IN-DEPTH SURVEY REPORT

CONTROL TECHNOLOGY FOR REMOVING LEAD-BASED PAINT FROM STEEL STRUCTURES
ABRASIVE BLASTING INSIDE TWO VENTILATED CONTAINMENT SYSTEMS

AT

BRIDGE STREET AND SHRIBNER STREET OVERPASS
Seaway Painting Company, Inc
Grand Rapids, Michigan

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Public Health Service
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BRIDGE FACILITY SURVEYED	Bridge street and Shribner Overpass Grand Rapids, Michigan Seaway Painting Company, Inc 31801 Schoolcraft Livonia, Michigan
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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 It is located 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 been given the lead within NIOSH to study the engineering aspects of hazard control

Because of increased reports of lead poisoning and silicosis among workers in the steel structures painting industry, researchers from ECTB developed a project to evaluate engineering controls in this industry [1] A basic need for nearly all steel structures is protection from corrosion Historically, lead-containing coating systems were used because they were low cost, aesthetically appealing, and corrosion resistant To adequately prepare the steel surface to receive a new coating system, the old coating must be removed [2] The cleaning process has traditionally been achieved by abrasive blasting Abrasive blast devices are designed to deliver a high-velocity stream of abrasive to remove the coating as well as 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 abrasives or from surface coatings), and other debris become 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 [3] 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 150 $\mu g/m^3$ average concentration over a 24-hour period [4] The Clean Air Act also limits the amount of airborne lead to 1 5 $\mu g/m^3$, evaluated as a maximum arithmetic mean averaged over a calendar quarter The containment structures used to collect waste materials and control emissions has increased workers' risk of occupational exposure to lead and other waste materials, by concentrating these agents in and around the paint removal containment structures

Support personnel as well as workers doing abrasive blasting are at risk of high exposures to potentially hazardous particulate mentioned above Support personnel may also receive exposure when containment structures (which may contain or be contaminated with residual lead and silica particles) are disassembled and moved or 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 [5]

Two separate engineering controls were evaluated during this survey They consisted of two separate containment, ventilation, and abrasive blasting systems

BRIDGE SITE AND PROCESS DESCRIPTION

The first control system consisted of abrasive blasting with low silica (<1% by weight) sand, Star Blast XL (E I DuPont DeNemours and Company, Inc , Wilmington, Delaware) in a large enclosure made of interconnected canvas tarps suspended from the top of the roadway down to the ground, creating a room with a volume of 200,000 cubic feet Within the left half of the containment the overpass was 50 feet above the ground From the middle of the containment the ground sloped up to the right so that the far right side of the overpass was 20 feet above the ground (Figure 1) The enclosure was ventilated by two 20-inch diameter exhaust ducts which were suspended from a light pole, this placed the duct openings approximately 12 feet above the ground There were no provisions for supply inlets, the seams of the tarp walls and other unplanned openings (most openings were at ground level where the tarps were not adequately fastened to the ground tarps) acted as supply air inlets Figure 1 shows a top and side view of the large containment and accompanying exhaust system The Star Blast abrasive was used one time and allowed to settle to the floor tarps along with other wastes created by the paint removal process, then it was collected for disposal

The second system consisted of abrasive blasting with recyclable steel grit in a 3,000 ft^3 enclosure (8' X 8' X 48') made of an alloy piping for the frame, rigid corrugated polycarbonate panels for the sides and an aluminum grating floor The enclosure was suspended from two adjacent I-beams under the bridge (Figure 2) The small enclosure had a supply air fan at one end and an exhaust duct with a fan at the other end The sloping walls under the grate flooring directed the used abrasive and wastes to the bottom center of the containment where the materials were removed from the containment The steel grit was air washed using a recycle machine (IPEC Advanced Systems, North Kingstown, RI) and reused

In both the large and small containment, the workers donned a single-use dust respirator under a continuous-flow, loose-fitting hood respirator prior to entering the containment and did not remove the respirator inside the containment

SAMPLING METHODS

The control techniques were evaluated by collecting and analyzing bulk samples of paint, abrasive, and waste materials, personal breathing zone (PBZ) air samples of blasters and support personnel, and area air samples Work practices and personal hygiene practices were also observed

