IN-DEPTH SURVEY REPORT

CONTROL TECHNOLOGY FOR REMOVING LEAD-BASED PAINT
FROM STEEL STRUCTURES
ABRASIVE BLASTING USING STEEL GRIT WITH RECYCLING

AT

I-75 BRIDGE (Project 255-92)
Corcon, Inc
Dayton, Ohio

REPORT WRITTEN BY
R Leroy Mickelsen
Phillip A Froehlich

REPORT DATE
June 1993

REPORT NO
ECTB 183-12a

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, Mailstop R-5
Cincinnati, Ohio 45226

BRIDGE FACILITY SURVEYED	I-75 Bridge (Project 255-92) Corcon, Inc 3763 McCartney Road Box 106 Lowellville, Ohio 44436
SIC CODE	1721, 1622
SURVEY DATES	July 22, 1992, and August 1 and 6, 1992
SURVEY CONDUCTED BY	R Leroy Mickelsen Phillip A Froehlich Ronald M Hall Dennis M O'Brien Erica C Gavlak Glen Hadwen Kevin E Ashley Jacqueline D Travis Greg Piacitelli
PAINT CONTRACTOR REPRESENTATIVE	Louis Lyras, President
EMPLOYEE REPRESENTATIVE	No union
FACILITY OWNER REPRESENTATIVE	Joe Frilling Construction Project Specialist One Ohio Department of Transportation District #7 Box 969 Sidney, Ohio 45365
INSPECTION CONTRACTOR REPRESENTATIVE	Jeff Montgomary, Engineer Chris Adams, Engineer Shaw Weiss & DeNaples Engineering and Environmental Sciences 14 W First Street Dayton, Ohio 45402
ANALYTICAL WORK PERFORMED BY	Mark Millson Division of Physical Sciences and Engineering 4676 Columbia Parkway Cincinnati, Ohio 45226 DataChem Laboratories 960 West LeVoy Drive Salt Lake City, Utah 84123-2547 (801) 266-7700

DISCLAIMER

SUMMARY

A study to evaluate engineering controls in the steel structures painting industry was initiated because of increased reports of lead poisoning and silicosis among workers in this industry One control approach in this industry consists of abrasive blasting using steel grit as the abrasive media, coupled with a temporary containment system and equipment to collect, clean, and recycle the abrasive Using steel abrasive in place of sand eliminates the respiratory hazards associated with the use of silica sand, cleaning the abrasive before reuse was done to minimize the amount of lead-contaminated waste and consequently reduce worker lead exposure by lowering the lead content of the recycled abrasive This technique of using steel abrasive with recycling was monitored at a highway bridge repainting site in Dayton, Ohio, on three nonconsecutive days The repainting project required the removal of lead-based paint and application of a new lead-free coating To collect the abrasive and wastes, a containment system was constructed around and attached to the bridge structure It consisted of scaffolding, solid tarps for flooring, and 85 percent opaque tarps for the sides The control technique was monitored by collecting and analyzing–bulk samples of paint, abrasive, and waste materials, personal breathing zone samples of blasters, vacuumers, and support personnel, area samples near workstations, and observations of work practices and personal hygiene practices The deteriorated paint from the bridge contained 15 percent lead by weight Lead content in the used steel grit before cleaning was 1100 ppm by weight and 73 ppm by weight after cleaning by the recycling equipment

During one evaluation period of 106 minutes, the personal breathing zone lead exposure of the recycle screen cleaner, 9100 micrograms of lead per meter cubed of air ($\mu g/m^3$), resulted in an 8-hour TWA of 2000 $\mu g/m^3$, 40 times greater than the occupational safety and health administration (OSHA) permissible exposure limit (PEL) for lead (50 $\mu g/m^3$) in the interim final rule construction standard which is effective June 3, 1993 Immediate attention must be focused on reducing this exposure Engineering controls, such as local exhaust ventilation or a mechanical-screen shaker, could be incorporated into the grit unloading process to reduce the lead exposure of the recycle screen cleaner The arithmetic mean, 8-hour TWA lead exposure for the workers inside the containment system during the blasting process was 4000 $\mu g/m^3$, 80 times greater than the OSHA PEL for lead in the interim final rule construction standard The NIOSH certified continuous-flow abrasive blast type-CE respirators used by workers inside the containment at this site did not provide the protection needed The calculated mean program protection factor (PPF) for the type-CE respirator was 90 for the combined group of blasters and vacuumers working inside the containment during blasting The bounds of the 95 percent confidence interval for the PPF were 53 and 150 Additional engineering controls and work practices must be developed and used to reduce the lead concentration inside containment systems of this type Blasting with dry-abrasive for the purpose of removing lead-based paint from steel structures will generate levels of airborne lead greater than 50 $\mu g/m^3$ unless additional engineering controls are used to collect (ventilation) or suppress (additives for dust suppression) the lead particles as they are generated

During the blasting process, dust was periodically observed escaping the containment and airborne-lead levels measured as area samples near the containment were as high as 1700 $\mu g/m^3$ Respiratory protection must be used by all personnel who work near containment structures of this type while abrasive blasting is being conducted

Some workers smoked, ate, and drank at the worksite before washing Workers routinely left the worksite at the end of the workshift without changing their work clothing Washing and changing of clothing are important work practices that will reduce lead exposure due to ingestion and prevent workers from carrying lead home

The control of lead exposures using steel grit with recycling may be further enhanced by including forced air ventilation into the containment design, by including local exhaust ventilation at the blast nozzle, or by including dust suppressants in the blasting stream Other existing and developing engineering controls for this industry will be evaluated A final report will summarize the engineering controls evaluated during these surveys

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary federal organization engaged in occupational safety and health research Located in the Department of Health and Human Services (DHHS), it was established by the Occupational Safety and Health Act of 1970 This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions conducted by the Occupational Safety and Health Administration (OSHA) in the Department of Labor 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

Since 1976, ECTB has conducted assessments of health hazard control technology based on industry, common industrial process, or specific control techniques The objective of each of these studies has been to document and evaluate effective techniques for the control of potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of effective hazard control measures

Because of increased reports of lead poisoning and silicosis among workers in the steel structures painting industry, researchers from ECTB developed a study 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 Lead coatings have low surface energies and properties that suppress galvanic corrosion, lead coatings can be used over surfaces with little or no surface preparation [2] Although correct surface preparation is beneficial when using lead-based coatings, it is the primary and most important requirement for satisfactory application of alternative protective coatings for steel structures [2] Without a properly cleaned surface, even the most expensive alternative coatings will fail to adhere to or prevent rusting of the steel substrate [3] The old coating and mill scale (a relatively thick layer of iron oxide formed during the steel fabrication process) must be removed from the steel surface Additionally, an anchor pattern (a rough surface profile) imparted to the steel surface will increase the adhesive character of any new coating system 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 and mill scale, 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 (if silica is contained in the abrasive), and other debris become airborne, and the used abrasive becomes contaminated with lead-containing paint particles 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[4] 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 micrograms of lead per meter cubed of air ($\mu g/m^3$) average concentration over a 24-hour period[5] The Clean Air Act also limits the amount of lead to 1 5 $\mu g/m^3$, evaluated as a maximum arithmetic mean averaged over a calendar quarter[5] 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 increasing the concentration of 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 waste materials Automated waste recovery systems used in conjunction with containment structures are not completely effective, requiring manual sweeping, shoveling, or vacuuming Support personnel may also receive exposure when containment structures (which may contain or be contaminated with residual lead particles) are disassembled and moved High exposures have been observed for auxiliary equipment operators and for those cleaning up the site after paint removal has been completed[6]

The engineering control used in this evaluation consisted of abrasive blasting using steel grit as the abrasive media, coupled with a temporary containment system and equipment to collect, clean, and recycle the abrasive Using steel abrasive in place of sand eliminates the respiratory hazards associated with use of silica sand, cleaning the abrasive before reuse was done to minimize the amount of lead-contaminated waste and consequently reduce worker lead exposure by keeping the lead content of the recycled abrasive low

The control of lead exposures using steel grit with recycling may be further enhanced by including forced air ventilation into the containment design, by including local exhaust ventilation at the blast nozzle, or by including dust suppressants in the blasting stream Other existing and developing engineering controls for this industry will be evaluated A final report will summarize the engineering controls evaluated during these surveys

BRIDGE SITE AND PROCESS DESCRIPTION

The Ohio Department of Transportation (ODoT) is responsible for maintenance and repair of roadways and bridges in the State of Ohio Project 255-92, the repainting of bridge MOT-75-1371R on I-75 over the Great Miami River and North Bend Street, was undertaken due to the failing coating system When bridge coatings are in need of repair, the ODoT replaces the failed coatings with lead-free paints

Bridge MOT-75-1371R, a steel-beam continuous structure, was constructed in 1958 from steel I-beam girders produced by the Bethlehem Steel Company The bridge is 810 feet long, 52 feet wide (7 I-beams wide), and consists of 7 spans Each span of the bridge was approximately 100 feet long, with the maximum span being 115 feet long The bridge was repainted in 1970 using an unspecified painting system The current project was conducted June 22, 1992, through September 19, 1992 The ODoT contracted with Corcon, Inc , Lowellville, Ohio, to remove the old lead-based coating using recyclable steel grit, to obtain a blasted steel finish grade of SSPC-SP-10 "near white,"[7] to contain and collect the waste, and to protect the steel by applying lead-free paints (organic zinc primer, epoxy intermediate, and urethane top coat)

Scaffolding was suspended 30 inches below and attached to the bridge girders The containment system consisted of solid tarps for flooring to collect the abrasive and waste and 85 percent opaque tarps for the sides This containment system was suspended from and constructed around the steel support structure and scaffolding system The blast equipment consisted of air compressors to provide air for the abrasive delivery system, blast pots to hold the abrasive, and blast hoses and nozzles to deliver the abrasive to the point of use The abrasive blasting material used was angular steel grit (40 to 60 sieve, previously unused material) Abrasive material was transported from a mobile blasting pot to hand-held blasting nozzles with compressed air During blasting, an aerosol comprised of corrosion, paint, steel, and grit particles was produced This aerosol was dispersed by the velocity and pressure of the abrasive blast directed at the bridge surfaces As the steel grit was used, fresh material was added periodically to make up for losses due to grit erosion and breakdown

