

**IN-DEPTH SURVEY REPORT:**  
**CONTROL TECHNOLOGY FOR REMOVING LEAD-BASED PAINT**  
**FROM STEEL STRUCTURES:**  
**CHEMICAL STRIPPING**

**AT**

**Columbus, Ohio Bridge  
Finishes, Inc  
Columbus, Ohio**

**REPORT WRITTEN BY  
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**U S DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Public Health Service  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health  
4676 Columbia Parkway, Mail Stop R5  
Cincinnati, Ohio 45226**

BRIDGE FACILITY SURVEYED	City of Columbus Bridge Roberts Road Bridge First overpass west of exit 10 off 270 Columbus, Ohio
SIC CODE	1721, 1622
SURVEY DATES	April 20-21, 25, 1994 June 21, 1994
SURVEY CONDUCTED BY	R Leroy Mickelsen Keith G Crouch Phillip A Froehlich Anthony T Zimmer
CONTRACTOR REPRESENTATIVE	Tom Falter Finishes, Inc 1772 Genessee Avenue Columbus, Ohio 43211
EMPLOYEE REPRESENTATIVE	Nonunion
FACILITY OWNER REPRESENTATIVE	Harold Wilkins Construction Supervisor City of Columbus 1800 E 17th Avenue Columbus, Ohio 43219
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## **DISCLAIMER**

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## INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary federal organization engaged in occupational safety and health research. NIOSH is in the Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC). An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has the lead within NIOSH to study the engineering aspects of hazard control.

Because of increased lead poisoning and silicosis reported among workers in the steel structures painting industry, researchers from ECTB developed a project to evaluate engineering controls in this industry.<sup>1</sup> A need for nearly all steel structures is protection from corrosion. Historically, lead-containing paint is used because it has low cost, aesthetic appeal, and corrosion resistance. The first step to adequately prepare the steel surface to receive a new coating system is to remove the old coating.<sup>2</sup> The removal process is traditionally abrasive blasting. Abrasive blast devices deliver a high-velocity stream of abrasive to remove the coating and impart an anchor pattern on the metal surface. The workers direct the blasting nozzles at the surface to be cleaned. As the paint is removed, small particles of lead paint, silica (silica from abrasive or from surface coatings), and other debris becomes airborne. Lead poisoning and silicosis are not uncommon among workers who remove lead-based paints from bridges and other steel structures.

Two environmental requirements have been the driving force for contractors to contain paint chips, dust, and used abrasive during paint removal processes. The Resource Conservation and Recovery Act (RCRA) requires that waste material must be collected, tested, and classified as hazardous or not hazardous.<sup>3</sup> Secondly, the Clean Air Act limits levels of particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM10) to a maximum of 0.15 mg/m<sup>3</sup> average concentration over a 24-hour period.<sup>4</sup> The Clean Air Act also limits the amount of airborne lead to 0.0015 mg/m<sup>3</sup>, evaluated as an arithmetic mean over a calendar quarter. The containment structures used to collect waste materials and control emissions have increased workers' risk of occupational exposure to lead and other waste materials by concentrating these agents in and around the containment structures.

Support personnel are also at risk for potentially hazardous particulate exposure as mentioned above. Support personnel may receive exposure when moving containment structures contaminated with residual particles and when handling abrasive and waste materials. High exposures have been observed for auxiliary equipment operators and for those cleaning up the site after paint removal has been completed.<sup>5</sup>

Lead and alkaline dust exposures were evaluated during the chemical stripping of lead-based paint from an overpass bridge. The chemical stripper used at this site was an alkaline paste (Peel Away ST1, Dumond Chemical, Inc., New York, NY) consisting of calcium hydroxide (21%),

magnesium hydroxide (16%), sodium hydroxide (9%), and the balance water and other nontoxic materials

## **BRIDGE SITE AND PROCESS DESCRIPTION**

Paint removal work was done at an overpass bridge that carried four lanes of traffic and spanned seven railroad tracks near a switching station. The city project engineer estimated that the bridge was last painted in 1980 with lead-based paint. The contract required removing thirty thousand square feet of existing coatings from an I-beam overpass bridge and a surface preparation to SSPC-SP10, "near white metal," before repainting<sup>6</sup> with unleaded paint. Several similar overpass bridges were included in the contract but exposure monitoring was done at only one site. The duration of the repainting project was April 15 to August 1, 1994, and took thirty-eight hundred hours to complete. Monitoring of the overpass site by NIOSH researchers took place on May 19-21 and 25 and June 21, 1994.