Figure 1

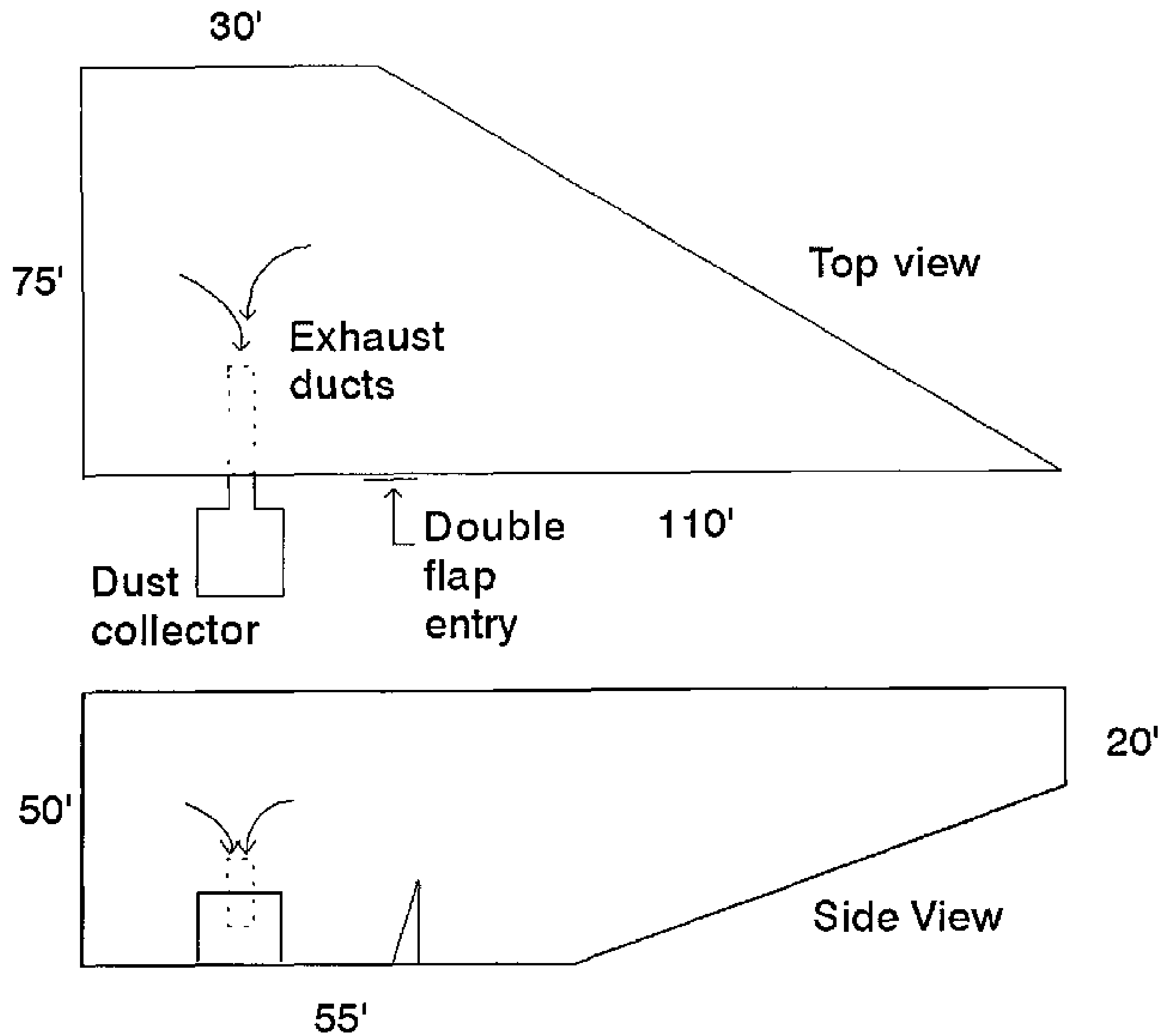
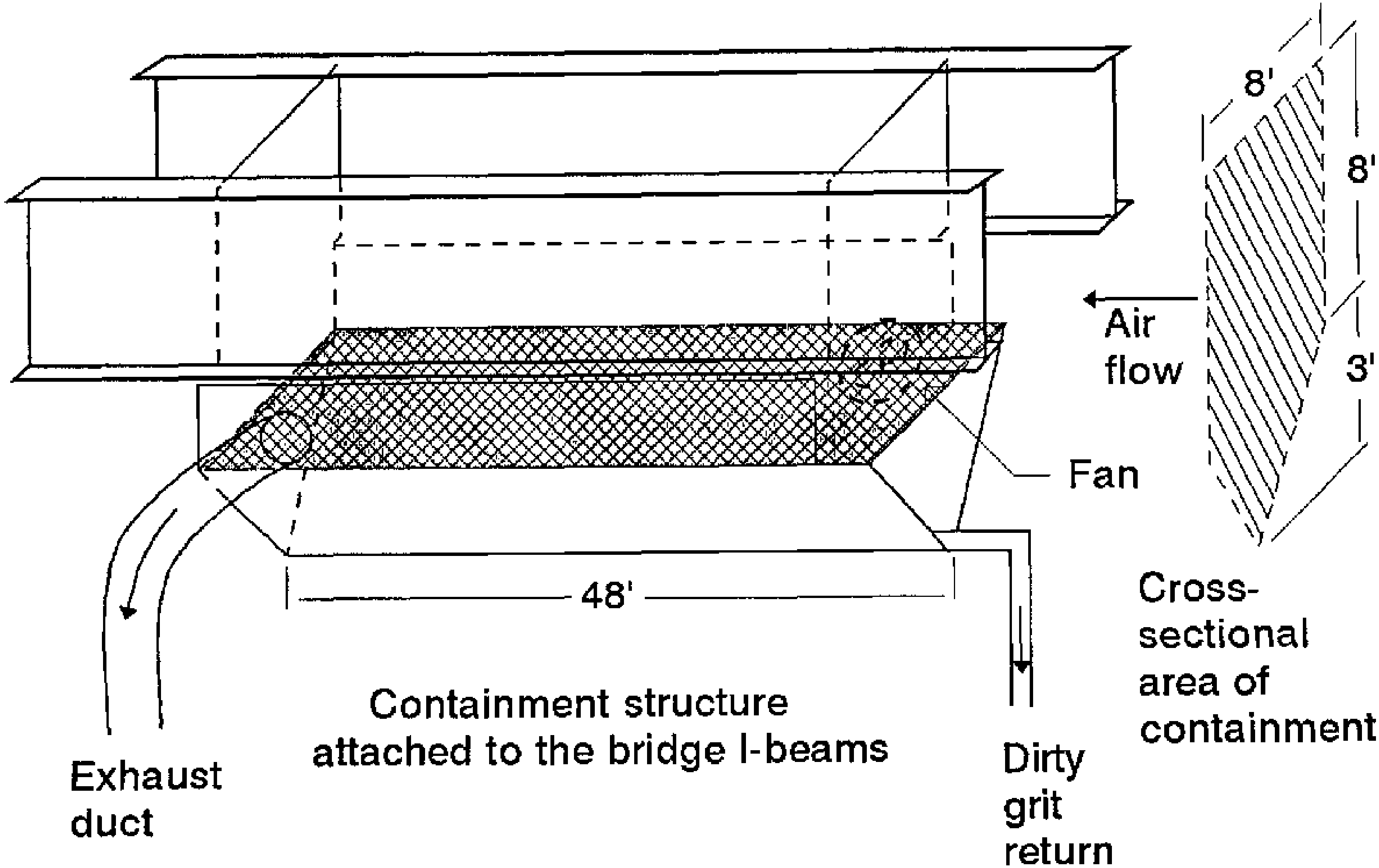

