IN-DEPTH SURVEY REPORT

OF

AMAX LEAD COMPANY OF MISSOURI
Buick, Missouri

Survey Conducted By:
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Report Written by:
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Division of Physical Sciences and Engineering
Engineering Control Technology Branch
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PURPOSE OF SURVEY:	To evaluate engineering control technology used in a lead ore benefication operation.

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STANDARD INDUSTRIAL CLASSIFICATION:

CODE: 1031

ABSTRACT

An indepth control technology survey of the lead ore beneficiation flotation process and reagent handling area was conducted at the Amax Buick mill in Buick, Missouri. The flotation process beneficiates over 7,500 tons per day of a complex sulfide ore containing an average of nine per cent lead. The lead flotation circuit, using a variety of reagent additions, selectively floats the galena mineral from other minerals to obtain a desired lead concentrate grade and lead recovery. The average lead concentrate grade is 75 per cent with a normal lead recovery of 96 per cent. The rougher, scavenger, cleaner, and recleaner flotation cells and reagent area were studied. The primary airborne hazards were lead, cyanide, and carbon disulfide (xanthate decomposition product).

The indepth study consisted of the assessment of widened rougher flotation cell launders, covered recleaner flotation cell launders, the use of a "water spike" in the reagent handling area, and the use of a centralized flotation process control room. Environmental concentration results indicated the widened launders were ineffective, the covered launders were moderately effective, and the "water spike" and centralized control room were effective in controlling airborne concentrations of the primary hazards.

INTRODUCTION

The Engineering Control Technology Branch of the Division of Physical Sciences and Engineering, NIOSH, is conducting a research study to assess and document control methods for minimizing worker exposure to harmful substances, operations, and processes in the beneficiation of galena and cerussite (lead) ore industry. Exposure to a number of substances used in the beneficiation of lead ore may lead to a variety of health problems. These substances include lead and flotation reagents (cyanide, xanthate, nuisance dusts).

The lead flotation process in this lead ore beneficiation facility was surveyed to evaluate the effectiveness of the following health controls:

1. Rougher flotation cell launders widened from approximately 9 inches to 17 inches to minimize froth (bubbles) striking the launder sides on overflowing and thus reducing the quantity of mist generated (Figure 3).

2. Recleaner flotation cell launder covers to minimize quantity of mist escaping into the general work area atmosphere (Figure 4).

3. The use of a "water spike" in the reagent handling area to empty drums of cyanide and xanthate (Figure 5, 6, 7).

4. The use of an isolated, enclosed, air-conditioned flotation cell control room where the operators can control the process away from the general work area atmosphere (Figure 1).

The Amax Lead Company's Buick Mine/Mill was discovered in 1960 and started production in 1969. The operation processes over 7,500 tons per day of a complex sulfide ore containing an average of nine per cent lead. The lead flotation process includes four banks of flotation cells with each bank consisting of twelve cells. The first eight cells in each bank are rougher cells and the last four in each bank are scavenger cells. The first stage of lead cleaning consists of three flotation cells and the second or recleaner stage consists of two banks with each bank consisting of six cells. The floor plan of the flotation process, reagent area, and related equipment and facilities is shown in Figure 1. The mill operates seven days per week, 24 hours per day, with the exception of one shift per week used for maintenance of facilities and equipment. Of the total 450 employees at the Buick Operation, 50 are employed in the mill, and the remainder in the mine, office, and maintenance operations.

PROCESS DESCRIPTION

Following underground primary crushing the ore is hoisted to the surface where it is processed through a series of grinding and classification operations consisting of a rod mill, ball mill, and cyclone classifiers operating in closed circuit. Overflow from the cyclone classifiers flows by gravity to lead flotation. The above-ground process is shown in Figure 2.

