preparation; plus lead pigments were versatile and low cost. Lead can also be present

in paint in the form of white pigments prior to the introduction of titanium dioxide, and as a drier for oil-based coatings but it is then found at much lower concentrations (van Alphen 1998). The widespread use of lead paints continued until the early 1980s when concerns about lead paint toxicity and the advent of less toxic protective coating



**Figure 2** | Condition of crane before treatment.

systems significantly reduced their usage. Many industrial structures throughout Australia are painted with lead paint systems and, while these systems remain intact, they are considered to present no significant health hazard or environmental pollution hazard. Generally a hazard is created when painted surfaces have deteriorated by cracking or blistering, allowing the lead within the paint to become airborne and/or ingested.

Lead can be toxic to humans when ingested, inhaled or absorbed. Repeated exposure to lead-containing paint particles may produce the cumulative effects of lead poisoning (plumbism). A relatively lesser intake

may adversely affect a child's mental and emotional development. The most common pathway of childhood lead exposure is through ingestion of lead dust through normal hand-to-mouth contact during which children swallow lead dust dislodged from deteriorated paint (Standards Australia 1995).

The Australian Standard 4361.1-1995 *Guide to Lead Paint Management* and the National Occupational Health & Safety Commission *National Code of Practice for the Control and Safe Use of Inorganic Lead at Work* (NOHSC:2015(1994)) state that exposure to lead should be either prevented or, where that is not practicable, adequately controlled so as to minimise risks to workers and the public, and pollution hazards to the environment.

Following the protocol established by AS4361.2:1998 the priorities for action when attending to lead-based paint materials are:

- **Leave in place** lead-based paint if it is in good condition, out of reach of children and not likely to be damaged or deteriorate due to wear and tear.
- **Paint over** lead-based paints to seal and protect from deterioration. Where lead-based paint is found to be in deteriorated condition it must be adequately sealed to prevent flakes, particles or dust containing lead from being released.
- **Replace components** if they are painted with deteriorating lead-based paint with new materials.
- **Remove** and completely replace lead-based paints using safe methods of management and disposal whenever none of the previous responses is appropriate.

### Risk assessment: Lead-based paint and its management

A heuristic risk analysis was undertaken by the Museum and concluded the risk of a staff member or volunteer developing lead poisoning as a result of handling or treating the Sydney Harbour Bridge crane was low provided the Museum took appropriate safety precautions. Stable and intact red lead primer, white lead paint, and other hazardous materials (PCBs, asbestos) were to be left intact and

managed as part of the Museum's ongoing hazards management strategy. Access to the crane was to be restricted to collection management staff trained in hazard awareness and mitigation.

## PRELIMINARY WORKS TO BOTH CRANES

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Although the cranes had been at the RTA depot, outdoors and exposed to the elements for 11 years, the preliminary work was seen to be actively disturbing the unstable hazardous fabric, in particular the flaking lead paint. The risk of further air and soil pollution was considered high, and all means were taken to prevent and contain any further environmental contamination. Before any conservation works could commence or the cranes be transported to the treatment workshops it was a requirement that the lead hazards had to be identified and contained.

ICS employed lead paint and asbestos removal crews, highly experienced in the handling and management of hazardous materials. They erected the appropriate safety hoarding to contain any hazards within the area, carried out regular air and soil monitoring for contamination throughout the duration of the project, and employed the appropriate level of personal safety equipment, including mobile wash stations. Contaminated items were dealt with by licensed disposal facilities with certified disposal methods.

Working on a large industrial heritage item, at various locations presented a number of challenges. Prior to transport it was a requirement that the cranes were wrapped – this was a difficult scaffolding procedure in an area with restricted access. The logistics of moving an item of such scale involved various lifting and vehicle movement plans, as well as skilled operators with lifting certifications, appropriate licences and qualifications to carry out the work. In addition to this, because of the height, weight and its classification as a 'wide load' item, the cranes could only be transported at limited and very specific times and through certain routes.

# CONSERVATION OF THE TWO CRANES

The conservation methodology for the two remaining cranes was driven by two main factors:

1. That one of the cranes be placed on public display (as a condition of removal); and
2. That the second crane (acquired by the NMA) retain its evidence and history of use as a critical component of its significance.

