

ENVIRONMENTAL AND OCCUPATIONAL  
PROTECTION IN THE SECONDARY  
LEAD INDUSTRY

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ABSTRACT

Test results from preliminary sampling studies performed at a secondary lead smelter are reported. The studies were performed before fugitive emission controls were installed. Some interim tests of the partially installed new control system have been completed. Additional work is scheduled.

In-duct air flows and hood capture characteristics were measured for the old ventilation system. Interim measurements indicate that order-of-magnitude increases in some hood face velocities and air flow will be provided by the new exhaust system. A list of the installed engineering controls is presented. Work practice changes and other suggested improvements are also discussed.

Stack sampling tests were conducted to determine lead, antimony, sulfur, and chlorine emissions. Personal breathing zone and in-plant area samples were collected and analyzed for lead, antimony, and sulfuric acid. High volume ambient air monitoring for total particulate and lead completed the sampling effort. Company supplied blood lead data are also presented.

INTRODUCTION

The environmental Protection Agency (EPA) and the National Institute for Occupational Safety and Health (NIOSH) are engaged in a demonstration of the Bergsoe agglomeration furnace and best management practices. The demonstration project is a test of these techniques for controlling fugitive

and workplace lead emissions. The purpose of this study is to gather data regarding the reduction of both employee exposure to lead and fugitive lead emissions to the ambient environment which can be accomplished by retrofitting controls to an existing secondary lead smelter.

Like almost all secondary lead smelting facilities in the United States, the test smelter has had difficulty controlling both fugitive emissions and the resultant employee exposures to lead. The company is currently in the process of implementing a major exposure abatement plan which involves improved process enclosure and local exhaust ventilation, yard paving, modified materials handling, and agglomeration of flue dust. While engineering controls are being designed and installed employee exposures are being controlled through use of respiratory protective devices and work and hygiene practices.

The demonstration of the agglomeration furnace and best management practices involves before and after characteristics of the smelter. Additionally, the demonstration study provides for limited technical assistance during the final design and installation of engineering controls. This paper contains the data developed in the "before" study and through subsequent contacts with the smelter.

#### BACKGROUND

Flue dust handling has historically been a serious problem to secondary lead smelters in the United States and other parts of the world. Flue dusts generated by secondary lead blast and reverberatory furnaces contain appreciable amounts of lead. The collection, handling, storage, and reintroduction of this dust to the smelting process involves opportunities for the dust to enter the ambient, as well as the workplace environment. The Bergsoe flash agglomeration furnace is a means of helping to control emissions from the handling of flue dust beyond the point of its collection in a baghouse. The agglomeration furnace melts the flue dust into a slag-like material which can be handled in bulk form and reintroduced to the process without generating an appreciable amount of dust.

Flue dust handling, however, is not the only source of employee exposure at a secondary smelter. Emissions from furnaces and other smelting equipment also can contribute to workplace and ambient pollution if they are not properly controlled. The test smelter is the first U.S. secondary lead smelting firm to utilize the Bergsoe agglomeration furnace to help control fugitive dust. This smelter is also actively engaged in the installation of exhaust ventilation and improved management practices which should provide substantial reduction in fugitive emissions and workplace exposures. The amount of improvement will be gauged by the work performed during this study and also by comparing the new conditions with those measured by the company during a two year period preceding this study.

#### SMELTER DESCRIPTION

At the test smelter, scrap batteries are broken using slow-moving shears. Battery plates, mud, plant scrap from an adjacent battery manufacturing facility, drosses, and a variety of other lead scrap are fed to a vertical

shaft blast furnace. This blast furnace is charged using a skip hoist and traditional slag-tapping and metal-tapping equipment is employed.

The smelter employs approximately 12 people per shift. Much of the work is manual. Charging the furnace and handling of crude and refined lead in the smelting building involve simple materials handling equipment. A small Bobcat loader is utilized to handle charge materials within the smelting building.

An open-air building houses the blast furnace, refining kettles and other smelting equipment. Several of the walls are open to allow movement of fresh air in and out of the building. The floor of the building is paved but rough. It is heavily contaminated with muds formed by water and paste from battery plates, as well as by other materials tracked in from the yard surrounding the smelting building. Housekeeping, at this particular smelter, is a difficult problem due to the rough surface of the floor and the lack of appropriate drains to flush accumulated lead-containing materials.

Local exhaust ventilation is provided for various emission points associated with the blast furnace and to some extent for the refining kettles. Figure 1 presents an overview of the original local exhaust ventilation system for the smelter building. Most of the system is serviced by a  $4.7\text{m}^3/\text{s}$  (10,000 cfm) baghouse and fan system. The slag tapping hood is connected to a separate  $2.4\text{m}^3/\text{s}$  (5,000 cfm) baghouse and fan. Not included in this overview sketch is the blast furnace flue gas control system. Flue gases are ducted through knockout chambers and cooling tubes to a separate baghouse and fan duct collecting system. A new baghouse and fan system will collect exhaust gases from the local exhaust ventilation hoods. The slag tapping hood will continue to be served by the separate baghouse and fan.

Figure 2 presents a sketch of the skip hoist ground level loading station. Local exhaust pickups are provided at each side of the hoist enclosure. As indicated in Figure 2 the skip hoist dumping station at the top of the hoist shaft is exhausted via the skip hoist furnace charging hood.

Figure 3 presents a sketch of the local exhaust hood associated with slag tapping. As stated earlier, this hood is served by a separate dust collector and fan. This exhaust system is operated during slag tapping. The front door to the hood is raised by means of a cable and pulleys. The sides to the hood are hinged and swing away to allow access to the slag tapping port. Slag containers are moved via forklift trucks.

Figure 4 illustrates the relationship of the three local exhaust hoods which serve the molten lead tapping and molding operation. The tapping hood is stationary and is provided with fold-up side curtains to facilitate access to the tapping port. The launder hood moves with the launder which is supported from beneath by a pivoting mechanism. The sides to the launder hood fold up to allow cleaning of the launder. The mold filling hood is portable and is manually lifted into position over the mold being filled. Molds are contained in a tub filled with water. Finished ingots are removed from the molds through use of an overhead monorail hoist.

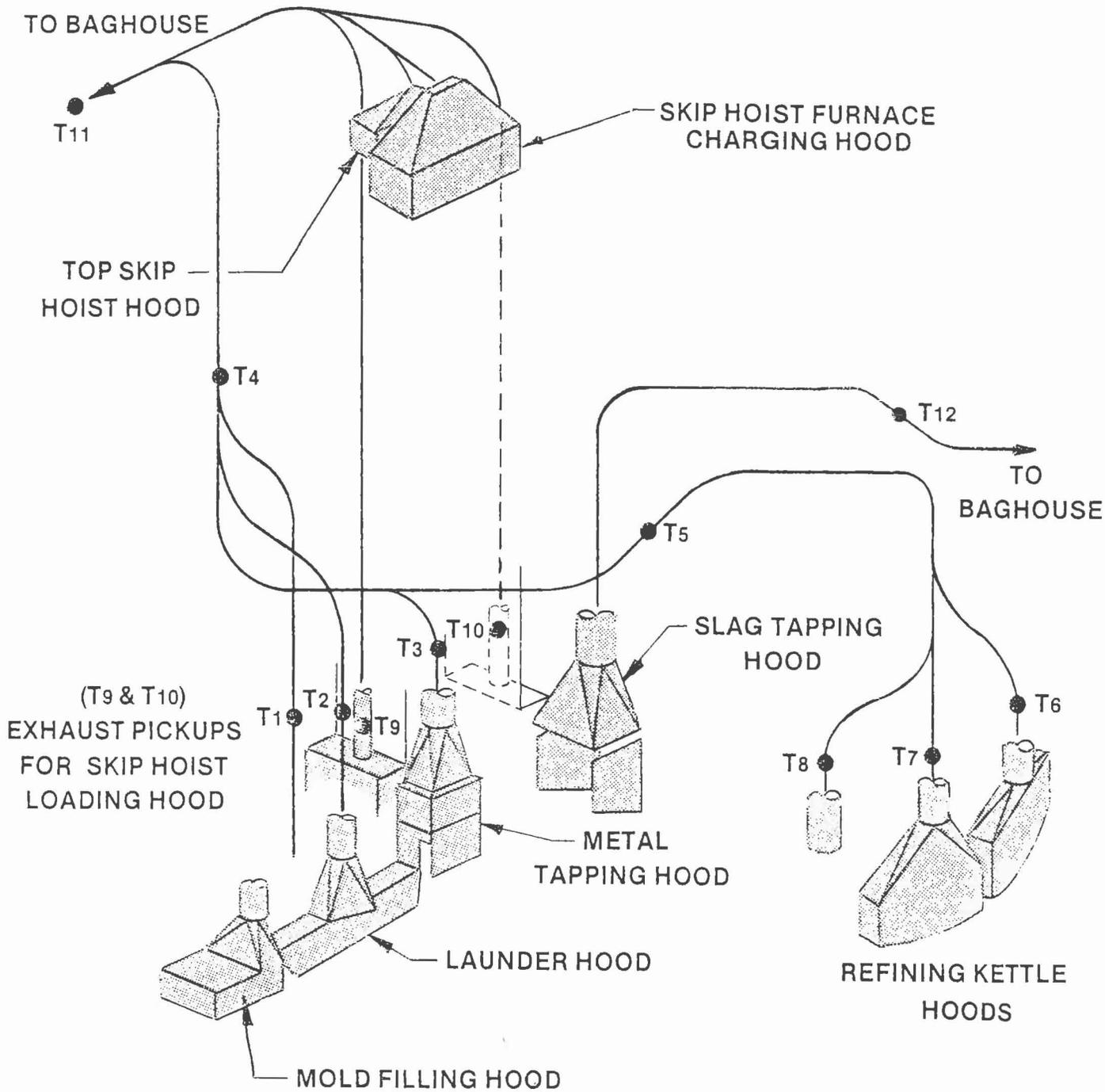


Figure 1. Overview of original local exhaust ventilation system.