30'
75'
Exhaust
ducts
Top view
Dust
collector
Double
flap
entry
110'
20'
50'
Side View
55'

Figure 2


8'
8'
3'
Air flow
Fan
Cross-sectional area of containment
48'
Containment structure attached to the bridge I-beams
Exhaust duct
Dirty grit return

BULK SAMPLES

Old paint was collected from the bridge by scraping the 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) Bulk samples of unused abrasive were obtained from freshly opened packages of Star Blast The used abrasive samples were collected by mixing abrasive from five locations within the storage bins or from the containment floor and taking one sample from the mixture for analysis Two samples of used steel grit from the small enclosure were collected before and after the recycle cleaning process

PERSONAL SAMPLES

Seven paired sets of PBZ samples were collected on 37-mm diameter, mixed cellulose ester membrane, 0 8-μm pore-size filters in closed-face cassettes using personal sampling pumps (Model 224-PCXR7, SKC Inc , Eighty Four, PA) each operating at 2 0 liters per minute (lpm) Paired PBZ samples were collected inside and outside of the respirator Tygon® tubing placed under the workers' blast-protective outer clothing, and passing beneath the respirator cape, was used to connect one pump to the inside of the respirator sample cassette The tubing was attached to the respirator collar, so that the cassette was in the breathing zone of the worker inside the respirator The outside respirator sample cassettes were attached to the back of the blasters' outer clothing rather than on the front lapels This procedure was used in an attempt to reduce the likelihood of getting the cassette knocked off the workers' lapels and to reduce the likelihood of pinching the tubing between the worker and the scaffolding or bridge members

Four PBZ samples were collected on recycle and blast pot equipment operators and one laborer who was sweeping up beneath the small containment These sampling cassettes were attached to the workers' lapels

AREA SAMPLES

Area samples for total lead, inhalable dust, and total dust samples were collected inside each containment, near the dust collector outlets, near the air intake of the respirator compressors, and near the equipment outside of the containments The area total lead samples were collected using the same equipment as for the PBZ samples The total dust samples were collected on preweighed 37-mm, 0 5-μm pore size, PVC filters in a closed-face cassette, at a flow rate of 2 0 lpm For convenience, pumps for area samples used inside the containments were placed in 5-gallon buckets and the cassettes were positioned on the periphery of the top of the buckets

A sampler (SKC, Eighty Four, PA) designed by the Institute of Occupational Medicine (IOM), Edinburgh, was used to collect inhalable dust (particles with equivalent aerodynamic diameters of up to approximately 100 μm) Air was drawn with a personal sampling pump (Model P2500, Ametek, Largo, FL) at 2 0 lpm The collection medium was a 25-mm diameter, 0 5-μm pore-size, PVC filter The IOM samples were weighed to determine the amount of inhalable dust, then analyzed to determine the amount of inhalable lead