A temporary containment system was constructed around each of five spans. The containment consisted of a floor made of half-inch plywood, covered with 6-mil polyethylene, and reinforced with 2 X 12's. Scaffolding supported the 2 X 12's when the bridge span did not travel over railway tracks. Steel cables suspended from the bridge supported the 2 X 12's when the span traveled over railway tracks. The sides of the containment consisted of mesh tarps, 80 percent opaque, which allowed natural ventilation through the containment.

The removal method consists of spraying the alkaline paste on the painted surface, allowing it to react overnight, then scraping the decomposed paint and excess caustic from the steel surface. After the scraping process, the debris was cleaned from the area and the surfaces were abrasive blasted.

The alkaline paste was applied using a Binks Model 7 spray nozzle (Binks Manufacturing Company, Franklin Park, IL) modified to independently operate the slurry and air supply valves. The workers wore an ensemble of personal protective clothing (PPC) consisting of a non-woven fabric coverall worn as undergarments, bib-type overalls and a hooded coat both made of a polyester coated polyvinyl chloride (rainsuit), and neoprene boots and gloves both taped to the polyvinyl rainsuit using duct tape. They also wore hard hats with face shield visors (some workers wore safety glasses under the visor) and half-mask respirators with high efficiency particulate air (HEPA) cartridge filters.

Listed in Table I are the actual man-hours for doing each task. Also listed in Table I are the estimates of the man-hours that would be needed to abrasive blast the same project without the aid of chemical stripping.

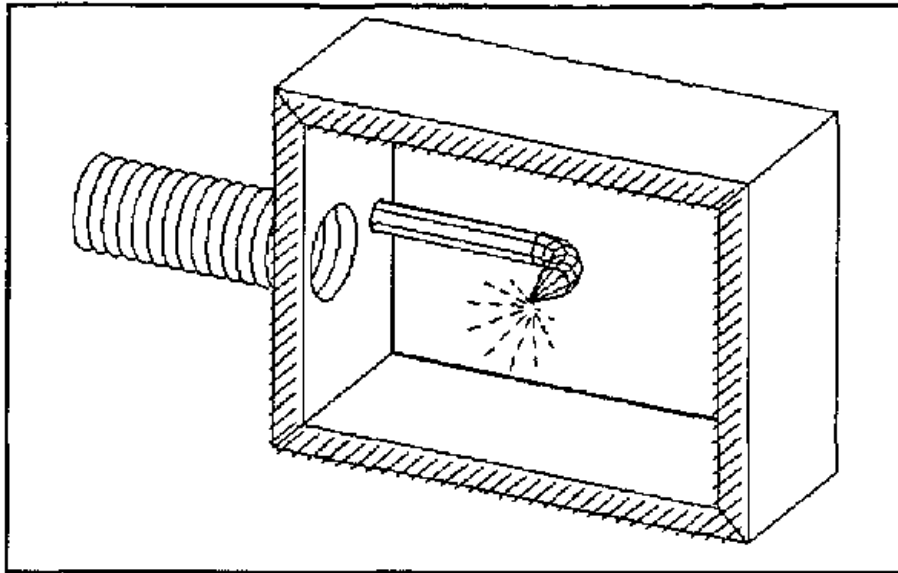
One man sprayed approximately 20 percent of the bridge steel (about six thousand square feet) with the caustic paste in about five hours. Then five workers used knives with blades from 4- to 12-inch long to evenly distribute the caustic paste on the surface. The paste reacted with the

painted surfaces over night. The next morning, workers scraped the decomposed paint and excess caustic from the steel surface. After the scraping process, debris was cleaned from the 6-mil plastic sheets of the containment floor.

