IN-DEPTH SURVEY REPORT
CONTROL TECHNOLOGY FOR METAL RECLAMATION INDUSTRIES

AT

East Penn Manufacturing Company Inc
Lyon Station, Pennsylvania

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), a federal agency located in the Centers for Disease Control and Prevention under the Department of Health and Human Services, was established by the Occupational Safety and Health Act of 1970 This legislation mandated NIOSH to conduct 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 and develop engineering controls and assess their impact on reducing occupational illness and injury Since 1976, ECTB has conducted a large number of studies to evaluate engineering control technology based upon industry, process, or control technique The objective of each of these studies has been to document and evaluate control techniques and to determine their effectiveness in reducing potential health hazards in an industry or at specific processes

This study of metal reclamation (and specifically lead reclamation) is being undertaken by ECTB to provide control technology information for preventing occupational disease in this industry The lead reclamation industry has historically had high occupational lead exposures which can result in neurotoxic disorders and disorders of reproduction These two work-related diseases have been targeted by NIOSH under the "ten leading work-related diseases and injury" initiative This list was based upon frequency of occurrence, severity of effect, and likelihood of developing effective preventative strategies

The goal of this study is to identify, evaluate, and disseminate information regarding practical control methods which reduce exposures to lead The study will be accomplished by identifying and evaluating existing control methods used in metal reclamation industries Information on control methods will be disseminated in scientific and trade journal articles and handbooks for use by workers, owners and operators, the OSHA consultation program, and other safety and health professionals

Walk-through surveys were conducted to collect air and blood lead data from smelters and to familiarize NIOSH personnel with the process and controls presently used in the industry Preliminary data on production rates, descriptions of the control methods, photographs, records of air contaminant results, and biological monitoring results were collected The blood and air lead data obtained from the different lead smelters during walk-through surveys were analyzed These results indicated that East Penn had the lowest air lead concentrations in the various areas of the smelter Therefore, East Penn was selected for in-depth evaluation The purpose of this survey was to evaluate potentially effective controls and work practices Occupational health programs (including training and incentive programs) were also considered when selecting in-depth survey sites

PLANT DESCRIPTION

East Penn Manufacturing Co , Inc (Metals Division) is a secondary lead smelter that operates 7 days a week, 343 days a year Smelter operations shut down two weeks in July and eight holidays throughout the year The facility recycles approximately 20,000 batteries a day Spent batteries are returned to East Penn Manufacturing by East Penn trucks

Batteries recycled by the plant are mainly automobile batteries, however, some industrial batteries are also recycled Lead, sulfuric acid, and plastic from spent batteries are reclaimed The lead and sulfuric acid are recycled on-site The plastic (polypropylene) is washed and placed in East Penn trailers to be transported to plastic recycling facilities which manufacture new battery cases for the company The reclaimed lead and sulfuric acid are used by the company to manufacture new batteries

PROCESS DESCRIPTION

The following process information was obtained from Leiby [1] Spent batteries (batteries at the end of their usable life) are brought to the plant by commercial trucks In the battery breaking area, batteries, stacked on pallets, are removed from trucks by forklift and placed on a work platform The batteries are then manually removed from the pallets and placed on a roller track This track feeds a series of conveyors which turn the batteries on their sides and carries them through a slow speed saw that cuts off the tops Electrolyte from the batteries is collected and pumped to storage at the Acid Reclaim Department Lead bearing material is extracted from the battery cases (using a group extractor) and conveyed to the material storage building The tops and empty battery cases are conveyed to a recovery unit A flotation separator is used to separate the lead bearing material from the plastic (polypropylene) The polypropylene sold to East Penn's current case and cover suppliers is recycled for the manufacture of cases and covers for new batteries

The lead bearing material in the material storage building is moved by a front-end loader to a vibratory feeder capable of holding up to 30 tons of charge material Charge material is vibrated into a weigh bucket and then discharged to a pusher feeder which in turn feeds it to the reverberatory furnace This material sits on a drying shelf inside the furnace where it is dried by radiation and convection from the furnace gases and walls before being smelted The principle objective of this furnace is to reduce the lead compounds to metallic lead and oxidize alloying agents to produce a slag

Slag is tapped from the furnace into 2,400-lb molds After the slag cools, it is taken to the material storage building Slag (from the reverberatory furnace) and industrial battery cells are the main feed material for the blast furnace The blast furnace is fed with an automated feeding and weighing system The feed stock for the blast furnace is charged in proportions designed to yield antimony levels close to refined metal specifications The slag and matte from the blast furnace can be reprocessed through the blast furnace to create a residual discard slag

Lead from the reverberatory furnace is tapped into one of two 75-ton kettles The lead is then pumped to one of four refinery kettles where it is refined according to specifications The lead is then pumped to a casting machine where it is cast into 70-lb ingots.

Lead from the blast furnace is tapped into 2,600-lb ingots The 2,600 lb ingots from the blast furnace are placed in storage and fed to the alloying kettles as needed This lead is alloyed to specifications and pumped to the casting machine where it is cast into 70-lb ingots The lead ingots are used by East Penn Manufacturing to manufacture new batteries

POTENTIAL HAZARDS

Workers in this secondary lead smelter are potentially exposed to lead and cadmium

Lead

Lead adversely affects a number of organs and systems in the human body The four major target organs and systems are the central nervous system, the peripheral nervous system, kidney, and hematopoietic (blood-forming) system [(2)] Inhalation or ingestion of inorganic lead can cause a range of symptoms and signs including loss of appetite, metallic taste in the mouth, constipation, nausea, colic, pallor, a blue line on the gums, malaise, weakness, insomnia, headache, irritability, muscle and joint pains, fine tremors, and encephalopathy Lead exposure can result in a weakness in the muscles known as "wrist drop," anemia (due to shorter red blood cell life and interference with the heme synthesis), proximal kidney tubule damage, and chronic kidney disease [(3-4)] Lead exposure is associated with fetal damage in pregnant women [(2-4)] Finally, elevated blood pressure has been positively related to blood lead levels [(5-6)] The occupational exposure criteria for inorganic lead in air is the current OSHA permissible exposure limit (PEL) 50 $\mu g/m^3$ [(7)] In addition, workers with blood-lead concentrations higher than 60 micrograms per deciliter (µg/dl) of whole blood, or a blood lead average of 50 µg/dl or greater averaged over six months or the last three samples, whichever is longer, must be immediately removed from the work environment In cases where the blood-lead concentrations exceed 40 µg/dl, blood-leads and protoporphyrin levels must be monitored every two months [(7)] A summary of the lowest observable effect levels of lead are listed in Table I

TABLE I
Summary of Lowest Observed Effect Levels for
Key Lead-Induced Health Effects in Adults and Children[@]

BLL* (µg/dl)		HEALTH EFFECT
>100	Adults	Encephalopathic signs and symptoms (disease of the brain)
>80	Adults	Anemia Encephalopathic signs and symptoms
	Children	Chronic nephropathy (kidney disease)
>70	Adults	Clinically evident peripheral neuropathy (diseases of the nerves of the extremities
	Children	Colic and other Gastro-Intestinal (GI) symptoms
>60	Adults	Female reproductive effects Central Nervous System (CNS) symptoms sleep disturbances, mood changes, memory and concentration problems, headache
>50	Adults	Decrease hemoglobin production Decreased performance on neurobehavioral tests Altered testicular function GI symptoms abdominal pain, constipation, diarrhea, nausea, anorexia
	Children	Peripheral neuropathy
>40	Adults	Decrease peripheral nerve conduction Elevated blood pressure (white males, 40-59 years old) Chronic nephropathy
	Children	Reduced hemoglobin synthesis
>25	Adults	Elevated zinc protoporphyrin levels in males
15-25	Adults	Elevated zinc protoporphyrin levels in females
	Children	Decreased IQ and Growth
>10**	Fetus	Pre-term Delivery Impaired Learning Reduced Birth Weight Impaired Mental Ability

[@] Adopted from ATSDR[8], and Goldman et al [9]
* Blood lead level (BLL) in micrograms per deciliter (µg/dl)
** "Safe" blood lead level has not been determined for fetuses

Cadmium and Compounds

Early symptoms of cadmium exposure may include mild irritation of the upper respiratory tract, a sensation of constriction of the throat, a metallic taste and/or cough [10] Short-term exposure affects include cough, chest pain, sweating, chills, shortness of breath, and weakness if enough cadmium dust has been inhaled Short-term exposure effects of ingestion of cadmium may cause nausea, vomiting, diarrhea, and abdominal cramps [11] Long-term exposure effects of cadmium may include loss of the sense of smell, ulceration of the nose, shortness of breath (emphysema), kidney damage, and mild anemia [11] Long-term exposure to cadmium may result in an increased risk of cancer of the lung and of the prostate [10] The OSHA PEL for cadmium is 5 $\mu g/m^3$ TWA [10]

CONTROL TECHNOLOGY

East Penn Manufacturing (Metals Division) employs automation, local exhaust ventilation, partial enclosures, and enclosed ventilation systems in the reverberatory furnace operations, blast furnace operations, and casting and refinery area to reduce employee exposure to lead In addition, HEPA-filtered half-mask respirators are worn in production areas of the plant

ENGINEERING CONTROLS

Examples of automation used in the smelter include the following 1) The battery dismantling operation is an automated system that cuts the tops off the batteries, the saws are located in enclosed ventilated hoods, 2) A conveyor feeds the cases to a flotation separator which recovers the plastic that can be recycled, 3) A front-end loader places lead bearing material on an automated vibratory feeder that vibrates the material into a weighing bucket, 4) The automated weigh bucket deposits the lead bearing material in front of an automated ram feeder which feeds the reverberatory furnace, 5) Dust collected in bag houses is conveyed and discharged in front of the ram feeder that feeds the material to the furnace, 6) Furnace charging operations are controlled by a programmable controller located in a control room next to the charging equipment, 7) Some lead is drossed in the kettles by using an automated drossing machine