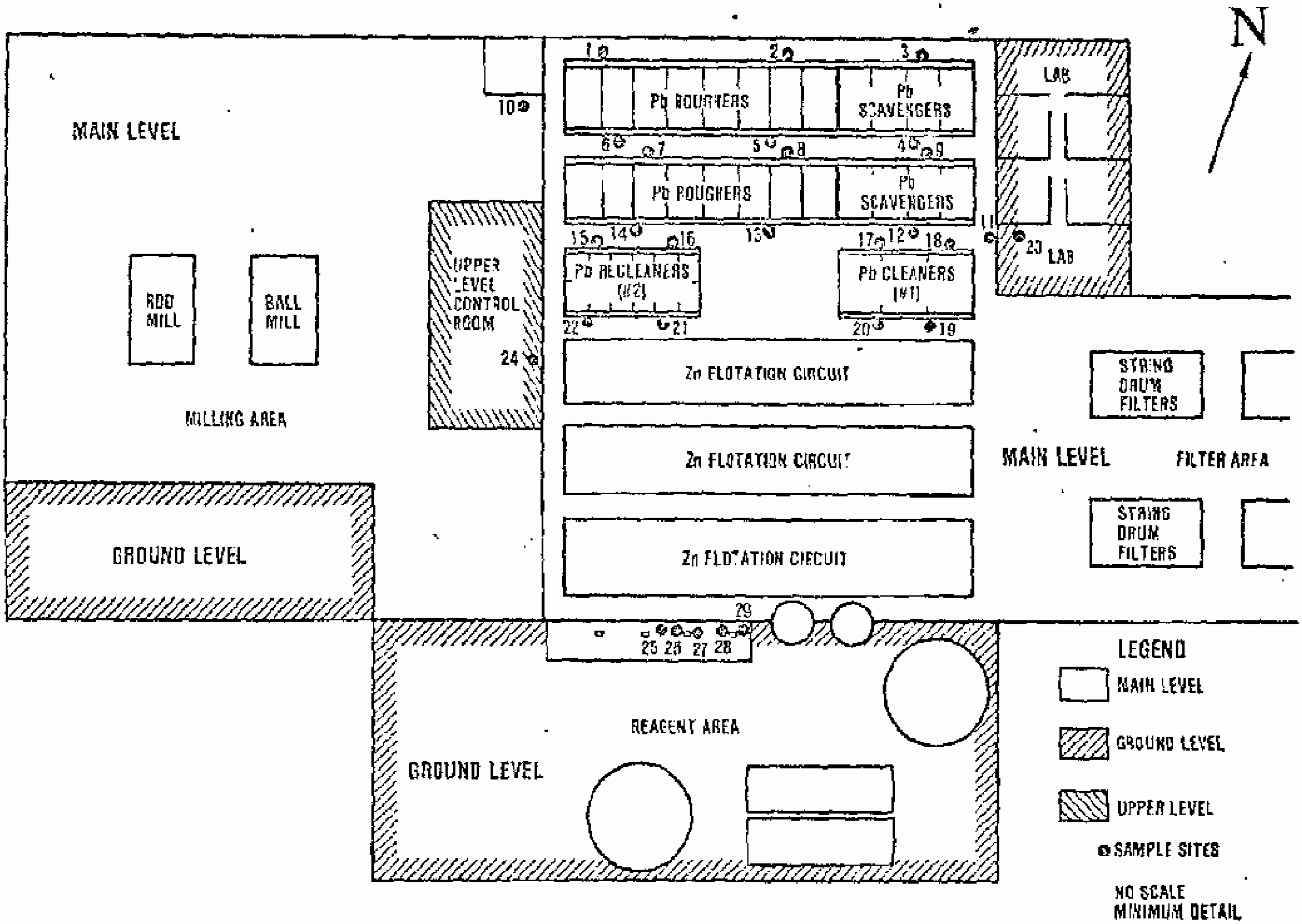


Figure 1 - Floor Plan of the Beneficiation Operations

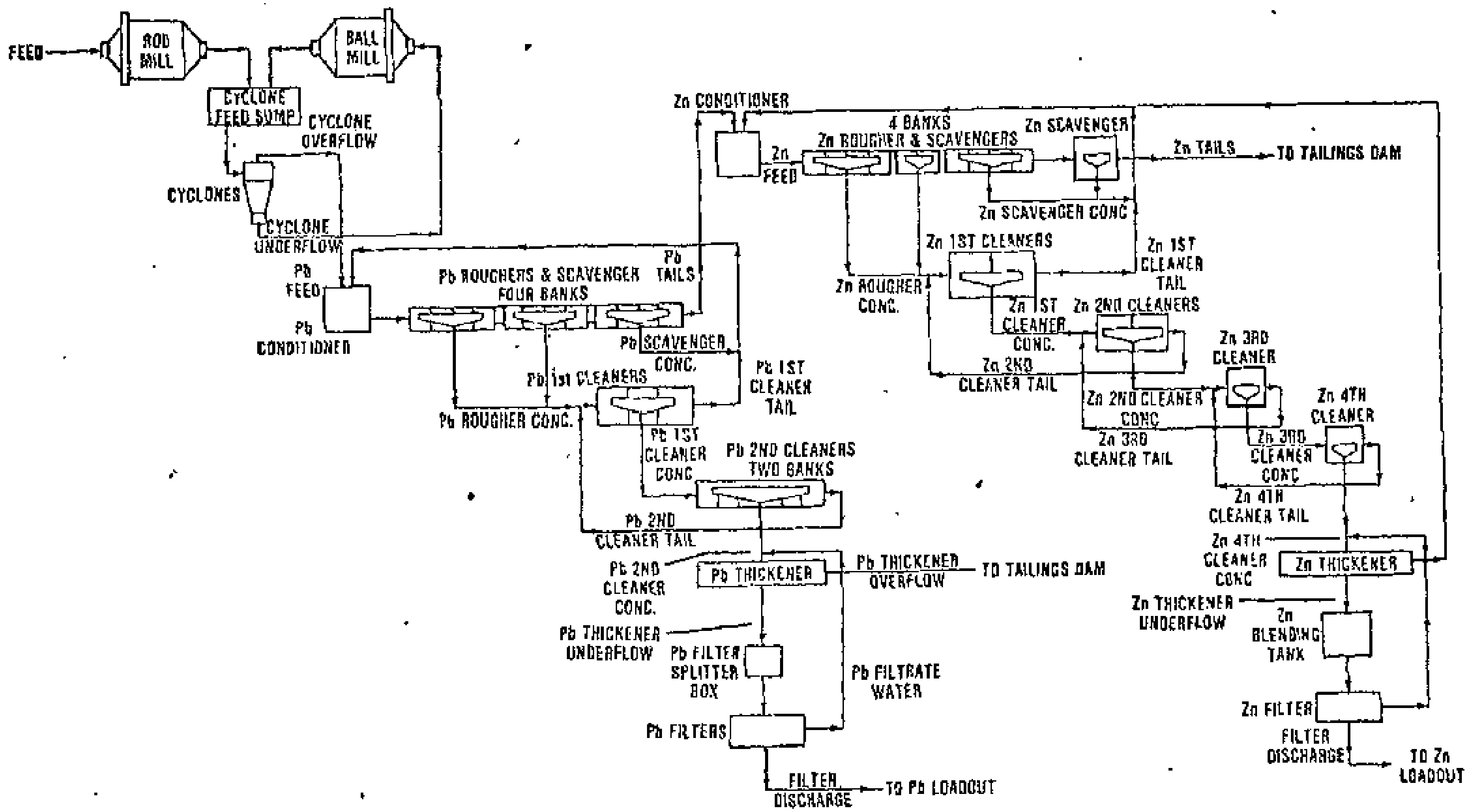


Figure 2 - Ore Beneficiation Process Flow

Rougher, scavenger, and cleaner flotation machines, combined with related pumps and blowers, are the basic components in the lead flotation process. Cyclone overflow from the grinding circuit flows to a 10 x 10 ft. conditioner where the lead-zinc slurry is further diluted and conditioned with reagents prior to flotation. The conditioner tank overflow is distributed to four banks of Denver and Galigher flotation cells with each bank consisting of 12 cells. Total lead rougher and scavenger flotation capacity is 4,800 ft^3. Rougher froth from the first eight cells in each bank is pumped to the first stage of lead cleaning by a 8 x 6 inch Denver SRL pump. These rougher cells are equipped with launders widened from approximately 9 to 17 inches to minimize froth (bubbles) striking the launder sides on overflowing and thus reducing the quantity of mist generated (Figure 3). Scavenger froth from the last four flotation cells in each bank is returned to the lead flotation feed by a 4-inch Galigher pump. Tailings from the lead scavenger flotation are pumped by a 12 x 10 inch Denver SRL pump to the zinc circuit feed.

Three Denver 300 ft^3 flotation machines make up the first stage of lead cleaning which receives lead rougher flotation froth as feed. Concentrate from the lead first cleaners is pumped by a 8 x 6 inch Denver SRL pump to the second stage of lead cleaning. Tailings from the first stage of lead cleaning are returned to the lead flotation feed jointly with the lead scavenger concentrate.

Utilizing 600 ft^3 of capacity, the second and final stage of lead cleaning produces a final lead concentrate for thickening and a tailing which returns to the lead first cleaner feed. Two banks of Denver 50 ft^3 flotation machines, each bank consisting of six cells, are the constituents of the second stage lead cleaners. Those second stage or recleaner cells are equipped with launder covers to minimize the quantity of mist escaping into the general work area atmosphere (Figure 4). Final lead concentrate is delivered to the lead thickening and filtering section by a 8 x 6 inch Denver SRL pump.

Low pressure air for the lead rougher, scavenger, and cleaner flotation machines is supplied by two Spencer compressors.

The objective of the lead flotation circuit is to selectively float the galena mineral from sphalerite, pyrite, and gangue minerals to obtain a desired lead concentrate grade and lead recovery. The average lead concentrate grade is 75% with a normal lead recovery of 96%.

Prior to lead rougher and scavenger flotation, the lead-zinc slurry is diluted in the lead conditioner to 40% solids.

Xanthate, for galena collection, and zinc sulfate, for depression of sphalerite, are the primary reagents utilized in lead flotation. Addition point for both collector and depressant is the ball mill.

Xanthate adjustments are made as the lead metal in the mill feed varies. Normal addition ratio is .023 lb. per ton of lead metal feed yielding an overall lead recovery of 96%.