SAMPLE ANALYSIS

Analyses of air samples for lead and other elements were conducted using NIOSH Method 7300,[6] which utilizes inductively coupled argon plasma atomic emission spectrometry, when the lead results were below the limit of detection (LOD), samples were reanalyzed using graphite furnace atomic absorption spectroscopy, NIOSH Method 7105 [7] Total dust and inhalable dust analyses were performed using NIOSH Method 0500 with a limit of detection of 0 02 mg [8]

VENTILATION MEASUREMENTS AND OBSERVATIONS

The ventilation airflow inside both containments was evaluated using a Rosco fog machine (Rosco Laboratories, Inc , Port Chester, NY) to determine the air flow direction and a Kurz hot-wire thermal anemometer (Kurz Instruments, Inc , Monterey, CA) to measure the air velocity Video recording was used to document the flow direction during the fog generation

REAL-TIME (RESPIRABLE) AEROSOL MONITOR

A Real-Time Aerosol Monitor (RAM) (MIE, Inc , Billerica, MA) was used to measure the transient respirable dust concentrations inside the large containment immediately following abrasive blasting

NOISE LEVELS AND OTHER OBSERVATIONS

A-weighted Noise Logging Dosimeters (Model M-27, Quest Electronics, Oconomowoc, WI) were included in the buckets containing the area samplers placed inside the containments Dosimeters placed outside of the containments were also used to determine noise levels Work practices, the use of personal protective equipment (i e , respirators and hearing protection), and the use of personal hygiene facilities (i e , hand washing and clothing changing) were documented

EXPOSURE EVALUATION CRITERIA

The OSHA PEL for lead in the construction industry during this survey was 200 $\mu g/m^3$ but since has been reduced to 50 $\mu g/m^3$ as an 8-hour TWA [9] The 50 $\mu g/m^3$ exposure limit is currently recommended for the construction industry by NIOSH as a more protective criteria and is used in this study as the evaluation criteria for personal exposures [10] The OSHA PEL for total particulate not otherwise regulated is an 8-hour TWA of 15 mg/m^3

The A-weighted decibel (dBA) is the preferred unit for measuring sound levels It is weighted to approximate the sensory response of the human ear The NIOSH REL for noise specifies an exposure limit of 85 dBA for 8 hours,[11] 5 dB less than the OSHA PEL of 90 dBA [12]

The respiratory program was evaluated based on the respirator program given in the NIOSH guide to industrial respiratory protection [13] The program should include information on selecting respirators, training users, and fitting each user with the appropriate NIOSH approved respirator

RESULTS AND DISCUSSION

BULK SAMPLES

Table 1 presents results of bulk sample analyses of paint obtained from the bridge, and clean and used abrasive Based on two samples, the deteriorated paint from the bridge contained an average of 600,000 ppm (60 percent) lead by weight Some other components of the deteriorated paint include the following aluminum, 17,000 ppm, zinc, 290 ppm, manganese, 230 ppm, and magnesium, 160 ppm The large amount of iron (31,000 ppm) in the bulk paint samples is probably due to the removal of rust and steel from the substrate during the paint sample collection process

Lead content in the new and used Star Blast abrasive was 50 and 12,000 ppm, respectively Lead content in the steel grit prior to cleaning was 3,700 ppm by weight After cleaning by the recycle equipment the lead content in the steel grit was 1,700 ppm This indicates a cleaning efficiency of approximately 50 percent Virgin steel grit was not available for sampling Normally, new steel grit and steel shot contains 70 to 120 ppm of lead [14] If abrasive is going to be reused, removing the lead from the abrasive may be an important element in the engineering control approach The concentrated waste from the recycle machine contained 27 percent of lead by weight The waste swept from the blacktop surface beneath the small containment system contained 2,800 ppm of lead by weight

PERSONAL AIR SAMPLES

Table 2 presents the results of PBZ air sampling during abrasive blasting Within the large containment, the blasters' geometric mean lead concentration outside of the respirator was 6200 $\mu g/m^3$, 120 times greater than the OSHA PEL for lead in the interim final rule Within the small containment, the blasters geometric mean lead concentration outside of the respirator was 20 000 $\mu g/m^3$, 400 times greater than the OSHA PEL for lead Six of seven lead concentrations measured inside the continuous-flow loose-fitting hood respirators were greater than 50 $\mu g/m^3$ with the highest being 150 $\mu g/m^3$

Within the small containment (as compared to the large containment) higher airborne lead concentrations (outside the respirator) may be a result of two major factors The steel grit was not adequately cleaned prior to reblasting (just over half of the lead was removed from the grit prior to reusing) and high velocity air introduced by the fan and the blast nozzle will tend to pick up and recirculate particles inside the containment Supply air should be introduced across the entire cross-section of the small containment to reduce turbulence that may re-entrain and recirculate particles Nevertheless, improvements to the abrasive recycle cleaning system and ventilation system may not adequately reduce airborne lead and dust concentrations near the worker Abrasive blasting systems currently being used require that the blaster be very close to the lead and dust generation source To be