Immediately after the day's abrasive blasting, blasters used compressed air wands to blow down surface dust and grit remaining on the clean steel surfaces The blow down was followed by inspection and application of an organic zinc primer, epoxy intermediate, and urethane top coats

Where the containment system was suspended over water, spent grit and wastes were vacuumed from the containment floor during the blasting process Where the containment was over land, the grit and waste were vacuumed after the blasting process was completed for that day The grit and waste were vacuumed into a truck, transported to the cleaning equipment, dumped from the vacuum truck onto a coarse screen, and than conveyed to the cleaning system where it was magnetically separated, air washed, and stored for reuse The air passing through the vacuum truck was filtered before being exhausted to the surroundings When the truck was dumping the grit and waste through the coarse screen, one worker, the screen cleaner, stood next to the screen to remove large objects from blocking the screen and disrupt the flow of grit

The workers used personal protective equipment, including heavy cotton canvas coveralls (blasters), disposable earplugs, and respirators, all provided by the contractor Blasters used NIOSH-certified type-CE continuous-flow supplied-air helmets (E D Bullard Company, Cynthiana, Kentucky), equipped with vortex-type air coolers [8] The support personnel working near the blast or recycle equipment used half-mask air-purifying respirators with dust and mist prefilters and organic vapor cartridges These respirators were also used during the repainting process

The painting contractor provided periodic medical monitoring for lead exposure Personal hygiene facilities provided on site included a hand-washing sink, changing area, and clothing storage hooks inside a portable trailer, and portable rest rooms, all remotely located from the containment system

On July 22 (Day One), only the steel grit cleaning and recycle operation was monitored The cleaning operation work crew generally included an equipment operator and a screen cleaner Figure 1 is a diagram of the grit recycle-cleaning area, numbers in the figure indicate area sample location and airborne lead concentration The grit recycle operation area was also monitored on Day Two of the survey

On August 1 (Day Two) and 6 (Day Three), abrasive blasting on the steel structure supports under the bridge was monitored The blast operation work crew generally included a foreman, six blasters, three vacuumers, and three support personnel Each typical blasting day consisted of one hour of setup, five hours of blast cleaning, and two to three hours of cleanup and painting Each day, approximately one-third of the span was blasted and painted Figures 2 and 3 are top view diagrams of the bridge site on Day Two The span being blasted was approximately 40 feet above the water and paint was removed from the middle one-third of the span Vacuuming inside the containment occurred during and after the blasting process on Day Two, but only after the blasting process had been completed on Day Three Figure 4 is a top view diagram of the bridge site on Day Three This section of the bridge was above the bank which sloped from south to north down to the Great Miami River The distance from the bottom of the steel beams to the ground was approximately 7 feet at the south side of the span to approximately 35 feet at the north side The floor tarps were not suspended from the scaffolding as on Day Two, but were placed on the ground The blasting on Day Three was done at the south one-third of the span, where the ground was only 10 feet below the beams

SAMPLING AND ANALYSIS

The control technique of using steel abrasive with recycling for reducing worker exposures was monitored at a highway bridge repainting site on three nonconsecutive days The control technique was monitored for lead by collecting and analyzing bulk samples of paint, abrasive, and waste materials, personal breathing zone samples of blasters, vacuumers, and support personnel, area samples near workstations, and observations of work practices and personal hygiene practices

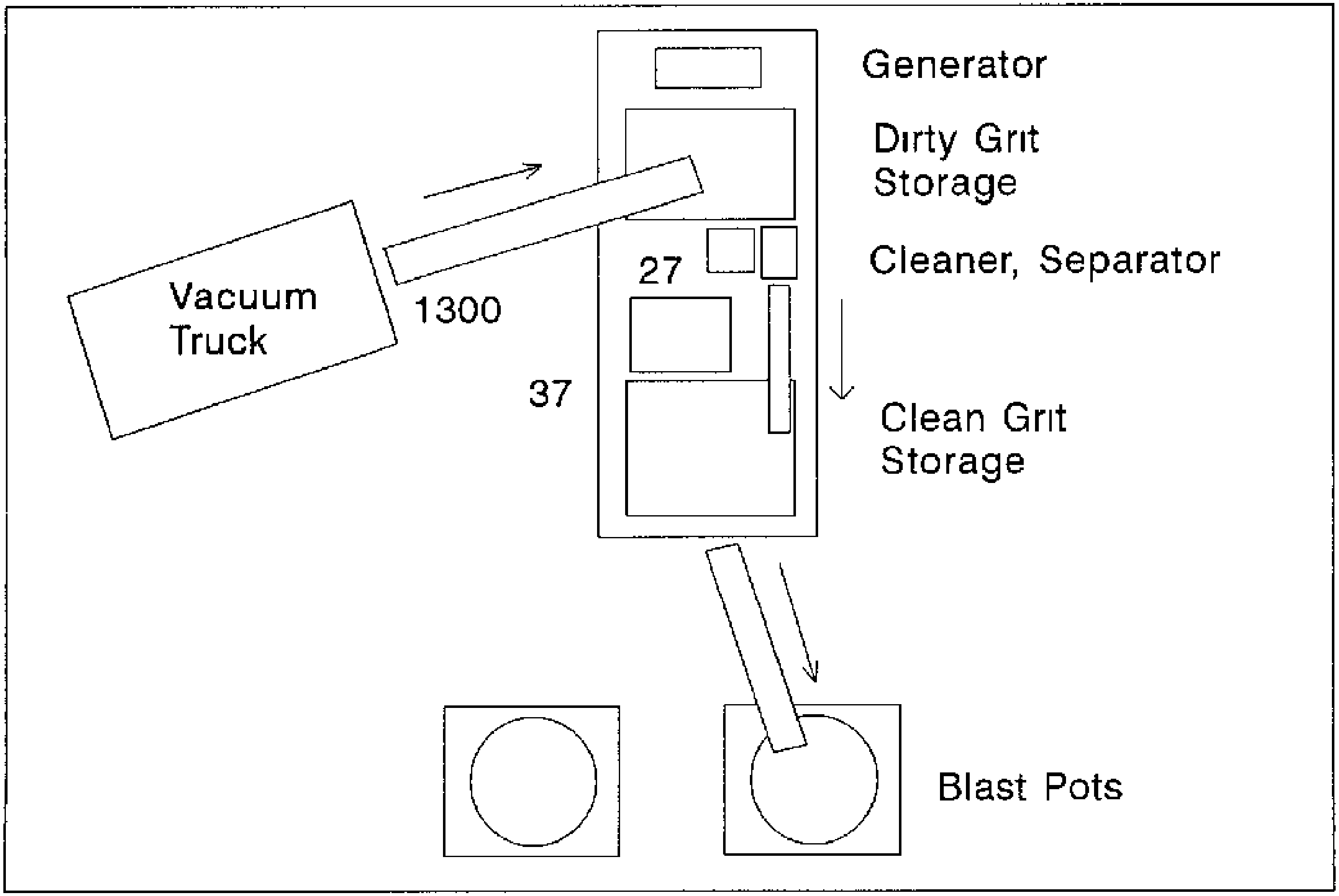
BULK SAMPLES

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 paint) Bulk samples of used abrasive and waste materials were collected during the grit cleaning process on Days One and Two The recycled abrasive was sampled to determine the effectiveness of the cleaning process

SURFACE SAMPLES

Surface dust samples (wipe samples) were collected using Wash 'n Dri® wipes inside company vehicles, inside the company office and changing trailer, inside blast helmets, and from workers' hands The wipe samples were collected by marking the wipe area, donning disposable gloves, removing the

Figure 1
Airborne Lead Concentrations During Recycling
(micrograms of lead per cubic meter of air)