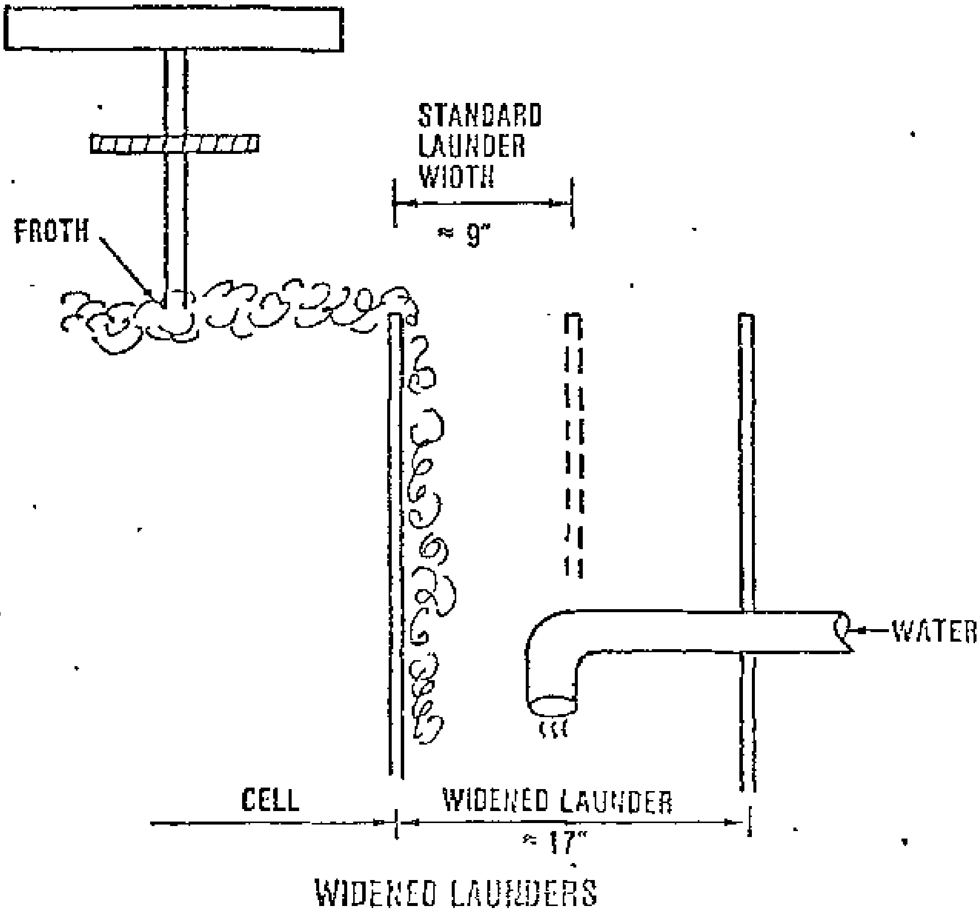


Figure 3 - Rougher Cell Widened Launders

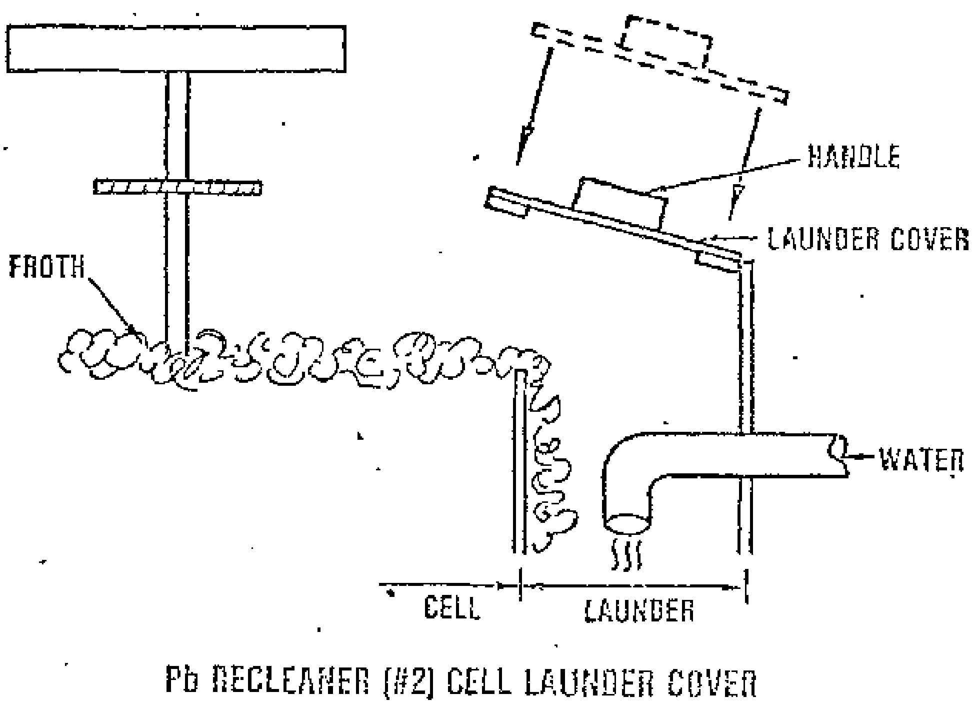


Figure 4 - Recleaner Cell Launder Cover

Zinc sulfate addition to the lead circuit is reasonably steady at .30 lb. per ton of ore feed. Excess zinc in the lead concentrate occasionally requires a slight increase in the zinc sulfate lb. per ton ratio, although an excess of the reagent can result in a reduced lead recovery.

MIBC (methyl isobutyl carbinol), the frother used, is added to the lead conditioner and is also distributed to the lead scavenger feed. Addition rates are constant and varied only if major tonnage changes occur.

Pyrite depression in lead flotation is obtained by the addition of sodium cyanide to the feed of the first stage of lead cleaning. Normal addition rate is .01 lb. per ton of ore feed and is dependent upon the iron assay in the mill feed.

The lead flotation process reagents are prepared in the reagent area where a "water spike" is used in the emptying of xanthate and cyanide drums (Figures 5, 6, 7).

Of considerable importance in lead flotation is air addition to the flotation cells. To maintain a desired lead recovery, varying lead grades in the mill feed requires adjustment of lead rougher and scavenger air flow to float more or less concentrate.

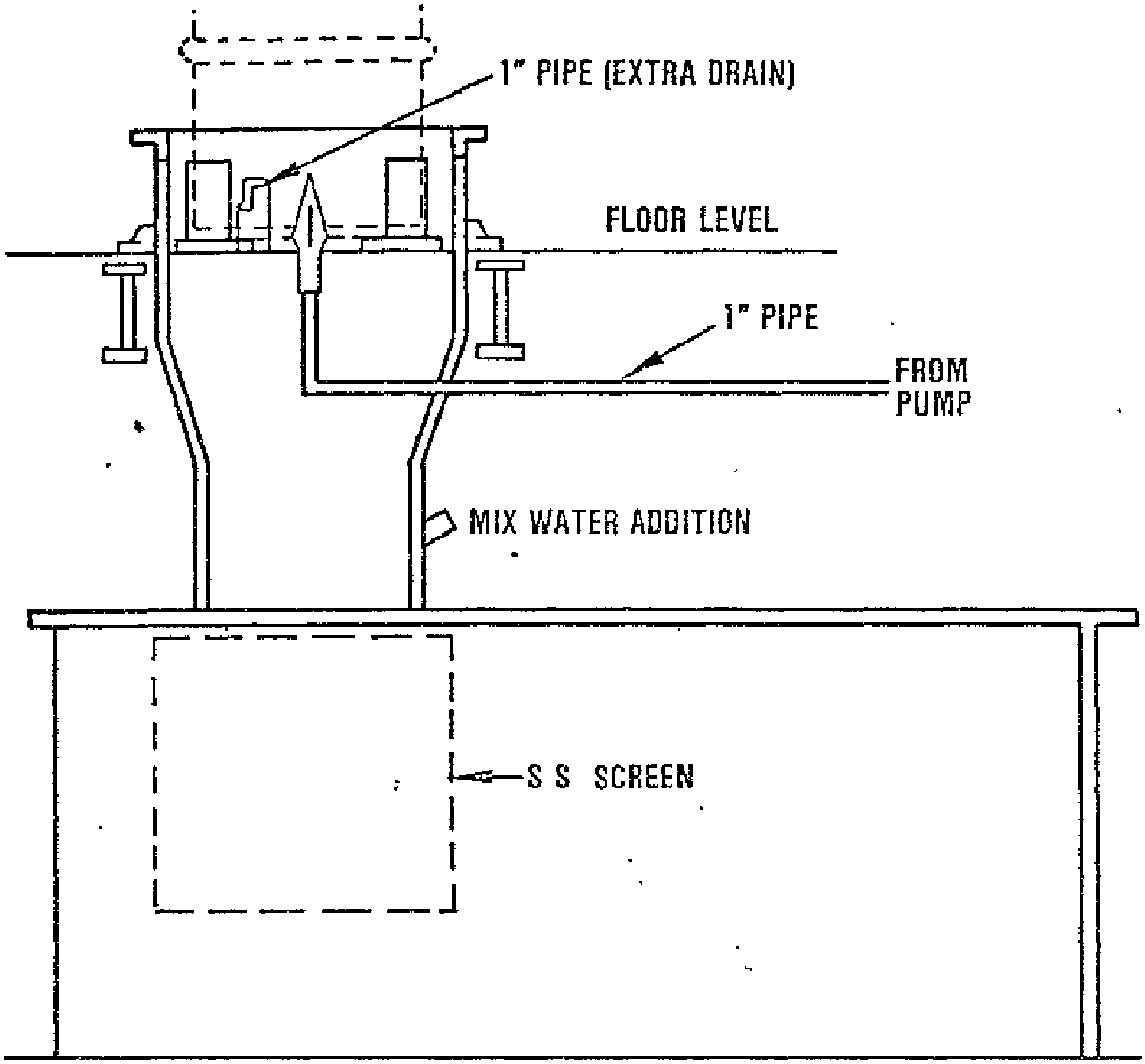
The air valve settings on the lead first cleaners are manipulated to maintain a reasonable lead grade in the lead first cleaner tailing. The desired grade is approximately equal to the lead grade in the mill feed. This insures controllable circulating loads and stable feed to the second stage of lead cleaning.