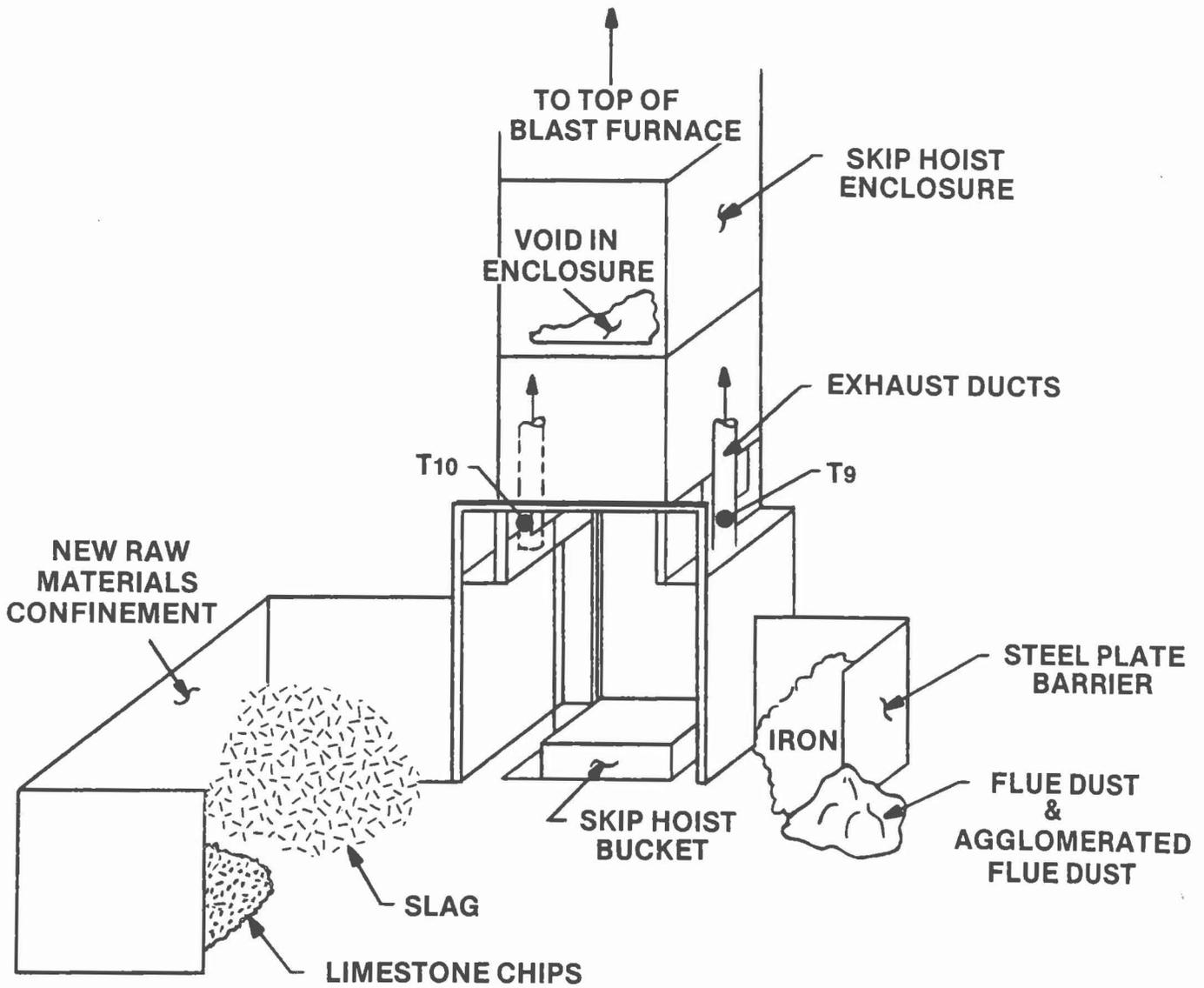


Figure 2. Skip hoist ground level loading station.

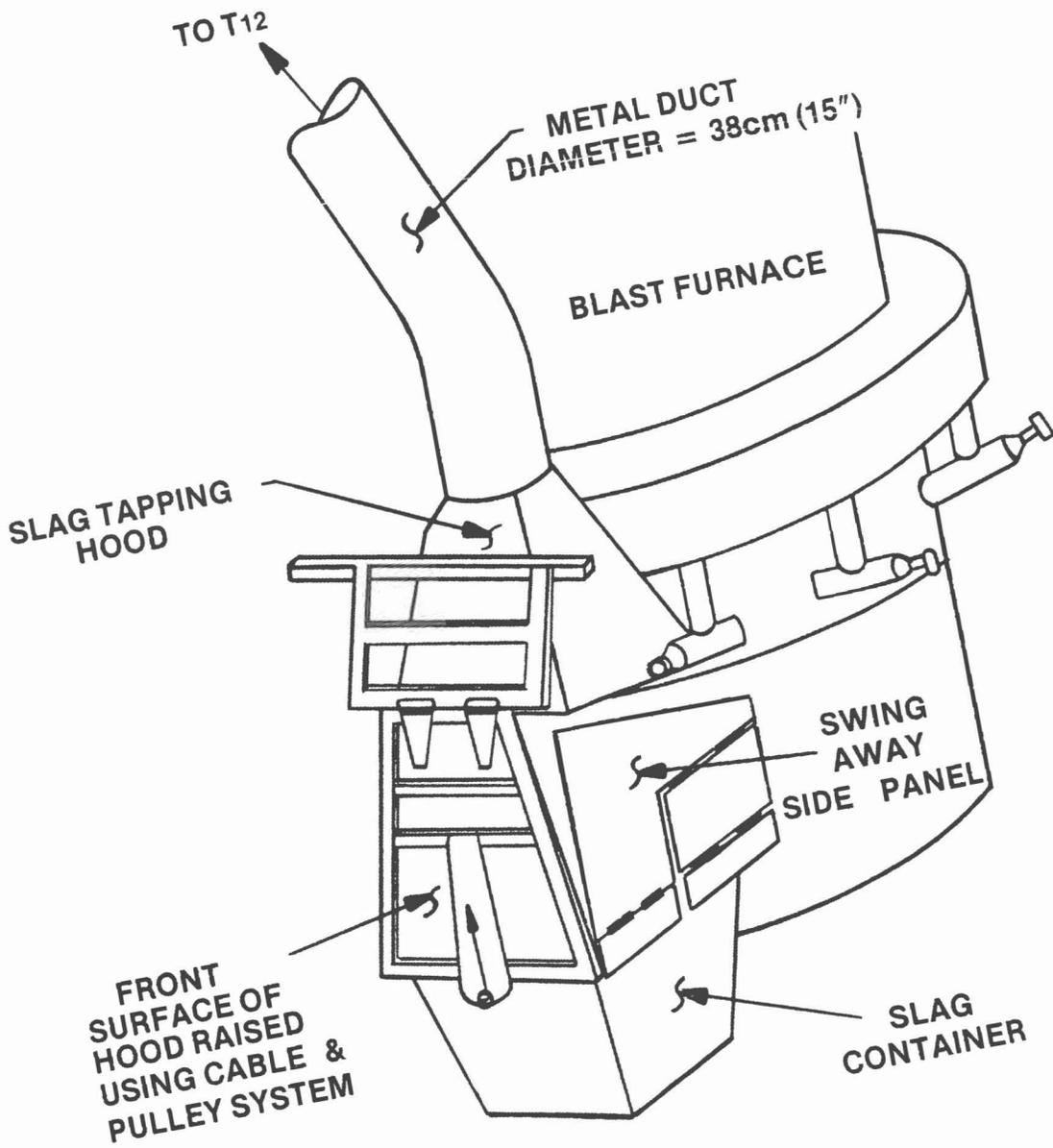


Figure 3. Blast furnace slag tapping hood.

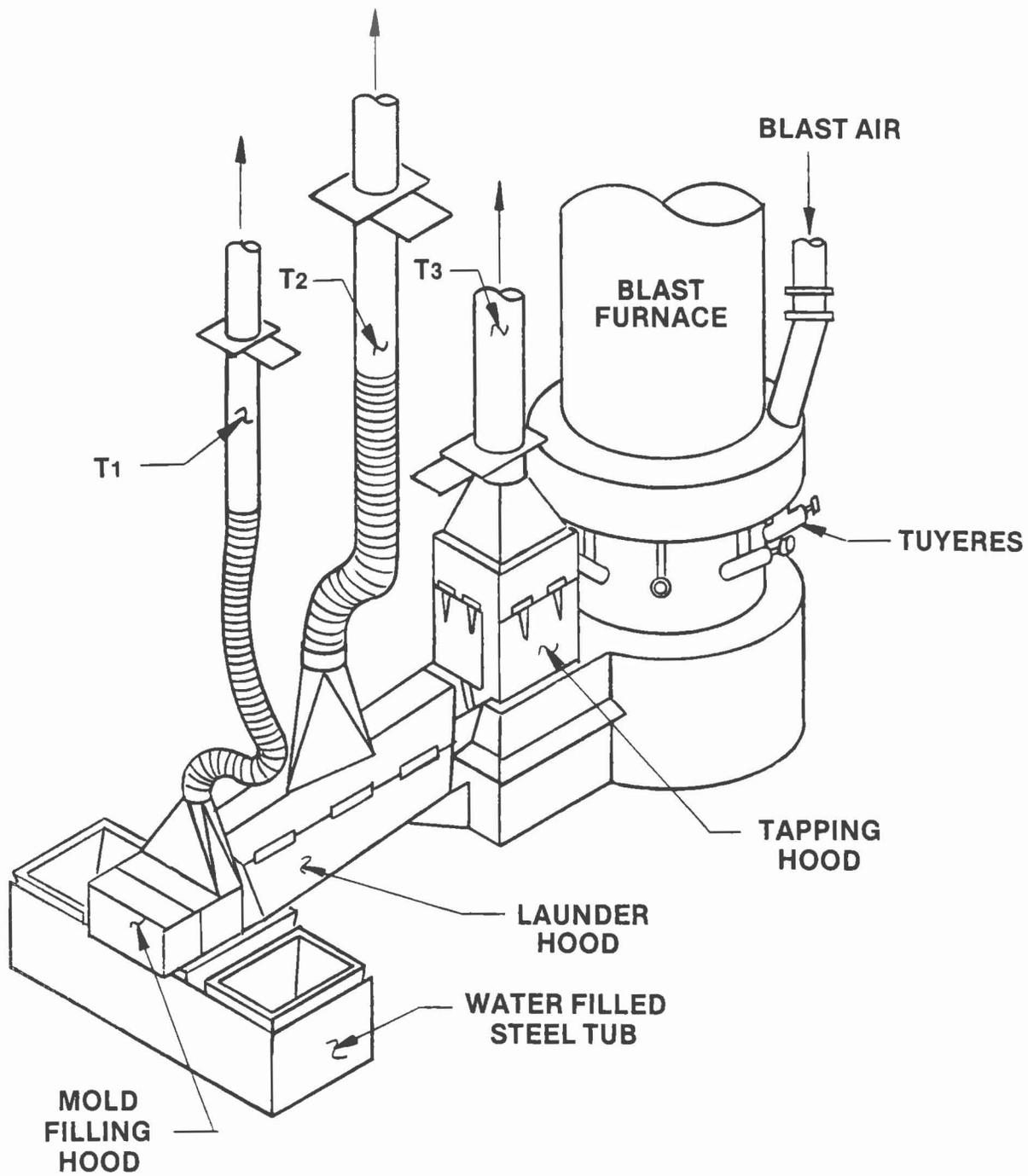


Figure 4. Local exhaust ventilation controls for molten lead tapping and molding.