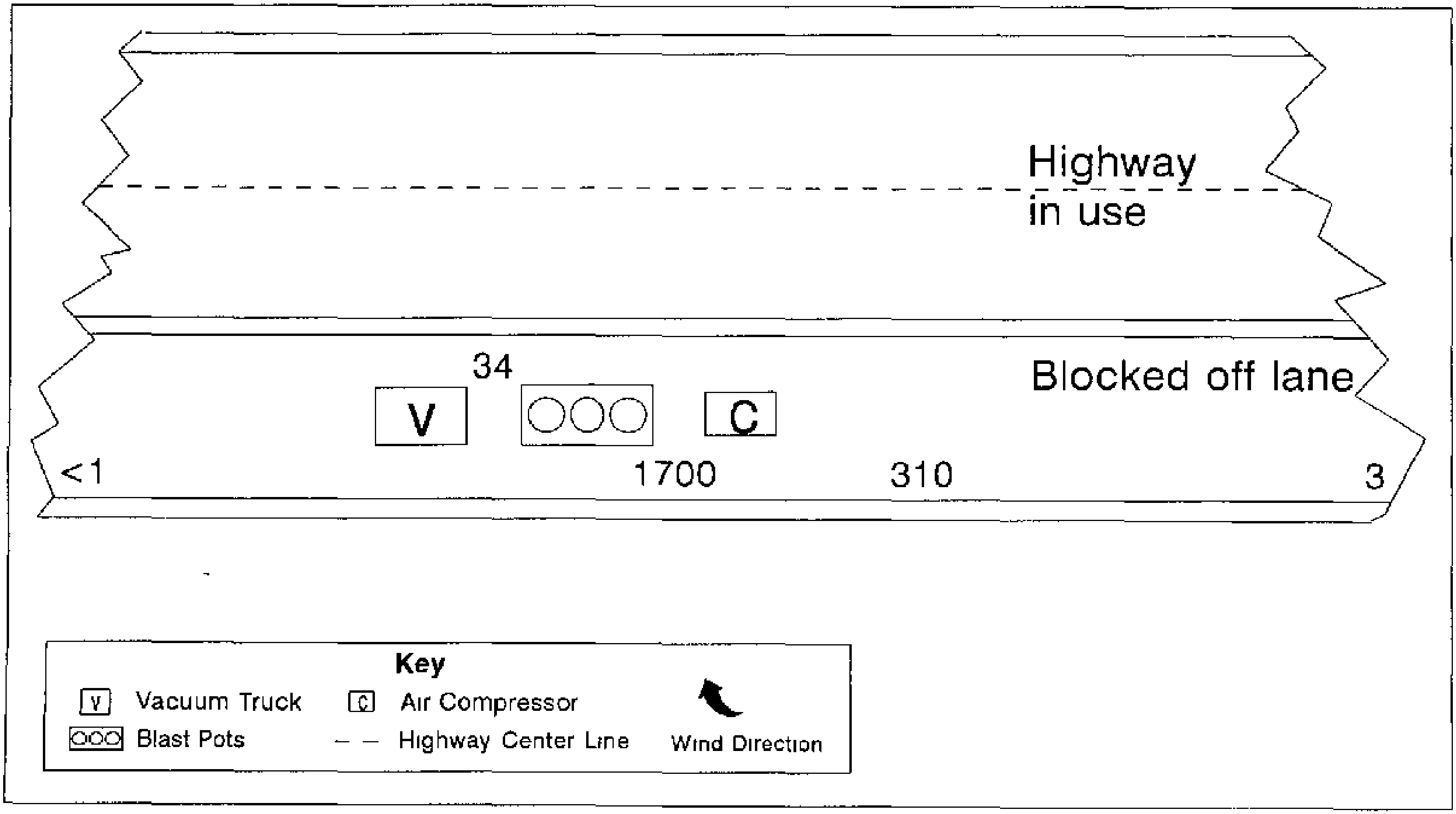


Recycle Operation (Day One)

Figure 2

Airborne Lead Concentrations on Top of the Bridge During Abrasive Blasting Under the Bridge

(micrograms of lead per cubic meter of air)

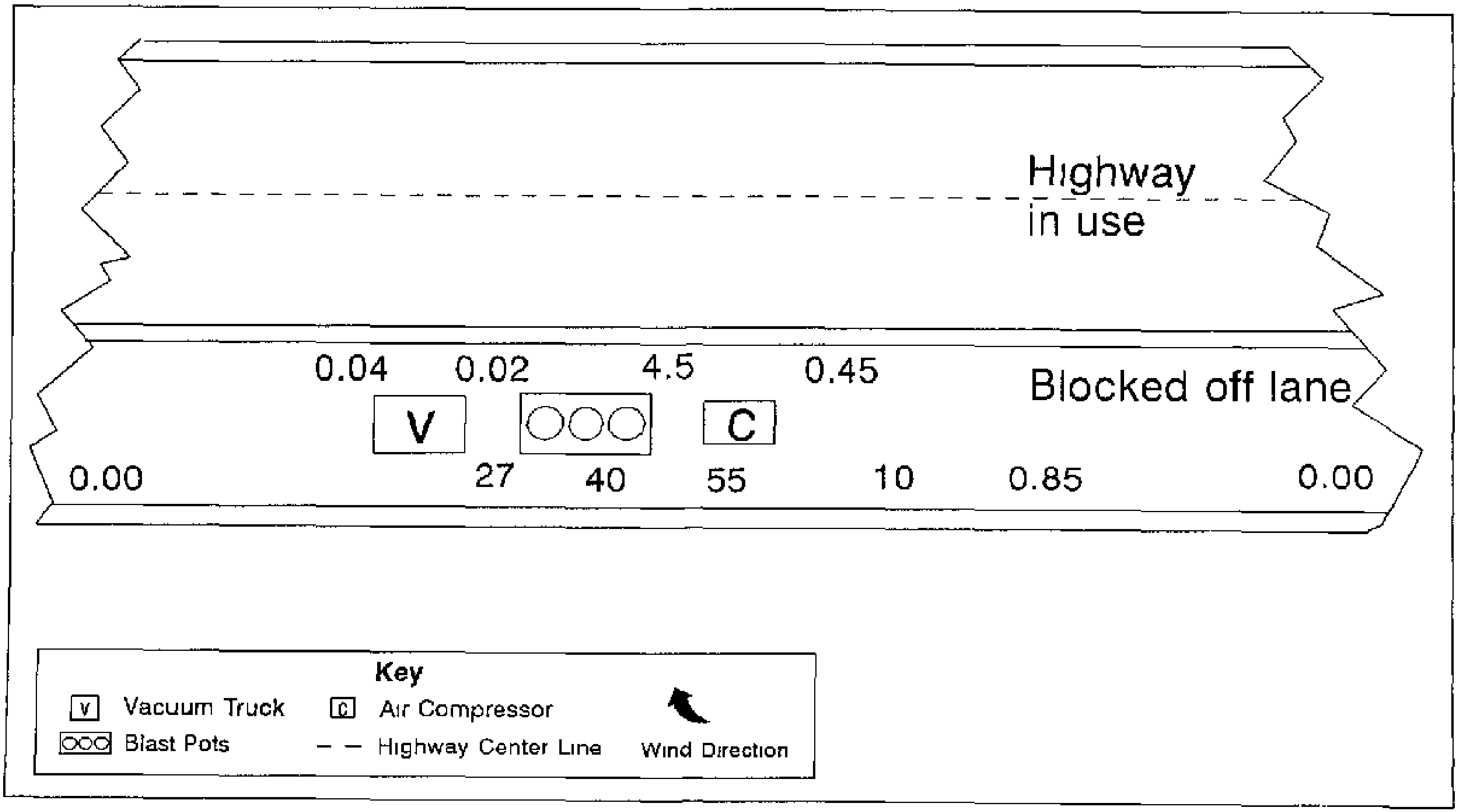


Top View of Bridge (Day Two)

Figure 3

Respirable Dust Concentrations on Top of the Bridge During Abrasive Blasting Under the Bridge

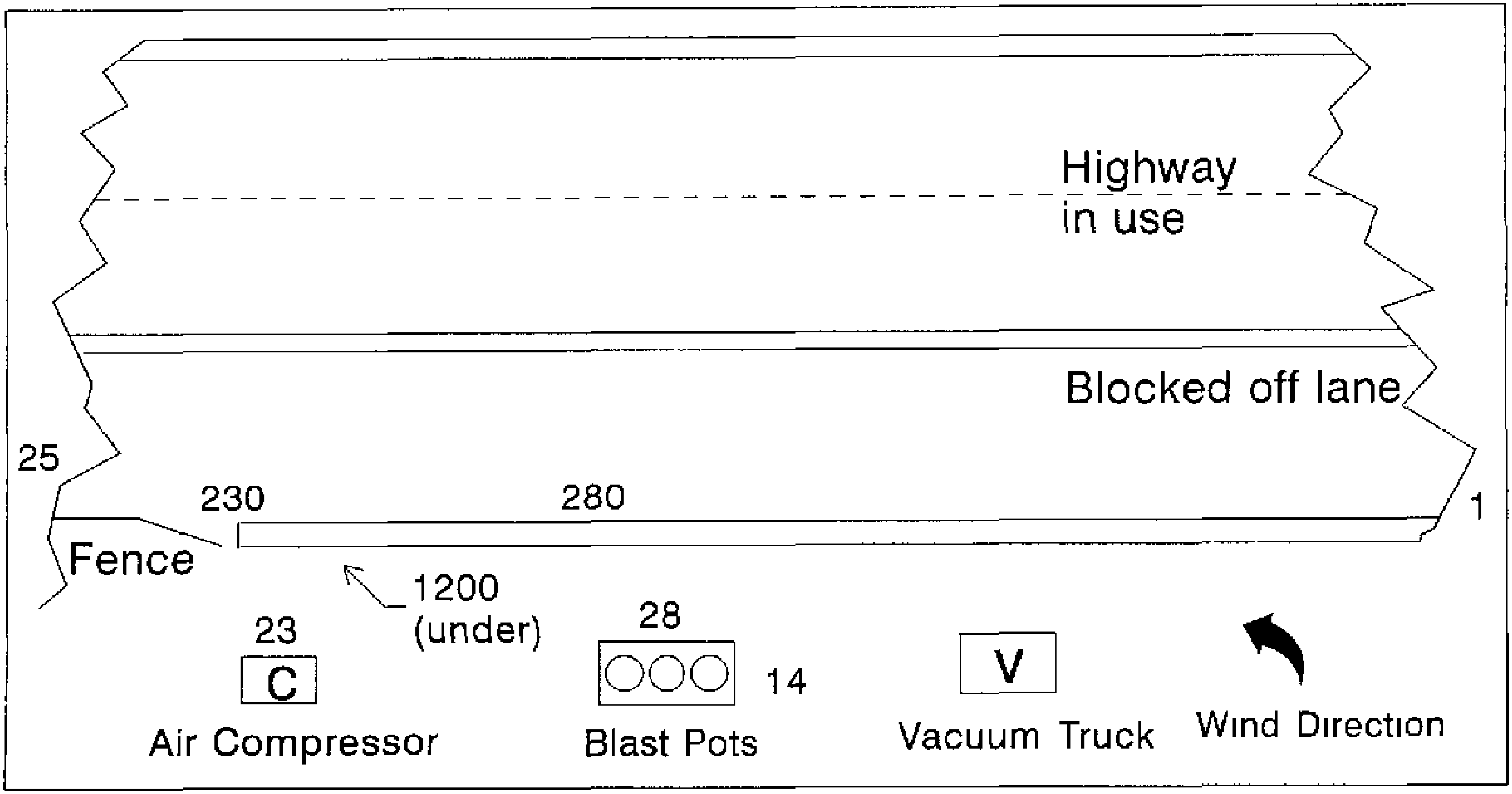
(milligrams of respirable dust per cubic meter, RAM data)



Top View of Bridge (Day Two)

Figure 4
Airborne Lead Concentrations on Top of the Bridge During Abrasive Blasting Under the Bridge