Table I Element Analysis of Bulk Samples, PPM by Weight
Seaway Painting Company, Inc , Grand Rapids, MI

	Paint Scrapings ppm			Bulk Abrasive and Waste Samples Concentration in ppm							
Element	Bridge Paint	Bridge Paint	Limit of Detection	Clean Grit	Dirty Grit	Recycle Waste	Sweep Waste	Raw Star-Blast	Dirty Star-Blast	Dirty Star-Blast	Limit of Detection
Lead	600,000	570,000	4	1,700	3,700	270,000	2,800	50	15,000	10,000	50
Iron	11,000	51,000	4	900,000	830,000	350,000	550 000	350	6,300	4 200	20
Aluminum	16,000	18,000	7	ND	ND	1,300	ND	720	740	840	180
Zinc	410	170	1	620	540	32,000	53	11	120	200	10
Manganese	130	330	1	4,100	4,500	2,400	4,000	44	58	46	20
Magnesium	190	130	7	ND	200	640	220	ND	ND	ND	180
Copper	78	65	1	920	920	300	450	ND	ND	ND	20
Cobalt	28	28	1	68	64	31	34	ND	ND	ND	30
Titanium	19	13	1	ND	ND	260	ND	280	260	350	20
Chromium	12	10	1	730	910	260	270	ND	ND	ND	20
Nickel	ND	13	2	930	850	160	200	ND	ND	ND	40

* ND = Below the detection level (Not Detected)

Table II Personal Breathing Zone Sampling for Lead Exposure Inside the Containment Structure During Blasting Seaway Painting Company, Inc , Grand Rapids, MI

Day	Worker	Containment Type	Sample Time (min)	Lead Concentration Inside Respirator Ci (µg/m3), TWA*	Lead Concentration Outside Respirator Co (µg/m3), TWA	Program Protection Factor (PPF) (Co/Ci)
1	A B	Large	362 414	62 100	4,600 24,000	73 240
2	A B	Large	173 173	83 79	2,700 4,900	32 62
Sum Mean		Large	260	80**	6,200**	77**
1	C	Small	544	110	22,000	200
2	D E	Small	291 317	150 33	58,000 6,300	390 190
Sum Mean		Small	380	81**	20,000**	250**

* TWA for sampling time
** Geometric mean

effective, the hazard must be controlled before it reaches the blast operator Dilution ventilation is not effective in this situation [15]

For this evaluation, the ratio of the lead concentration on the samples outside the respirator to inside the respirator are considered to be the program protection factor (PPF) [16] The PPF is a measure of the effectiveness of the complete respirator program As such, any element (i e , respirator selection, fit, training, maintenance, storage) of the program which is deficient will adversely affect the PPF The calculated geometric mean PPF for the continuous-flow loose-fitting hood respirator was 130 for the combined group of blasters in both containments during blasting The PPF lower and upper 95 percent confidence intervals were 56 and 290, respectively [Note that the sample cassettes were not placed in a standard location for the inside the respirator samples and the workers could not be visually observed during the blasting process]

While additional controls are being developed, it would seem prudent that workers near the lead paint abrasive blasting process use a respirator with a higher protection factor (higher then the assigned protection factor of the loose-fitting respirator) However, to achieve an increase in the respiratory protection the respirator must be worn A tight-fitting respirator (which is needed to obtain a higher APF) may be less comfortable to wear than the loose-fitting respirator Substituting the loose-fitting respirator with one that is tight-fitting may result in a net increase in worker exposure if the latter is worn less than the former Further evidence is needed before clear guidance can be given

Table 3 presents the results of PBZ air sampling, for lead exposures of the support personnel near the large and small containment structures The support personnel wore half-mask air-purifying respirators with HEPA filters which were supplied by their employer All four of the lead exposures measured were greater than 50 $\mu g/m^3$ Those working near the large containment had air-borne lead concentrations over 2,000 $\mu g/m^3$ With an assigned protection factor (APF) of 10, the half-mask respirators are not acceptable if lead levels exceed 500 $\mu g/m^3$ The half-mask respirators are acceptable for the equipment operator and sweeper working around the small containment [Note that worker D, the sweeper, also performed abrasive blasting during day two His overall exposure was 35,000 $\mu g/m^3$ which was mostly due to abrasive blasting]

The high PBZ lead concentrations for workers near the large containment may be a result of the seams and closures of the large containment not being air tight, allowing air and contaminants to move in or out of the containment with the gusting wind The small containment was rigid and had tight seams and seals Also, some of the support personnel were exposed to high levels of airborne lead upon entering the large containment immediately after the blasting process (before airborne particulate had settled), and from walking through the waste on the tarp floor of the containment which stirs up and re-entrains particulate into the air Exposures may also come from moving equipment which is contaminated with lead dust

Table III Lead Exposures of Blast Site Support Personnel
Seaway Painting Company, Inc , Grand Rapids, MI