Following the initial characterization, the smelter building exhaust ventilation system was modified. These modifications are shown in part in Figure 5. The slag tapping hood is still served by the 2.4m<sup>3</sup>/s (5,000 cfm) baghouse and fan. However, the remainder of the system is now served by a new baghouse and fan system with capacity in excess of 19.8m<sup>3</sup>/s (42,000 cfm). An additional local exhaust ventilation hood has been provided at the top of the blast furnace to capture fugitive emissions leaking from side access doors to the furnace. Other local exhaust hoods have not been modified.

In addition to the local exhaust hoods and ductwork shown in Figure 5, the new ventilation system also serves the flue dust agglomeration furnace and associated flue dust handling equipment. As indicated in Figure 5, ductwork has been provided to serve the new refining kettle hoods which were in the final design stage at the time of the initial visit. Eventually both refining kettles will be provided with near total enclosure. The existing backdraft hoods will be removed and refractory chimneys installed to handle kettle burner exhaust gases.

#### Operating Conditions

The smelter operated normally during the entire initial test period. Battery plates were the major lead-bearing feed material charged to the blast furnace. Small amounts of flue dust and dross were also being recycled to the furnace. The plate material was generated by two men operating a hydraulic battery shear.

Rubber-cased automotive (SLI) and industrial batteries comprised a majority of the batteries processed. Some polypropylene-cased batteries were also present. All battery cases were removed and discarded prior to smelting. Only fragments of the rubber or plastic cases were included in the furnace charge.

#### Materials Handling and Housekeeping

The smelter began a major effort to clean up yard areas and improve housekeeping after the initial visit. Much of the large flue dust storage pile located adjacent to the process control baghouse system had been removed. Unpaved yard areas were being graded to begin removal of lead bearing dirt and rubble. Flue dust being collected in knockout chambers and baghouses was being fed to the agglomeration furnaces. However, since the agglomeration furnace was not completely online, some flue dust was being stockpiled. Tote boxes used to handle flue dusts collected in knockout boxes and small baghouses had been fitted with lids to prevent dispersal of lead bearing dust during transportation of the tote boxes.

During an interim visit, it was observed that the floors of the smelter building were visibly cleaner and wetter than during the initial visit. Major accumulations of dust had been removed from floor surfaces and additional physical barriers (low walls, partitions, etc.) had been provided to contain the spread of charge materials. Although simple in design, the raw

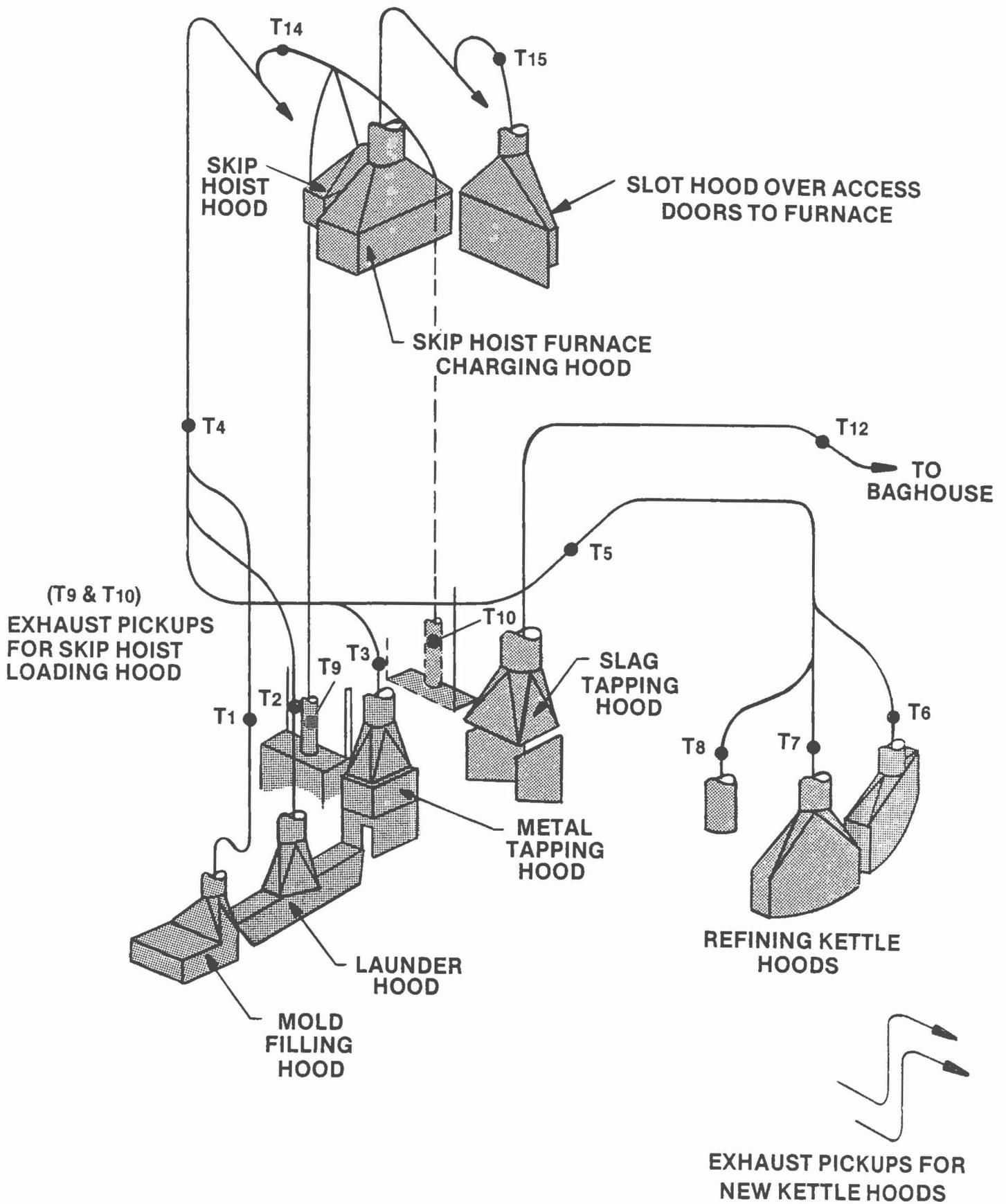


Figure 5. Overview of modified local exhaust ventilation system.

materials confinement structure provided at the base of the skip hoist did appear to improve housekeeping in this work area.

The implemented improvements in housekeeping and materials handling were discussed with smelter management. Although major strides have been made to improve housekeeping, much work remains to be accomplished. Plans to improve enclosure of the smelter building and isolate raw materials handling were reviewed. A major housekeeping cleaning effort was completed during the summer shutdown which concentrated on removing accumulations of lead particulates from ceilings, walls, girders, etc.

A major problem at this smelter involves the removal of flue dust from yard areas and floor surfaces. Lead bearing flue dust is difficult to wet. It has a slippery almost greasy property which causes water to bead up and enhances its ability to adhere to surfaces. At present, large unpaved areas of the yard are coated with compacted flue dust. Much of this lead contaminated earth will be excavated and replaced with clean fill and paving. Future contamination by flue dust should be greatly minimized by improved flue dust handling methods and agglomeration of flue dust into a slag-like material. However, paved areas beneath baghouses, U-tube coolers, and knockout chambers will be periodically contaminated by spills of flue dust. These spills could result in widespread yard area contamination if not promptly and completely cleaned up. Improved methods for cleaning flue dust from concrete and asphalt surfaces must be developed. Use of wetting agents and vacuum systems will be explored.

Housekeeping within the smelter building will be made easier with the elimination of flue dust handling associated with furnace charging. However, lead bearing particulate from battery plates, drosses, etc. will continue to contaminate the charge materials handling area. Isolation of this area from other work areas by means of a floor to ceiling partition may help isolate this problem. Maintenance of wet floors and prohibition of dry sweeping will also help if strictly implemented. Floor surfaces within the smelter building are rough and should be smoothed to facilitate cleaning.

#### Flue Dust Agglomeration

At the time the interim visit was made, the agglomeration furnace had been operating for several days. Several startup problems had been encountered which mainly dealt with furnace burner adjustment and furnace temperature control. These problems were nearly solved during the interim visit. A suitable furnace operating temperature must be found once the flue dust composition and dust generation rate stabilize.

A more difficult problem was encountered in providing a steady feed of flue dust to the furnace. After several days of operation it was determined that individual baghouse compartments released collected flue dust in highly irregular quantities following a bag shaking cycle. Since flue dust is fed directly from the baghouses to the agglomeration furnace, inconsistent feeding of the furnace was being experienced. Surges of flue dust would cause excessive charging of the furnace requiring operation at high heat

to clear the furnace. These surges also created plugging at the slag tap which required almost continuous attention by an operator. Plans were being implemented to provide better control of furnace charging to eliminate these problems.

When uniformly fed, the agglomeration furnace did produce a steady stream of agglomerated material which was in appearance very similar to the material produced at the Bergsoe smelter in Glostrup, Denmark. However, the problem of emptying tote boxes of dust cleaned from the numerous dropout points in the system into the agglomerator has not been solved. This is one problem which could be avoided in a new smelter design. In this case, the retrofit of the agglomeration system did not include eliminating the dropout points. Thus, the tote box problem remains. Vacuum systems are being investigated as a means of emptying the tote boxes and charging the cleanout material to the agglomerator.

#### CONTROL EVALUATION

One major objective of the test work performed was to determine what contribution stack emissions make to ambient and workplace lead-in-air concentrations and what contribution fugitive emission sources make. To accomplish this, the following tests were performed: ventilation measurements, stack sampling, ambient air testing, and workplace monitoring.

In addition, the smelter provided blood lead data which had been collected over the previous three years. Similar data will be collected during a final smelter characterization once all the fugitive emission controls are installed.