Examples of ventilation controls in the smelter include the following 1) Lead plates are separated from the battery cases in an enclosed ventilated group extractor, 2) As a method of exposure control for the general smelter population, the lead bearing raw material used to feed the furnaces is stored in a separated and enclosed material storage building The enclosed building is under negative pressure to minimize fugitive emissions, 3) A front end loader (equipped with a HEPA filtered air-conditioned cab) is used to move the lead-bearing material in the material storage building, 4) Slag is tapped from the furnaces into 2,400-lb molds under enclosed ventilated hoods, 5) Lead is tapped from the reverberatory furnace into enclosed ventilated kettles, 6) Lead is tapped from the blast furnace into 2,400-lb molds that are located under a ventilated hood, 7) Kettles in the refinery area are enclosed and ventilated, 8) Lead is pumped to a ventilated casting machine and cast into 70-lb ingots

RESPIRATOR PROTECTION PROGRAM

A respirator protection program has been established according to the Occupational Safety and Health Administration's (OSHA) lead standard [7] This program was designed to reduce worker exposure to lead to below the mandated PEL

PERSONAL PROTECTIVE EQUIPMENT

Half-mask respirators (with HEPA filters) and work clothes or coveralls are worn by employees in all production areas of the plant In addition, hearing protection, hard hats, safety shoes, safety glasses, and gloves are worn by employees in production areas Face shields and heat protective clothing are worn during furnace operations and casting and alloy pot operations

WORK PRACTICES AND HYGIENE

East Penn (Metals Division) has strict policies on personal hygiene When employees arrive at work, they enter the clean area of the locker room where they are supplied clean work clothes or coveralls and a clean respirator for the day After the work shift, employees enter the dirty side of the locker room where they remove the dirty work clothes, then the respirator Mandatory showers are taken by each employee before entering the clean side of the locker room Work clothes are laundered on site everyday so that clean ones are provided for each shift Respirators are also cleaned after each shift No eating or smoking is permitted in the work areas Employees vacuum clothes and wash their hands and face thoroughly before entering the break room

INCENTIVE PROGRAMS

In an effort to reduce blood lead levels and promote good personal hygiene and work practices among full-time employees, East Penn Metals Division uses incentive bonus programs which are described below

Blood Lead Level Bonus Program

An employee with a blood lead level (BLL) below 25 μg/dl receives a bonus of $25 a week If the employee has a BLL between 25 to 34 μg/dl, a weekly $15 bonus is awarded Employees that have BLL greater than or equal to 35 μg/dl do not receive a bonus

Air Lead Bonus Program

An air lead bonus program has been in place at the plant since July 1991 Air samples for the bonus program are taken separate from compliance samples Both bonus program samples and compliance samples are included when calculating the air lead bonuses Air samples are taken in each job category during each shift every month. If a sample exceeds 100 $\mu g/m^3$, no bonus is awarded If the sample result is 50 to 100 $\mu g/m^3$, than a bonus of $50 is rewarded to workers in the job category on the shift where the sample was taken If the sample result is less than 50 $\mu g/m^3$, a bonus of $100 is rewarded to workers in that job category on that shift

METHODOLOGY

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Both full-shift sampling and short-term sampling for the duration of a specific task were performed Personal and area samples were collected for lead, arsenic, cadmium, antimony, and additional metals These samples were analyzed quantitatively using Inductively Coupled Argon Plasma, Atomic Emission Spectroscopy (ICP/AES) according to NIOSH Method 7300 [12] These samples were collected on 37-mm diameter mixed cellulose ester (MCE), 0 8-µm pore-size filters using SKC pumps at 2 0 liters per minute (Lpm)

Indoor samples were collected to determine if there are exposure sources other than from production activities and to measure any cross-contamination between the production areas and offices Outdoor background samples were taken to identify possible outside sources of air contaminants

Video Exposure Monitoring

Real-time sampling coupled with video recording was performed to evaluate worker exposures Real-time monitoring was conducted during the following operations 1) front end loader (FEL), 2) hammer mill, 3) industrial battery breaking, 4)reverberatory furnace, 5) blast furnace, 6) casting, and 7) refining Video exposure monitoring was conducted to study the relationship between the workers' individual tasks and exposure to air contaminants

During smelter operations, the Handheld Aerosol Monitor (HAM) was used to measure relative air contaminant concentrations In using this instrument, the workplace aerosol is drawn through a sensing chamber The aerosol scatters the light emitted from a light emitting diode The scattered light is detected by a photomultiplier tube The analog output of this instrument is proportional to the quantity of the scattered light detected by a photomultiplier tube The quantity of scattered light is a function of aerosol concentration, particle size, and refractive index Because the calibration of the HAM varies with aerosol properties, the analog output of the HAM is viewed as a measure of relative concentration The analog output of the HAM is recorded by a data logger The data collected on the data logger is downloaded to a computer and placed in a spreadsheet for analysis The HAM was on the 0-2 mg/m^3 scale during real-time monitoring activities in the plant except front end loader operations The HAM was on the 0-20 mg/m^3 scale during these operations

RESULTS

AIR SAMPLING

Individual air lead sampling results are listed in Appendix A Personal breathing zone samples for lead, collected in the different areas within the smelter, were compared for significant differences Statistical analyses were performed on log transformed data [13] Analysis of variance (ANOVA) showed that personal sampling location had a significant effect upon exposures (probability = 0 0018) [14] A multiple comparison test, Least Significant Difference (LSD), was used to examine the exposure differences between the smelter areas Exposure differences are shown in Table II An overall significance level of 0 05 is the basis for the following discussion

Exposures to lead in the reverberatory furnace area were significantly higher than exposures in the hammer mill, casting, blast furnace, and industrial battery breaking areas Exposures to lead in the refinery area were significantly higher than exposures in the casting, blast furnace, and industrial battery breaking areas The lead exposures in the hammer mill, casting, blast furnace, and industrial battery breaking areas were not significantly different It should be noted that daily variation among the different areas in the plant may have an effect on statistical differences

Indoor ambient lead samples were taken in the smelter offices near the shipping area Full-shift (8-hour) indoor ambient air lead concentrations had a geometric mean of 9 µg/m^3 Outdoor ambient air lead samples were collected outside the shipping area of the smelter near the smelter office parking Full-shift outdoor ambient lead concentrations had a geometric mean of 6 µg/m^3

All personal samples taken during the survey were below the current PEL for cadmium [10] However, the FEL operator in the raw material storage building, had an exposure of 4 6 µg/m^3 during a 59 minute sample Area samples taken outside the FEL, in the raw material storage building, had cadmium concentrations as high as 11 µg/m^3

Table II
Personal Exposures (including breathing zone samples attached to the HAM) to Lead by Smelter Area

Location	Number of Samples	Geometric Mean (µg/m³)	Range (µg/m³)	* Multiple Comparison Test Code
Reverberatory Furnace	4	190	130-270	A
Refining	8	100	48-140	A B
Hammer Mill	4	54	15-140	B C
Casting	6	49	48-71	C
Blast Furnace	6	54	32-90	C
Industrial Battery Breaking	2	43	32-57	C

* Least Significant Differences (LSD) method geometric means with different letters differ significantly

Industrial Battery Breaking Area

Layout of the industrial battery breaking area is shown in Figure 1 One personal and two area air samples were collected in the industrial battery breaking area The lead concentrations measured near this operation were relatively low compared with some of the other operations The worker was exposed to approximately 57 µg/m³, and the area concentrations were 8 µg/m³ and 40 µg/m³ The 8 µg/m³ was measured in the vicinity of the hydraulic blade which chopped batteries into pieces prior to being transported to the raw materials storage area (sample #2 in Figure 1) The other sample was collected in the area where batteries were manually opened using an axe and sledge hammer (sample #1 in Figure 1)

Hammermill Area

The layout of the hammermill area is shown in Figure 2 Air samples taken in the hammermill area indicated relatively low levels of airborne lead compared to the furnace areas (see Table III) The worker was sampled for approximately four hours and was exposed to a geometric mean of 76µg/m³ Area samples measured in the hammermill area were found to be 49 µg/m³ (sample location #1 in Figure 2) and 58 µg/m³ (sample location #2 in Figure 2)