**Table I**  
**Comparison of Time Man-Hours Spent at Each Task**

Chemical Stripping (Actual)	Task	Abrasive Blasting (Estimate)
36	Moving on Site	30
340	Chemical Application	0
268	Blasting	600
596	Moving Containment	600
219	Paint	220
240	Clean Up	240
160	Quality Control	160
58	Move Off Site	60
1917	Total Hours	1910

On May 21, 1994, the chemically stripped steel surface was rinsed with water before abrasive blasting. The rinse equipment consisted of a spray nozzle, housing to contain the spray nozzle, a compressor and a vacuum system with collecting tank, and appropriate hoses and connectors. Figure 1 shows a diagram of the housing that holds the water spray nozzle. The water rinse spray housing is held tightly against the flat steel surfaces to keep the nozzle close to the surface and to collect water with the vacuum system. The water is sprayed, collected in the housing, vacuum transported to the holding tank, then sprayed again. The only cleaning action of the rinse water after collecting is the settling of particulate to the bottom of the holding tank, there was no filtration. Angular and hard to reach areas were rinsed with a small brush frequently dipped in a bucket of water. The rinse water from the brush ran off the bridge onto the containment floor. There was very little liquid runoff and only a small amount of water collected on 6-mil plastic sheets that covered the containment floor. Most of the water on the bridge and on the plastic sheets evaporated.



**Figure 1** Water Spray Nozzle and Housing

On June 21, 1994, the steel surfaces were abrasive blasted after the scraping process. The water rinse process was not used.

The contract required a surface preparation to SSPC-SP10, "near white metal" before repainting, thus, a simple "brush-off blasting" (a quick abrasive blasting process where the dwell time is very short per area of surface) could not be used. Despite the need for a near white metal surface, the blasting process went very quickly because the majority of paint had been removed by the chemical and scraping processes. The steel surfaces were abrasive blasted using coal slag to remove traces of remaining paint and to establish a minimum of 1-2 mil anchor pattern before repainting. The steel was repainted with organic zinc epoxy primer, epoxy intermediate, and polyurethane top coat.

## **SAMPLING METHODS**

This paint removal technique was evaluated by collecting and analyzing bulk samples of paint, personal breathing zone (PBZ) air samples of the caustic applicator, scrapers, rinsers, and abrasive blast operators, and area air samples. Work practices and personal hygiene practices were also observed.

## **BULK SAMPLES**

Samples of old paint were collected from the bridge by scraping the steel surface with a sharp chisel. The bulk paint collection process removed all of the top and intermediate paint coatings, leaving a metal surface with only traces of the primer coating (less than 10 percent of the surface).

was covered by thin traces of paint) Samples were taken from locations where the paint was removed Both intact and deteriorated paints were sampled

## **PERSONAL SAMPLES**

PBZ samples were collected on 37-mm diameter, mixed cellulose ester membrane, 0.8- $\mu$ m pore-size filters in closed-face cassettes using personal sampling pumps (Model 224-PCXR7, SKC Inc., Eighty Four, Pennsylvania) each operating at 2.0 liters per minute (lpm) The sample cassettes were attached to the lapel of the worker Only one sample was taken on each worker

## **AREA SAMPLES**

Area samples for total lead and alkaline dust were collected directly under the bridge near the compressor equipment, about 30 feet below the work area The area samples for total lead were collected using the same equipment as for the PBZ samples The alkaline dust samples were collected on preweighed 37-mm, 1- $\mu$ m pore size, PTFE filters in a closed-face cassette, at a flow rate of 2.0 lpm using a personal sampling pump (Model P2500, Ametek, Largo, Florida)

## **SAMPLE ANALYSIS**

Analyses of air samples for lead and other elements were conducted using NIOSH Method 7300,<sup>7</sup> which uses inductively coupled argon plasma atomic emission spectrometry, when the lead results were below the limit of detection (LOD) of 0.002 mg/filter, samples were further analyzed using graphite furnace atomic absorption spectroscopy, NIOSH Method 7105, with LOD of 0.00004 mg/filter.<sup>8</sup> Alkaline dust analyses were performed using NIOSH Method 7401 with LOD of 0.03 mg per sample.<sup>9</sup>

## **EXPOSURE EVALUATION CRITERIA**

The OSHA PEL for lead in the construction industry during this survey was 0.05 mg/m<sup>3</sup> as an 8-hour TWA.<sup>10</sup> Although the NIOSH recommended exposure level is 0.1 mg/m<sup>3</sup>, NIOSH currently recommends the more protective criteria of 0.05 mg/m<sup>3</sup> and this lower value is used in this study as evaluation criteria for personal exposures.<sup>11</sup> The NIOSH REL and OSHA PEL for sodium hydroxide (alkaline dust) is an 8-hour TWA of 2 mg/m<sup>3</sup>.