The importance of these measurements to this particular smelter is evident when a plot plan of the smelter and the surrounding property is examined. As can be seen in Figure 6, the smelter actually extends beyond the company property line. This creates a significant problem when interpreting the new EPA ambient air quality standard for lead of  $1.5\mu\text{g Pb}/\text{m}^3$ . As a result, it is of particular interest to this smelter and EPA to determine what the ambient lead levels are and where they come from. The results of the testing are presented below.

#### Ventilation Measurements

Table 1 presents a comparison of exhaust air flows at several locations in the smelter building exhaust ventilation system. Several of the local exhaust hoods are now collecting two to three times the volume of contaminated air previously collected. Greatly increased quantities of air are being collected by the hoods serving the skip hoist and blast furnace charging operation. The slag tapping emission control system was measured to be collecting somewhat more air than in January. As indicated by measurements made in the new open ended ducts which will serve the refining kettles, approximately  $4.0 \text{ m}^3/\text{s}$  (8,500 cfm) of exhaust capacity will be available for the new refining kettle hoods.

Table 1. Comparison of exhaust air flows.

Flow measurement location	Volumetric flow rate, Q			
	m <sup>3</sup> /s (1)	cfm (1)	m <sup>3</sup> /s (2)	cfm (2)
Mold filling hood (T <sub>1</sub> )	0.30	630	0.78	1650
Launder hood (T <sub>2</sub> )	0.39	820	1.2	2460
Metal tapping hood (T <sub>3</sub> )	0.65	1380	1.7	3660
Refining kettle hoods (T <sub>5</sub> )	0.70	1480	2.2	4700
Skip hoist hoods + skip hoist furnace charging hood	2.8	5990	7.6	16030
Skip hoist furnace charging hood			5.7	12100
Skip hoist hoods (top and bottom (T <sub>14</sub> ))			1.9	3930
Slot hood over furnace access doors (T <sub>15</sub> )			0.91	1940
Slag tapping hood (T <sub>12</sub> )	1.8	3850	2.1	4540
Exhaust pickups for new kettle hoods			1.4	2940
Discharge from slag tapping baghouse			2.4	5000
Inlet to main exhaust fan for smelter exhaust ventilation system			20	41700

(1) Measurements made 1/23-24/79 with old exhaust system in operation.  
(Refer to Fig. 1).

(2) Measurements made 6/19-20/79 with new exhaust system in operation.  
(Refer to Fig. 5)

The increased air volume being collected by each of the local exhaust hoods has increased hood face velocities. Face velocity measurements were made for several of the hoods using an Alnor<sup>R</sup> Velometer. As can be seen from the data in Table 1, substantial improvement has been realized and improved control was apparent by observation of fume capture. However, the degree of emission source enclosure offered by many of these hoods could be improved. Hood modifications are planned once more major modifications are complete.

#### Stack Sampling

Stack sampling was performed in the exhaust duct leading to the main stack. Sampling personnel worked from a platform located approximately six meters from ground level. The duct was rectangular and was inclined at approximately a 30 degree angle from horizontal. The interior dimensions of the duct were 813mm in height and 711mm in depth.

At the platform level, the duct was equipped with three access ports on the vertical surface of the duct. These were located approximately 135mm from the edge of the duct on 270mm centers. The place in which the sample ports were located was approximately two equivalent diameters upstream and eight equivalent diameters downstream of any flow disturbances. Velocity and sampling traverses were made at four points in each of these three ports, for a total of twelve points.

The EPA Method 5 sampling train was used to determine average duct temperature, velocity, and moisture content on January 21, 1979. These measurements were used to select the appropriate nozzle and isokinetic sampling rates for subsequent tests. Isokinetic sampling was performed at each point for the remaining tests conducted on January 22 and 23.

On January 22 one Method 5 experiment was conducted. Isokinetic sampling was conducted at each point within each port for a period of five minutes. When all the points in all the ports had been traversed, sampling was repeated. This continued for approximately six hours so that sufficient sample for analysis could be obtained.

On January 23, the experiment was repeated, however, each point was sampled over a fifteen-minute period to minimize sampling time. Sampling took approximately three and one-half hours.

Sampling was performed for SO<sub>x</sub> emissions using the Method 5 equipment as well. One thirty-minute sample was obtained at the center of the duct. Proportional sampling was conducted to obtain a 0.217 Nm<sup>3</sup> sample.

Stack particulates were collected on a glass fiber filter heated to 121°C (250°F) in a thermostated oven. Both the filter and probe were heated during sampling. Table 2 presents the results of this experiment for both test days. It is important to note that the average grain loadings for both days were nearly identical. This indicates that the baghouse was operating normally and was allowing a constant amount of fine particulate to pass through with the gas streams.

Table 2. EPA Method 5 sampling results.

	Average velocity determination	Particulate, chlorine, and sulfur determinations	
Date	21 Jan 79	22 Jan 79	23 Jan 79
Time	1744-1803	1313-1905	1012-1344
Sample duration	19 min	3 hr 40 min	3 hr
Sample volume at meter	0.286m <sup>3</sup>	3.64m <sup>3</sup>	2.89m <sup>3</sup>
Avg. meter temperature	18°C	19°C	19°C
Meter pressure	747 mm Hg	773 mm Hg	779 mm Hg
Avg. stack temperature	70°C	83°C	85°C
Stack pressure	746 mm Hg	772 mm Hg	778 mm Hg
Avg. gas velocity	21.45 m/s	20.56 m/s	20.33 m/s
Total gas flow	3.36 x 10 <sup>4</sup> Nm <sup>3</sup> /hr	3.22 x 10 <sup>4</sup> Nm <sup>3</sup> /hr	3.18 x 10 <sup>4</sup> Nm <sup>3</sup> /hr
Moisture content of gas (Volume %)	3.8	3.5	3.6
Gas molecular weight	28.63	28.6	28.8
Mass collected, filter		43.14 mg	35.48 mg
Mass collected, probe		1.16 mg	0.49 mg
Mass collected, total		44.30	35.97 mg
Nozzle diameter		0.442 cm	0.442 cm
Nozzle area		1.53 x 10 <sup>-5</sup> m <sup>2</sup>	1.53 x 10 <sup>-5</sup> m <sup>2</sup>
Stack dimensions		8.13 mm x 711 mm	8.13 mm x 711 mm
Stack area		0.578m <sup>2</sup>	0.578m <sup>2</sup>
Avg. sample velocity at nozzle		22.7 m/s	22.2 m/s

(continued)

Table 2 (continued).

	Average velocity determination	Particulate, chlorine, and sulfur determinations	
Total particulate concentration		12.8 mg/Nm <sup>3</sup>	13.0 mg/Nm <sup>3</sup>
Total particulate mass rate by area		0.456 kg/hr	0.453 kg/hr
Total particulate mass rate by concentration		0.412 kg/hr	0.414 kg/hr
Total particulate mass rate		0.434 kg/hr	0.434 kg/hr
Percent isokinetic		110.7%	109.4%

Sulfur and chlorine compounds were collected in a series of three impingers which were placed behind the heated filter in the Method 5 sampling train. Two impingers in series containing 1 percent NaOH followed by an impinger containing 6 percent H<sub>2</sub>O<sub>2</sub> were used for the experiment. A Dionex<sup>R</sup> ion chromatograph was used for the sulfur determinations. A colorimetric determination using mercuric thiocyanate was used for the chlorine determinations.

An analysis of the matter collected as particulate and vapor was made for lead, antimony, sulfur, and chlorine. The results are presented in Table 3. These results indicate that both particulate and vaporous species are being emitted from the baghouse.

Lead is emitted mostly as particulate matter (99.99 percent). Antimony, however, is present mostly as a vapor (57 to 66 percent). It is likely that lead oxide (PbO), lead chloride (PbCl<sub>2</sub>), and antimony pentachloride (SbCl<sub>5</sub>) are the compounds being emitted. The boiling point of SbCl<sub>5</sub>, 79°C, would account for the antimony being at least partially present as vapor.

Chlorine emissions were significantly higher on 1/23/79 than on 1/22/79. This might be due to a larger recycle of flue dust from the knockout chambers or because of a larger percentage of polyvinyl chloride separators in the feed materials that day.

Sulfur was emitted mostly as sulfur dioxide (SO<sub>2</sub>). Some sulfur was detected in the collected particulate matter, perhaps present as calcium sulfate (CaSO<sub>4</sub>). This compound is formed by the reaction of SO<sub>3</sub> or sulfuric acid mist with the lime injected into the flue gas. The sulfur emission rates of 33,500 and 30,400 g/hr were checked on 1/23/79 using the EPA Method 5 equipment with isopropyl alcohol in one impinger and hydrogen peroxide in another. The emission rate using this technique was 29,600 g/hr which agrees closely with the Method 5 results.

#### Ambient Air Testing

Four high volume air samples were operating during the sampling study. Figure 6 shows the location of these four hi-vols (locations no. 5 through no. 4) and one other location measured by smelter personnel (location no. 5). Location no. 4 was also a smelter hi-vol. Two samples were collected from locations no. 1, no. 3, and no. 4 and one from no. 2 during the test period. Other data from location no. 4 and no. 5 were provided by the smelter. Table 4 presents the hi-vol test results.

The weather on January 22, 1979, was cold, clear and windy. Winds from the W-NW ranged from 9 to 16 meters per second (20 to 35 miles/hr) during January 22. On January 23, 1979, it was clear, dry and relatively calm. The ground was snow-covered during the entire test period, however, the snow did not cover the flue dust pile behind the smelter.

The results presented in Table 4 are not conclusive, but they do show some trends. For example, location no. 3 shows a significantly higher lead-in-air concentration on 1/22/79, a windy day, than on 1/23/79, a calm day.