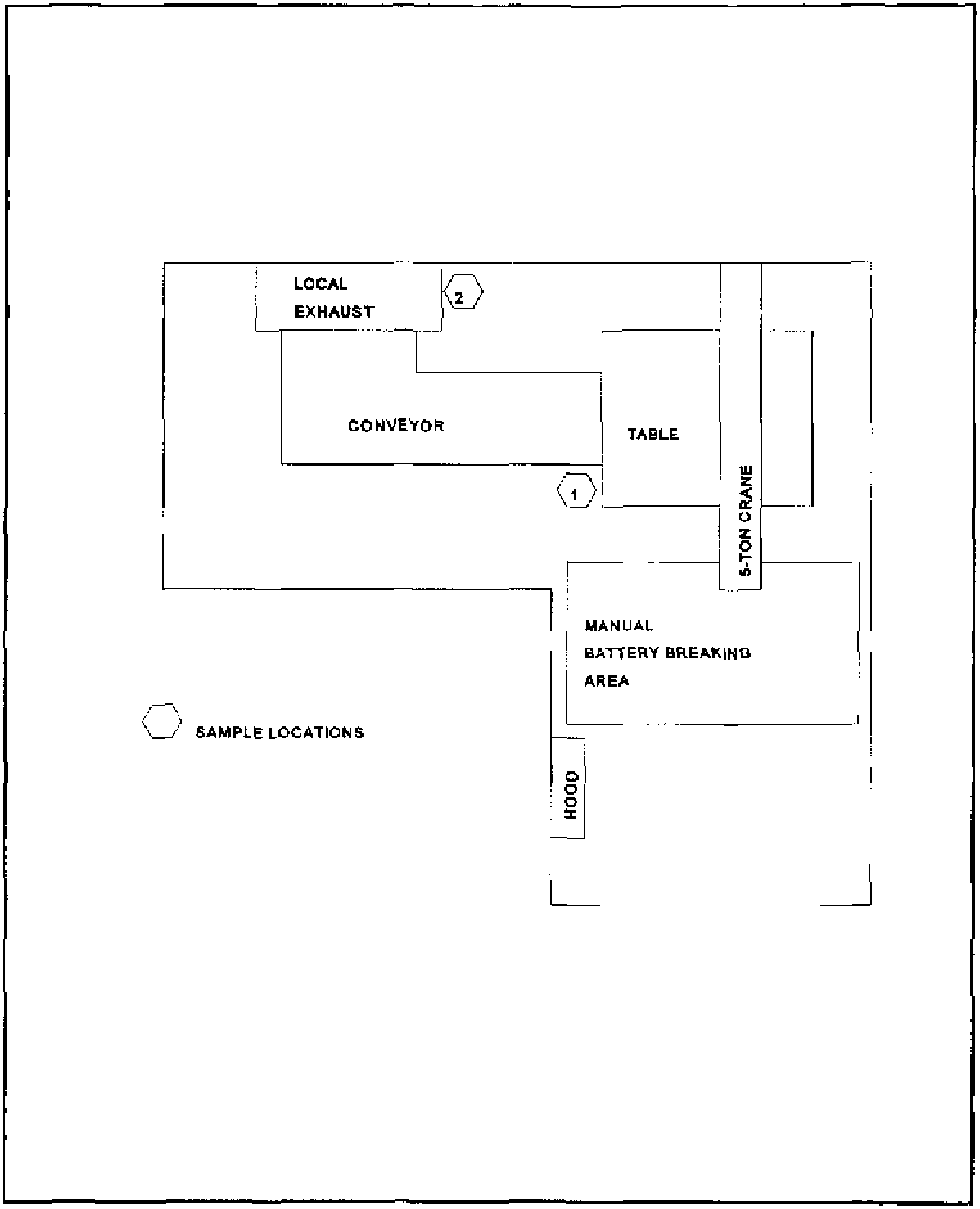

Figure 1 Industrial battery breaking layout

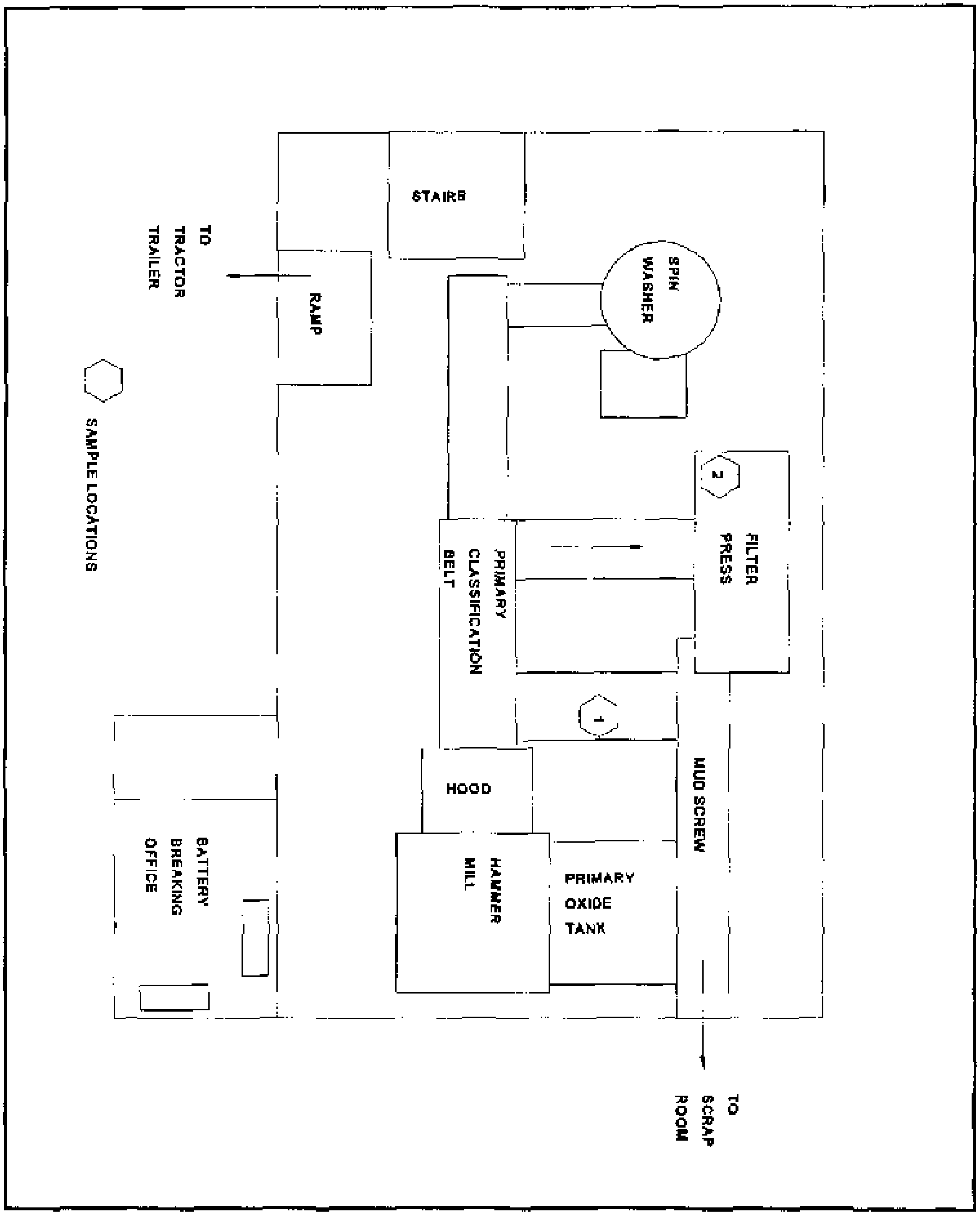

Figure 2 Hammermill layout

Table III
Air Sample Concentrations of Lead Near the Hammermill

Type	Number of Samples	Location	Total Sample time (min)	Lead Conc (μg/m³)	Geo Mean Conc (μg/m³)
Area	1	1	240	49	
Area	1	2	230	58	
Personal	2	worker	290		76
Personal	2	HAM	170		39

Blast Furnace Area

Air sampling was conducted at seven different locations near the blast furnace (see Figure 3 and Table IV) Worker personal samples ranged between 32 μg/m³ and 91 μg/m³ Samples taken near the blast furnace showed that the highest average area concentrations of lead were found at locations 6 and 7 The geometric mean concentration of lead in these two areas were 110 μg/m³ and 95 μg/m³, respectively Measurements above the lead and slag tap hoods indicated that concentrations were nearly twice as high near the lead tap hood Area samples collected in the blast furnace control room had a geometric mean of 19 μg/m³.

Ventilation measurements were taken at the slag tap hood The door opening was approximately 11 ft² and the air velocity at the face was approximately 540 fpm Results of the ventilation measurements showed that approximately 6,000 cfm of air was being drawn through the open doors of the hood enclosure for the slag tap of the blast furnace

Reverberatory (Reverb)Furnace Area

Area air samples were taken at four locations near the reverberatory furnace (see Figure 4 and Table V) The worker near the reverberatory furnace was exposed to relatively high concentrations of airborne lead during the workday The worker's exposure was 190 μg/m³ The worker spent significantly more time near the slag tap than the lead tap Air samples near the slag side of the reverberatory furnace indicated that the lowest air lead concentrations were found on the left side of the slag tap (location 1) The highest concentrations of 420 μg/m³ were measured near the cooling slag molds (location 3) Area samples collected in the reverberatory furnace control room had a geometric mean concentration of 65 μg/m³