Air flow to the second stage of lead cleaning is varied to maintain an acceptable final lead concentrate grade. If an acceptable grade cannot be obtained with air adjustments, then a change in xanthate addition is justified.

In essence, to obtain the desired metallurgical performance in lead flotation, the simplified control strategy is to feedforward with reagents based on mill feed variables, and to feedback or trim with air flow adjustments based on circuit performance.

All control operations for the grinding and flotation circuits are performed from a centralized control room located on the upper level between the grinding and flotation sections (Figure 1). Located in the central control room are all analog controls, recorders, and indicators for control of both grinding and flotation circuits. An annunciator system, mill bearing protection systems, and motor controls are also included in the centralized operations.

The lead and zinc flotation circuits are operated by controlling lead and zinc concentrate grades and recoveries through adjustment of reagents, by maintaining a desired flotation feed density, by controlling flotation pulp levels, and by flotation cell air adjustments.



1. FORCE BARREL ON SPIKE
2. START CIRCULATING PUMP
3. START DILUTION WATER
4. OPERATE CIRCULATING PUMP

NOTE: ADEQUATE ROOM IS NEEDED AROUND SPIKE SO MATERIAL CAN DISCHARGE FROM THE BARREL.

LEAVE EMPTY BARREL ON SPIKE FOR SAFETY WHEN DISSOLVER IS NOT IN USE.