Day	Worker	Containment Type	Task	Sample Time (min)	Lead Exposure ($\mu g/m^3$) TWA*
1	F	Large	Equipment Operation	406	2,200
2	F	Large	Equipment Operation	169	2,500
1	G	Small	Equipment Operation	547	51
2	D	Small	Sweeping	67	360**

* TWA for sampling time
** Worker D total TWA exposure for Day 2 was 35,000 $\mu g/m^3$, see Table 2

AREA SAMPLING

Airborne lead and aerosol concentrations from area sampling are presented in Table 4 Inside the large containment the area samples were in a bucket located on the floor in the center of the containment, 50 feet below the blast operation Inside the small containment a bucket was located on the grate floor midway between the supply inlet and exhaust outlet

The equipment area 15 feet from the large containment had an airborne lead concentration of 210 $\mu g/m^3$ and 25 feet away the concentration was 56 $\mu g/m^3$ These results strongly support the practice of wearing respiratory protection near the large containment The equipment area 40 feet below the small containment had a lead concentration of 17 $\mu g/m^3$ The combination of distance and better control of the contaminant resulted in a much lower exposure concentration in the area beneath the small containment

The inlet air to the compressors which supplied breathing air to the air-supply respirators for the workers in the large and small containment had a concentration of 6 and 20 $\mu g/m^3$, respectively Each air compressor was located 40 to 50 feet away from their respective containments Breathing air passed through the compressor, an oil filter, a particulate filter, and a CO detector and alarm system before going to the respirator

The outlet stacks of each dust collector used to filter the ventilation exhaust air from each containment were monitored using a personal sampling pump and filter The airborne lead concentrations from the outlet ducts were 220 and 1 $\mu g/m^3$ from the large containment dust collector and 110 $\mu g/m^3$ from the small containment dust collector This represents a 99 percent reduction in airborne lead concentration as compared to inside the containment

The samples collected inside the large containment (Table 5) show that the IOM sampler lead results were higher than the closed-face sampler lead results

Table IV Area Air Samples
Seaway Painting Company, Inc , Grand Rapids, MI

Day	Containment Type	Location	Time (min)	Concentration (µg/m³)		Noise (dBA)
				Lead	Aerosol	
1	Large	Inside the containment	453	15,000	480,000	94
1	Large	Dust collector outlet	254	220	2,000	-
1	Large	15' away from containment	497	210	-	-
1	Large	25' away from containment	495	56	-	92
2	Large	Dust collector outlet	222	1	-	-
2	Large	Inlet to respirator compressor	216	6	-	-
1	Small	Inside the containment	538	10,000	55,000	110
1	Small	Equipment control panel	537	17	-	91
2	Small	Dust collector outlet	288	110	-	-
2	Small	Inlet to respirator compressor	297	20	-	-

However, the aerosol results from the IOM samplers were lower than the closed-face aerosol sampler results Area dust levels were an order of magnitude greater than lead levels In general, in areas where visible dust levels were high, a correspondingly high lead and dust concentration were determined by personal and area sampling

Noise levels (Table 4) measured as area samples ranged from 110 dBA as a TWA in the small containment to 91 dBA in the support equipment area The area noise levels indicate that noise levels are well above the NIOSH REL of 85 dBA During the survey workers both inside and outside the containment routinely wore foam ear plugs Hearing protection must continue to be used When blasting was in progress, the noise level inside the containment increased by 20 dBA over the background noise level Based on the area noise levels observed at this site, it is recommended that a hearing conservation program be implemented Noise levels should be considered when selecting paint removal equipment

REAL-TIME MONITORING

In addition to the integrated area samples, the RAM was used to monitor the respirable dust inside the large containment immediately following abrasive blasting A respirable dust concentration decay curve is shown in Figure 3 The airborne dust levels decreased 60 percent in 10 minutes and 90 percent in 35 minutes once dry abrasive blasting stopped

The small containment structure dilution ventilation system approached plug flow (as desired) but did not significantly reduce airborne lead levels Even a well designed dilution ventilation system, such as this plug-flow ventilation system, may not be capable of reducing hazardous concentrations near the blast operator to an acceptable level

VENTILATION MEASUREMENTS

Fog was generated to visually evaluate the airflow patterns within each containment Fog within several feet of the exhaust duct vents flowed into the vents But throughout the rest of the large containment there was no obvious airflow pattern (mostly stagnant air) The air velocities at the face of each exhaust vent were 5,500 feet per minute (fpm) The calculated total volumetric flow rate was 24,000 cubic feet per minute (cfm) through the two 20-inch diameter exhaust ducts

The air velocity near the supply fan of the small containment could not be measured due to the turbulence Structural cross members ran perpendicular to the flow of air and connected the two I-beans The airflow was stagnant near these cross members The air velocities measured at two separate cross-sections, upstream from the exhaust vent, were both 110 fpm as an average across the working cross-sections At the face of the exhaust vent the air velocity was 2,800 fpm, hence, 6,000 cfm was removed through the 20-inch diameter duct The dilution ventilation system of the small containment could be improved by introducing the supply air through a plenum across the entire cross-section of the containment This will reduce turbulence caused by the high velocity supply air fan, reducing the reentrainment of particles However, this may not be the total engineering control solution for lead paint removal operations