For the purposes of this paper, the two treatments have been identified as “the NMA approach: preservation”; and “the RTA approach: restoration”.

## The NMA approach: Preservation

The NMA treatment was based on a minimal intervention approach, yet within the guidelines of AS4361.1, where as much of the original fabric of the crane as possible was retained, including stable paint deemed not to be a hazard. It had been established the crane was to be stored indoors in a relatively stable environment (Canberra has average low humidity) therefore further degradation of paint and metal would be slow. The crane would be managed

and maintained in a restricted collection area by professional, trained collection staff.

The initial treatment proposal was specified by NMA Conservators, who then worked with ICS and RTA staff on implementation. The treatment undertaken included:

- Preliminary removal of plant material and debris (accumulated over 11 years of outdoor exposure) undertaken by sub-contracted lead and hazardous materials removal specialists.
- Wrapping with 25µm plastic stretch film to ensure all hazardous substances were contained for transport.
- Lifting, loading and transport to offsite specialist facilities
- Controlled removal by light water blast of any further unstable lead paint; some red lead paint remained, but was considered stable enough to retain as is.
- Treatment of exposed iron corrosion with tannic acid.
- Light wash of interior cabin and timber surfaces using sugar-soap solution.



Figure 3 | NMA Motor controller box pieces before and after treatment (mounted on new timber frame).

- Retention of all original material, including original lead paint finishes, stabilised asbestos putty in cabin, damaged window glazing, damaged timber machine and electric covers, gantry timber flooring, etc. Damaged glazing was removed from

the cabin for transport, but retained, wrapped and stored in the cabin. Also retained were original timbers from the traverse motor controller on the front of the crane. The partially rotten and incomplete timbers were mounted on a new frame, using non-penetrating temporary fixings. This solution served to both conserve and aid interpretation of the items.

- Retention of all loose or damaged original elements including original operator hand tools.
- Design, fabrication and trial installation of new jib pins. New jib pins were provided to the same design and specifications as the restored crane (see RTA approach below), the originals having been cut with oxyacetylene and rendered irreparable.
- Design and fabrication of support trolley and crane cover for storage.
- Production of measured drawings for archival purposes.

## The RTA approach: Restoration

The display plans for this crane included permanent outdoor display. After treatment the crane needed to be able to withstand exposure to sun, wind, rain, salt and high relative humidity. With the crane to be outside for many years the treatment methodology took into account the protection of the components against further deterioration, public access, ongoing maintenance costs and frequency of maintenance. For the RTA crane the overall appearance, public interpretation and the suitability or protection of the various materials for outdoor display were priorities.

Treatment of the RTA crane for long-term display included:

- Preliminary removal of plant material, debris and asbestos undertaken by sub-contracted lead and hazardous materials removal specialists.
- Wrapping as per 'conserved crane' to ensure all hazardous substances were contained for transport.

- Lifting and transport to offsite specialist facilities for repainting of all elements.
- Controlled removal of both original paints and hazardous materials, including lead-based paint by abrasive blasting (removed to AS Class 2½ grey metal, paint contained with custom-made enclosure in canvas tarpaulin); and paint stripper (PeelAway 1, collected and disposed of in EPA certified facility).
- The crane was then repainted (all exterior elements) with a protective coating rated to outdoor exposure. An epoxy zinc primer (75µm thickness), intermediary coating (epoxy intermediate, 125µm thickness) and two-pack epoxy/polyurethane micaceous iron oxide (MIO) topcoat (150µm thickness) was applied. A MIO in "Bridge Grey" was selected to replicate the original colour.
- Cleaning of interior cabin and timber surfaces by light water blast to remove loose paint.
- Fabrication of new machine covers, replicating the form of originals using painted steel sheet.
- Waterproofing of cabin roof (as this crane was expected to be on permanent outdoor display) by application of strip membrane at joins of sheet metal roof.
- Replacement of damaged parts (window glazing, expanded mesh chassis floor).
- Removal of original timber gantry floorboards, replacement with new waterproofed timber boards.
- Design and fabrication of new jib pins.

With an understanding that this crane would eventually be reassembled and used for public display, ICS aimed to provide new replicated elements for the crane that were up to current building standards, while at the same time representing the original.