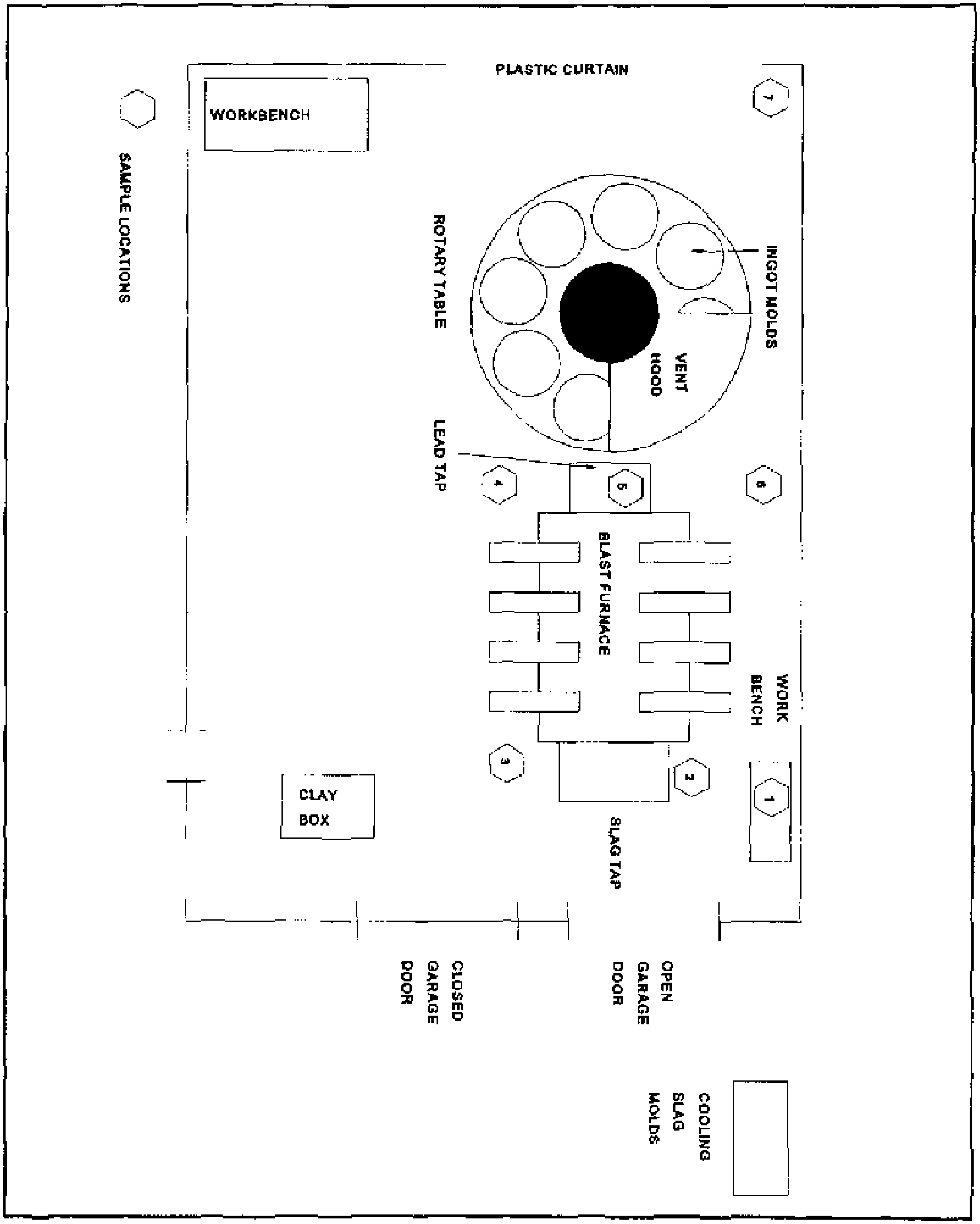

Figure 3 Blast furnace layout

Table IV
Air Sample Concentrations of Lead Near the Blast Furnace

Type/ Area	Number of Samples	Location (see Fig 3)	Total Sample Time (min)	Lead Conc ($\mu g/m^3$)	Geo Mean Conc ($\mu g/m^3$)	Geo Std Dev	Range ($\mu g/m^3$)
bench	2	1	380		84	1.5	54-130
slag hood	2	2	460		49	1.1	44- 55
left side	2	3	430		44	1.0	43- 45
control for rotary transport	2	4	380		49	1.5	33- 73
lead hood	2	5	410		79	1.2	66- 95
rear-center	2	6	370		110	1.1	100-120
rear kettles	2	7	420		95	1.4	66 -140
personal	5	Worker	660		52	1.5	32 - 91
personal	1	HAM	89	67			

Table V
Air Sample Concentrations of Lead Near the Reverb Furnace

Type	Location	Total Sample Time (min)	Concentration ($\mu g/m^3$)
Area	1	1400	33
Area	2	250	12
Area	3	240	420
Area	4	1400	76
Personal	Worker	570	190

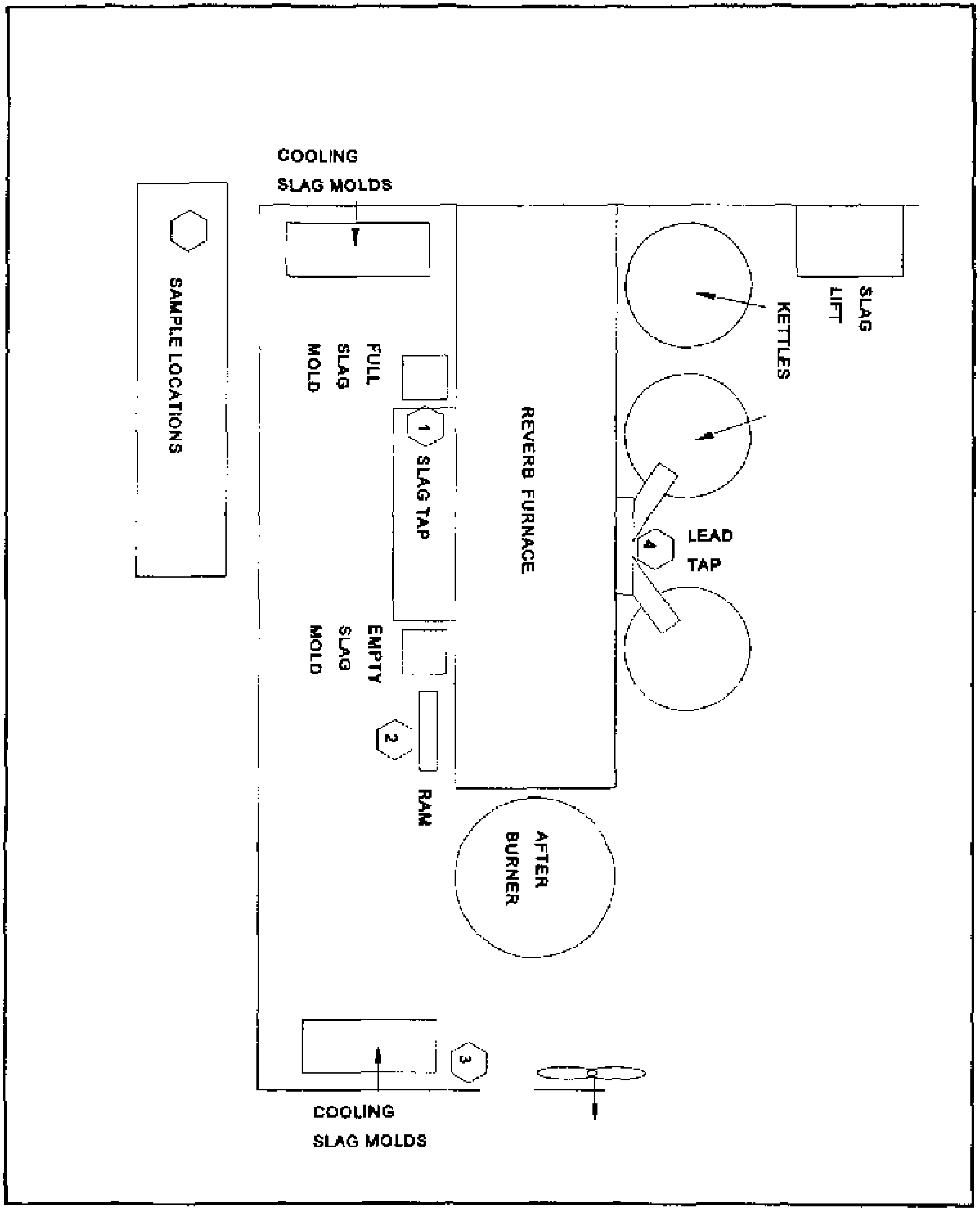

Figure 4 Reverberatory furnace layout

Ventilation measurements taken near the reverberatory furnace found that air flow at the face of the reverberatory slag tap hood was approximately 8,500 cfm Measurements were also taken at the face of the hoods over the lead tap of the reverberatory furnace The hoods covering the left and right troughs which carry lead to the kettles had a face opening of approximately 6 ft^2 Based on air velocity measurements, the air flow was determined to be approximately 3,300 cfm on the left-side and 2,300 cfm on the right-side Measurements taken for the hood in the center were approximately 2,000 cfm

Refinery Area

Personal and area air samples were collected in the refinery area Five personal samples were collected on workers during real-time monitoring evaluations These samples ranged between 77 and 140 $\mu g/m^3$ and had a geometric mean of 120 $\mu g/m^3$ Six area samples were collected over the doors on the refinery pots during the evaluation These samples ranged between 22 and 160 $\mu g/m^3$ and had a geometric mean of 64 $\mu g/m^3$ See Figure 5 for sample locations during survey

Front End Loader (FEL) (Outside Operations)

Personal and area air samples were collected both inside and outside of the (FEL) enclosure during outside activities The FEL was loading a truck with waste slag material that was collected from a building located outside of the smelter Personal and area samples were collected on the inside of the FEL enclosure, and area samples were collected directly outside of the enclosure Personal samples collected on the inside of the FEL enclosure had a geometric mean lead concentration of 130 $\mu g/m^3$, and area samples collected on the inside had a geometric mean lead concentration of 97 $\mu g/m^3$ Area samples collected directly outside of the FEL enclosure had a geometric mean lead concentration of 360 $\mu g/m^3$. These results indicate that the FEL enclosure was effective in reducing lead levels by approximately 73 percent as compared to lead levels directly outside the enclosure

Front End Loader (Raw Material Storage Area Operations)

Personal and area air samples were collected both inside and outside of the FEL enclosure during operations in the raw material storage area The FEL was moving lead bearing material around in the raw material storage area and loading the ram that feeds the furnace Personal and area samples were collected on the inside of the FEL enclosure and area samples were collected directly outside of the enclosure The personal sample collected on the FEL operator had a lead concentration of 530 $\mu g/m^3$ and the area samples collected inside the enclosure had a geometric mean lead concentration of 200 $\mu g/m^3$ Area samples collected directly outside the enclosure had a geometric mean lead concentration of 3900 $\mu g/m^3$ The area sample results indicate that the FEL enclosure was effective in reducing lead levels by approximately 95 percent as compared to lead concentrations directly outside the enclosure