(micrograms of lead per cubic meter of air)



Top View of Bridge (Day Three)

wipe from the foil wrap, wiping the entire area using a horizontal S-pattern without lifting the wipe The wipe was then folded in half and the same area was wiped using a vertical S-pattern, the wipe was folded again and the area was wiped once more using the horizontal S-pattern Finally, the wipe was folded and placed in a sealable plastic bag The hand and helmet wipe samples were collected in a similar fashion, but the S-pattern and direction of wiping were loosely followed and the area wiped was estimated but not directly measured

PERSONAL SAMPLES

Eleven sets of personal breathing zone samples, outside and inside the CE-type blasting helmet respirator, were collected on 37-mm diameter, mixed cellulose ester membrane, 0 8-µm pore-size filters in closed-face cassettes using personal sampling pumps A sampling pump (Model 224-PCXR7, SKC Inc , Eighty Four, Pennsylvania) operating at 2 0 liters per minute (lpm) was used to collect the sample inside of the respirator Tygon® tubing placed under the workers' blast-protective outer clothing, and passing beneath the respirator cape, was used to connect the pump to the sample cassette The tubing was attached to the respirator collar, which placed the cassette in the breathing zone of the worker inside the respirator

Because overloading of the filter which was placed outside the respirator was anticipated, and changing the cassettes during the blasting operation was not always possible, a low flow pump was used for the personal samples collected outside the respirator The pump (Model LSF 113, Gilian Instrument Corporation, West Caldwell, New Jersey) operated at 0 1 lpm Tubing was used to connect the pump to the sample cassette The cassette was attached to the back of the workers' outer clothing rather than on the front lapel This was done to protect the filter from the aggressive blasting process and to reduce the likelihood of collecting large particles (>100 µm diameter, but <40,000 µm, the sampler inlet diameter) moving at high velocity during the blasting process The sampling pumps were worn on the workers' waist belt

When the blasting was completed, each sample cassette was detached from the collar of the respirator and attached to the worker's shirt collar The respirator was then removed and remained inside the contaminated containment The sampling pumps continued to run and remained on during one 15-minute break The samples and pumps were collected and turned off during a 40-minute lunch Upon returning to the blast area from the break and lunch, the cassettes used inside the respirator were reattached prior to blasting

For this evaluation, the ratio of the lead concentration on the sample outside the respirator to inside the respirator is considered to be the program protection factor (PPF) The PPF implicitly accounts for worker exposure for the time the respirator is and is not worn during the work cycle The PPF is, therefore, a measure of the effectiveness of the complete respiratory protective program and not just a measure of the effectiveness of the respirator [9]

Nine personal breathing zone samples for other employees on the worksite were also collected Recycle equipment operators, blast pot equipment operators, and laborers who set up and moved equipment were monitored using a belt-mounted 2 0 lpm sampling pump Tubing connected to the sampling cassette was attached to the worker's lapel All of these support personnel wore half-mask air-purifying respirators which were supplied by their employer

AREA SAMPLES

To compare several samplers and obtain a more complete picture of the area lead concentrations, five side-by-side area samples were collected inside the containment and another set of five samples was collected outside near the blast pots on two separate days These samples were for the determination of total lead (2 0 lpm and 0 1 lpm flow rates), inhalable dust, total dust, and particle size The sampler inlets were positioned so that all were collecting from approximately the same location to eliminate spatial concentration variations among samplers 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 Particle size results are discussed in Appendix A

A sampler 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 (SKC, Eighty Four, Pennsylvania) Air was drawn through the samplers using a personal sampling pump (Model P2500, Ametek, Largo, Florida) 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, followed by analysis to determine the amount of inhalable lead

The samplers inside the containment were placed in a 5-gallon bucket and lowered over the side of the bridge via a rope The bucket was located 15 inches above the scaffolding/tarp floor and just inside the edge of the containment structure The location of the bucket allowed for the changing of the filters without entering the containment during the blasting operation

Closed-face, 37-mm cassette sampling (both 2 0 and 0 1 lpm) was conducted outside the containment Sample locations were selected based on areas where workers were located and to measure the effectiveness of the containment

SAMPLE ANALYSIS

Analyses of air samples for lead were conducted using NIOSH Method 7300, inductively coupled argon plasma atomic emission spectrometry, when the lead results were below the limit of detection (LOD), samples were then analyzed using graphite furnace atomic absorption spectroscopy, NIOSH Method 7105 [10] A portion (0 5 grams) of each bulk sample was weighed and digested according to NIOSH Method 7300, modified for bulk analysis Because the bulk abrasive samples contained high levels of iron, which interfered with the detection of lead and other elements, these samples were diluted by 20 times to reduce the iron interference This resulted in a higher LOD for lead in the bulk abrasive samples Total dust and inhalable dust analyses were made using NIOSH Method 0500 with a limit of detection of 0 02 mg [11]

RESPIRABLE AEROSOL MONITOR

A Respirable Aerosol Monitor (RAM) was used to determine the respirable dust concentrations along the railing at the top of the bridge The optical characteristics of the RAM are such that it is most sensitive to respirable aerosols (dust and mists well below about 10 μm in diameter)

NOISE LEVELS

Noise Logging Dosimeters (Model M-27, Quest Electronics, Oconomowoc, Wisconsin) were included in the bucket of area samplers inside the containment and near the area samplers located by the equipment outside of the containment The A-weighted characteristics were used to compare the noise exposures to the NIOSH recommended exposure limit (REL)

OTHER OBSERVATIONS

Blood lead levels (BLL) were not collected as part of this study, however, BLL data collected by the employer were reported to the NIOSH investigators The half-life of lead in human blood is 28 to 36 days, thus, BLL may reflect relatively recent exposure to lead [12] However, there may not be a correlation between the BLL and the daily or weekly exposure to lead because lead cycles between the blood and bone Lead absorbed into the bone from previous exposures may be released into the bloodstream causing an increase in the BLL regardless of the most current lead exposures Thus, a single BLL may not directly correlate with the level of lead exposure obtained during a short survey (one to five days), the time necessary to evaluate engineering controls at a site

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 Although not the primary focus of this study, these practices are important elements of any program for protecting workers from exposure to lead dust [13]

EXPOSURE EVALUATION CRITERIA

GENERAL GUIDELINES

As a guide to the evaluation of exposures to chemical and physical agents in the workplace, NIOSH employs criteria which are intended to suggest levels of (airborne) exposure to which most workers may be exposed up to 10 hours/day, 40 hours/week for a working lifetime without experiencing adverse health effects It is important to note, however, that a small percentage of workers may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy) In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the levels set by the evaluation criteria Some substances are absorbed by direct contact with the skin and mucous membranes, or by ingestion, and thus the overall exposure may be increased above measured airborne concentrations Evaluation criteria are typically changed over time as new information on the toxic effects of an agent become available

The primary sources of environmental evaluation criteria in the United States that can be used for the workplace are (1) NIOSH Recommended Exposure Limits (RELs),[14] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values® (TLVs),[15] and (3) the U S Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) [16] The OSHA PELs are required to consider the feasibility of controlling exposures in various industries where the agents are used, the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease ACGIH TLVs refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects ACGIH states that the TLVs are guidelines The ACGIH is a private, professional society It should be noted that industry is legally required to meet only those levels specified by OSHA PELs

In addition, for some substances, there are short-term exposure limits or ceiling limits which are intended to supplement the TWA limits where there are recognized toxic effects from short-term exposures

Inhalation (breathing) of dust and fume, and ingestion (swallowing) resulting from hand-to-mouth contact with lead-contaminated food, cigarettes, clothing, or other objects are the major routes of worker exposure to lead Once absorbed, lead accumulates in the soft tissues and bones, with the highest accumulation initially in the liver and kidneys [17] Lead is stored in the bones for decades, and may cause toxic effects as it is slowly released over time or rapidly released during times of stress, such as illness or pregnancy

The frequency and severity of symptoms associated with lead exposure increase with increasing blood lead levels (BLLs) Signs or symptoms of acute lead intoxication include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort, colic, anemia, high blood pressure, irritability or anxiety, fine tremors, pigmentation on the gums ("lead line"), and "wrist drop "[18 19 20]

SURFACE LEAD SAMPLES

There are currently no state or Federal standards governing the level of lead in surface dust However, lead-contaminated surface dust represents a potential exposure to lead through ingestion Standards established by the Department of Housing and Urban Development (HUD) as final clearance standards for lead in house dust after lead abatement are an indication of what is "clean" floors, 200 micrograms per square foot ($\mu g/ft^2$), walls and window sills, 500 $\mu g/ft^2$, and window wells, 800 $\mu g/ft^2$ [21]

These criteria were empirically established as feasible limits for clearance following final cleaning during residential lead-based paint abatement HUD recommends the use of these criteria until they are refined or replaced through additional research The degree of precision normally required for industrial hygiene evaluations is not available with wipe sample methods, there can be a large variance in wipe sample results A previous study showed that only 50 percent of the ratios of side-by-side wipe sample concentrations fall between 0 6 and 1 5 [22] Therefore, the lead results obtained using surface wipe sampling is only a crude estimation of relative surface contamination

AIR SAMPLING

Under the OSHA standard regulating occupational exposure to inorganic lead in general industry, the PEL is 50 $\mu g/m^3$ as an 8-hour TWA [23] The standard requires semi-annual monitoring of BLL for employees exposed to airborne lead at or above the Action Level of 30 $\mu g/m^3$ (8-hour TWA), specifies medical removal of employees whose average BLL is 50 $\mu g/dl$ or greater, and provides economic protection for medically removed workers The construction industry was exempted from this regulation when it was promulgated in 1978 The OSHA PEL for the construction industry was 200 $\mu g/m^3$ during the survey Effective June 3, 1993, an OSHA interim final rule has amended the construction standard and reduces the PEL from 200 $\mu g/m^3$ as an 8-hour TWA to 50 $\mu g/m^3$ [24] The interim standard also includes many other requirements similar to requirements in the general industry standard The NIOSH REL for lead is less than 100 $\mu g/m^3$ as a TWA for up to 10 hours This REL is an air concentration to be maintained so that worker blood lead remains below 60 μg/100 grams of whole blood NIOSH is presently reviewing literature on the health effects of lead to reevaluate its REL The OSHA PEL for general industry is currently recommended for the construction industry by NIOSH as a more protective criteria OSHA and NIOSH coauthored a booklet entitled "Working with Lead in the Construction Industry,"[25] which contains general guidance for the following areas health effects, exposure monitoring, engineering and work practice controls, protective equipment, and medical monitoring