The equipment housing on the back of the crane required replacement as the original could not be repaired to withstand outdoor exposure. The new housing was fabricated from steel sheeting (rather than timber plywood as per the original) for long-term durability. The dimensions were taken from equipment housing located on another crane, therefore enabling a representative housing to be fabricated.

New jib pins (used to erect the jib in place at the chassis) were required as the originals were cut during decommission and removal from the Bridge. During the treatment process, it became apparent that due to the configuration of engine and rotary parts on the chassis, the jib pin could not be reinserted as a single-piece unit without in turn dismantling much of the cabin and chassis. A new design involving a three-piece jib pin was developed and certified by structural engineers to ensure that it would be structurally adequate for anticipated jib loadings. Drawings and certifications were obtained for new jib backstrap fishplates, also required for future re-assembly.

## INTERPRETATION & DISPLAY

The decision to display one of the cranes was determined early on in the project, when the conservation strategy was being developed. An interpretation strategy was prepared by ICS so that the full potential of the crane as a significant heritage item for public appreciation could be realised. The plan to display the crane within the vicinity of the Bridge encouraged the visual connection between the two items. The crane, and accompanying interpretation would have been mounted as a piece of industrial heritage for display. The proposals were put forward to the local community, who struggled to see the visual attraction of a piece of industrial heritage, installed in a picturesque area such as Bradfield Park. Eventually, the plan to install one of the cranes, which would have been placed under the care of North Sydney Council and retained the association with between crane and Bridge, was rejected.



**Figure 4** | RTA equipment housing before and after treatment.

## Redevelopment of the NMA Forecourt and Main Hall

In 2010 the NMA began discussing ideas for redevelopment of the Museum's forecourt and main hall. For the first time this opened up the possibility of display of large objects that had previously had limited display opportunities due to their size. One proposal included putting the NMA's Sydney Harbour Bridge crane on exterior display at the entrance to the Museum.

As outlined, the NMA crane has lead based paint, degraded asbestos putty, exposed metal surfaces, exposed wood surfaces and exposed cabling (possibly including PCBs). Lead, asbestos and PCBs are all known hazards that need to be managed in accordance with relevant standards and codes of practice. The regulations require that these hazards be removed, or where that is not practicable, controlled to minimise risks to staff and the public.

Again, from a simple heuristic risk assessment it was clear

that outdoor exposure of the crane would rapidly accelerate lead-paint and asbestos degradation. Since display of the crane at the entry to the Museum at Acton would expose staff and public (especially children) to hazards such as lead and asbestos these hazards would need to be removed or completely

sealed. The situation, and therefore the risk, was completely different from an indoor storage environment with tightly controlled access.

To meet regulatory requirements and allow the conserved NMA crane to be placed on outside display, further treatment works would have to occur including the application of a protective coating to all metal and wood surfaces. A number of options were

considered and their implications for the integrity for the object were explored. These options included:

### Remove asbestos putty and lead paint

- Strip and remove the original paint and asbestos putty.
- Repaint with an exterior grade paint system with top layers of micaceous iron oxide to match 'bridge grey'.
- Replace the asbestos window putty with a modern synthetic material.

All wood and metal surfaces would need to be covered with paint to provide them protection. The benefits of this approach are the reduced risk of lead exposure to the public and the modern

exterior grade paint system that should provide protection for around ten years. However the complete removal of one of the most significant components and the aesthetics of a continuous modern (and fresh) paint system would compromise important historic and technical aspects for which



**Figure 5** | Cable drums with missing jib pins before treatment (top) and with new stainless steel jib pins installed after treatment (bottom – note jibs not yet installed pending relocation for display).



the crane had been acquired. This treatment would be similar to that undertaken by the RTA. If the museum's goal was to ensure that at least one crane retained as much of its original fabric and evidence of use as possible, there seemed little benefit in producing the same end product as the RTA.

### Apply barrier

- Apply a barrier over the original paint and over-paint the whole crane.
- Repaint with a similar paint system as outlined above but recognising it would be less stable and coherent due to reduced surface preparation. It would require more ongoing maintenance checks and could require repainting at an earlier stage. Repainting would be more complex as surface preparation would again aim to leave intact the remaining original paint. The success of this removal and re-treatment could not be guaranteed.