## **RESULTS**

### **BULK SAMPLES**

Lead content in the bulk samples of tightly held paint scraped from the bridge averaged 24 percent (range 20-26) by weight Deteriorated paint samples from the bridges contained an average of 9 percent lead by weight (range 4.3-14) The lead content of unused coal slag



abrasive was below the limit of detection, 0.03 mg/g (<0.003% by weight). A sample of used abrasive collected from the containment floor included 0.2 percent lead by weight.

## PERSONAL AND AREA AIR SAMPLES

Table II shows the results of PBZ and area air sampling during the application of caustic. Because the alkaline dust is the primary exposure hazard during this process, all PBZ samples were collected for alkaline dust. The PBZ alkaline dust average concentration was 0.6 mg/m<sup>3</sup> (range 0.3 - 1.0). The area lead concentration inside the containment was 0.003 mg/m<sup>3</sup>.

Table II  
Exposure During Application of Caustic

Job Type	Sample Time Minutes	Alkaline Dust mg/m <sup>3</sup>	Lead Dust mg/m <sup>3</sup>
Sprayer	443	0.53	NS
Equipment Operator	173	0.33	NS
Knife I	425	0.48	NS
Knife II	360	1.0	NS
Area Inside Containment			
Entrance	451	NS	0.002
Middle	450	NS	0.004
NS = Not Sampled			

Table III shows the results of PBZ and area air sampling during scraping caustic and coatings and during rinsing. The alkaline dust concentration was 0.3 mg/m<sup>3</sup> for PBZ samples and 0.04 mg/m<sup>3</sup> for the area sample inside the containment. The lead concentration was 0.024 mg/m<sup>3</sup>, geometric mean, (range 0.018-0.041) for the PBZ scraper samples, 0.018 mg/m<sup>3</sup> for the PBZ rinse operator sample, and 0.007 mg/m<sup>3</sup> inside the containment area.

During the blasting process following a water rinse, the PBZ lead concentrations for the blasters were 2.0 and 4.7 mg/m<sup>3</sup> (geometric mean 3.1 mg/m<sup>3</sup>), see Table IV. The PBZ lead concentration for the blast equipment operator (outside the containment) was 0.07 mg/m<sup>3</sup>. The lead concentration 20 feet outside the containment was 0.045 mg/m<sup>3</sup>. Alkaline dust concentration was 0.6 mg/m<sup>3</sup> inside and near the middle of the containment and 1.9 mg/m<sup>3</sup> inside and near the entrance of the containment.

Table III  
Exposure During Removal of Caustic and Coatings

Job Type or Area	Sample Time Minutes	Alkaline Dust mg/m <sup>3</sup>	Lead Dust mg/m <sup>3</sup>
Scraper I	485	0.36	NS
Scraper II	497	0.30	NS
Scraper III	314	NS	0.020
Scraper IV	495	NS	0.041
Scraper V	179	NS	0.018
Water Rinser	240	NS	0.018
Area Inside Containment			
Middle	477	0.04	0.007
NS = Not Sampled			

Table IV  
Exposure During Blasting After Water Rinsing

Job Type or Area	Sample Time Minutes	Alkaline Dust mg/m <sup>3</sup>	Lead Dust mg/m <sup>3</sup>
Blaster I	58	NS	0.55
	58	NS	3.40
Blaster II	48	NS	6.50
	59	NS	3.30
Equipment Operator	261	NS	0.07
Area Inside Containment			
Entrance	504	1.9	NS
Middle	503	0.62	NS
Area Outside Containment			
20" Away	260	NS	0.045
NS = Not Sampled			

The PBZ lead concentrations for the blasters were 5.0 and 5.3 mg/m<sup>3</sup> without rinsing with water before blasting, see Table V. The PBZ lead concentration for the equipment operator was 0.027 mg/m<sup>3</sup>. Lead concentrations were 2.8 mg/m<sup>3</sup> inside and near the middle of the containment and 0.025 mg/m<sup>3</sup> near the equipment outside the containment. The alkaline dust concentration was 6.8 mg/m<sup>3</sup> near the middle inside the containment and <0.07 mg/m<sup>3</sup> near the equipment outside the containment.

## DISCUSSION

The bulk samples scraped from locations on the bridge where paint was visually deteriorating had lower lead levels than the intact paint samples. This is likely because much of the sample consisted of ferric oxide, thus, dilution of the lead level in the paint sample. Further analysis showed that there was 4 percent iron in samples from intact paint and 34 percent iron in samples from deteriorated paint. Determination of the lead content in painted structures is very dependent on the condition (rusted versus intact substrate) of the paint that is sampled.