The prevailing wind, gusting to perhaps 10 miles per hour, was generally from the west The side tarps of the large containment reduced the flow of air through the blast area to a minimum The winds did not affect the small containment During the blasting process and at periodic intervals, dust was observed escaping the large containment Abrasive and dust escaped from the small containment only rarely

RESPIRATOR AND HYGIENE PRACTICE

The workers used personal protective equipment, including heavy cotton canvas coveralls (blasters), disposable earplugs, disposable Tyvek® coveralls, and respirators provided by the contractor Blasters used NIOSH-certified continuous-flow loose-fitting hoods (E D Bullard Company, Cynthiana, KY), equipped with vortex-type air coolers A paper dust mask was also worn under

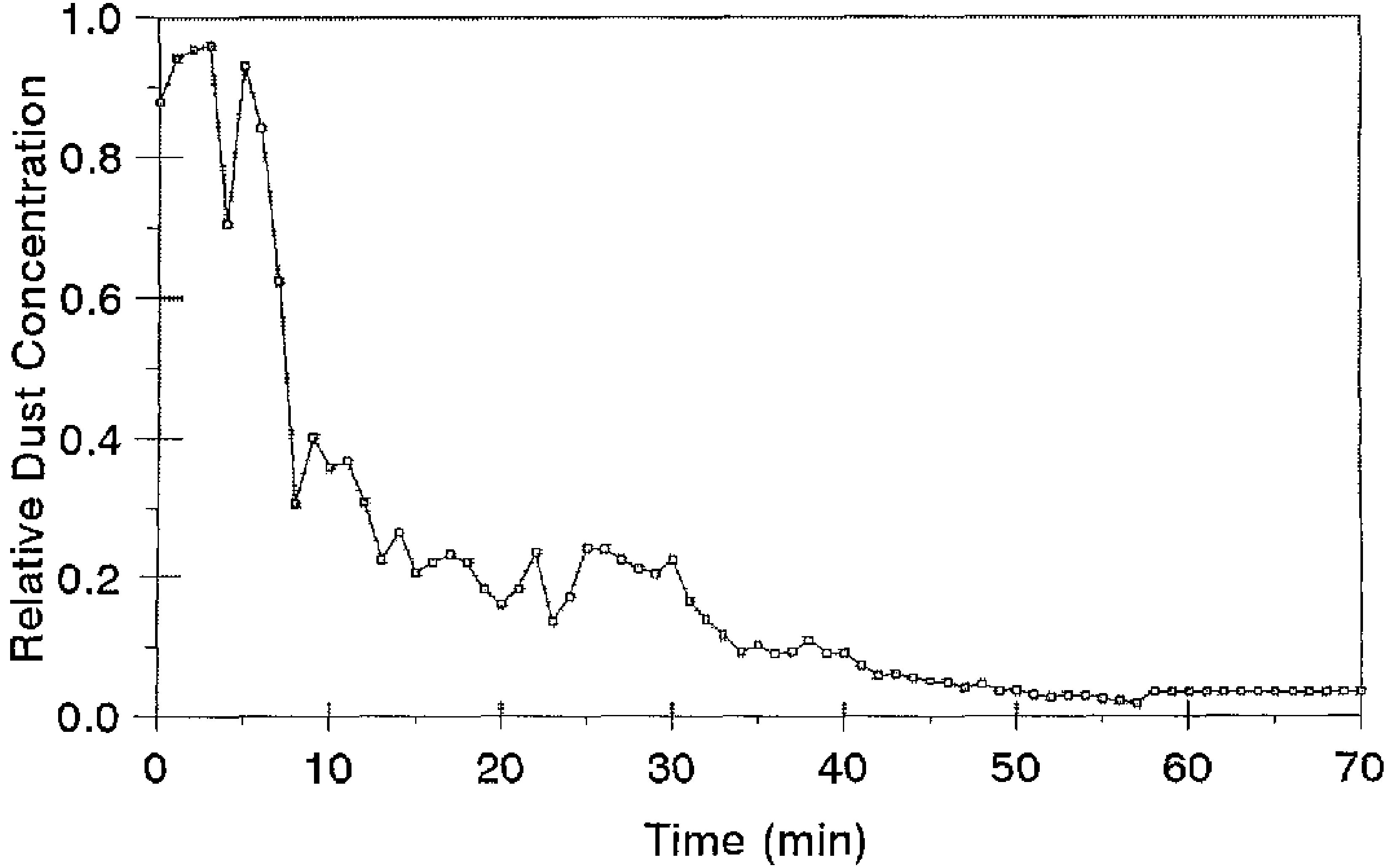
Table V Consecutive Area Sampling Results from Inside the Large Containment
Seaway Painting Company, Inc , Grand Rapids, MI