**Figure 7** | Proposed installation of restored crane in Bradfield Park, Kirribilli, beneath Sydney Harbour Bridge.

### No further treatment and alternate display crane

Another option existed that allowed the conserved crane to be retained as intended, with the original paint and other components intact. Given that the treatment of the restored RTA crane had been designed for outdoor display and the original display plans had fallen through the possibility existed to display this crane in the outdoor forecourt and retain the conserved NMA crane in storage. The RTA crane could be obtained on loan without the expense of additional conservation and the possibility would remain for the future display, research and study of the NMA conserved crane.

In 2011, the NMA requested temporary loan of the restored RTA crane for display on the forecourt of the

National Museum, for a minimum period of five years, with the option to extend.

### Further quantitative risk analysis

The acquisition of the Sydney Harbour Bridge crane by the NMA highlighted the usefulness of both heuristic risk assessments plus the benefit of more quantitative analysis of risk pending resources. The NMA collection contains many objects with lead paint in various stages of deterioration, as do many other public collections.

The constitution of paint can be highly variable as can be the toxic components. Dust

generated by the abrasion of a number of different paint layers of different ages may readily contain several hundred different compounds. A 'quick and easy' assessment of the potential health risk of a paint film is analysis of 'total lead' but the toxic properties of the paint will also be influenced by the condition of the paint, binding media, paint technology (encapsulation of pigment particles), particle size and bioavailability (a pharmacological measure of absorption) (van Alphen 1998, Chisholm 1986). A major factor affecting bioavailability of lead after ingestion appears to be its solubility (Stopford & Turner 2011). The lead oxides of red lead and lead white are highly soluble in the acidic medium of the human digestive tract (Fisher & Russell 2004).

Paint film thickness does vary across the crane from single paint layers to more than a 10mm-thick build-up of successive re-coatings. From published data on lead content in paint layers (van Alphen 1998) we would expect the red-lead primer on the crane to comprise around 70–75% lead by weight, and the older paint layers to contain from 50–75% lead (from lead white used as a white pigment in the original 'bridge grey' paint). These would then be overlain

with many layers of material with substantially lower lead concentration because by the 1940–50s lead white had been replaced by titanium dioxide as it was a more effective and cheaper pigment.

Van Alphen (1998) indicates that for an area of around 300m<sup>2</sup> (similar to the size of a crane) a red-lead primer in linseed oil could contain from 43 to 45kg of elemental lead. Although some of this, and much of the upper layers of lead white on the crane, would have been lost to the environment over the years, it indicates that a substantial amount of lead, in a highly soluble form, may still remain on the object.

Existing data on lead from Australian houses can also be a useful guide for collection management. Hundreds of kilograms of lead in paint can be present on walls of older houses and even low levels of paint loss from old wall surfaces can generate high lead concentrations in house dust and surrounding soil (van Alphen 1998). This has implications for collecting institutions where dust can build up over decades. However there are a number of factors that will influence the amount of lead that is ‘available’ such as if the exposed lead paint is stable and intact or covered with an intact non-lead paint system.

During this project lead oxides from red lead primers and white lead pigments were investigated. However



**Figure 7** | Cranes after ‘preservation’ (top) and ‘restoration’ (bottom) treatment.

many museum objects contain other types of lead paint or even other paint system not containing lead, that can also be toxic. As stated earlier, lead was often contained in an oil paint to enhance drying but the quantity of lead was very low. Lead chromate complexes were common for yellow, orange, red and green – the total lead levels are high but lead bioavailability is low, and toxicity is often related to the chromate content rather than lead.

More detailed investigation of the paint system of the crane confirms the initial risk assessment. Lead paint on historic objects (including industrial heritage and

buildings) is a serious issue and must be recognised within the range of hazards that heritage professionals manage.

## CONCLUSION

Two Sydney Harbour Bridge cranes, items significant to Australia’s industrial heritage, underwent conservation treatments at the same time. The treatments were very different in approach and outcome, and the difference was directed by the expected end-use of the crane: outdoor public display and storage and potential research/display within a museum collection. A minimal approach was taken with the NMA crane to retain any research potential

and allow for future conservation work as required, whereas the RTA crane was abrasive-blasted, repainted and had replica components installed to allow the structure to be displayed outdoors.

Managing the hazard of the lead paint was a major driver in many of the decisions made by the NMA and throughout the treatments by ICS.

These two large, and rare, industrial heritage items, treated in such different ways, are now both held at the NMA in Canberra.

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