Several states have instituted programs to protect construction workers from the hazards of occupational lead exposure For example, Maryland enacted in 1984 (and modified in 1988) a comprehensive standard regulating occupational lead exposure in construction work [26] Under this standard, the permissible exposure limit for lead is 50 $\mu g/m^3$ as an 8-hour TWA This standard must be incorporated in all contracts involving bridge maintenance work in Maryland Connecticut has similar requirements for inclusion in contracts [27]

NOISE

The A-weighted decibel (dBA) is the preferred unit for measuring sound levels The dBA scale 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,[28] 5 dB less than the OSHA standard of 90 dBA [29]

RESPIRATORY PROTECTION AND PERSONAL HYGIENE

The respiratory program was evaluated based on the sample respirator program given in the NIOSH guide to industrial respiratory protection [30] The designated safety officer who writes the respirator program, selects the respirators, trains the users, and fits each employee with the appropriate NIOSH-approved respirator, should also assure that the wearing, cleaning, inspection, and storage of each respirator is carried out. Personal hygiene was evaluated based on the hygiene practices listed in the NIOSH lead alert.[1]

RESULTS AND DISCUSSION

BULK SAMPLES

Table 1 presents results of bulk sample analyses of paint obtained from the bridge, and clean and used abrasive collected from the recycling equipment. The deteriorated paint from the bridge contained 150,000 ppm (15 percent) lead by weight. The LOD for lead and other elements are shown in the tables. Other components of the deteriorated paint include: aluminum, 60,000 ppm, chromium, 8000 ppm, zinc, 5000 ppm, and magnesium, 2000 ppm, some of the 15,000 ppm iron is probably attributable to the removal of rust/steel from the substrate during the paint collection process.

Because of the large amount of iron in the bulk samples taken from the recycle equipment, a 20-fold dilution was necessary to reduce interference of the iron with the analysis of other components, thus, raising the limits of detection (LOD) for all components. The analyses of the clean recycled grit is very similar to the analyses of the unused grit with increases only in the amount of manganese and nickel for the recycled grit. Because the lead concentration of the cleaned grit was below the LOD when analyzed by NIOSH Method 7300, an additional analysis for lead only was done using NIOSH Method 7082, flame AA spectroscopy, to obtain a lower LOD for lead concentration in the grit samples. With a lower LOD, the cleaning efficiency of the recycle equipment can be evaluated. Lead content in the steel grit prior to cleaning was 1100 ppm by weight and 73 ppm after cleaning by the recycle equipment. This indicates a cleaning efficiency of 94 percent.

Bag house waste (fine dust) and large waste (i.e., paint chips) from the recycle cleaning process contained significant amounts of lead, 17,000 and 100,000 ppm, respectively. However, the ODoT reported that the wastes were classified as nonhazardous when tested for leachable lead. Under the Resource Conservation and Recovery Act (RCRA), waste material must be collected and tested. If the leachable lead concentration in the waste is greater than or equal to 5 ppm by weight, the waste must be classified as hazardous.[31] Iron has been reported to interfere with the leachable lead test. Samples of waste which include iron and hazardous amounts of leachable lead may yield a false negative result from the leachable lead test. Both the bag house dust and large waste had significant amounts of iron, 680,000 and 210,000 ppm (68 and 21 percent), respectively, which may explain the negative lead leachability test. The high level of lead in the large waste sample was most likely due to the large number of paint chips in the sample. The raw grit and bridge steel may be the primary source of nickel found in the grit and waste bulk samples, because nickel was not found in the initial paint samples scraped from the bridge. The raw grit and bridge steel may also contribute to the aluminum, copper, magnesium, and manganese contained in the bulk samples.

Table 1 Elemental Analysis of Bulk Samples, Concentration in PPM by Weight
ODoT Project 255-92, Dayton, Ohio

	Paint Scrapings		Recycle Equipment Bulk Sample Concentrations					
Element	Bridge Paint	Detection Limit	Raw Grit	Clean Grit	Dirty Grit	Large Waste	Bag House Dust	Detection Limit
Lead	150,000	40	ND*	73**	1,100	100,000	17,000	100
Aluminum	59,000	50	300	300	500	21,000	4,000	200
Chromium	8,000	10	ND	400	500	6,300	1,600	60
Cobalt	100	10	ND	ND	ND	100	ND	60
Copper	100	10	200	600	600	200	400	40
Iron	15,000	20	850,000	890,000	840,000	210,000	680,000	200
Magnesium	1,500	50	500	600	600	2,000	1,300	200
Manganese	100	10	800	1,800	2,100	800	200	20
Nickel	ND	20	200	1,000	1,200	100	700	80
Zinc	4,900	10	100	100	200	22,000	36,000	40

* ND - Below the detection level (Not Detected)
** Follow-up analysis was conducted with a LOD of 20 parts lead per million parts of sample

SURFACE LEAD SAMPLES

The surface sample results are listed in Table 2 These results indicate lead dust contamination in areas of the office, change room, on worker hands, inside blast helmets, and inside vehicles It appears from this small set of data that flat undisturbed surfaces accumulate the most lead contaminated

Table 2 Wipe Sample Lead Analysis, ODoT Project 255-92, Dayton, Ohio

Location		µg Lead/ft² Wipe area*
Office	Telephone	830
	Desk	96
	Window	6200
	File cabinet	640
Change Room	Wall	1800, 1800
	Water dispenser	9600
	Window	17000
	Storage doorknob	290
Hands	Before washing	190, 680, 1000, 1100
	After washing	61, 69, 190
Inside Blast Helmets		920, 1400, 1400, 1400, 1600, 1700, 1900
Inside Vehicles	Armrest	3400, 7200, 16000
	Steering wheel	120, 180, 260
	Dash	1300, 30000
	Seat	600
	Water cooler lid	100

* A value is given for each determination

dust vehicle dashboards and windows The office desk, office file cabinet, and vehicle seat are often disturbed, removing some of the dust from these surfaces Surfaces that are directly handled by workers with lead-contaminated hands include the telephone, the water dispenser, the storage doorknob, the vehicle armrests, and the steering wheel The high lead level on the water dispenser is a concern because of the possibility of drinking water becoming contaminated by this lead dust Another concern is the high level of surface contamination of the interior of the blast helmet respirator Air passing through the hood may entrain the lead which could then be inhaled by the worker The respiratory program should include regular cleaning, storage, and maintenance of the respirator [30] Washing hands prior to wipe sampling reduced the concentration of lead in the hand wipe samples by an order of magnitude

RESPIRATOR AND HYGIENE PRACTICE

The workers used personal protective equipment, including heavy cotton canvas coveralls (blasters), disposable earplugs, and respirators provided by the contractor Blasters used NIOSH-certified type-CE continuous flow supplied-air helmets (E D Bullard Company, Cynthiana, Kentucky), equipped with vortex-type air coolers Respirators were removed (after blasting) while inside the containment, workers should exit the containment area before removing their respirators

Workers performing jobs outside the containment were provided half-mask air-purifying respirators with organic vapor cartridge filters and dust, fume, and mist prefilters so that the same respirator could be used for both paint and dust protection Some workers who were wearing half-mask respirators with dust filters moved in and out of the containment while blasting was being conducted These workers should not enter the containment during or immediately after the blasting process because half-mask respirators do not provide adequate protection against the high airborne lead concentrations

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 Some workers smoked, ate, and drank at the worksite prior to washing Workers routinely left the worksite without changing their work clothing

AIR SAMPLES

Personal Exposure - Blasters and Vacuumers

Table 3 presents the results of personal breathing zone air sampling, outside and inside the CE-type respirator, for lead exposures inside the containment structure during blasting The arithmetic mean lead concentration for the sampling period inside the respirator (combining both the blast and vacuum operators who were inside the containment during the blasting process) was 76 $\mu g/m^3$ Seven out of 10 lead exposures measured inside the type-CE respirators were greater than 50 $\mu g/m^3$ Outside of the respirator, the arithmetic mean lead concentration was 5200 $\mu g/m^3$ The arithmetic mean, 8-hour TWA exposure was 4000 $\mu g/m^3$, 80 times greater than the OSHA PEL for lead in the interim final rule construction standard

Table 3 Personal Breathing Zone Air Sampling for Lead Exposures Inside the Containment Structure During Blasting ODoT Project 255-92, Dayton, Ohio

Day	Job Task	Sample Time (min)	Inside Respirator Concentration Ci (µg/m3)		Outside Respirator Concentration Co (µg/m3)		Program Protection Factor (PPF) (Co/Ci)
			TWA*	8-hr TWA**	TWA	8-hr TWA	
2	Blast	374	-	-	7,100	5,600	-
2	Blast	375	43	34	2,400	1,900	55
2	Blast	370	52	40	14,000	11,000	280
2	Vacuum	600	160	160	-	-	-
2	Vacuum	598	110	110	7,900	7,900	73
2	Vacuum	350	100	75	3,900	2,800	38
3	Blast	283	110	65	1 500	860	13
3	Blast	370	52	40	3 100	2,400	59
3	Blast	362	35	27	5,500	4 200	160
3	Blast	418	62	54	2,900	2,600	47
3	Blast	100	36	7	3,300	730	92
All Data	mean (sd)***	380 (140)	76 (41)	61 (44)	5,200 (3,800)	4 000 (3 300)	90 (81)****

* TWA for sampling time
** 8-hr TWA extrapolated values assume no other airborne lead exposure during the workshift
*** Standard deviation, (sd)
**** The lower and upper 95% confidence interval for the PPF were 53 and 150, respectively