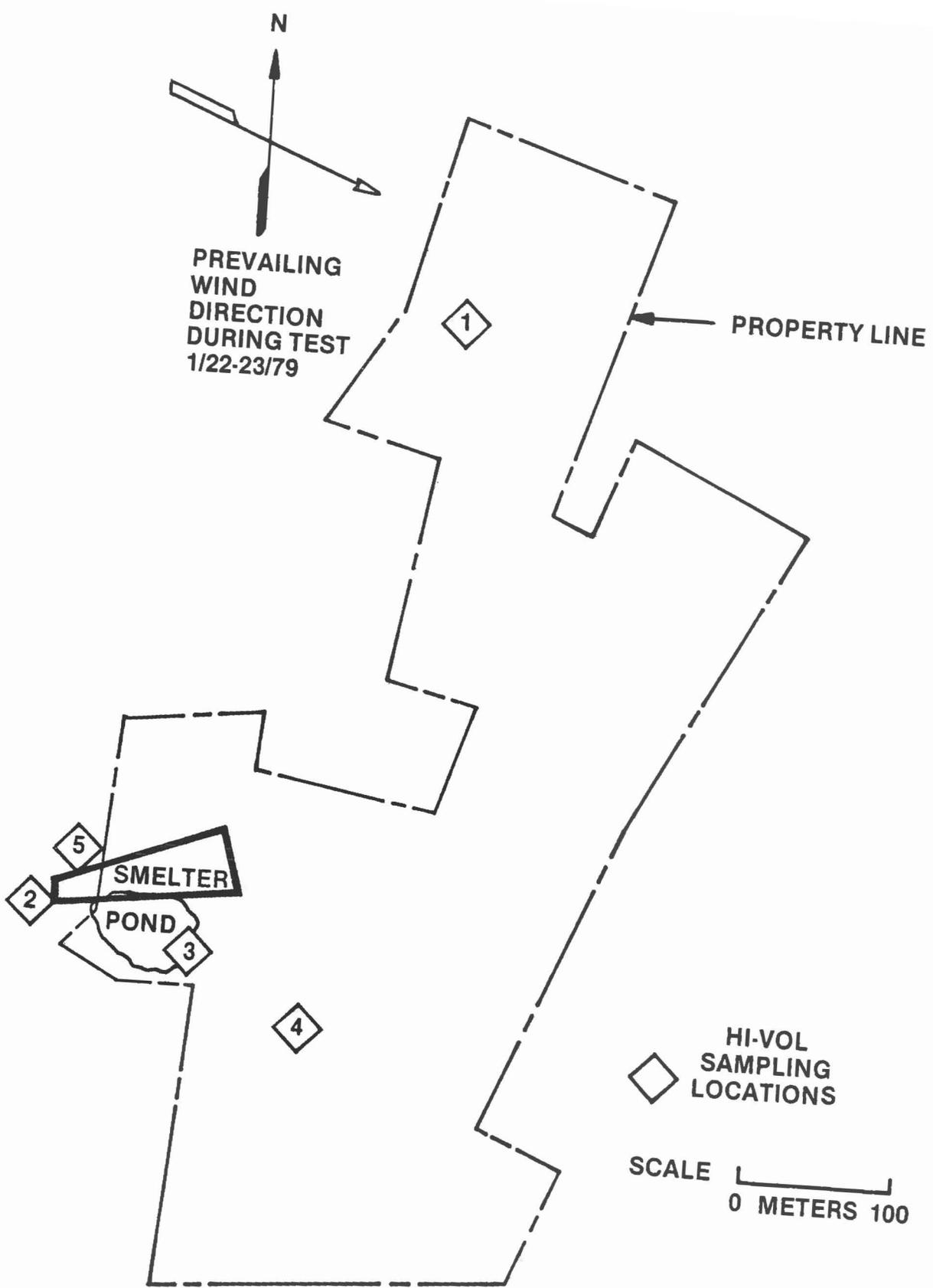


Figure 6. Pilot plan of smelter property.

Table 3. EPA Method 5 analytical results.

Element/date	Stack gas flow, 10 <sup>4</sup> Nm <sup>3</sup> /hr	Particulate (filter)		Particulate (probe wash + cyclone)		Condensibles* (g/hr)
		(g/hr)	(% of total filter catch)	(g/hr)	(% of total probe wash + cyclone)	
Lead (as Pb)						
1/22/79	3.22	10.6	2.6	1.15	10.6	0.05
1/23/79	3.18	12.3	3.0	4.65	82.6	0.17
Antimony (as Sb)						
1/22/79	3.22	0.06	0.01	0.006	0.06	0.13
1/23/79	3.18	0.09	0.02	0.025	0.45	0.15
Chlorine (as Cl)						
1/22/79	3.22	0.62	0.15	1.23	†	4.6
1/23/79	3.18	1.72	0.42	12.64	†	4.7
Sulfur (as S)						
1/22/79	3.22	13.5	3.4	3.93	36.4	33500.
1/23/79	3.18	13.2	3.2	0.46	8.21	30400.
Total particulate (by concentration)†						
1/22/79	3.22	402.	100.0	10.8	100.0	unknown
1/23/79	3.18	408.	100.0	5.6	100.0	unknown

\*Material collected in impinger solutions

†Some HCl is believed to have evaporated when probe and cyclone wash sample was evaporated.

The calm conditions apparently reduced fugitive windblown dust from the smelter yard. Also, lead-in-air levels at location no. 4 remained fairly constant while location no. 3 varied by an order of magnitude. This indicates that the fugitive lead particulate from the smelter yard may be settling within a relatively short distance (location no. 3) while some constant background level, perhaps generated by the stack, accounts for conditions at location 4. The windy conditions on 1/22 could thus cause an order-of-magnitude increase in lead concentrations at location 3 without seriously affecting location no. 4. Certainly more data are required before these trends can be substantiated.

Table 4. Hi-vol sampling results.

Location	Date	Total particulate collected, $\mu\text{g}$	Total lead collected, $\mu\text{g}$	Ambient lead concentration, $\mu\text{g Pb/m}^3$
1	1/22/79	54,000	1,750	0.88
	1/23/79	83,300	2,220	1.3
2	1/22/79	101,000	6,740	3.0
3	1/22/79	106,000	29,500	16.
	1/23/79	72,800	2,830	1.6
4	1/22/79			9.3
	1/23/79			7.4
	8/24/78			1.1
	8/30/78			0.8
	9/1/78			1.0
	9/5/78			3.3
5	5/22/78			370.

Two Gaussian dispersion computer models were used to estimate the dispersion of particulates from the lead smelter. These two models are the Climatological Dispersion Model (CDM) and CRSTER. Both models employ the standard Gaussian plume assumption. These models assume that the pollutant concentration in a smokestack plume advects downwind with the ambient air while diffusing in both the horizontal and vertical directions. The pollutant distributions in the plume are assumed to obey Gaussian, or normal, distributions.

The emission data used in the two models are as follows:

Emission rate	0.126 g/sec
Stack height	16.8 m
Stack diameter	8.6 m
Stack gas velocity	20.5 m/sec
Stack gas temperature	84°C

Only total suspended particulate (TSP) was modelled. No attempt was made to separate the lead fraction of TSP from the total emission.

One significant assumption involved with Gaussian models is that no loss of mass occurs from the plume, e.g., settling or deposition. This is a conservative assumption for this analysis because the lead fraction of the particulate matter emitted by the smelter is dense and may settle rapidly. The result is that ambient concentrations predicted by the models will be higher than actual concentrations.

The CDM model predicts annual or seasonal concentrations due to pollutant emissions. It uses meteorological information in the form of a joint frequency distribution of wind speed, wind direction, and atmospheric stability. For this analysis, ten years of meteorological observations at a nearby local airport were averaged together to yield the joint frequency distribution.

The CRSTER model predicts both short term and seasonal or annual concentrations based upon actual observed meteorological data. The CRSTER model calculates the hourly concentration at a grid of receptors for each hour of a year's worth of data. It then averages these concentrations together to yield average concentrations for periods of up to a year in length. Local meteorological data for 1964 were used and the model averaged concentrations over the winter months of January, February, and December to yield a seasonal average concentration.

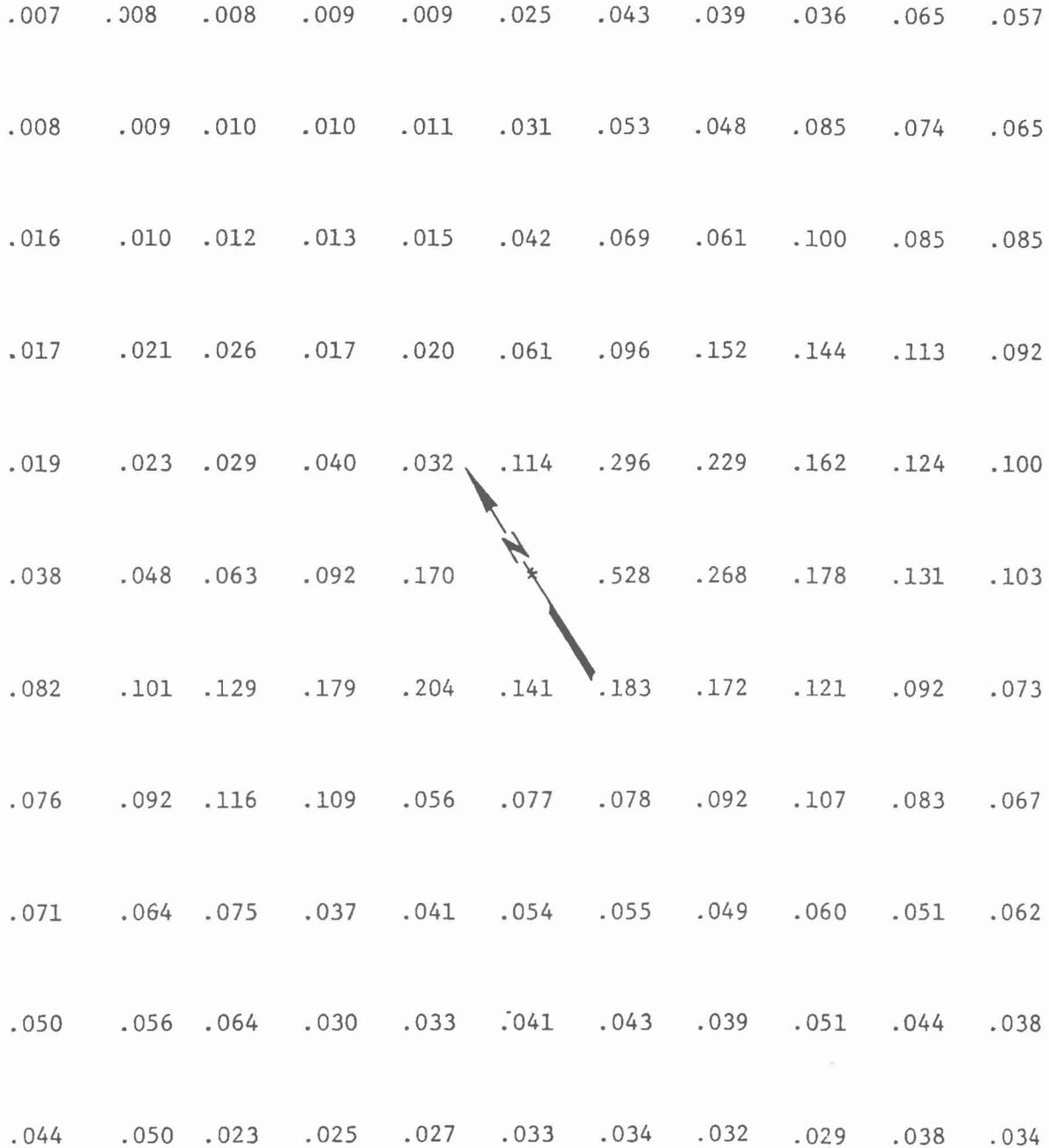
Both the short term 24-hour average concentrations predicted by CRSTER and the seasonal average concentrations predicted by CDM are very small (Figure 7). Using a 200m by 200m grid, the highest concentration predicted by CDM for the winter season is  $0.5 \mu\text{g}/\text{m}^3$ , 200m east of the smelter. This is one-half of the concentration value used for point source dispersion (PSD) analysis to determine area of impact of a source. All other concentrations produced by the CDM model fall off rapidly with distance from the smelter and are at or below  $1.0 \mu\text{g}/\text{m}^3$ , 600m away from the smelter.