Sequence	Time (minutes)		Lead concentration (μg/m³)		Aerosol concentration (μg/m³)	
	Sample duration	Blast duration during sampling	Cassette (closed face) MCE filter	IOM	Cassette (closed face) PVC filter	IOM
1	84	82	11,000	50,000	1,200,000	680,000
2	89	70	29,000	39,000	410 000	350,000
3	167	110	3 300	-	200,000	-
4	97	97	26,000	-	440,000*	-
5	16	16	12,000	-		-
Sum TWA**	453	375	15,000	44 000	480,000	510,000

* One sample taken over both sequence 4 and 5 time intervals (total sample time = 113 min)
** Time-weighted average (TWA) concentration for the cumulative sampling period of each sampler type

Figure 3

Dust Decay From Large Containment
Seaway Painting, Inc., 10-7-92, Grand Rapids



the loose-fitting hood respirator Workers exited the containment area before removing their hood respirators and removed their tyvek coveralls before removing the paper dust mask During the lunch break the hood respirators were placed on the ground outside the containments One blaster stopped working several times during the day to take smoking breaks He came out of the containment, removed his respirators, and smoked adjacent to the large containment

Workers performing jobs outside the containment were provided half-mask air purifying respirators with HEPA filters An organic-vapor cartridge respirator was used during painting To help with equipment, some workers who were wearing half-mask respirators with HEPA filters moved in and out of the large containment before blasting started and just after the blasting was completed

The painting contractor provided periodic medical monitoring for lead exposure Personal hygiene facilities were provided on site, which included portable toilets and a changing area with a hand-washing sink and clothing storage hooks inside a portable trailer Although disposable protective coveralls were worn by the workers, many of the coveralls were torn several times by the end of the work day, thereby, worker clothing was contaminated with lead containing dust Since workers did not change clothing at the site, the dust could be carried by the workers to their automobiles, housing, and laundry facilities A more comprehensive respirator program providing for better training, use of respirators, storage of respirators and enforcement may also improve the PPF

Although some hygiene facilities were provided, they were not always used as evident by the blaster who took frequent breaks to smoke without first washing his hands Although disposable protective coveralls were worn, many of the coveralls were torn by the end of the workday In which case the workers clothing was contaminated with lead containing dust which was worn when the worker left the site

CONCLUSIONS AND RECOMMENDATIONS

- The large containment dilution ventilation system is almost of no value in reducing airborne lead exposures for those workers performing abrasive blasting inside the containment The lead exposures were as high as 24,000 $\mu g/m^3$ (geometric mean of 6,200 $\mu g/m^3$) and smoke tube tests showed containment air movement was negligible The small containment dilution ventilation system was effective in moving air as shown by the smoke tube tests but this air movement did not result in significantly lower lead exposures which were as high as 58,000 $\mu g/m^3$ (geometric mean of 20,000 $\mu g/m^3$)

- Persons working inside both large or small ventilated containment structures during dry abrasive blasting may be exposed to airborne lead concentrations in excess of 100 times the OSHA PEL for lead The continuous-flow loose-fitting hood respirator with an APF of 25 would not be the respirator of choice for this application because of the high airborne lead levels Additional engineering controls (i e , automation, local exhaust, or dust suppressants) and work practices should be developed and used to reduce the lead concentration inside the containment systems during abrasive blasting In the interim, as these more effective techniques and work practices are developed, a comprehensive respirator program, providing for good worker training, use and storage of respirators, and enforcement of the respirator programs could improve the PPF of the workers Additional research is needed to evaluate the exposure effect of replacing the loose-fitting respirator with a tight-fitting respirator in this work environment

- Environmental monitoring should be routinely performed to measure worker exposure to airborne lead and other hazardous agents (e g , silica and solvents) Respiratory protection must be selected based on measured airborne hazards for each job type It is recommended that the combination of distance and better control of the contaminant be applied so that equipment operators are not over exposed to lead At this site, the equipment area near the small containment had airborne lead concentrations less than 50 $\mu g/m^3$ because of adequate control and the distance from the equipment area to the containment However, the equipment area near the large containment had airborne lead concentrations greater than 50 $\mu g/m^3$ Support personal wearing only a half-mask respirator should not enter the containment during or immediately after the blasting process and must limit the time spent near the large containment where lead exposures are high Change rooms with showers and washing facilities need to be provided and used

- Based on the levels of airborne lead measured near the large containment and results from previous studies reporting lead contamination on workers hands, this practice of smoking prior to hand washing and smoking near the containment must be discontinued Respirators should be stored in a clean area when they are not in use It is recommended that employers re-enforce their hygiene program by routinely encouraging employees with walk-through and verbal contact during the work day Contaminated clothing should be laundered by the employer and the laundry should be informed that the clothing is contaminated with lead dust

- Further research is needed to verify the results of the small number of samples taken in this study and to investigate the effect of loose-fitting versus tight-fitting respirator performance, the effect of cleanliness of recycled grit, the type of filter needed to clean the ventilation exhaust air, and the effect of sampling in turbulent abrasive blasting atmospheres

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