Respirator Protection Factor

The calculated program protection factor (PPF) for the type-CE respirator was 90 for the combined group of blasters and vacuumers working inside the containment during blasting One of the nine PPFs was below 25 and three were below 50 The PPF lower and upper 95 percent confidence levels for the CE-type respirator are 53 and 150 The observations of this survey provide supporting evidence for the NIOSH assigned protection factor (APF) of 25 for the CE-type respirator Vacuumers worked inside the containment during the abrasive blasting process on Day Two, and after the blasting process was completed on Day Three

Additional engineering controls and work practices should be developed and used to reduce the lead concentration inside the containment system In the interim, a more comprehensive respirator program providing for better training, use of respirators, storage of respirators, and enforcement may improve the PPF Respirators were removed (after blasting) while inside the containment, workers should exit the lead-contaminated blast area and enter a relatively noncontaminated area before removing their blasting helmets Wearing the blasting helmet when entering and exiting the contaminated area may increase the risk of trips and falls due to the air line and obstruction of vision If a noncontaminated area cannot be accessed safely while wearing the respirator, then other measures (i e , a clean ventilated area inside the containment to remove and store respirators prior to exiting the containment) should be used to avoid increased lead exposure and respirator contamination Respirators should not be stored in lead-contaminated areas when not in use In addition, the use of a positive-pressure type-CE respirator with an APF of 2000 will greatly reduce the exposure to workers as compared to the continuous-flow type-CE respirator with an APF of 25 [1]

Personal Exposure - Support Personal and Recycle Personal

Table 4 presents the results of support and recycle personal breathing zone monitoring During the sampling period (106 minutes), the personal breathing zone lead exposure of the recycle screen cleaner, 9,100 $\mu g/m^3$, was greater than the current OSHA construction industry PEL of 200 $\mu g/m^3$ His 8-hour TWA lead exposure was 2000 $\mu g/m^3$, 40 times greater than the OSHA PEL for lead in the interim final rule construction standard On Day Two, the recycle equipment operator performed both the equipment operation and the screen cleaning His 8-hour TWA lead exposure was also 2000 $\mu g/m^3$ This lead concentration was 10 times higher when he performed both jobs than on the previous day when he performed only the equipment operator's job Based upon the assigned protection factor (APF), the half-mask respirators worn by these workers do not reduce workers' exposure to an acceptable level This high lead exposure is unsafe even for short periods of time and immediate attention should be focused on reducing the exposure around the recycle screen area An engineering control, such as local exhaust and/or a mechanical screen shaker, could be incorporated into the grit unloading process in order to reduce the lead exposure to below 50 $\mu g/m^3$

Lead exposures of support personnel wearing half-mask respirators fitted with dust filters were below the OSHA PEL for lead exposure, 50 $\mu g/m^3$, as long as the workers did not enter the containment structure during or immediately after the blasting process Some workers wearing only a half-mask respirator (who were not being monitored), moved in and out or the containment while blasting was being conducted Workers wearing only half-mask respirators should not enter the containment during or immediately after the blasting process During the blasting process and at periodic intervals, "clouds" of dust were observed escaping the containment Respiratory protection should be used by all personnel in the vicinity of the containment structure

Table 4 Personal Breathing Zone Air Sampling for Lead Exposures of Blast Site Support Personnel
ODoT Project 255-92, Dayton, Ohio

Day	Location	Task	Sample Time (min)	Exposure ($\mu g/m^3$) TWA*	8-hr TWA**
1	Recycle	Operator	96	200	40
1	Recycle	Screener	106	9,100	2,000
1	Recycle	Hygienist	222	42	20
2	Recycle	Operator & Screener	576	2,000	2,000
3	Not Stationary	Laborer	198	15	6
3	Not Stationary	Laborer	390	48	40
3	Not Stationary	Laborer	390	42	34
3	Blast Equipment	Foreman	344	60	43
3	Not Stationary	Hygienist	246	63	32

* TWA for sampling time
8-hr TWA, extrapolated values assume no other airborne lead exposure during the workshift

Area Concentrations Within the Containment

The area samplers located inside the containment structure were frequently changed to prevent overloading of the filter cassettes Table 5 presents the analytical results from the series of consecutive area samples taken inside the containment on Day Two, the TWA resulting from those consecutive samples, and the area samples taken near the blast pots on Day Two There is a large variation of lead (ranging from 60 to 15,000 $\mu g/m^3$) and dust (ranging from 15 to 470 mg/m^3) concentrations among the sequenced samples This may be due in large part to the location of the sample relative to the blasting process and the amount of blasting being done during each sampling period The filter media of three IOM samplers were torn by the impact of particles (probably when the blasting process was conducted closest to the sampling area), the other sampling methods collected their highest lead concentrations during this time Blasters moved approximately 40 feet over the course of the day while the sampling location was stationary

Area Concentrations Outside of the Containment

The blast pot area, which was located on top of the bridge on Day Two and on the bank on Day Three, had much lower lead and dust levels than inside the containment

Table 5 Consecutive Area Sample Results and Summation Statistics For Day Two
ODoT Project 255-92, Dayton, Ohio

Sequence	Time (minutes)		Lead concentration (µg/m³)				Aerosol concentration (µg/m³)		
	Sample duration	Blast duration during sampling	Cassette (closed face) 2 lpm flow rate	Cassette (closed face) 0 1 lpm flow rate	IOM	Marple	IOM	Marple	Cassette (closed face)
1	58	48	4,400	5,500	3,900	2,100	180,000	100,000	90,000
2	42	42	12,000	11,000	-	5,200	-	-	400,000
3	39	39	15,000	6,600	3,500	2,800	470,000	-	320,000
4	56	20	3,500	2,700	4,200	-	180,000	-	70,000
5	92	65	670	1,800	610	-	120,000	-	15,000
6	162	89	1,100	370	-	-	-	-	22,000
7	110	0	70	60	-	-	-	-	-
Sum TWA*	559	303	3,200	2,500	2,700	3,200	200,000	100,000	97,000
Pot	590	303	30	30	60	44	3,300	2,600	800

* Time weighted average (TWA) concentration for the collective sampling period of each sampler type

It was anticipated that the IOM sampler would yield higher lead and total dust results than the other samplers, because the closed-face cassette samplers do not collect large particles as efficiently as the IOM sampler In agreement with these expectations, the IOM aerosol results were significantly higher than the closed-face dust sampler results However, the lead results from the IOM sampler were not significantly different from the 2 0 lpm closed-face sampler results when compared over the entire survey This suggests that the lead is present primarily as small particles As discussed previously, three of the 13 IOM samples collected inside the containment had torn filters from large-particle impact From visual inspection, most of the remaining 10 IOM samples had collected particles much larger than 100 μm aerodynamic diameter Because the blasting process produces a nonisokinetic sampling environment, the IOM sampler, with its 22-mm inlet, is an easy target for abrasive blast media and debris The IOM sampler results and discussion are uncertain because of this problem

The cumulative lead and aerosol concentration for the Marple impactor stages are shown in Table 5 Some of the impactors had particles with a diameter greater than 100 μm wedged in the air passages down to the third and fourth stages The Marple sampler was not designed to accommodate particles of this size or to sample in this nonisokinetic airstream Further results and discussions are uncertain because of this problem and are placed in Appendix A Table 6, a summary of data collected on Day Three, is similar to Table 5 (no impactor data were collected on Day Three)

Comparison of Sample Efficiency Between Collection Flow Rates

Samples inside and outside the respirator were collected in identical fashion, except the flow rates through the inside and outside samplers were 2 0 and 0 1 lpm, respectively Thirty-one paired, closed-face cassette lead samples were collected during the course of the study to determine if there was a significant difference between the results obtained by the two different collection flow rates A student's t-test for the mean difference between sample collection rates determined that the results were statistically equivalent Samples taken in the highly turbulent airflow patterns around an abrasive blasting process may tend to yield highly variable results A technique for long-term (4 hours or more) air sampling in high lead and aerosol concentrations needs to be developed (intermittent short-term sampling by cycling the sampling pump on and off may be an viable alternative) A technique for air sampling in highly turbulent flow during abrasive blasting also needs to be developed so that large, high velocity particles do not impinge on the sampling surface

To reduce the chance of collecting large particles, the sample cassettes were attached to the back of the workers' outer clothing to avoid the high velocity particles which ricocheted in front of the worker However, because there were six blasters working concurrently and in close proximity, this technique may not have eliminated the collection of large particles Three of the 13 IOM samples taken inside the containment had torn filters from large particle impact

Table 6 Consecutive Area Sample Results and Summation Statistics for Day Three
ODoT Project 255-92, Dayton, Ohio

Sequence	Time (minutes)		Lead concentration ($\mu g/m^3$)			Aerosol concentration ($\mu g/m^3$)	
	Sample duration	Blast duration during sampling	Cassette (closed face) 2 lpm flow rate	Cassette (closed face) 0 1 lpm flow rate	IOM	Cassette (closed face)	IOM
1	27	27	1,863	3,367	-	64,000	-
2	30	30	2,949	5,724	6,041	130,000	180,000
3	30	30	1,392	1,804	2,379	38,000	95,000
4	26	26	1,153	1,166	1,605	26,000	78,000
5	52	26	428	583	539	16,000	130,000
6	84	60	848	962	1,964	19,000	53,000
7	48	12	226	210	515	9,000	25,000
8	24	24	-	1,263	-	-	-
9	39	39	1,085	777	-	26,000	-
Sum TWA*	360	274	1,100	1,500	1,900	35,000	85,000
Pot	398	274	30	10	40	2	0 8

* Time weighted average (TWA) concentration for the collective sampling period of each sampler type

Other Area Samples

The results observed for the area sampling are given in Table 7 Figures 1 and 2 present graphically the locations and airborne lead concentrations of some area samplers The high levels of lead observed in the area samples located inside the containment and next to the recycle vacuum truck during dumping correspond to the high lead levels found for the personal samples taken in those areas The high lead levels atop the bridge (designated as bridge top and top of ladder) on both Day Two and Day Three and just downwind of the bridge at the fence on Day Three indicates that lead was escaping through the side tarps During the blasting process and at periodic intervals, dust was observed escaping the containment In general, in areas where visible dust levels were high, a correspondingly high lead concentration was determined by the personal and area samples