The 24-hour maximum concentration predicted by CRSTER is  $0.9 \mu\text{g}/\text{m}^3$  at  $5 \mu\text{g}/\text{m}^3$  level of significance used in PSD analysis for TSP.

Based upon these dispersion modelling results the conclusion can be drawn that particulate emissions from the test smelter stack have a negligible impact on ambient particulate concentrations in the vicinity (<1 km) of the smelter.

#### Workplace Lead-in-Air Contamination

The test smelter has monitored workplace lead-in-air contamination for a number of years. To assist this demonstration study, monitoring data covering approximately the last two years were submitted for review and evaluation. The results of this monitoring are summarized in Table 5. These data indicate that severe lead-in-air concentrations have accompanied operation of this smelting complex. Employee exposures have varied over a wide range and incorporate the expected seasonal and process fluctuations.



\* stack

————— 1 kilometer —————

Figure 7. Modelled map of TSP concentration (CDM model, no deposition, winter conditions) around test smelter stack in  $\mu\text{g TSP}/\text{m}^3$ .

Table 5. Historic employee exposures to lead-in-air, mg/m<sup>3</sup>.

Sampling date	Function or position										n	Mean
	Hoist/ coke	Payloader/ furnace	Clean-up	Lead pot	Furnace	Payloader	Hoist	Coke	Foreman	OMC loader		
9/11/78	0.30	0.51									4	0.37
9/11/78	0.28	0.38										
8/17/78	0.77	0.31									5	0.32
8/17/78	0.22	0.18	0.10									
7/18/78	0.31	0.35									4	0.34
7/18/78	0.41	0.30										
6/21/78	0.47	0.35									4	0.30
6/21/78		0.17		0.19								
5/12/78		0.91			0.53		1.10				3	0.85
4/26/78	1.90	1.85									3	2.10
4/26/78		2.55										
3/21/78	0.58	0.78					0.88				4	0.82
3/21/78		1.02										
2/22/78						0.58	0.89	0.85			3	0.77
1/4/78					0.73	1.04	0.09	0.13			4	0.50
12/16/77						0.30	0.38		0.42		3	0.37
12/26/77					0.42						1	0.42
11/16/77		0.85					0.82				3	0.69
11/16/77		0.39										

(continued)

Table 5 (continued).

Sampling date	Function or position										n	Mean
	Hoist/ coke	Payloader/ furnace	Clean-up	Lead pot	Furnace	Payloader	Hoist	Coke	Foreman	OMC loader		
10/14/77		0.8					1.0				3	0.9
10/14/77		0.8										
9/15/77		0.8			0.13	0.43	0.37				3	0.31
8/12/77					1.46	0.35	1.00	0.49			4	1.08
8/30/77										0.19	1	0.19
8/31/77										0.29	1	0.29
7/27/77					0.29	0.36	0.18	0.55			5	0.39
7/27/77						0.55						
6/20/77		0.63					0.64				3	0.57
6/20/77		0.45										
5/23/77					0.48	0.46	0.52				3	0.49
4/20/77					0.64	0.90	1.12	0.41			4	0.77
2/23/77			1.49	0.56	0.61	0.33	0.79	2.04			6	0.97
n	9	19	2	2	9	10	14	6	1	2		
Mean	0.58	0.71	0.80	0.38	0.59	0.53	0.70	0.91	0.42	0.24		

As part of the "before" study of this smelter a limited amount of breathing zone and work area air sampling was conducted. The purpose of this sampling was to 1) corroborate the sampling performed previously by the smelter, and 2) define employee exposures during a known set of smelter operating and ambient weather conditions.

Resource limitations of the study confined air sampling to two consecutive operating days. The selection of an optimum time for sampling was constrained by the fact that the smelter was actively engaged in a major modification program. To obtain air contaminant information before the agglomeration furnace and other controls were operational required sampling at the site during midwinter.

Breathing zone and work area sampling for lead and antimony were performed on January 23 and 24, 1979. January 23, 1979, was a relatively normal operating day at the smelting complex. The weather was sunny and cold with light winds blowing from several compass directions. Employees at the smelter performed normal tasks and rotated jobs at the halfway point in the work shift as is indicated by the change in employee initials associated with each of the jobs or operations shown in Table 6. January 24, 1979 was a relatively unusual day at the smelter complex. Heavy rains and strong winds were present throughout the period monitored. The strong gusty winds caused vigorous drafts through the smelting building which disturbed the capture characteristics of local exhaust ventilation hoods and resulted in the introduction of dust into the atmosphere from building surfaces. By the afternoon of January 24, large volumes of runoff water were entering the smelting complex and leaving on the downhill side. The smelting building itself was very wet with pools of water in most of the work areas. Several of the employees did not show up for work on this day due to flooded roads in the countryside. The sampling conducted on these two days indicates that exposures were generally higher on the second day. This result is possibly due to the strong air currents which entrained contaminants from the capture zone of the local exhaust ventilation hoods. As stated earlier, the smelting work area was very wet, however, the production of fume from slag tapping, metal tapping, and refining operations was still present. On both days, the amount of antimony in the air was very low by comparison to the current OSHA permissible exposure limit of  $0.5 \text{ mg/m}^3$ .

Several employees were found to have very high exposures ( $>500 \mu\text{g Pb/m}^3$ ) during portions of work shifts on each day sampled. Battery breakers on the first day sampled showed high exposures to lead and the hoist operator encountered very high lead exposure during the afternoon of the second day sampled. It is possible that relatively large particles of lead entered the filter cassette during the sampling period in each of these operations. In the case of battery breaking, a splash of lead laden solution may have caused excessive contamination. In the case of the hoist operator, the handling of flue dust as it is charged to the hoist could have caused the deposition of lead particles onto the filter. However, in each of these cases, the measured exposure may not have been adversely influenced by artifact particulate and may represent the actual lead exposure.

Table 6. Results of breathing zone sampling for lead and antimony.

Job/operation	1/23/79			1/24/79		
	Sampling interval	Pb* mg/m <sup>3</sup>	Sb** mg/m <sup>3</sup>	Sampling interval	Pb* mg/m <sup>3</sup>	Sb** mg/m <sup>3</sup>
Furnace						
(LW)/(DH)	0758-1232	0.51	0.051	0803-1212	0.62	<0.030
(NH)/(LW)	1300-1547	0.38	<0.044	1234-1559	0.87	0.047
Hoist						
(DH)/(LW)	0803-1205	0.37	<0.031	0801-1233	0.87	<0.027
(RH)/(JM)	1300-1547	0.20	<0.044	1238-1558	7.8	<0.037
Payloader						
(NH)/(RH)	0807-1300	0.78	<0.025	0807-1300	1.2	<0.025
(LW)/(NH)	1258-1547	0.48	<0.044	1343-1557	0.83	<0.025
Coke						
(RH)/(NH)	0828-1233	0.18	<0.030	0818-1342	0.66	<0.023
(DH)/-	1205-1547	0.25	<0.033			
Lead pot						
(WE)/-	0807-1206	0.21	<0.031			
(WE)/-	1206-1425	0.37	<0.064			
Foreman						
(CS)/(CS)	0825-1207	0.27	<0.033	0821-1205	0.66	<0.033
(CS)/(DH)	1207-1547	0.28	0.037	1214-1603	1.2	<0.032
Industrial battery breaker						
(JM)/(JM)	0805-1300	0.43	<0.025	0815-1237	0.73	<0.028
(JM)/-	1300-1615	0.35	<0.029			
Yardmen						
(DS)/-	0817-1235	0.69	<0.029			
(DS)/-	1235-1615	0.25	<0.034			
(RM)/-	0818-1236	0.37	<0.029			
(RM)/-	1236-1615	0.23	<0.034			
Battery breaking						
(KA)/(KA)	0833-1209	2.5	<0.034	0823-1200	0.26	<0.034
(WD)/-	0826-1211	3.5	<0.029			
(KA)-	1210	0.18	<0.040			
-/(WD)				1203-1520	0.20	<0.037

\*Time-weighted average lead-in-air concentration for the period sampled.

\*\*Time-weighted average antimony-in-air concentration for the period sampled.  
OSHA permissible exposure limit 0.5 mg/m<sup>3</sup>

The general conditions described at this smelter are similar to many other secondary smelters. The employee exposures which result from relatively unsophisticated materials handling procedures and marginally controlled emission sources are high by comparison to the recommended limits for employee exposure. Many secondary smelters in this country found difficulty in complying with the historical  $0.2 \text{ mg/m}^3$  OSHA lead standard. The new OSHA lead standard will require significant changes to be made in all existing facilities to approach compliance. The test smelter, at present, has a severe employee lead exposure problem. Exposures monitored during the initial part of this survey confirm smelter sampling results and indicate that the smelter does operate with workroom lead-in-air concentrations well above, or many times, currently accepted exposure limits. There is no apparent reason to discount the values measured by the company and they are assumed to characterize exposures (without regard to the use of respirators) during the period monitored.

The work area sampling results shown in Table 7 indicate the same trend from the first to second day of sampling. Sampling results of the second day are generally higher than those of the first. Work area concentrations tend to be much lower than breathing zone concentrations and reflect the fact that employees are much closer to the sources of emission within the smelting building than were the stationary area samples.

Area sampling results do indicate that the employee break room or lunchroom is significantly contaminated with airborne lead. This condition offers the distinct possibility for employees to eat food and use smoking and chewing materials which are contaminated by lead. The contamination of the lunchroom area may result from lead from an industrial battery department which may give rise to infiltration of lead contaminated air. A more obvious source of contamination is the traffic of employees dressed in work clothing to and from the lunchroom. Lead particulate lodged on clothing, hardhats, etc., may be dislodged while these materials are removed or during normal movement within the lunchroom.