Figure 5 - Xanthate and Cyanide "Water Spike" Assembly

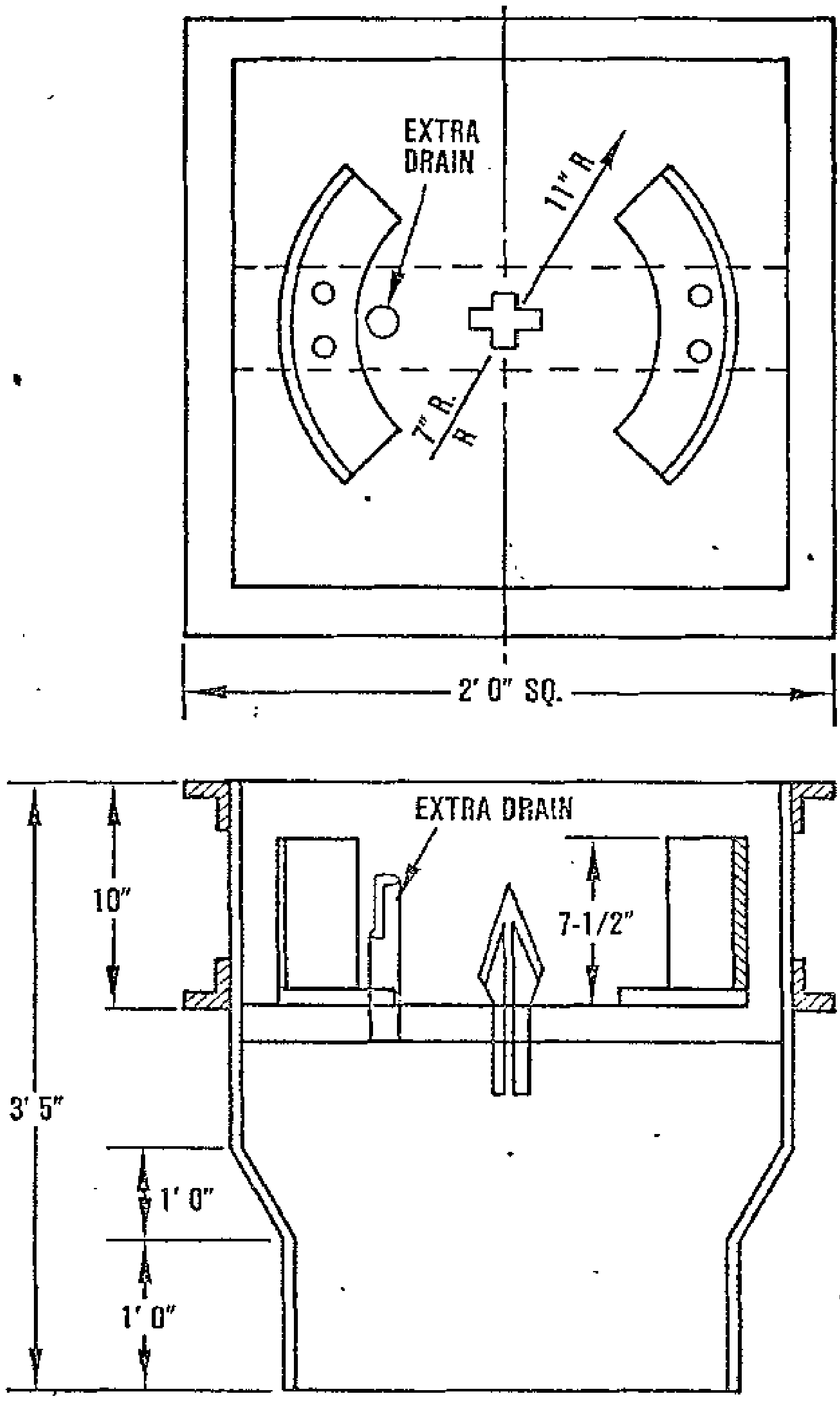


Figure 6 - "Water Spike" in Drum Basket

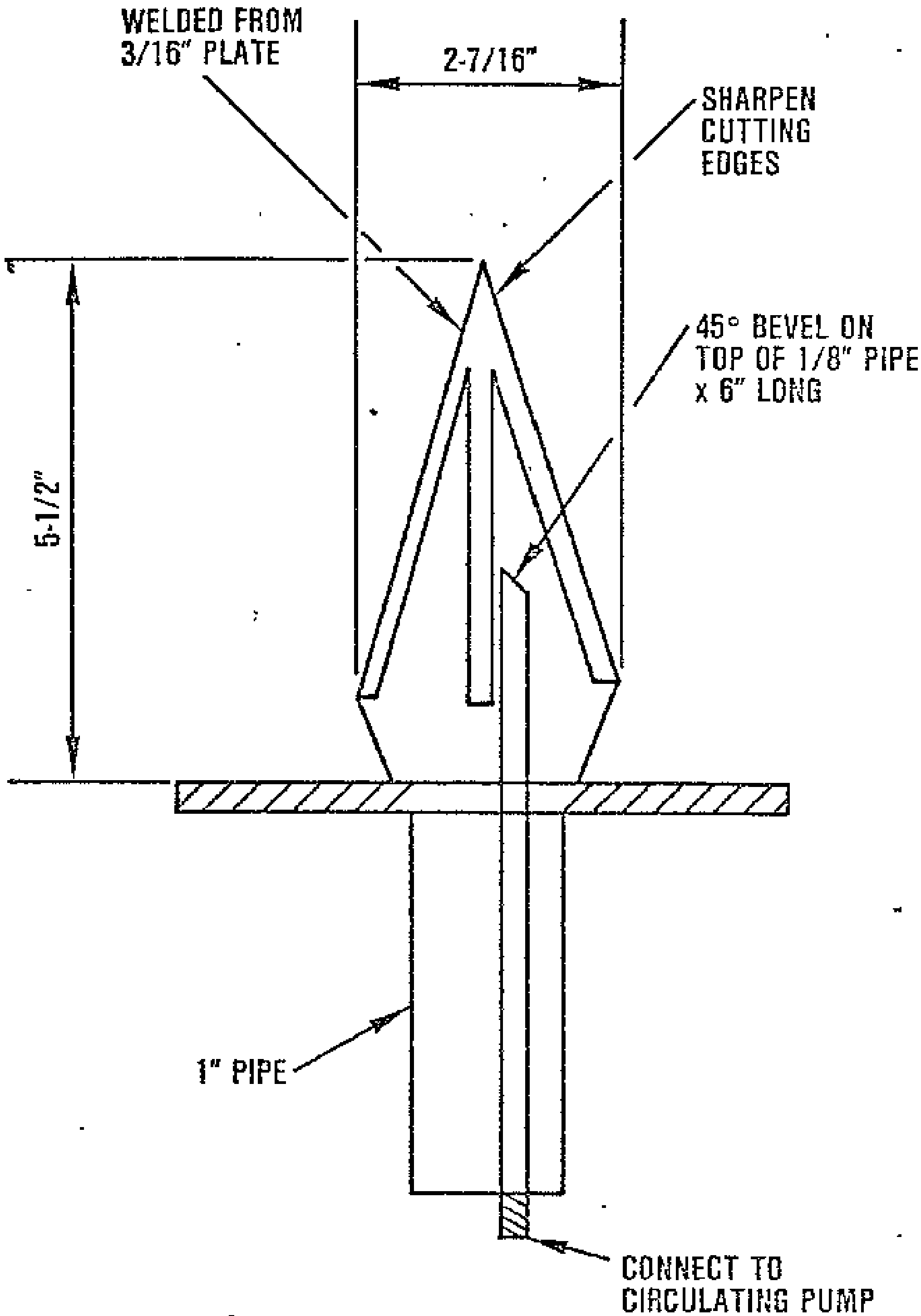


Figure 7 - "Water Spike" Detail

Following selective flotation, lead and zinc concentrates are each thickened in separate 60 ft. diameter Eimco thickeners. For each slurry, Galigher vacseal pumps deliver thickener underflows to the dewatering section. In the dewatering section, two 10 x 20 ft. Ametek string discharge drum filters are employed to filter the lead concentrate to a moisture of 8%. Both lead and zinc filters are connected to Nash vacuum pumps for dewatering.

Filtered lead and zinc concentrates are collected separately and conveyed to a concentrate storage area where they are shipped by rail or truck to various smelters or seaports.

HAZARD ANALYSIS

The primary hazards from the lead flotation process are lead and mill reagents (xanthates, cyanide, and nuisance dusts, e.g., lime and starch). These substances may be present in the air due to the generation of mist and particulates from the flotation cells and reagent mixing operation. Workers also come in contact with the substances when handling reagent containers and performing maintenance and monitoring responsibilities associated with the flotation process.

The following information is excerpted from the NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards and the NIOSH Mining Information Bulletin on Mill Reagents. There is no attempt here to present all known data but merely some pertinent information in summary form. If more information is desired, the reader should refer to the specific health guideline and bulletin referenced.

LEAD

Although lead may occur in such forms as lead oxide, lead sulfide, and lead carbonate, this study is primarily concerned with the total lead exposure. The 1980 American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV) and MSHA standard for inorganic lead fumes and dust exposure is 0.15 mg/m^3, Time-Weighted Average (TWA), or 0.45 mg/m^3, Short Term Exposure Limit (STEL). The NIOSH recommended standard is 0.10 mg/m^3 TWA. Lead enters the body primarily by inhalation of lead dust, fume, or mist. Another important route of entry is by ingestion through hand-to-mouth contact. Three types of intoxication as a result of exposure to lead or its compounds are alimentary, neuromuscular, and encephalic.

Alimentary is the most common type. Symptoms include abdominal discomfort or pain, or colic in severe cases. Other complaints include constipation and/or diarrhea, loss of appetite, metallic taste, nausea and vomiting, lassitude, insomnia, weakness, joint and muscle pains, irritability, headache, and dizziness. Signs include pallor, lead line on the gums, pyorrhea, loss of weight, abdominal tenderness, basophilic stippling, anemia, slight albuminuria, increased urinary excretion, and an increase in whole blood lead content. Weakness, especially of wrist and hand extensor muscles, is the chief indication of the neuromuscular type. These are often termed "wrist drop" or "foot drop" when progressing to a palsy. Other symptoms of the alimentary type are generally present, and joint and muscle pains are more severe. Headache, dizziness, and insomnia are additional symptoms. Paralysis rarely occurs. Encephalic is the most severe but rarest type of lead intoxication. It is the result of rapid and heavy lead uptake. Inhalation followed by selective concentration in the central nervous system causes this type. Symptoms include abrupt stupor, headache, dizziness, and insomnia. Coma after the initial stupor often terminates in death, with or without convulsions. Signs include possible excitation, confusion, mania, or somnolence. Cerebrospinal pressure may increase.

XANTHATES (Carbon Disulfide)

At present there is no MSHA standard regulating occupational exposure to xanthate compounds. An exposure limit does exist for carbon disulfide, which is a xanthate decomposition product and a chemical used in xanthate production, of 60 mg/m^3 which is equal to 20 ppm. This standard has a skin notation. NIOSH has recommended that the permissible exposure limit be reduced to 3 mg/m^3 or 1 ppm averaged over a workshift of up to 10 hours per day, 40 hours per week, with a ceiling of 10 ppm averaged over a 15-minute period. This recommendation was developed by applying a safety factor to the lowest level of exposure shown to cause cardiovascular disorders (31 mg/m^3). A safety factor was used because coronary heart disease frequently results in sudden death. Carbon disulfide has been classified as a central nervous system depressant, neurotoxin, hepatoxin, nephrotoxin, and primary irritant of the skin. Massive, short-term exposure to concentrations of about 10,000 mg/m^3 can cause hyperacute poisoning characterized by rapid falling into coma, and eventually death. Acute and subacute poisoning is associated with short-term exposure to concentrations of 3,000 - 5,000 mg/m^3 accompanied by predominantly psychiatric and neurological symptoms such as extreme irritability, uncontrolled anger, rapid mood changes, euphoria, hallucinations, paranoic and suicidal tendencies, and manic delirium. Exposure can effect the central and peripheral nervous systems and result in damage to the cranial nerves and development of peripheral neuropathy with parethesis and muscle weakness in the extremities, unsteady gait, and dysphagia. In extreme cases of intoxication, a Parkinson-like syndrome may result, characterized by speech disturbances, muscle spasticity, tremor, memory loss, and mental depression. Other reported effects of exposure to carbon disulfide are ocular changes, gastrointestinal disturbances, renal impairment, and liver damage. Also, overexposure to carbon disulfide has been regarded as potentially atherogenic for cerebral, renal, and coronary arteries and that long-term exposure can cause coronary heart disease.