Table 7 Area Air Samples, ODoT Project 255-92, Dayton, Ohio

Day	Location	Time (min)	Lead concentration (μg/m³)	
			2 lpm flow rate	0 1 lpm flow rate
1	Recycle vacuum truck	177	1,300	-
1	Recycle equipment	213	37	-
1	Recycle equipment	206	27	-
2	Recycle equipment	566	20	ND
2	Inside containment	559	3,200	2,500
2	Top of ladder	574	1,700	5,500
2	Bridge, top side	403	310	390
2	North of site	558	3	-
2	South of site	569	ND	-
2	Blast pots, top side	590	30	30
3	Fence down wind	345	230	-
3	Inside containment	360	1,100	1,500
3	Bridge, top side	369	210	290
3	North of site	345	1	ND
3	South of site (down wind)	375	30	10
3	Blast pots, ground	398	30	10

Real-Time Monitoring

In addition to the integrated area samples, the RAM was used to monitor the respirable dust on top of the bridge during the blasting process These measurements were short (about 1 minute) and may not reflect actual exposures measured by integrated sampling methods The RAM measurements performed at this site are best judged as they relate to differences by location The RAM measurements, respirable dust concentration in mg/m^3, are shown on Figure 3 for Day Two Directly above the blast area and at the edge of the bridge, the respirable aerosol concentration was the highest The aerosol concentration dissipated quickly as the RAM was moved away from the area directly above the blast and the edge of the bridge

NOISE

The blast duration during each sampling period was determined by evaluating the sound level meter results When blasting was in progress, the noise level, as detected by the noise dosimeter inside the containment, increased by 25 dBA over the background noise level Because direct visual observations were not always possible, the noise level meter provided valuable information about the blasting process The blast duration data are shown in Table 5 The results of the area noise monitoring are given in Table 8 Both the

Table 8 Area Noise Levels, (dBA)
ODoT Project 255-92, Dayton, Ohio

Day	Location	Duration (min)	Noise level (dBA)	Noise level during blasting only (dBA)
1	Recycle	100	93	-
2	Inside containment	480	93	106
	Equipment	480	91	93
	South of site	480	80	80
	North of site	480	72	72
3	Inside containment	404	98	110
	Equipment	414	95	98
	Equipment	409	94	94
	South of site	406	77	77

blasting and equipment areas are above the NIOSH and OSHA noise exposure levels Inside the containment, the noise levels were as high as 110 dBA during blasting and may have been higher closer to the operation The noise levels inside the blasters' or vacuumers' helmets were not recorded Because noise level readings were collected as area samples, not personal samples, a direct evaluation of personal exposure levels cannot be made However, the noise levels observed at this site indicate the need for a hearing conservation program The CE-type respirators may provide some attenuation of the noise, high airflow velocities may contribute to the noise Workers both inside and outside the containment routinely wore foam ear plugs

OTHER OBSERVATIONS

The prevailing wind, gusting to perhaps 10 miles per hour, was generally from the east, however, the 85 percent opaque side containment tarps reduced the flow of air through the blast area Air flow through the containment was variable and not readily measured During the blasting process and at periodic intervals, dust was observed escaping the containment

CONCLUSIONS AND RECOMMENDATIONS

During the sampling period, the personal breathing zone lead exposure of the recycle screen cleaner, 9,100 $\mu g/m^3$, was greater than the current OSHA construction industry PEL of 200 $\mu g/m^3$ This high lead exposure is unsafe even for short periods of time and immediate attention should be focused on reducing the exposure around the recycle screen area It is recommended that an engineering control, such as local exhaust and/or a mechanical screen shaker, be incorporated into the grit unloading process in order to reduce the lead exposure to below 50 $\mu g/m^3$ The contractor is retrofitting this area with local exhaust ventilation

The abrasive blast CE-type respirators used inside the containment at this site generally provided the amount of protection needed to meet the current construction industry PEL of 200 $\mu g/m^3$, which was in effect during this survey but would not provide sufficient protection to meet more stringent standards of the June 3, 1993, interim final rule (50 $\mu g/m^3$) The program protection factor (PPF) for the type-CE respirator was calculated to be 90 for the combined group of blasters and vacuumers working inside the containment during blasting However, the field observations provide supporting evidence for the 25 APF for the CE-type respirator It is recommended that additional engineering controls and/or work practices be developed and used to reduce the lead concentration inside the containment system In the interim, a more comprehensive respirator program providing for better training, use of respirators, storage of respirators, and enforcement may improve the PPF Respirators should not be stored in lead-contaminated areas when not in use Workers should exit the lead-contaminated blast area and enter a relatively noncontaminated area before removing the blasting helmets If a noncontaminated area cannot be accessed safely while wearing the respirator, then other measures (i e , a clean ventilated area inside the containment to remove and store respirators prior to exiting the containment) should be used to avoid increased lead exposure and respirator contamination

Lead exposures of support personal using half-mask respirators fitted with dust filters were below the interim final rule OSHA PEL of 50 $\mu g/m^3$, as long as the workers did not enter the containment structure during or immediately after the blasting process Some workers wearing a half-mask respirator (who were not being monitored) moved in and out of the containment while blasting was being conducted Workers wearing half-mask respirators should not enter the containment during or immediately after the blasting process During the blasting process and at periodic intervals, dust was observed escaping the containment It is recommended that respiratory protection be used by all personnel in the vicinity of the containment

It is recommended that the contractor continue to provide periodic medical monitoring for lead exposure Providing personal hygiene facilities on site, such as a hand-washing sink, changing area, and clothing storage, should continue Contaminated work clothes should be removed before leaving the worksite and shower facilities are recommended It is recommended that incentives and enforcement of the use of these hygiene facilities be increased so that regular use becomes routine

Based on the surface lead wipe sampling, it is recommended that all workers exposed to lead wash their hands and faces before eating, drinking, or smoking, and not eat, drink, or use tobacco products in the work area

The analyses of the clean recycled grit is very similar to the analyses of the new unused grit with increases only in the amount of manganese and nickel for the recycled grit This indicates a cleaning efficiency of greater than 93 percent, the maximum detectable by the analytical method used

From the 31 paired samples tested at this abrasive blasting site, sampling at the 0 1 lpm or 2 0 lpm flow rates yield results that are statistically equivalent Samples taken in the highly turbulent airflow patterns around an abrasive blasting process may tend to yield highly variable results It is recommended that a technique for long-term (4 hours or more) air sampling in high lead and aerosol concentrations be developed (cycling the sampling pump on and off may be an viable alternative) It is also recommended that a technique for air sampling in highly turbulent flow during abrasive blasting be developed so that large, high velocity particles do not impinge on the sampling surface

Both the blasting and equipment areas are above the NIOSH and OSHA noise exposure level of 85 and 90 dBA, respectively It is recommended that workers both inside and outside the containment continue to wear hearing protection When blasting was in progress, the noise level increased by 25 dBA over the background noise level Thus, even though direct visual observations were not always possible, the noise level monitor served as a means for recording the start and stop times for the blasting process

The waste from the recycle cleaning process contained significant amounts of lead, 17,000 and 100,000 ppm, respectively However, the lead leachability tests were negative Iron has been reported to interfere with the leachable lead test Samples of waste which include iron and hazardous amounts of lead may yield a false negative result from the lead leachable test

REFERENCES

1 NIOSH [1991] NIOSH Alert Request for assistance in preventing lead poisoning in construction workers Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No 91-116

2 Spangenberg WC, Stoner H [1989] History of lead containing coatings and pigments In Appleman BR, Rex J, eds Proceedings of the Steel Structures Painting Council, Lead Paint Removal Conference Arlington, VA Steel Structures Painting Council, pp 6-9

3 McGannon HE [1970] The making, shaping and treating of steel 9th ed Pittsburgh, PA The United States Steel Corporation, Herdick and Held Publishers, p 986

4 CFR [40 CFR 260 (1990)] Code of Federal Regulations Washington, DC U S Government Printing Office, Office of the Federal Register

5 CFR [40 CFR 50 (1990)] Code of Federal Regulations Washington, DC U S Government Printing Office, Office of the Federal Register

6 CONSAD Research Corporation [1992] Lead in construction - site visit #11 Research performed for the U S Department of Labor, Occupational Safety and Health Administration, Office of Regulatory Analysis, Contract J-9-F-0011, March 10

7 SSPC [1989] Visual standard for abrasive blast cleaned steel SSPC VIS1-89 Pittsburgh, PA Steel Structures Painting Council, Publication No 89-05

8 National Institute for Occupational Safety and Health *NIOSH Certified Equipment List as of December 31, 1991* (DHHS/NIOSH Pub No 92-101) Washington, D C Government Printing Office, 1992 p C-45

9 Guy HP [1985] Respirator performance terminology [letters] Am Ind Hyg Assoc J *46*(5) B-22

10 National Institute for Occupational Safety and Health *Elements (ICP) Method 7300, and Lead Method 7105* In NIOSH manual of analytical methods 3rd rev ed , edited by P M Eller (DHHS/NIOSH Pub No 84-100) Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1984

11 National Institute for Occupational Safety and Health *Nuisance Dust, Total, Method 0500* In NIOSH manual of analytical methods 3rd rev ed , edited by P M Eller (DHHS/NIOSH Pub No 84-100) Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1984

12 ATSDR/EPA [1990] Toxicological profile for lead Prepared by Syracuse Research Corporation under Contract No 68-C8-0004 Syracuse, NY U S Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, in collaboration with U S Environmental Protection Agency, ATSDR/TP-88/17

13 Ulenbelt P, Lumens MEGL, Geron HMA, Herbert RFM, Broersen S, Zielhuis RL [1990] Work hygienic behavior as modifier of the lead air-lead blood relation Int Arch Occup Environ Health *62*(3) 203-207