Table 8 indicates the results of air sampling for sulfuric acid mist which was performed in the battery breaking operation. Exposures were measured at well below the OSHA permissible exposure limit for sulfuric acid mist of  $1.0 \text{ mg/m}^3$ . Observation of work performed in the battery area indicated the very distinct possibility of employee eye and skin contact with battery electrolyte (sulfuric acid).

#### Biological Monitoring Data

The development of biologic monitoring data was outside the scope of this demonstration study. However, the test smelter did supply blood lead monitoring data covering a period of approximately two years directly preceding this study. Tables 9 and 10 contain summaries of these data.

The majority of blood lead concentrations fall in the range of 0.06 to 0.07 mg or 60 to 70  $\mu\text{g}$  of lead per 100 grams of whole blood. This is true

Table 7. Results of work area monitoring for lead and antimony.

	1/23/79			1/24/79		
	Sampling interval	Pb* mg/m <sup>3</sup>	Sb** mg/m <sup>3</sup>	Sampling interval	mg/m <sup>3</sup>	mg/m <sup>3</sup>
Employee breakroom/ lunchroom (refer to Figure 6)	0838-1214 1215-1559	0.15 0.17	<0.034 <0.033	0739-1145	0.11	0.030
Location no. 1 (refer to Figure 1)	0852-1219	0.050	<0.034	0745-1144	0.37	0.031
Location no. 2 (refer to Figure 1)	0854-1222	0.089	<0.036	0755-1142	0.33	0.033
Location no. 3 (refer to Figure 1)	0910-1224	0.18	<0.038	0749-1144	0.25	0.031
Location no. 4 (refer to Figure 1)	0901-1222	0.12	<0.037	0758-1158	0.30	0.030

\*Time-weighted-average lead-in-air concentration for the period sampled.

\*\*Time-weighted-average antimony-in-air concentration for the period sampled.  
OSHA permissible exposure limit 0.5 mg/m<sup>3</sup>

Table 8. Results of breathing zone sampling for sulfuric acid mist.

Job/operation	1/23/79		1/24/79	
	Sampling interval	H <sub>2</sub> SO <sub>4</sub> * mg/m <sup>3</sup>	Sampling interval	H <sub>2</sub> SO <sub>4</sub> * mg/m <sup>3</sup>
Battery breaking				
-/(WD)			0821-1200	0.18
-/(KA)			1203-1520	0.067
(WD)/-	1211-1515	0.10		

\*Time-weighted average sulfuric acid mist-in-air concentration for the period sampled. OSHA permissible exposure limit 1.0 mg/m<sup>3</sup>.

Table 9. Blood lead concentrations -smelter employees.

Sampling date	Number of persons with blood lead concentrations* of:										n	mean*
	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12		
12-04-78		1	5	8	5	1					20	.06
10-30-78			5	7	3	3	1				19	.06
10-02-78		1	3	3	4	1					12	.06
09-05-78				3	9						12	.07
06-31-78				2	6	4	1				13	.07
06-27-78			1	1	3						5	.06
05-30-78			3	6	12	2					23	.07
04-24-78			1		2						3	.06
04-04-78			1	7	10	1					19	.07
02-07-78			4	10	5	5					24	.06
01-03-78				1	2	1					4	.07
12-06-77			4	8	7	1					20	.06
11-07-77			2		2	3					7	.07
10-04-77		1		11	3	2	1				18	.06
09-06-77			1		2	4		1			8	.08
08-01-77			6	6	3	4	2				21	.06
06-29-77				5		1	1				7	.07
05-31-77			2	6	7	7					22	.07
05-03-77				2	2	3					7	.07
03-29-77			4	7	6	2		1			20	.06
02-01-77			4	4	4	3	1	2			18	.07
01-04-77					2		2	1			5	.08
12-07-76	2		2	7	6	3		1		1	22	.07
n	2	3	48	104	105	51	9	6		1		
% of Total	0.6	0.9	14.5	31.6	31.9	15.5	2.7	1.8		0.3		

\*Milligrams lead per 100 grams whole blood

Table 10. Blood lead concentrations - battery breakers.

Sampling date	Number of persons with blood lead concentrations* of:						n	mean*
	.03	.04	.05	.06	.07	.08		
10-30-78		1	1	1	2		5	.06
09-05-78			1	2	1		4	.06
05-30-78		1	1	1	2		5	.06
03-13-78						4	4	.08
02-07-78			1	1	1		3	.06
12-06-77		1			2		3	.06
10-04-77		2			2	1	5	.06
09-06-77					1		1	.07
08-01-77			1				1	.05
06-29-77		1		1			2	.05
05-31-77				2	1		3	.06
12-07-76		1	1	1			3	.05
n		7	6	9	12	5		
% of Total		17.9	15.4	23.1	30.8	12.8		

\*Milligrams lead per 100 grams whole blood.

for both employees working in the smelter building and in the battery breaking area. A significant number of measured blood lead concentrations have indicated even more serious lead absorption.

The elevated blood lead concentrations measured by the company indicate that existing employee exposures to lead are significant despite use of respiratory protection devices. There are many possible sources of insufficiently controlled lead exposure. The contaminated lunchroom facility and improper use of respirators by employees are perhaps the major sources of exposure. Improved hygiene facilities and practices would be expected to help reduce continued excessive contact with lead.

#### CONTROL CRITIQUE AND RECOMMENDATIONS

##### Planned Improvements

The test smelter management has recognized the serious lead exposure problem associated with the secondary lead smelting complex. The company is in the process of making major modifications to its smelting complex to better control emissions to the ambient environment and workplace exposure of employees. An important element in this modernization program is in the Bergsoe flash agglomeration furnace. The furnace will work in concert with a new baghouse facility. The new baghouse system is of much greater capacity than the system which has served the smelter historically. The new baghouse exhaust ventilation system will provide the capability to exhaust between 68,000 and 93,500 m<sup>3</sup>/hr of air from the smelter building. This exhausted air volume will be gathered from strategically located exhaust ventilation hoods which will serve major sources of emission associated with the smelting facility. The following list of major emission sources will be served by the new ventilation system:

1. The charging location at the top of the blast furnace.
2. The skip hoist charging elevator.
3. The lead tapping and pouring station.
4. The refining kettles.
5. Flue dust tote box dumping station associated with the agglomeration furnace feed.

The existing slag-tapping exhaust ventilation system will not be modified since it is quite effective in capturing emissions. It will still be serviced by a separate 8640m<sup>3</sup>/hr (5000 acfm) baghouse.

The final hood designs for local exhaust ventilation of these emission sources are in the development stage at present. The first step in implementing the new exhaust ventilation control program will be to attach existing exhaust ventilation hood structures to the new system. The next stage in implementation of the total control program will be to complete the installation of the flash agglomeration furnace. Once the flash agglomeration furnace is operating in concert with the dust collecting system, attention will be given to the final design of local exhaust ventilation hoods for refining kettles, etc. Completion of this control program will consume several months. The data collected in this "before" study describe

employee exposures and engineering controls at a point in time when the plant was being serviced by its historical exhaust ventilation system and local exhaust hoods located within the smelting facility.

Minimizing employee exposure and fugitive emissions will require more than simply increasing the amount of air exhausted from the smelting building and installing better local exhaust hoods. The smelter has plans to improve paving of outside yard surfaces; to enclose portions of the smelting building (cutting down cross drafts which would interfere with contaminant capture); and to make materials handling modifications which should help to control escape of contaminants into the work environment.

#### Recommended Control Considerations

Following the field work associated with this "before" study, a list of recommendations was developed to assist the test smelter in controlling the lead exposure problem. These recommendations were made within the framework of retrofitting controls to existing process equipment. This constraint ruled out some more radical changes that could be incorporated in a new plant construction. Examples of changes which cannot be accomplished at the existing smelter are:

Complete removal of existing smelter building floors and replacement with elaborate washdown and water collection sumps and drains.

Complete separation of all raw materials handling from the furnace operating and refining areas of the smelter.

The recommendations which have been forwarded to the test smelter are described below. They are organized by smelting operation and other industrial hygiene control considerations. During the interim while engineering controls are being designed and installed, it is imperative that employees be afforded maximum protection from exposure through use of respiratory protective devices and rigorous personal hygiene. Several recommendations are included which pertain to respiratory protection, hygiene facilities and practices and employee training.

#### Battery Breaking--

A suitable eye fountain and emergency shower station should be provided in close proximity to the battery shearing work station.

Lead mud deposits should be cleaned from all surfaces in the battery breaking area (walls, roller conveyor, shear, floor, etc).

Plexiglas or other transparent barriers or enclosures should be installed at the shear to prevent splashing of battery acid and mud onto employees.

A means of periodically washing mud and acid from the transparent barrier or enclosure should be provided.

A means of periodically washing down the battery breaking work area to remove accumulations of caked-on mud, etc., should be provided.

Depending on the reduction in employee exposures afforded by the above recommendations, an exhaust ventilation system should be designed and installed to serve the battery shears.

Employees should be instructed to clean accumulations of battery mud from their protective aprons at periodic intervals. Water and a sponge should remove most of this material and prevent it from becoming dry and entering the air in the breathing zone of the worker.

#### Skip Hoist Charging and Materials Handling--

Improved materials handling should be instituted in association with skip hoist charging.

- a. Raw materials stored (piled) in the charging area should be kept damp. Sprinklers or hoses with spray nozzles could be utilized.
- b. Deliveries of plant scrap such as reject battery plates, etc. should be brought to the smelter in covered tote boxes or other covered containers. Before dumping into a storage pile, dry materials should be thoroughly wetted.
- c. The floor area near the skip hoist should be kept as clean as possible and wetted to help limit dust generation.
- d. Cross drafts through the furnace charging area should be minimized by closing sliding doors.
- e. Sweeping and shoveling of dry lead bearing materials should be prohibited. Shoveling of wetted materials or vacuuming of dry materials is preferred.
- f. Charging of flue dust should cease once the agglomerator is operational. Until agglomerated material is available, any dry flue dust should be wetted before handling and should be stored wet in an area protected from cross drafts.

Improved local exhaust ventilation should be provided at the skip hoist loading station.

- a. Initially the new exhaust system should be attached to the existing exhaust ducts serving the loading station.
- b. Extensions from the side of the loading station should be considered to create better dust control in front of the loading station.
- c. Tapered entries to exhaust ductwork should be considered for the exhaust pickups on each side of the loading station enclosure.