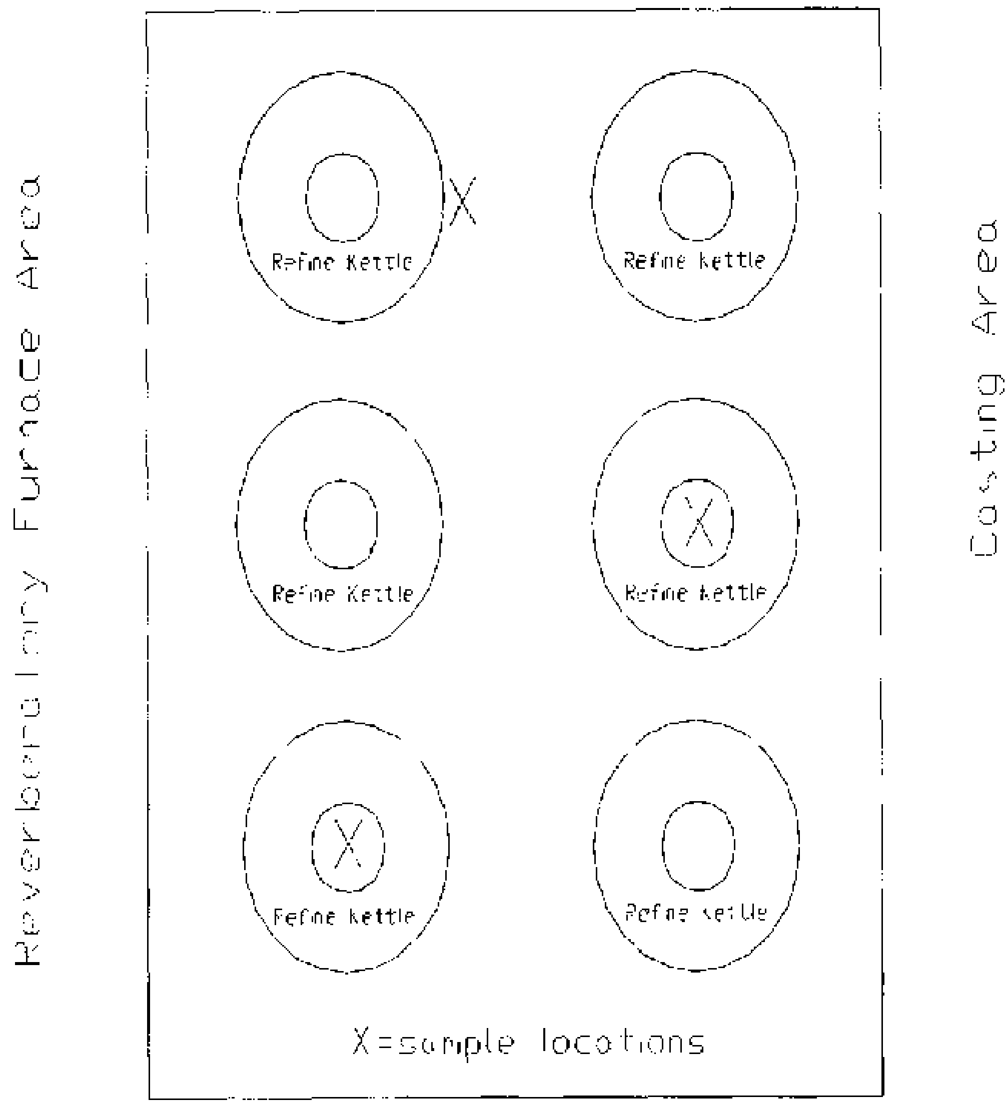

Figure 5

Figure 5 Refinery area layout

Casting Area

Personal samples were collected during casting operations where the worker skimmed dross off the top of ingots During this operation, the personal samples had a geometric mean lead concentration of 53 µg/m^3 Samples were also collected at the exhaust of the HAM sampling probe during skimming operations These samples had a geometric mean lead concentration of 42 µg/m^3

VIDEO EXPOSURE MONITORING RESULTS

Real-time analysis was performed in two teams consisting of two industrial hygienists/engineers Real-time analysis was performed on three days in various areas of the plant Video exposure monitoring (VEM) was used in these areas to measure relative air contaminant concentrations and improve our understanding of how the worker's individual tasks affects personal exposure to air contaminants [15] Samples for lead were collected at the exit of the HAM probe (near the workers breathing zone) and on the workers collar during smelter operations The samples at the exit of the HAM probe were collected for calibration purposes The samples were used to convert HAM output (volts) to concentration of lead In doing the conversion, one assumes that the aerosol's lead content is constant During the following discussion of results, the HAM output will be given in terms of "estimated lead concentration" or "estimated lead exposure "

Hammermill and Industrial Battery Breaking

VEM was performed in the hammermill and industrial battery breaking areas Both of these areas had significantly lower air lead concentrations than in other areas within the smelter (see Table II) This was confirmed with real-time monitoring where there did not appear to be a significant quantity of airborne lead An air sample collected at the exhaust of the HAM sampling probe, during VEM in the industrial battery breaking area, had an air lead concentration of 32 µg/m^3 Air samples collected at the exhaust of the HAM sampling probe in the hammermill area had a geometric mean of 39 µg/m^3 Probably the biggest reason that these two areas had relatively low air leads was that much of the process was wet

Blast Furnace

A sample collected at the exhaust of the HAM sampling probe during VEM in the blast furnace area had a lead concentration of 67 µg/m^3. Personal samples collected during VEM in the blast area had a geometric mean lead concentration of 52 µg/m^3

Analysis of data collected near the blast furnace showed that significant exposures to lead occurred when the worker was in the vicinity of the rotary transport for the lead ingots (see Figure 6) This was consistent with the air sampling results Analysis showed that both the

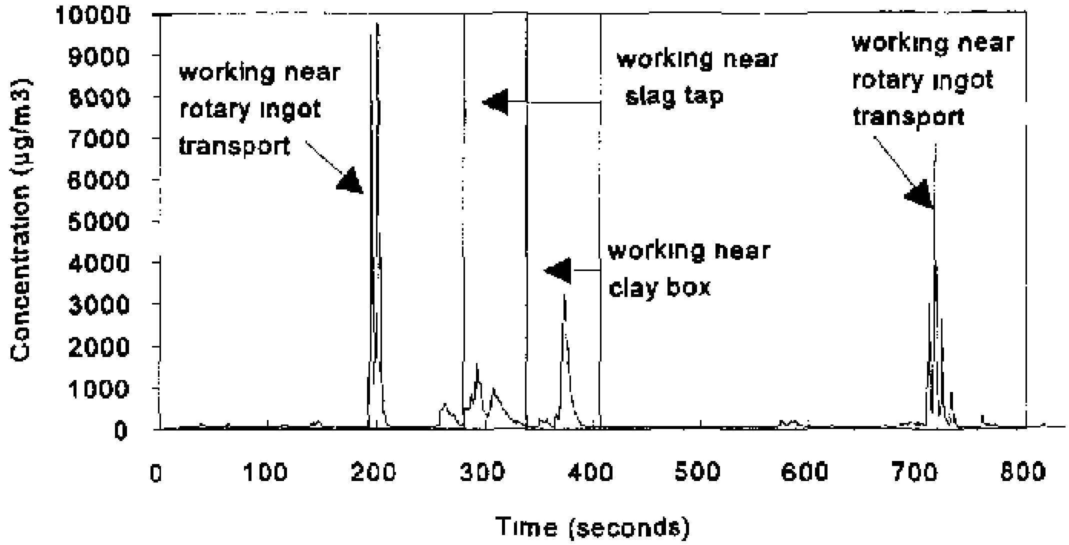

Figure 6 Worker estimated lead exposure near blast furnace

estimated average and integrated exposure to lead was greatest while the worker was in the vicinity of the rotary transport The estimated lead exposure during this activity was 595 µg/m^3 This activity accounted for 40 percent of the workers exposure during VEM.

The second greatest source of exposure to lead occurred when the slag tap was being opened with a rotary drill (see Figure 6) The average exposure during this activity was 547 µg/m^3 This activity took a total of 38 seconds (2 percent of the time during the evaluation) and accounted for 10 percent of the workers exposure

Reverb Furnace

An air sample collected at the exhaust of the HAM sampling probe during VEM in the reverb furnace area had a lead concentration of 180 µg/m^3 A personal sample collected during VEM in the reverb area had a lead concentration of 193 µg/m^3

VEM at the reverb furnace revealed that the greatest worker exposures occurred when working near the lift for slag molds (see Figure 4 and 7) By looking at Figure 7, it is clear that although the peaks were not particularly high, they had a significant area beneath them The average estimated exposure to lead during this activity was 994 µg/m^3 This activity accounted for 20 percent of the workers exposure during VEM operations

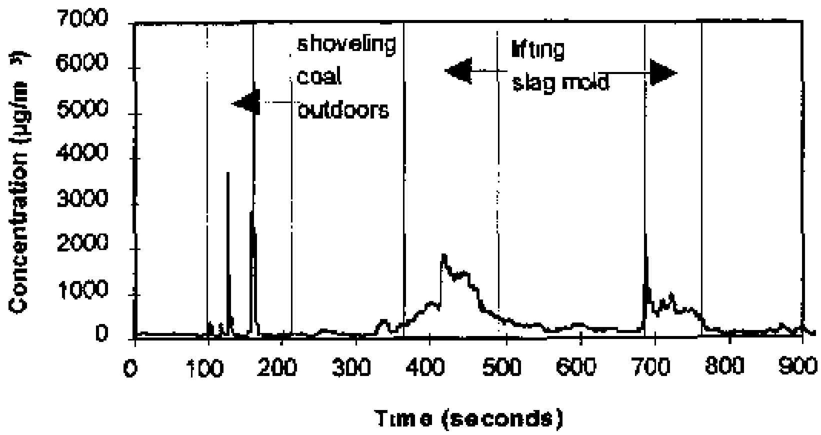

Figure 7 Worker estimated lead exposure while working near reverb furnace

Refinery Area

Air sampling results indicate that the airflow through the HAM probe in the refinery area during VEM had a geometric mean lead concentration of 74 µg/m³ Samples collected on the workers' collar during VEM had a geometric mean lead concentration of 121 µg/m³