14 CDC (Centers for Disease Control) [1988] NIOSH recommendations for occupational safety and health standards MMWR *37*(S-7) 1-29

15 ACGIH [1992] 1992-1993 Threshold limit values and biological exposure indices Cincinnati, OH American Conference of Governmental Industrial Hygienists

16 CFR [29 CFR 1910 1000 OSHA 3112 (1989)] Code of Federal Regulations Air contaminants-permissible exposure limits Washington, D C U S Government Printing Office, Office of the Federal Register

17 NIOSH [1988] Occupational safety and health guideline for inorganic lead In NIOSH Occupational health guidelines for chemical hazards Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No 88-119 Supplement I-OHG

18 Hernberg S, et al [1988] Lead and its compounds In Occupational medicine 2nd ed Chicago, IL Year Book Medical Publishers, pp 547-582

19 Landrigan PJ, et al [1985] Body lead burden summary of epidemiological data on its relation to environmental sources and toxic effects In Dietary and environmental lead human health effects Amsterdam Elsevier Science Publishers

20 Proctor NH, Hughes JP, Fischman ML [1988] Lead In Chemical hazards of the workplace 2nd ed Philadelphia, PA J B Lippincott Company, pp 294-298

21 HUD [1990] Lead-based paint Interim guidelines for hazard identification and abatement in public and indian housing Washington, DC U S Department of House and Urban Development, Office of Public and Indian Housing

22 Lichtenwalner CP [1992] Evaluation of wipe sampling procedures and elemental surface contamination Am Ind Hyg Assoc J *53*(10) 657-659

23 CFR [29 CFR 1910 1025 (1989)] Code of Federal Regulations OSHA lead standard Washington, DC U S Government Printing Office, Office of the Federal Register

24 CFR [29 CFR 1926 62 (1993)] Code of Federal Regulations Washington, DC U S Government Printing Office, Office of the Federal Register

25 NIOSH/OSHA [1991] Working with lead in the construction industry Washington, DC U S Government Printing Office, U S Department of Labor, Occupational Safety and Health Administration, U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health OSHA 3126

26 Maryland Regulations Code [1988] Occupational exposure to lead in construction work Title 09, Subtitle 12, Chapter 32 (COMAR 09 12 32)

27 Connecticut Department of Transportation [1991] Bid specifications - construction, lead health and safety program, 4/8/91 Hartford, CT The Department of Transportation

28 NIOSH [1972] NIOSH criteria for a recommended standard occupational exposure to noise Cincinnati, OH U S Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No 73-11001

29 CFR [29 CFR 1910 95 (1990)] Code of Federal Regulations Washington, DC U S Government Printing Office, Office of the Federal Register

30 NIOSH [1987] Guide to industrial respiratory protection Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No 87-116

31 CFR [40 CFR 261 (1990)] Code of Federal Regulations Washington, DC U S Government Printing Office, Office of the Federal Register

APPENDIX A

PARTICLE SIZE DETERMINATION

The evaluation of particle size distribution was determined to be necessary because the size of the particles will determine the site of deposition in the lung or airway The smaller particles, below 4-μm aerodynamic diameter, will deposit in the lung and be absorbed into the system at an efficiency of 30 to 50 percent [32] The larger particles, between 4- and 20-μm aerodynamic diameter, will deposit in the airways and end up in the gastrointestinal tract where there is approximately 10 percent absorption efficiency

The lead particle size determination was made using a six-stage Marple Personal Cascade Impactor Kit, Model 290 (Andersen 2000, Inc , Atlanta, Georgia) at a rate of 2 0 lpm Three types of collection substrates were used uncoated, 34-mm diameter, mixed cellulose ester (MCE), uncoated, 34-mm diameter, PVC, and silicon oil coated, 34-mm diameter, mylar films Within the cascade impactor, two consecutive stages that have the same cut point were used to provide a means to evaluate the effects of particle bounce and/or overloading [33] The following stages and cut-points were used

Impactor Stage	Cut-Point (μm)
1a	21
2a	15
1b	21
2b	15
3	10
4	6
5	3 5
F	0

Mylar and PVC substrates were pre- and post-weighed to determine total aerosol on each stage, NIOSH method 0500 [34] The MCE was not weighed PVC and MCE substrates were analyzed for total lead per NIOSH methods 7300 and/or 7082 The oil used on the mylar films interferes with the lead digestion and analysis, thus they were not analyzed for lead

In theory, particles with the aerodynamic size greater than 15 μm in diameter should impact and stay on the first two stages, 1a and 2a The second set of stages, 1b and 2b, should only have a small fraction of the amount of aerosol that would be found on stages 1a and 2a unless particle bounce and/or overloading has occurred With the uncoated MCE and PVC substrates, the second set of stages, 1b and 2b, contained 27 to 130 percent (average of 65 percent) of lead and aerosol as compared to the first set of stages, 1a and 2a The large amount of dust on the second set of stages indicates a large degree of particle bounce and/or overloading as shown in Table A With the coated mylar film substrates, there was less particle bounce and/or overloading The second set of stages, 1b and 2b, contained 15, 16, 17, and 40 percent (average of 22 percent) of aerosol as compared to the first set of stages, 1a and 2a The particle bounce and/or overloading will yield large particles on lower stages of the impactor and bias in the results The cumulative particle size distribution for the first set of data from Table A is shown in Figure A as a straight line plotted on a natural log versus a probability log plot Although the data looks normal (a straight line), it is biased because of the large amount of particle bounce and/or overloading The results show an erroneously large mass of smaller particles, the distribution is shifted toward the small particles as compared to the actual distribution

Table A Particle Size Distribution Data
ODoT Project 255-92, Dayton, Ohio

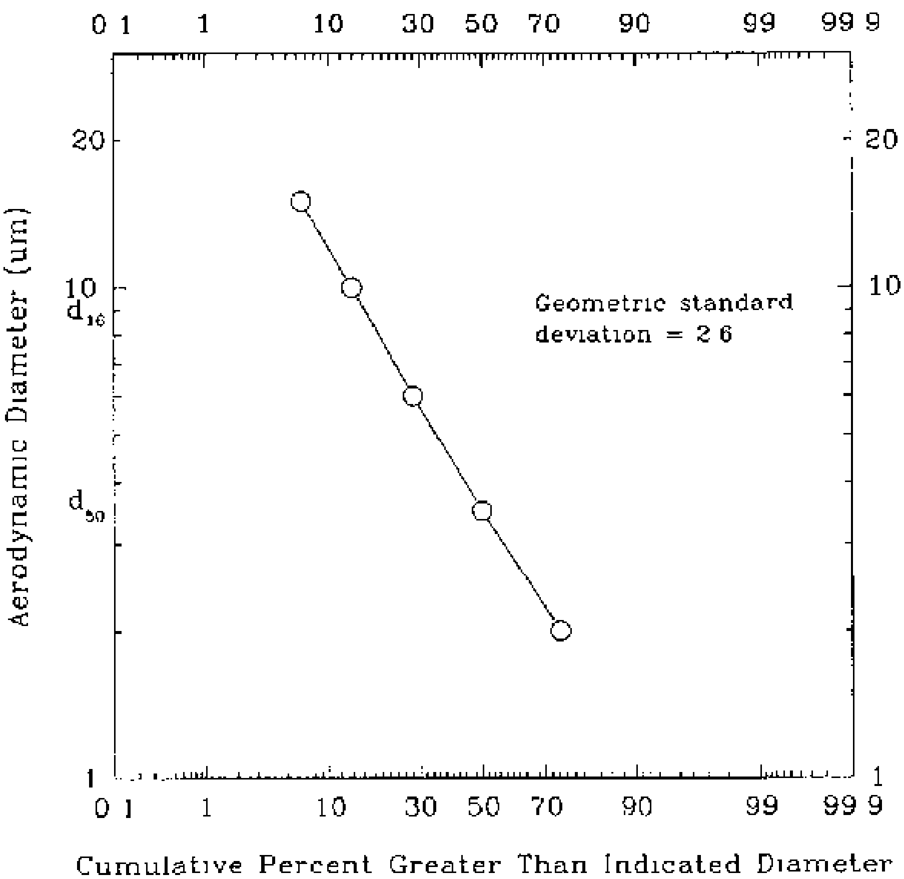
Headings	Samples taken during abrasive blasting						
Substrate	MCE	MCE	MCE	Mylar	Mylar	PVC	PVC
Time (min)	40	54	58	58	447	474	474
Analyte Location	Lead Inside*	Lead Inside	Lead Inside	Aerosol Inside	Aerosol Outside	Aerosol Outside	Lead Outside
Stage No / Cut-Point (μm)	μg / filter	μg / filter	μg / filter	μg / filter	μg / filter	μg / filter	μg / filter
1a/21	24	35	32	2,300	790	2,300	2 4
2a/15	27	37	33	2,000	690	1,600	6 7
1b/21	13	14	10	350	130	630	3 2
2b/15	26	25	31	810	110	1,100	2 4
3/10	52	36	18	1,200	170	1,000	4 2
4/6 0	80	60	29	2,400	150	1,000	5 5
5/3 5	88	40	19	1,400	70	-390	4 7
F/0 0	94	52	74	1,200	270	1,400	12

* Inside = samples were taken inside the containment
Outside = samples were taken outside the containment

Appendix A

Figure A

Cumulative Lead Particle Size Distribution
40 Minute Sample Inside Containment



REFERENCES

32 ATSDR/EPA [1990] Toxicological profile for lead Prepared by Syracuse Research Corporation under Contract No 68-C8-0004 Syracuse, NY U S Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, in collaboration with U S Environmental Protection Agency (EPA), ATSDR/TP-88/17

33 Hinds WC, Liu WV, Froines JR [1985] Particle bounce in a personal cascade impactor a field evaluation Am Ind Hyg Assoc J *46*(9) 517-523

34 NIOSH [1984] Nuisance Dust, Total, Method 0500 In Eller PM, ed NIOSH manual of analytical methods 3rd rev ed Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No 84-100