The materials storage area should be kept as clean as possible. Splashes of mud should be cleaned from surfaces to prevent drying and entrainment into the air.

Mechanized materials handling equipment (Bobcat) should not be allowed to **track** mud into other smelter areas.

#### Tuyere Punching--

A hood should be considered for above all tuyeres to control emissions when tuyere covers are removed.

#### Blast Furnace Charging--

Improved local exhaust ventilation of the blast furnace charging port should be provided.

- a. Initially the new ventilation system should be attached to the charging hoods provided at the top of the furnace.
- b. Capture characteristics at the charging hood should be evaluated to determine whether improved enclosure or otherwise altered hood designs are necessary.

#### Slag Tapping--

The slag tapping hood should be repaired to correct damaged ductwork.

Better enclosure of the taphole and receiving vessel should be provided.

- a. The hood front and side pieces should be made to fit together better reducing gaps where sparks, etc., may escape.
- b. The hood sides and front should fit more tightly around the slag receiving vessel to better contain sparks, splashes, etc. which drop to the floor at the base of the receiving vessel.
- c. A means of clearing the slag taphole with the front portion of the slag tapping hood in its lowered position should be investigated. Possibly a small opening in the hood front would allow sufficient access.

Sweeping and shoveling of dry particulate materials resulting from slag tapping should be discontinued. Fugitive settled particulate should be wetted before being cleaned up. Alternatively, it could be picked up using vacuum methods.

The slag tapping work area should be protected from strong wind currents. Doors leading to the yard area should be closed during windy conditions.

The filled slag receiving vessel should remain under the slag tapping hood until it has cooled sufficiently to prevent fuming.

#### Crude Metal Tapping from Blast Furnace--

Initially the new exhaust ventilation system should be hooked up to the existing local exhaust hoods provided for the lead well, launder and molding line.

Improved local exhaust ventilation enclosures should be designed and installed for the crude metal tapping/pouring operation.

- a. A stationary hood could be constructed which would enclose the lead well, launder and molding line. This hood could be provided with access panels for inspection and service. The launder could remain stationary with the ingot molds passed in front of the pouring station by means of a rolling molding car at the pouring station. The hood over the pouring station should accommodate the mold being poured and the one cooling after pouring.
- b. A movable hood similar in some respects to the existing three-hood system could be constructed. This movable hood should be of one or two piece construction. The hood system should be self supporting (supported on pivots, etc.). The hood(s) should enclose the lead well, launder, the mold being poured and the mold in the cooling position.
- c. A combination of fixed and movable hoods could be applied. Any movable hood should be self supporting. The hood system should enclose the mold being poured and the one in the cooling position. Transitions between hoods should overlap with no gaps in local exhaust coverage.

Sweeping and shoveling of dry particulate materials resulting from metal tapping and pouring should be discontinued. Settled fugitive particulate should be wetted before being cleaned up, or vacuumed.

#### Kettle Refining--

Local exhaust ventilation hoods should be designed and installed for the refining kettles.

- a. Sufficient enclosure should be provided to capture heated air from kettle firing and fume from the surface of the molten lead in the kettle.
- b. The local exhaust hood should be designed to permit charging of the kettle with large crude lead ingots.
- c. The local exhaust hood should be designed to permit insertion of a mechanical stirring apparatus used during drossing. Sufficient enclosure during drossing and stirring should be provided to control fume and particulate emanating from the molten lead.

- d. The local exhaust hood should accommodate the pigging operation. Swing-away doors could provide reasonable access for the molten lead pumping device.

Depending on the final design of refining kettle hoods, varying configurations of additional local exhaust ventilation for the skimming operation will be necessary.

- a. Fume from kettle skimmings ("pies") should be controlled near the source.
- b. The present practice of building pies on a pallet should be reviewed to determine whether a more compact method of handling skimmings can be devised.
- c. The auxiliary local exhaust ventilation for skimming should take advantage of the enclosure (swing away doors, etc.) of the kettle refining hoods. It may be possible to control skimming emissions by attaching local exhaust ductwork to the swing-away portion of the hood, thus eliminating the need for extra equipment.
- d. Any additional local exhaust ventilation for skimming operations should be easily operated by employees. Complicated ductwork, hoisting, and moving systems should be avoided.

Removing skimmings from the kettle could be accomplished by a long handled implement supported at a pivot point at the center of the handle. The increased length of handle would give more mechanical advantage to the skimming operator than using a flat point shovel. Also the skimming operator would no longer have to reach out over the molten lead, thereby decreasing his potential exposure to fume.

Sweeping and shoveling of dry particulate materials resulting from kettle refining and skimming operations should be discontinued. Settled fugitive particulate should be wetted before being cleaned up or vacuumed. Splashes of molten lead and skimmings will require manual removal from surfaces and placement into scrap containers.

During windy weather, doors should be closed to help minimize cross drafts within the smelting building. These cross drafts can entrain contaminants which would otherwise be captured by kettle and skimming hood enclosures.

#### Pigging--

Exhaust enclosure for the pigging machine should be designed and installed on the machine.

- a. Of primary importance is the portion of the pigging machine where the reservoir of molten lead and pouring of lead into the ingot molds occurs.

- b. An enclosure of the "hot" end of the pigging machine could be made with hinged side access doors. The hood could be supported by metal extensions from the machine framework.
- c. The hood could be made a permanent part of the traveling pigging machine. Drops of flexible ductwork from the overhead local exhaust ductwork could be attached to the hood when the machine was positioned beside either refining kettle.

During windy weather, cross drafts past the pigging machine should be minimized by closing the large sliding doors. This will help to minimize entrainment of contaminants from under the pigging machine exhaust hood.

#### Housekeeping--

A smelter-wide cleanup should be undertaken. Lead dust and mud should be removed from yard surfaces, building surfaces, equipment, etc. Settled particulate which has accumulated on building structural members should be removed.

Dry sweeping and shoveling should be discontinued. Shoveling of wet materials or vacuum methods are preferred.

#### Hygiene Facilities and Practices--

Smoking and food and beverage consumption should be strictly prohibited in the smelter building and yard area. Smoking and chewing materials should not be carried by employees into the smelter building and yard area.

Use of the existing smelter lunchroom facility should be discontinued. Smelter employees should be required to use the main plant lunchroom or outside food establishments.

Smelter employees should not enter lunchroom facilities with protective work clothing or equipment unless surface lead dust has been removed. Alternatively, smelter employees could be provided with overalls which can be worn over their work clothing and removed before entering lunchrooms, breakrooms, or food establishments. Clean smocks could be provided to put on over work shirts and trousers.

A shoe/boot cleaning station should be provided at the entrance to the locker room and to areas where food and beverages are consumed.

Smelter employees should be required to thoroughly wash their hands, forearms, face and neck before consuming food or drink. As a minimum, hands and face should be washed before smoking or chewing materials are utilized.

Smelter employees should be provided with clean work clothing each day.

The employee locker room should be frequently cleaned and mopped on all shifts of the working day.

Smelter employees should shower and change into street clothing at the conclusion of the workshift. Work clothing should not be taken home. It should be deposited in closed containers.

#### Employee Training and Information--

Employees should be informed in organized training sessions of the following:

- a. OSHA requirements as set forth in 29 CFR 1910.1025.
- b. The hazards associated with exposure to lead and how they can be controlled.
- c. The purpose, proper selection, fitting, use and limitations of respirators.
- d. The purpose and description of the medical surveillance program.
- e. The engineering controls and work practices associated with controlling employee exposure to lead associated with a particular job.
- f. The contents of existing compliance plans.
- g. The dangers of chelating agents.

Privately each employee should be told what his measured lead-in-air exposure is (without regard to use of respiratory protection) and what the results of his blood lead monitoring are. These results should be explained in terms of compliance with OSHA standards and related to potential adverse health effects.

#### Respiratory Protection Program--

Plant management should review OSHA's respiratory protection requirements (29 CFR 1910.134 and 29 CFR 1910.1025). Appropriate updating and improvement of the existing program should be instituted.

Specifically, attention should be placed on the following items:

- a. A respiratory protection training session should be presented to employees. The intent of the session should be to refresh workers' knowledge with regard to the fitting, use, care and limitations of the respirators they are required to wear.
- b. A determination should be made whether all smelter employees can obtain a proper face fit from the respirators in use. It may be necessary to obtain respirators of another manufacturer to accommodate all variations in facial size and shape. All respirators utilized should carry appropriate NIOSH approvals.

- c. A determination should be made whether all employees who are required to wear respirators can perform their normal duties wearing the respirator. Employees who cannot effectively breathe through the respirator during normal work activity should be identified. The plant physician can assist in this determination. A different form of respiratory protection, e.g., powered air-purifying respirator, may be supplied or the employee could be transferred to an area where respirators are not required.
- d. Special emphasis should be given to impressing the employees that respirators must be worn at all times while working in the smelting building and yard area.
- e. Employees should be instructed to prevent contamination of the respirator when it is removed at breaks or during lunch. Paper towels or soft clean cloths should be provided to wipe off the respirator facepiece before it is reused after a break.

Medical Monitoring--

The existing blood lead monitoring program should be continued.

The OSHA medical monitoring requirements of 29 CFR 1910.1025 should be implemented.

Recordkeeping--

The OSHA recordkeeping requirements of 29 CFR 1910.1025 should be implemented.

QUESTIONS, ANSWERS AND COMMENTARY

Question (J. Goulias, Goulias Associates):

Are your paper and reports available now or can you let me know when they will be available?

Answer (A. Craig):

The report that was done on the Danish facility should be out, I would expect, within a month or a month and a half, which talks about the engineering and additive controls. The paper and discussion here will be in the symposium proceedings.

Question (J. Goulias):

Was all of the sampling outside the premises hi-vol sampling?

Answer (A. Craig):

Yes.

Question (J. Goulias):

Was anything analyzed from the filters besides total lead? Was there any compound identification or particle size characterization?

Answer (R. Coleman):

We had some analysis done for chlorine, antimony and sulphur.

Answer (A. Craig):

When we go back and retest this facility after installation of controls, we'll be using particle sizing to get some information on the percent of this material is in the respirable range.

Question (J. Goulias):

It's my understanding at this point that neither NIOSH nor EPA have sponsored any work that involves a fundamental change in any pyrometallurgical processing technology. Is that correct?

Answer (A. Craig):

No, we have not. We've focused on add-on technology. The Bureau of Mines has done some work on hydrometallurgy, but this is in the pilot plant stage.



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