VEM was performed during drossing operations in the refinery area During drossing operations the kettle is mechanically agitated and the dross is manually skimmed from the surface using a shovel, and placed into a ventilated dross bin The hood over the dross bin was designed to work with the ventilation on the refinery kettle The hood was designed to extend over the opening on the refinery kettle and enclose the dross bin After dross was dumped in the dross bin, a visible cloud of dust would be pulled under the hood back into the refinery kettle During this process, it was possible that some of the dust generated by dumping the dross into the dross bin could escape the capture of the hood and be released into the air The greatest worker exposures occurred when the worker (standing beside the hood over the dross bin) was stirring dross in the refinery kettle immediately after dumping dross into the dross bin During this task, the estimated exposure to lead was 152 µg/m³ This activity accounted for 41 percent of the workers exposure during VEM operations. The worker also received exposures while working outside of the refinery area During the time spent outside of the refinery area the estimated exposure to lead was 137 µg/m³ This activity accounted for 16 percent of the workers exposure See Figure 8 for VEM results taken during drossing operations in the refinery area

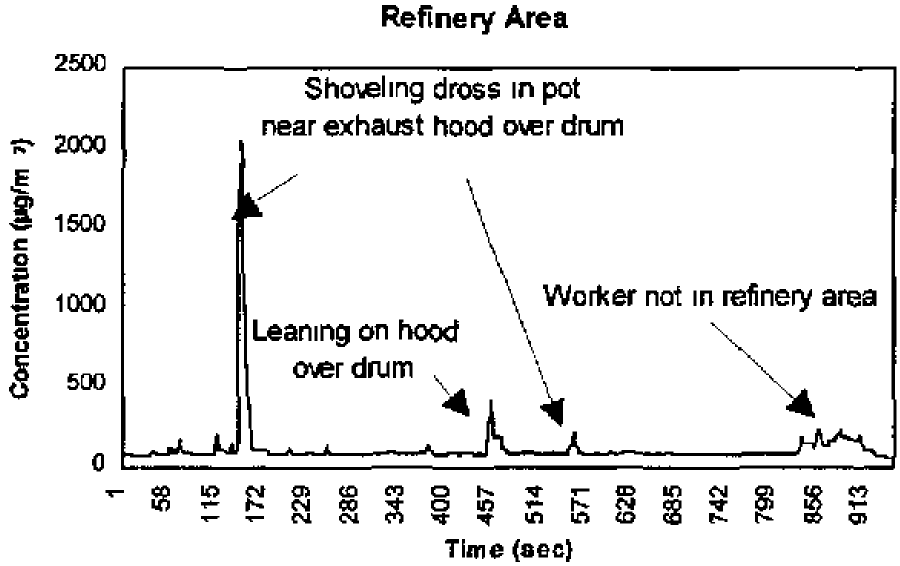

Figure 8 Worker estimated lead exposure during drossing operations

Front End Loader (Outside Operations)

Air samples collected at the exhaust of the HAM sampling probe inside the FEL enclosure had a geometric mean lead concentration of 122 µg/m^3 Air samples collected at the exhaust of the HAM sampling probe located directly outside the FEL enclosure had a geometric mean lead concentration of 706 µg/m^3 These results are similar to the area sampling results and indicate that the FEL enclosure was effective in reducing lead levels by approximately 80 percent

During VEM, the highest estimated concentrations of lead were recorded when the FEL operator was moving waste slag material inside the waste slag storage building (see Figure 9)

During operations inside the building the estimated concentration of lead (outside the enclosure) was 941 µg/m^3 This activity accounted for 85 percent of lead concentrations during FEL outside activities The second highest estimated concentrations of lead were recorded during the transportation of slag material to the truck The estimated lead concentration (outside the enclosure) during this activity was 137 µg/m^3 This activity accounted for 14 percent of the lead concentrations

The HAM located inside the FEL enclosure had an elevated baseline of approximately 60 µg/m^3 (see Figure 10)

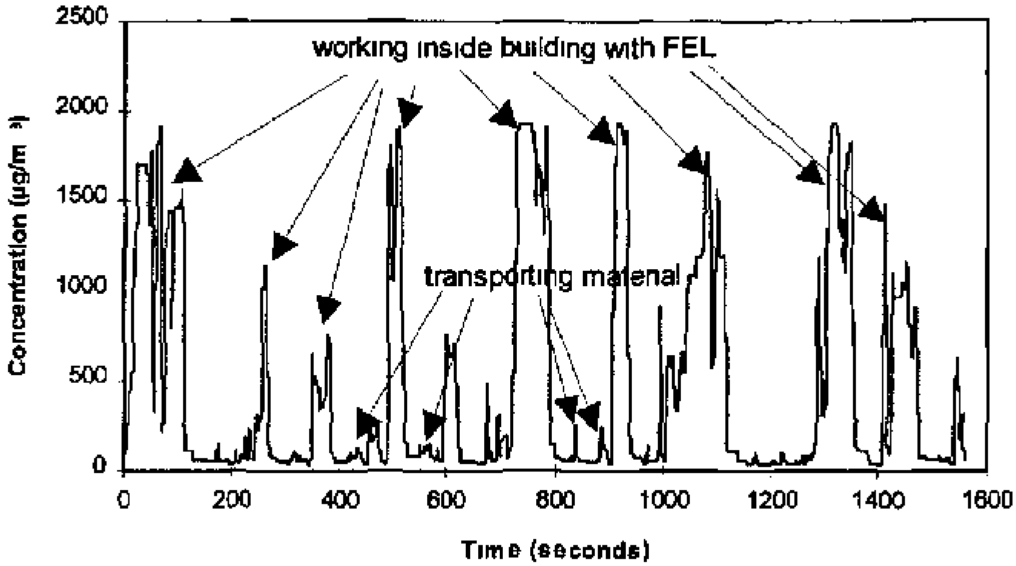

Figure 9 FEL operations outside in slag storage building (Estimated lead concentrations outside of cab)

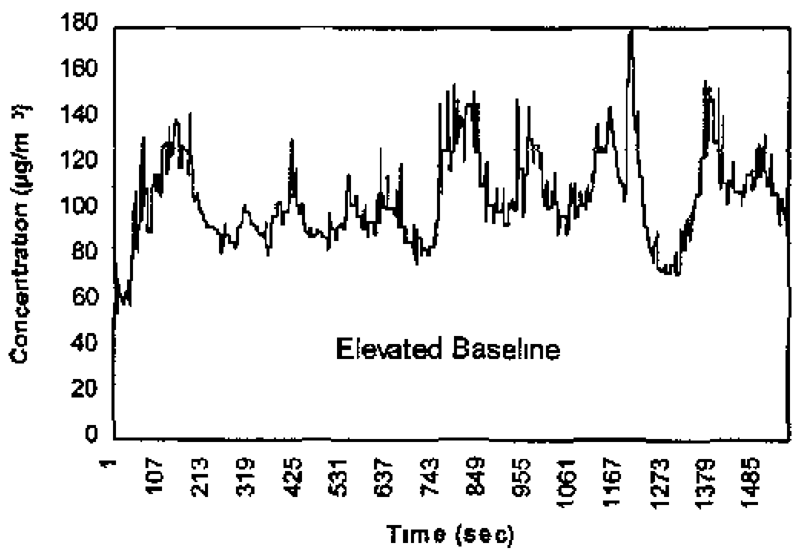

Figure 10 Estimated lead concentrations (inside FEL cab) taken outside during FEL operations in the slag storage building

This indicates that the inside of the enclosure was dirty and was being contaminated This result is confirmed by the results of the air samples collected inside the cab The peak HAM responses inside the cab were a result of the FEL working inside of the waste slag building

Front End Loader (Raw Material Storage Area Operations)

Air samples collected at the exhaust of the HAM sampling probe inside the FEL enclosure had a geometric mean lead concentration of 150 $\mu g/m^3$ Air samples collected at the exhaust of the HAM sampling probe located directly outside the FEL enclosure had a geometric mean lead concentration of 2500 $\mu g/m^3$ These results verify the area sampling results which indicate that the FEL enclosure was effective in reducing lead levels by approximately 95 percent

CONCLUSIONS AND RECOMMENDATIONS

East Penn Manufacturing (Metals Division) employs local exhaust ventilation, enclosed ventilated booths, partial enclosures, and automated operations through-out production areas of the plant Some examples of automation used in the smelter include the following 1) An automated vibratory feeder that vibrates the material into a weighing bucket, 2) Automated weigh bucket deposits the lead bearing material in front of an automated ram feeder which feeds the furnace, and 3) Dust collected in bag houses is conveyed and discharged in front of the ram feeder that feeds the material to the furnace As a method of exposure control for the general smelter population, the lead bearing raw material used to feed the furnaces is stored in a separated and enclosed material storage building The enclosed building is under negative pressure to minimize fugitive emissions This isolation helps to prevent lead contamination from the raw material storage area to other areas in the plant In addition to the use of automation, ventilation, and isolation, East Penn also employs the use of central vacuums and roadway cleaning equipment to help reduce lead emissions in the plant Safety and health programs are used at the plant including occupational and safety training, a respirator protection program, various hygiene programs, and blood lead monitoring programs All these programs should be continued

Hammermill and Industrial Battery Breaking

Both of these areas had significantly lower air lead concentrations than other areas within the smelter (see Table II) This was also confirmed with real-time monitoring where there did not appear to be a significant quantity of airborne lead Examples of automation and ventilation controls used in the hammermill area include the following 1) The battery dismantling operation is an automated system that cuts the tops off the batteries, 2) An enclosed screw conveyor feeds the cases to a flotation separator which recovers the plastic that can be recycled, 3) Lead plates are separated from the battery cases in an enclosed ventilated group extractor, and 4) The saws are located in enclosed ventilated hoods A ventilated hood was utilized in the industrial battery breaking process to control emissions during hydraulic blade activities which chopped batteries into pieces prior to being transported to the raw materials storage area Relatively low air leads in these areas are attributed to the use of automation, ventilation controls, and that the majority of the process is wet

Blast Furnace Area

Furnace charging operations are controlled by a programmable controller located in a control room next to the charging equipment Slag and lead from the blast furnace is tapped into 2,400-lb molds which are located under enclosed ventilated hoods Automated tuyere punchers are also utilized on the blast furnace to help minimize lead emissions These controls are utilized to limit lead emissions from blast furnace operations