CYANIDE

MSHA's occupational exposure limit for cyanide is 5 mg/m^3 of air averaged over an eight-hour workshift with a skin notation. NIOSH has recommended that the permissible exposure limit be changed to a ceiling of 5 mg/m^3 averaged over a 10-minute period. This change was recommended to prevent allowable cyanide exposure to higher concentrations for short periods of time.

Cyanide salts are rapidly acting poisons. When released in the body, the cyanide ion is capable of inhibiting certain metabolic systems, most notably cytochrome oxidase. Cytochrome oxidase is present in all cells that function under aerobic conditions. Inhibition of this enzyme by the cyanide ion can result in chemical asphyxia at the cellular level. A worker dying of cyanide exposure will have venous blood bright red in color because oxygen remains unabsorbed from the capillaries. The signs and symptoms of cyanide poisoning appear shortly after exposure. The warning signs include dizziness, headache, rapid pulse, nausea, vomiting, and bloodshot eyes. If large amounts of cyanide have been absorbed, collapse is usually instantaneous; the worker will become unconscious, often with convulsions, and die almost immediately. Chronic exposure to cyanide at levels insufficient to produce clinical effects has caused dermatitis, itching, scarlet rash, papules, and nasal irritation.

Temporal aspects of potential exposure are important. Clearly, the longer an individual is exposed to a substance, the greater the consequences may be. For some agents, the net effect can be lessened by intervening periods of reduced exposure; while for others, the doses are cumulative and the effects may be irreversible. Approximately, some exposure criteria are average concentrations currently considered acceptable for lifetime occuptional exposure, while others are maximum levels allowable only for short periods of time or ceiling values not to be exceeded, even instantaneously.

Likewise, the physical arrangement of the beneficiation facilities cannot be ignored. Although the primary concern is for the workforce directly involved with the process of interest, other employees in adjacent areas may also be affected. The size of rooms, the location of various processes, the personnel distribution and traffic patterns in the building, the heating and ventilation airflow throughout the building, and other factors all may affect each person's occupational environment.

On the plus side, a number of control measures are available to reduce the worker's exposure. Less hazardous agents may be substituted with no decrement in performance in many cases. A process change, or simply a different method of application, may be more efficient as well as less hazardous. Physical barriers between the worker and the process may be economically included in automation modifications. Systems to remove much of the contaminant at the source of generation may be engineered for existing equipment. Work schedules may be rearranged to lessen the time spent in areas of high concentration without decreasing productivity. These are but a few of the techniques which may be applied for the right blend of economy and effectiveness of control, and it is the goal of this project to compile and disseminate information on their implementation so that this control technology becomes an integral part of technology development.

EVALUATION

To determine the effectiveness of the controls used in this lead ore beneficiation operation, personal and area air samples were collected for the duration of the workshift on three consecutive days. Breathing zone samples for lead were collected on the Sampler, Mill Operator, Filter Operator, and Laborer and for cyanide and carbon disulfide on the Flotation Operator. These workers were in their respective work areas except during lunch and occasional short breaks. Breathing zone personal samples were clipped to the collar, on the front side of the work shirt. This placed them in the breathing zone, only a few inches below the face, in a manner so as not to interfere with the workers activities. Area samples were placed at fixed locations around the rougher, scavenger, cleaner and recleaner flotation cells, in the general flotation area, in the control room, and in the sampling laboratory. All but a few room air samples were positioned close to the edge of the tanks, above the launders.

Personal and area samples for lead and particulate cyanide and area samples for total dust were collected using closed-face cassettes with 37 mm polyvinylchloride membrane filters of 5 um pore size and MSA Model G personal pumps operated at a flow rate of 2 liters of air per minute. These samples were analyzed for lead by atomic absorption spectroscopy using NIOSH Method No. S-341 (modified), particulate cyanide by direct potentiometry using a cyanide ion-selective electrode essentially following NIOSH Method No. S-250, and total nuisance dusts by the gravimetric method. Personal and area samples for carbon disulfide were collected using charcoal tubes, preceded by pre-filter dryer tubes and Dupont P-200 pumps operated at a flow rate of 50 cc of air per minute. These samples were analyzed for carbon disulfide by gas chromatography using NIOSH Method S-248 (modified).

AIR SAMPLING RESULTS

Personal sampling results for lead, carbon disulfide, and cyanide are shown in Table 1. Mean concentrations for all personal samples were 0.117 mg/m^3 for lead, 1.41 mg/m^3 for carbon disulfide, and 0.007 mg/m^3 for cyanide. Flotation cell and general area sampling sites are shown in Figures 8, 9, and 10.

The Sampler employee working in the sampling laboratory and collecting samples from various locations throughout the beneficiation operation had an average lead exposure of 0.135 mg/m^3 for the three days sampled. This concentration is 90 per cent of the MSHA Standard of 0.15 mg/m^3 and 135 per cent of the NIOSH recommended level of 0.1 mg/m^3. In addition, this employee's exposure on the second day was 0.172 mg/m^3 or 115 per cent of the MSHA Standard and 172 per cent of the NIOSH recommended level. The Mill Operator working in the control room and flotation cell area had an average lead exposure of 0.041 mg/m^3 for the three days sampled. This concentration is 27 per cent of the MSHA Standard and 41 per cent of the NIOSH recommended level. The Filter Operator working in the control room and flotation cell area had an average lead exposure of 0.222 mg/m^3 for the three days sampled. This concentration is 148 per cent of the MSHA Standard and 222 per cent of the NIOSH recommended level. This employee's exposure ranged up to 0.337 mg/m^3 or 225 and 337 per cent respectively, of the MSHA Standard and NIOSH recommendation. The Laborer working throughout the beneficiation operation had an average lead exposure of 0.07 mg/m^3 for the three days sampled. This concentration is is 47 per cent of the MSHA Standard and 70 per cent of the NIOSH recommended level. The Flotation Operator working in the reagent area had an average carbon disulfide exposure of 1.41 mg/m^3 and an average cyanide expousre of 0.007 $mg/m^3$for the three days sampled. This concentration for carbon disulfide is 2 per cent of the MSHA Standard and 47 per cent of the NIOSH recommended level and for cyanide is less than 1 per cent of the MSHA Standard.

Table 1
Employee Exposure (mg/m^3)

Job Description	Date	Lead	Carbon Disulfide	Cyamide
Sampler	2-15-82	0.098		
	2-16-82	0.172		
	2-17-82	0.135		
Mean		0.135		
Mill Operator	2-15-82	0.037		
	2-16-82	0.039		
	2-17-82	0.047		
Mean		0.041		
Filter Operator	2-15-82	0.337		
	2-16-82	0.216		
	2-17-82	0.114		
Mean		0.222		
Laborer	2-15-82	0.068		
	2-16-82	0.067		
	2-17-82	0.076		
Mean		0.070		
Flotation Operator	2-15-82		1.220	0.009
	2-16-82		0.910	0.006
	2-17-82		2.090	0.006
Mean			1.410	0.007
Grand Mean		0.117	1.410	0.007
Limit of Detection		0.003	0.002	0.005
MSHA Standard		0.15	60.0	5.0
ACHIG (TLV (1981/TLV Book)		0.15	30.0	5.0
NIOSH Rec.(NIOSH/OSHA Pocket guide)		0.10	3.0	*5.0