Table V  
Exposure During Blasting Without Rinsing

Job Type or Area	Sample Time Minutes	Alkaline Dust mg/m <sup>3</sup>	Lead Dust mg/m <sup>3</sup>
Blaster I	78	NS	5.8
	132	NS	5.0
Blaster II	78	NS	5.0
Equipment Operator	170	NS	0.04
	131	NS	0.01
Area Inside Containment			
Middle	81	NS	4.6
"	190	7.2	2.0
"	166	6.3	2.8
Area Outside Containment			
Near Equipment	345	<0.07	0.025
NS = Not Sampled			

The blast operators experienced the highest airborne lead and alkaline dust concentrations at this site. It was assumed that silica exposure was not a significant hazard because coal slag was

substituted for the more traditional silica sand as the abrasive, thus, silica exposures were not monitored

The actual exposure time during abrasive blasting was approximately one-half that of the traditional abrasive blasting process without the aid of chemical strippers. The chemical stripping process removed most of the paint and reduced adhesion for the paint left on the steel. The summation of time for chemical stripping and abrasive blasting is very similar to the time for abrasive blasting without chemical stripping. There is very little exposure during the caustic paste application and the scraping process. There is a net reduction in worker lead exposure by using this method as compared to abrasive blasting without chemical stripping.

Improving the rinsing system to remove more of the lead waste may be an effective approach for further reducing exposures. Improving the rinse process by adding a filter to the water recycling process may reduce lead on the surfaces. This filter would remove the suspended particles from the water and may result in more effective cleaning of lead from the steel surfaces. A more effective rinsing process would in turn result in a reduction in airborne lead during subsequent abrasive blasting.

Additionally, using other engineering controls (i.e., automation or ventilation) to reduce the lead and dust may enable the operator to reduce the respirator protection factor needed during this process. Air monitoring should be done to confirm airborne hazards after changing any process of installing engineering controls.

The contractor reported blood lead levels (BLL) measured in micrograms of lead per deciliter of whole blood ( $\mu\text{g}/\text{dL}$ ) for their workers as shown on Table VI. BLL increased an average of  $7 \mu\text{g}/\text{dL}$  over the three-month interval of the project. This increase in BLL shows that exposures are not adequately controlled. The largest increase in BLL was  $15 \mu\text{g}/\text{dL}$  which was found for a laborer (scraping and moving containment operations). Laborers did not do the job that created the highest airborne lead concentrations, blasting. The large BLL increase cannot be accounted for based on the measurements taken during this survey. Other possible exposures that the laborers could encounter include the clean up process and ingestion both of which were not monitored but could be assessed in future work.

## **CONCLUSIONS AND RECOMMENDATIONS**

The duration of lead exposure during abrasive blasting was reduced by approximately one-half that of traditional abrasive blasting without the aid of chemical strippers. There is very little exposure during the caustic paste application and scraping of the paste.

Research is needed to improve and evaluate the water rinsing system used in combination with chemical stripping and abrasive blasting to further reduce lead exposure. The rinse system could be improved by adding a filter to the water recycling process. Better cleaning would reduce airborne lead during subsequent abrasive blasting.

Table VI  
Blood Lead Levels of Workers

Job Type	Blood Lead Level ( g/dl) and Date	
Equipment Operator	32 (4-15-94)	37 (6-4-94)
Laborer	13 (4-28-94)	28 (7-28-94)
Laborer	18 (4-18-94)	28 (7-18-94)
Blaster	18 (4-15-94)	18 (7-13-94)
Blaster	23 (4-18-94)	33 (7-14-94)
Quality Control	14 (4-18-94)	17 (7-18-94)

If enhancements to the rinse system do not significantly reduce airborne lead exposures, other engineering control solutions should be used. Research and development should be conducted with the goal of reducing lead and alkaline dust exposures during the paint removal process.

Research is needed to develop and evaluate surface tolerant coatings. If the final blasting step could be eliminated (painting after the rinsing process), the chemical stripping process would result in lead concentrations at or below the PEL.

While other engineering controls are being developed, blasters should be fitted with a respirator that have a higher protection factor. Tight-fitting air-supplied respirators with assigned protection factors of 1000 are now available for abrasive blasting.

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