Air sampling and VEM in the blast furnace area was conducted to help identify emission sources and work task that can result in worker lead exposure Samples taken near the blast furnace showed that the highest average area concentrations of lead were found at locations 6 and 7 (see Figure 3) These locations were along the rear wall and downwind from the blast furnace Lead vaporization from the rotary ingot transport could be elevating the concentrations at these locations

Analysis of VEM data collected near the blast furnace showed that significant exposures occurred when the worker was in the vicinity of the rotary transport for the lead ingots (see Figure 6) There are two reasonable explanations for these exposures 1) Air flows through the open garage door and transports any airborne lead, emitted from the furnace, toward the rotary transport Additionally, lead which had recently been poured into the ingots was only under the exhaust hood for several minutes Certainly, this hood was able to significantly reduce the air lead levels, however, as the ingots moved out from under the hood, airborne lead could be emitted into the workplace, 2) Lead emissions also occurred when the slag tap was being opened with a rotary drill (see Figure 6) Although the slag tap area was almost completely surrounded by an exhaust hood, there was a small opening where the rotary drill was inserted and apparently some lead was able to escape from the hood during this process Additionally, some of the exposure may have occurred from cooling slag molds which were located just outside of the garage door Again, air currents passed over the cooling slag molds and directly into the work area

Reverberatory Furnace Area

The following controls are utilized during reverberatory furnace operations to limit lead emissions 1) Furnace charging operations are controlled by a programmable controller located in a control room next to the charging equipment, 2) Slag is tapped from the furnaces into 2,400-lb molds under enclosed ventilated hoods, and 3) Lead is tapped from the reverberatory furnace (under a ventilated hood) into enclosed ventilated kettles Air sampling and VEM in the reverberatory furnace area was conducted to help identify emission sources and work task that can result in worker lead exposure

Strong air currents entered through the open garage door and moved air through the area toward the slag tap hood entrance. Air samples near the slag side of the reverberatory furnace indicated that the lowest air lead concentrations were found on the left side of the slag tap (see Figure 4). Highest concentrations of 415 μg/m^3 were measured near the cooling slag molds (see Figure 4). Air currents played a very important role and influenced worker exposures. The worker near the reverberatory furnace was exposed to relatively large concentrations of air lead during the workday. The worker spent significantly more time near the slag tap than the lead tap. During VEM, the estimated worker exposure to lead was much greater near the slag mold entrance than the slag mold exit (500 μg/m^3 versus 190 μg/m^3). However, because the worker was near the slag mold exit approximately four times longer than the entrance, integrated exposure was higher at the exit

VEM data collected in the reverberatory furnace area revealed that the greatest worker exposures to aerosols occurred when working near the lift for slag molds (see Figure 7). The reason for this result is unknown. Additional data and information is needed during this operation in order to control worker exposures in this area

Area samples collected in the reverberatory furnace control room had a geometric mean concentration of 65 μg/m^3. Based on the area sample results in the reverberatory control room, workers in this area have the potential for overexposure

Refinery Area

Controls utilized in the refinery area to limit lead emissions consist of the following 1) Some lead is drossed in the kettles by an automated drossing machine, 2) Kettles are enclosed and ventilated, 3) Ventilated hoods are located over dross bins, and 4) Lead is pumped to a ventilated casting machine

VEM results during drossing operations indicate that the greatest worker exposures occurred when the worker (standing beside the hood over the drum) was stirring dross in the refinery pot directly after dumping dross in the dross bin (see Figure 8). Dust generated when dumping the dross in the dross bin was pulled back into the refinery pot by the ventilation system on the pot. The hood over the dross bin was designed to fit against the refinery pot in order to take advantage of the ventilation system on the refinery pot. During the drossing process, dust could potentially escape the capture of the ventilation system and expose the worker. A hood placed over a dross bin should be modified and tested in an effort to capture the dust being emitted from dumping the dross (i e , making the existing hood/control more effective). It is recommended that the open areas of the hood be enclosed. The enclosure should be hinged at the top to allow for adjustment according to the height of the worker. The bottom of the hood should be extended up to form a slot. The shovel handle should be moved under the hood through the open slot when dumping dross into the dross bin It is also recommended that the hood over the drum be modified so that air can enter the back of the hood through properly designed slots and travel over the dross bin into the refinery pot The air being pulled from the back of the hood by the ventilation system on the refinery pot can entrain the dust being generated after dross has been dumped into the dross bin See Figure 11 for a diagram of the modifications recommended for the dross bin enclosure

Front End Loader Operations

Front end loaders (equipped with HEPA filtered air-conditioned cabs) are used to move lead-bearing material in the raw material storage building and the waste slag building (located outside the smelter) VEM results and air sampling results obtained during FEL operations indicated that the enclosures were effective in reducing lead concentrations There was approximately an 80 percent reduction in lead concentrations inside the enclosure as compared to lead concentrations outside of the enclosure during outside FEL operations During raw material storage area operations the FEL enclosure had approximately a 95 percent reduction in lead concentrations However, visible dust was noticed inside the enclosures during our survey and data collected during VEM indicated that the inside of the enclosures were contaminated with lead These results were confirmed by the air sampling data collected inside the enclosures

In an effort to reduce lead concentrations inside the enclosures, we recommend that the enclosures be throughly cleaned after each shift The cleaning can be accomplished by wet methods, if appropriate and do not create any safety hazards or with a HEPA filtered vacuum cleaner The outside of the FEL's should also be throughly cleaned after each shift FEL operators' should avoid opening the door of the enclosure when operating in dirty areas such as inside the waste slag building (located outside the smelter) or inside the raw material storage building In the raw material storage building, the FEL should be isolated in the room between the raw material storage and the outside before the enclosure is opened Sufficient time should be allowed before opening the enclosure doors in an effort to let air lead concentrations in the room to decrease Though not looked into, the filters used in the FEL should be properly maintained (changed as needed and make sure that they are properly seated) and the fan should be checked periodically to make sure that it is operating within design criteria

FEL enclosures equipped with a self-contained breathing air supply may provide additional protection from lead concentrations inside the enclosure