*Ceiling averaged over a 10-minute period

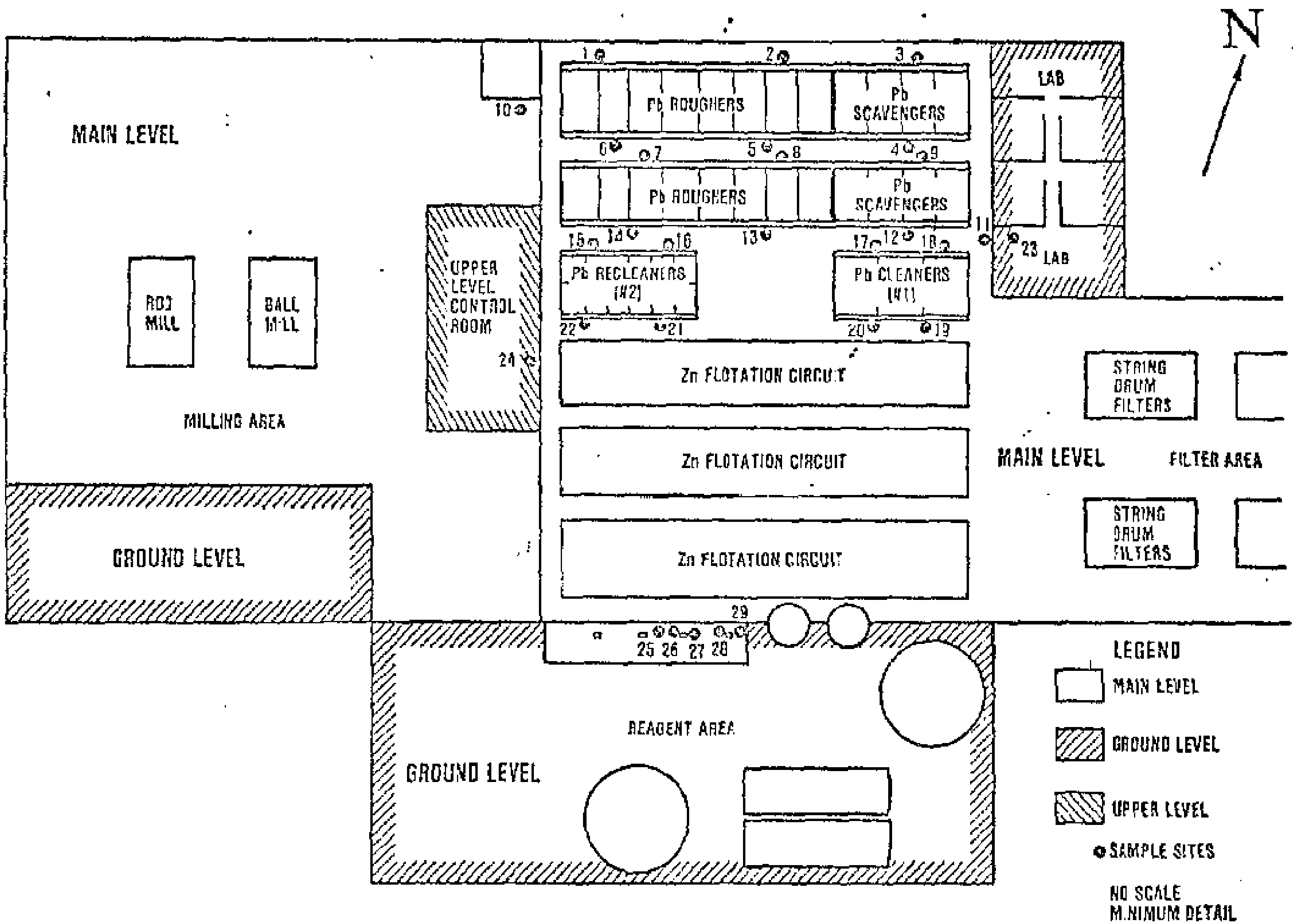


Figure 8 – Total Area Sampling Sites

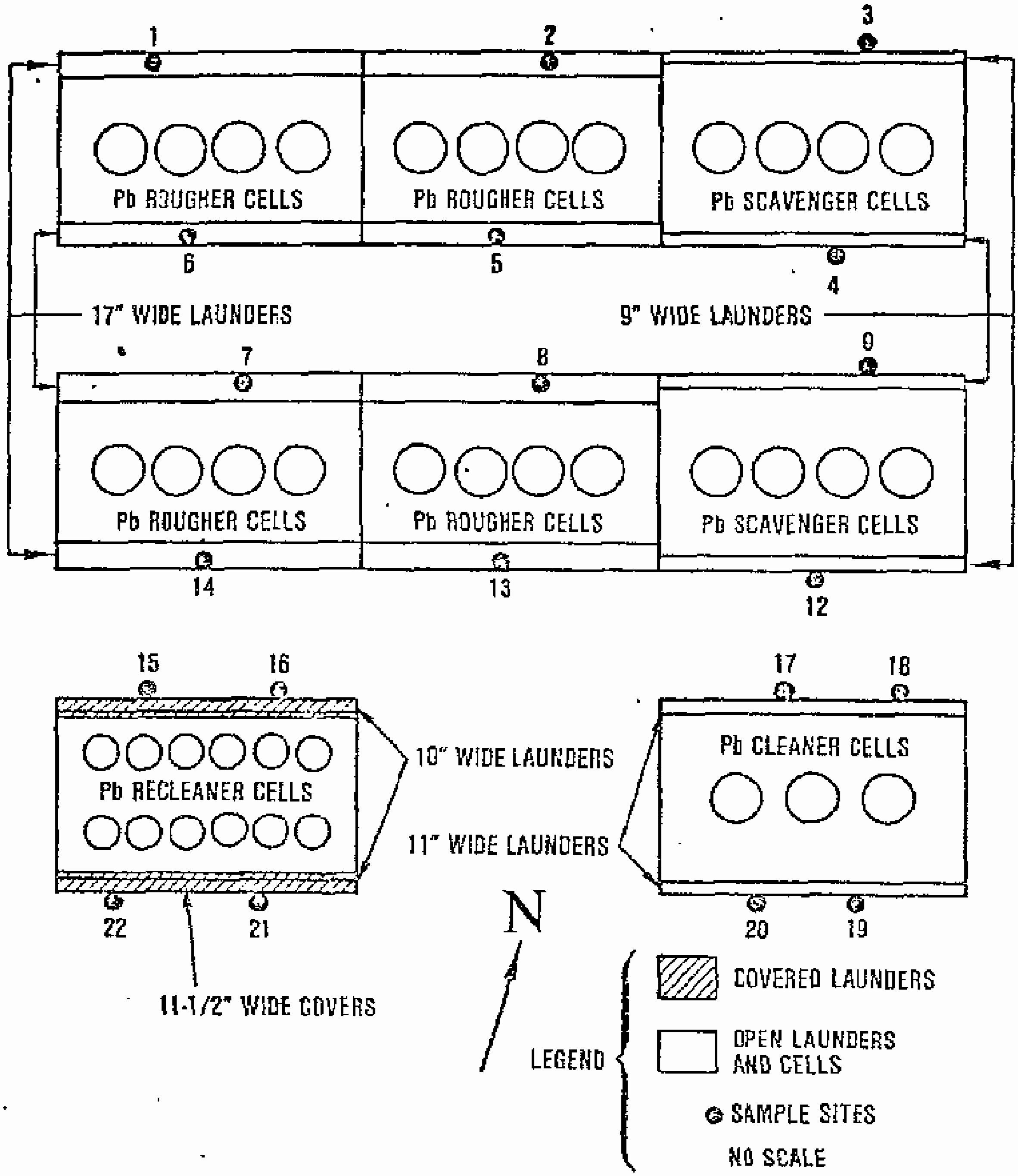


Figure 9 - Flotation Cell Sampling Sites

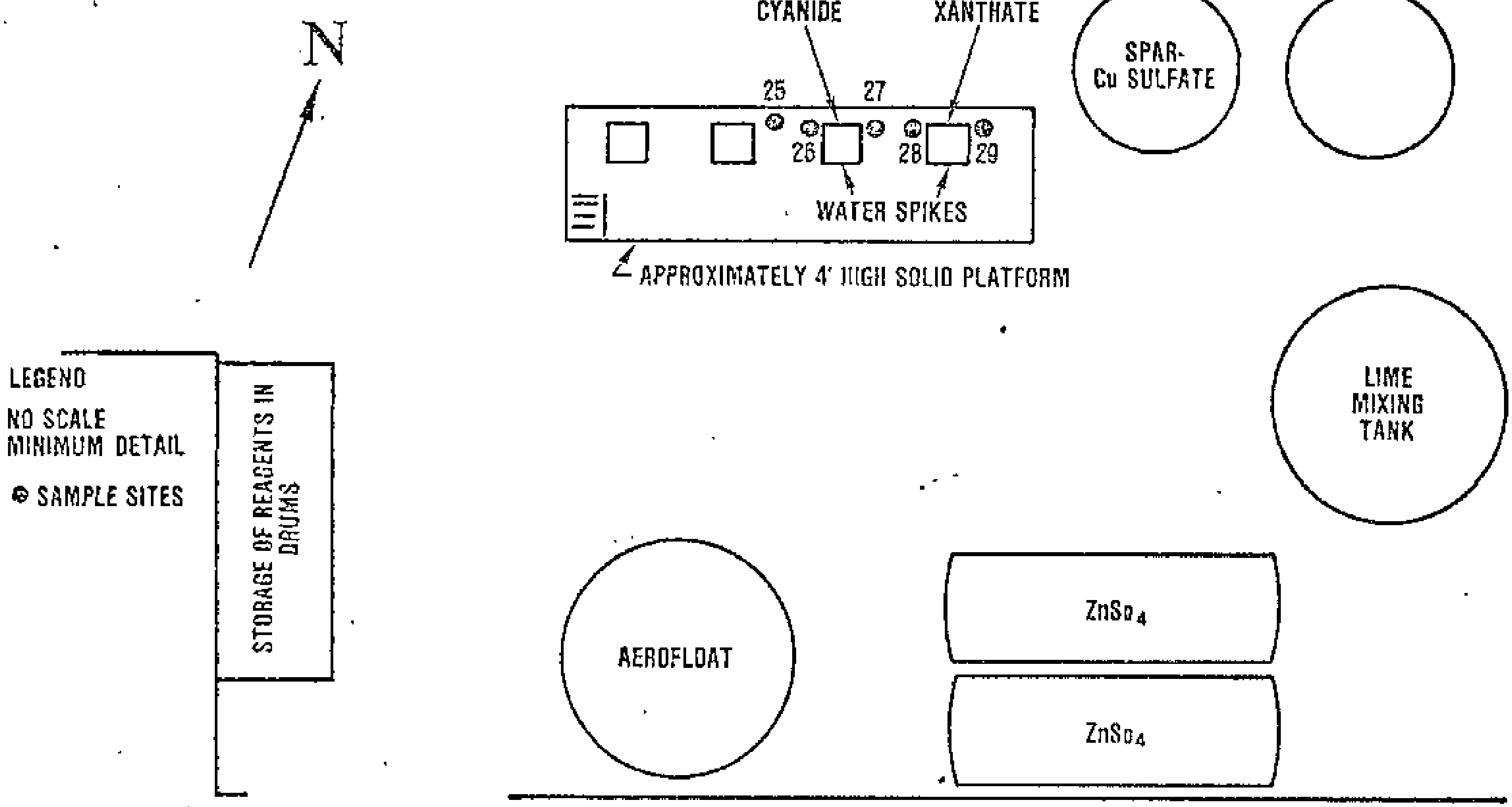


Figure 10 - Reagent Area Sampling Sites

Area samples are shown in Table 2 for lead collected near the rougher, scavenger, cleaner, and recleaner flotation cells, general flotation cell area, sampler room, and control room, total dust collected in the reagent area, cyanide collected near the cyanide water spike, and carbon disulfide collected near the xanthate water spike. Concentrations of samples collected at the rougher flotation cells ranged from 0.064 mg/m^3 at site 5 to 5.457 mg/m^3 at site 7 with an average concentration for the 24 samples of 1.324 mg/m^3. Only 3 of 24 samples were below the MSHA Standard of 0.15 mg/m^3 and only one sample was below the NIOSH recommended level of 0.10 mg/m^3. The average concentrations for all eight sites were above the MSHA Standard for each of the three days sampled. The average concentration for the 24 samples of 1.324 mg/m^3 is approximately 9 times the MSHA Standard and 13 times the NIOSH recommended level. Although area samples can not readily be used to estimate compliance with the legal standard, they are a valuable indicator of control system effectiveness. Area samples collected for lead at the scavenger flotation cells ranged in concentration from 0.057 mg/m^3 at site 9 to 0.277 mg/m^3 at site 4 with an average concentration for the 12 samples collected over the three-day period of 0.143 mg/m^3. Seven of twelve samples were below the MSHA Standard and six were below the NIOSH recommended level. The average concentration for two of the four sites was slightly below the MSHA Standard with the other two being slightly above. The average concentration for the 12 samples of 0.143 mg/m^3 is approximately 95 per cent of the MSHA Standard and 143 per cent of the NIOSH recommended level. Area samples collected for lead at the cleaner flotation cells ranged in concentration from 0.117 gm/m^3 at site 19 to 3.835 mg/m^3 at site 20 with an average concentration for the 12 samples collected over the three-day period of 1.69 ug/m^3. Only one of the twelve samples was below the