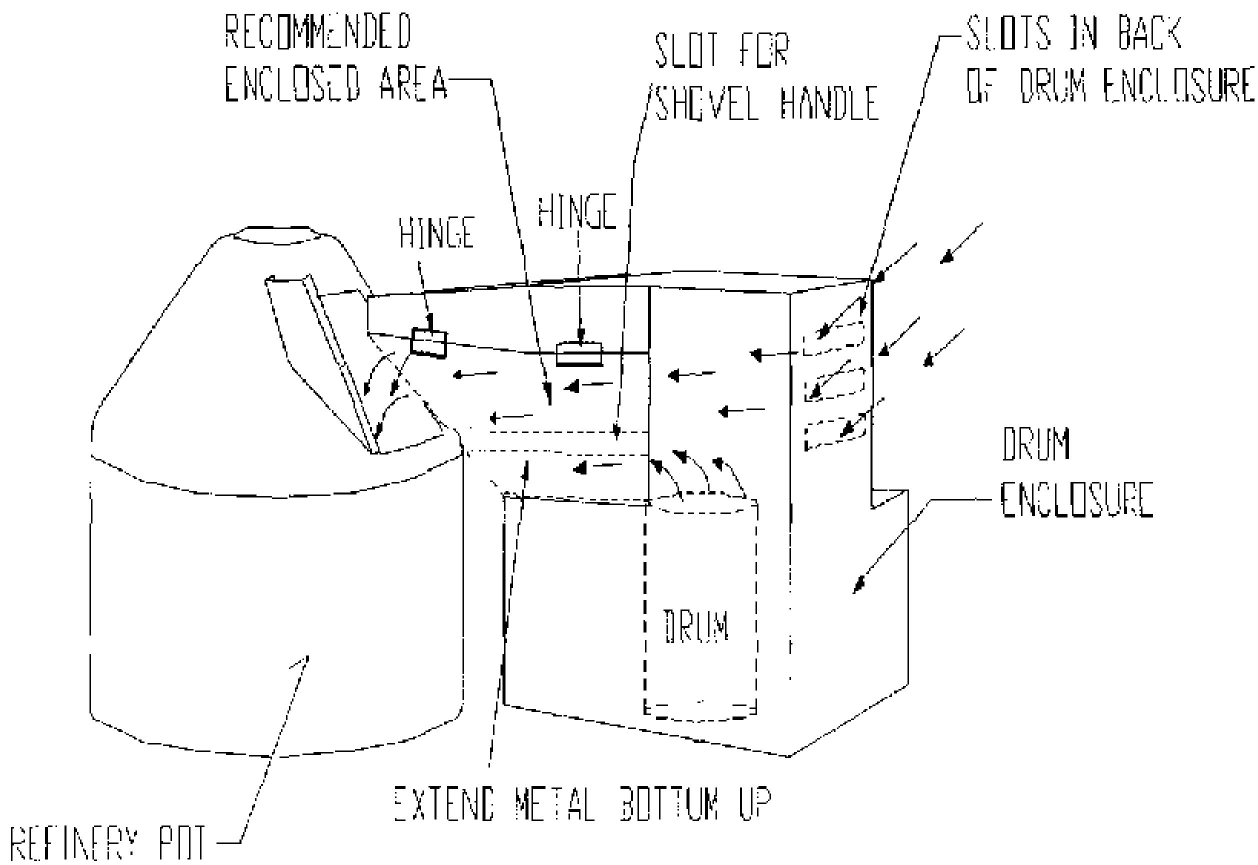

Figure 11 Diagram of drum enclosure with recommended modifications

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APPENDIX A

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DATE	SAMPLE NUMBER	TYPE	SAMPLE LOCATION	LOCATION DETAILS	SAMPLE TIME (min)	FLOW RATE (LPM)	VOLUME (liters)	lead DET LIMIT	lead MASS (ug)	lead CONC (ug/m3)	ln conc
12/13/94	117	AREA	blast controlrm		186	2 0	372	2	5 7	15	2 73
12/13/94	119	AREA	reverb leadtap		192	2 0	384	2	45	117	4 76
12/13/94	124	PERSONAL	reverb area		295	2 0	590	2	77	131	4 87
12/13/94	123	AREA	refinery	above doors	187	2 0	374	2	39	104	4 65
12/13/94	118	AREA	reverb slagtap		210	2 0	420	2	13	31	3 43
12/13/94	127	AREA	backgroud	outside	152	2 0	304	2	2	7	1 88
12/13/94	126	AREA	backgroud	inside	163	2 0	326	2	4	12	2 51
12/13/94	164	AREA	blast controlrm		226	2 0	452	2	11	24	3 19
12/13/94	139	AREA	reverb leadtap		230	2 0	460	2	64	139	4 94
12/13/94	154	PERSONAL	reverb area		128	2 0	256	2	70	273	5 61
12/13/94	149	AREA	refinery	above doors	204	2 0	408	2	25	61	4 12
12/13/94	147	AREA	reverb slagtap		230	2 0	460	2	15	33	3 48
12/13/94	158	AREA	backgroud	outside	230	2 0	460	2	2	4	1 47
12/13/94	148	AREA	backgroud	inside	216	2 0	432	2	4 10	9	2 25
12/14/94	110	AREA	backgroud	inside	162	2 0	324	2	4 6	14	2 65
12/14/94	140	AREA	backgroud	outside	245	2 0	490	2	3 00	6	1 81
12/14/94	130	AREA	reverb leadtap		244	2 0	488	2	110	225	5 42
12/14/94	162	AREA	refinery	above doors	264	2 0	528	2	84	159	5 07
12/14/94	165	AREA	reverb slagtap		236	2 0	472	2	27	57	4 05
12/14/94	161	AREA	reverb controlrm		256	2 0	512	2	85	166	5 11
12/14/94	274	AREA	backgroud	inside	275	2 0	550	2	5 4	10	2 28
12/14/94	256	AREA	backgroud	outside	285	2 0	570	2	4 4	8	2 04
12/14/94	272	AREA	reverb leadtap		259	2 0	518	2	37	71	4 27
12/14/94	250	AREA	refinery	above doors	247	2 0	494	2	36	73	4 29
12/14/94	268	AREA	reverb slagtap		259	2 0	518	2	20	39	3 65
12/14/94	251	AREA	reverb controlrm		240	2 0	480	2	17	35	3 57
12/15/94	177	AREA	backgroud	inside	245	2 0	490	2	3	6	1 81
12/15/94	180	AREA	backgroud	outside	242	2 0	484	2	3	6	1 82
12/15/94	181	AREA	reverb leadtap		246	2 0	492	2	85	173	5 15
12/15/94	185	AREA	refinery	above doors	251	2 0	502	2	11	22	3 09
12/15/94	182	AREA	reverb slagtap		247	2 0	494	2	16	32	3 48
12/15/94	189	AREA	reverb controlrm		247	2 0	494	2	62	126	4 83
12/15/94	357	AREA	backgroud	outside	240	2 0	480	2	2	4	1 43
12/15/94	350	AREA	backgroud	inside	236	2 0	472	2	3	6	1 85
12/15/94	359	AREA	refinery	above doors	235	2 0	470	2	20	43	3 75
12/15/94	358	AREA	reverb leadtap		230	2 0	460	2	2	4	1 47
12/15/94	355	AREA	reverb slagtap		221	2 0	442	2	8 3	19	2 93
12/15/94	362	AREA	reverb controlrm		227	2 0	454	2	11	24	3 19

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Real Time Monitoring Samples											
12/13/94	144	HAM	Refining		49	2 0	98	2	7 9	81	4 39
12/13/94	169	PER	Refining		49	2 0	98	2	13	133	4 89
12/13/94	159	PER	Refining		91	2 0	182	2	14	77	4 34
12/13/94	199	HAM	Refining		42	2 0	84	2	4	48	3 86
12/13/94	198	PER	Refining		42	2 0	84	2	12	143	4 96
12/14/94	168	PER	Refining		23	2 0	46	2	6 5	141	4 95
12/14/94	156	HAM	Refining		23	2 0	46	2	4 8	104	4 65
12/14/94	135	PER	Refining		23	2 0	46	2	5 9	128	4 85
12/14/94	252	HAM	FEL OutS Inside Cab run1		50	2 0	100	2	12	120	4 79
12/14/94	271	PER	FEL OutS Inside Cab run1		50	2 0	100	2	13	130	4 87
12/14/94	257	PER	FEL OutS Inside Cab run1		50	2 0	100	2	13	130	4 87
12/14/94	150	HAM	FEL OutS Inside Cab run2		40	2 0	80	2	9 9	124	4 82
12/14/94	262	PER	FEL OutS Inside Cab run2		40	2 0	80	2	5 8	73	4 28
12/14/94	263	PER	FEL OutS Inside Cab run2		40	2 0	80	2	11	138	4 92
12/14/94	166	HAM	FEL OutS Outside Cab run1		50	2 0	100	2	61	610	6 41
12/14/94	172	AREA	FEL OutS Outside Cab run1		50	2 0	100	2	31	310	5 74
12/14/94	277	HAM	FEL OutS Inside Cab run2		33	2 0	66	2	54	818	6 71
12/14/94	278	AREA	FEL OutS Inside Cab run2		39	2 0	78	2	33	423	6 05
12/13/94	111	PER	FEL RMSB Inside cab		59	2 0	118	2	62	525	6 26
12/13/94	106	PER/BACK P	FEL RMSB Inside cab		65	2 0	130	2	24	185	5 22
12/13/94	112	HAM	FEL RMSB Inside cab		65	2 0	130	2	23	177	5 18
12/13/94	107	HAM	FEL RMSB Outside cab		120	2 0	240	2	600	2500	7 82
12/13/94	113	AREA/BACK P	FEL RMSB Outside cab		61	2 0	122	2	690	5656	8 64
12/13/94	142	PER/BACK P	FEL RMSB Inside cab		60	2 0	120	2	26	217	5 38
12/13/94	143	HAM	FEL RMSB Inside cab		60	2 0	120	2	16	133	4 89
12/13/94	138	AREA/BACK P	FEL RMSB Outside cab		60	2 0	120	2	320	2667	7 89
12/14/94	265	HAM	Casting Operations		21	2 0	42	2	1 4	33	3 51
12/14/94	282	PER	Casting Operations		21	2 0	42	2	1 4	33	3 51
12/14/94	270	PER	Casting Operations		21	2 0	42	2	2	48	3 86
12/15/94	283	HAM	Casting Operations		28	2 0	56	2	3	54	3 98
12/15/94	264	PER	Casting Operations		28	2 0	56	2	4	71	4 27
12/15/94	279	PER	Casting Operations		28	2 0	56	2	4	71	4 27
12/13/94	102	AREA	blast	left side	276	2 0	552	2	25	45	3 81
12/13/94	101	PERSONAL	blast		100	2 0	200	2	17	85	4 44
12/13/94	103	AREA	blast	rkettles	271	2 0	542	2	74	137	4 92
12/13/94	116	HAM	blast		89	2 0	178	2	12	67	4 21
12/13/94	141	AREA	blast	control	240	2 0	480	2	16	33	3 51

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12/13/94	137	AREA	blast	rearctr	244	2 0	488	2	50	102	4 63
12/13/94	121	AREA	blast	bench	242	2 0	484	2	63	130	4 87
12/13/94	146	PERSONAL	blast		237	2 0	474	2	18	38	3 64
12/13/94	131	AREA	blast	leadhd	235	2 0	470	2	31	66	4 19
12/13/94	145	AREA	blast	slaghd	230	2 0	460	2	20	43	3 77
12/13/94	153	PERSONAL	blast		206	2 0	412	2	13	32	3 45
12/13/94	155	AREA	blast	left side	153	2 0	306	2	13	42	3 75
12/13/94	167	AREA	blast	rkettles	144	2 0	288	2	19	66	4 19
12/13/94	171	AREA	blast	control	144	2 0	288	2	21	73	4 29
12/13/94	170	AREA	blast	rearctr	125	2 0	250	2	29	116	4 75
12/13/94	173	AREA	blast	bench	138	2 0	276	2	15	54	4 00
12/13/94	105	PERSONAL	blast		42	2 0	84	2	7 6	90	4 51
12/14/94	174	HAM	hmill		131	2 0	262	2	4	15	2 73
12/14/94	196	AREA	hmill	one	244	2 0	488	2	24	49	3 90
12/14/94	190	AREA	hmill	two	234	2 0	468	2	27	58	4 06
12/14/94	195	PERSONAL	hmill		250	2 0	500	2	21	42	3 74
12/14/94	275	HAM	hmill		39	2 0	78	2	7 7	99	4 59
12/14/94	276	PERSONAL	hmill		40	2 0	80	2	11	138	4 92
12/14/94	253	HAM	reverb		139	2 0	278	2	50	180	5 19
12/14/94	259	PERSONAL	reverb		145	2 0	290	2	56	193	5 26
12/14/94	258	AREA	reverb	rightempslag	247	2 0	494	2	5 9	12	2 48
12/14/94	254	AREA	reverb	rightcoolslag	241	2 0	482	2	200	415	6 03
12/14/94	261	AREA	reverb	leftfurn	239	2 0	478	2	27	56	4 03
12/15/94	292	AREA	indbrk	wallequip	264	2 0	528	2	4	8	2 02
12/15/94	284	HAM	indbrk		147	2 0	294	2	9 5	32	3 48
12/15/94	289	PERSONAL	indbrk		149	2 0	298	2	17	57	4 04
12/15/94	281	AREA	indbrk	axearea	286	2 0	572	2	23	40	3 69
12/15/94	280	AREA	blast	leadhd	174	2 0	348	2	33	95	4 55
12/15/94	290	AREA	blast	slaghd	229	2 0	458	2	25	55	4 00
12/15/94	353	PERSONAL	blast		70	2 0	140	2	5 9	42	3 74