MSHA Standard and none being below the NIOSH recommended level. The average concentration for the 12 samples of 1.69 mg/m^3 is approximately 11 times the MSHA Standard and 17 times the NIOSH recommended level. Area samples collected for lead at the recleaner flotation cells ranged in concentration from 0.098 mg/m^3 at site 22 to 0.436 mg/m^3 at site 16 with an average concentration for the 12 samples collected over the three-day period of 0.202 mg/m^3. Six of the 12 samples were below the MSHA Standard and three were within the NIOSH recommended level. The average concentration for the 12 samples of 0.202 mg/m^3 is approximately 135 per cent of the MSHA Standard and 202 per cent of the NIOSH recommended level. Area samples collected for lead in the general flotation cell area ranged in concentration from 0.065 mg/m^3 at site 11 to 0.156 mg/m^3 at site 10 with an average concentration for the six samples collected over the three-day period of 0.111 mg/m^3. Five of the six samples were below the MSHA Standard and two were below the NIOSH recommended level. The average concentration for the six samples of 0.111 mg/m^3 is approximately 74 per cent of the MSHA Standard and 111 per cent of the NIOSH recommended level. The three area samples collected for lead in the sampler room averaged 0.025 mg/m^3 and were well below the MSHA Standard and the NIOSH recommended level. The three area samples collected for lead in the control room averaged 0.019 mg/m^3 and were well below the MSHA Standard and NIOSH recommended level. The three area samples collected for total dust in the reagent area averaged 0.28 mg/m^3 and were well below the MSHA Standard. The six area samples collected for particulate

Table 2
Area Samples - Air Concentration (mg/m3)

Area	Sample Site	Contaminant	2-15-82	2-16-82	2-17-82	Mean
Rougher	1	Lead	2.655	0.281	0.479	1.138
Flotation	2	"	0.487	0.323	0.105	0.305
Cells	5	"	1.770	1.354	0.064	1.063
	6	"	2.065	2.323	0.941	1.776
	7	"	5.457	4.669	0.617	3.581
	8	"	0.324	0.219	0.149	0.231
	13	"	1.558	0.635	1.022	1.072
	14	"	3.687	0.292	0.298	1.426
Mean			2.250	1.262	0.459	1.324
Scavenger	3	Lead	0.084	0.146	0.099	0.110
Flotation	4	"	0.277	0.152	0.064	0.164
Cells	9	"	0.221	0.188	0.057	0.155
	12	"	0.265	0.077	0.088	0.143
Mean			0.212	0.141	0.077	0.143
Cleaner	17	Lead	3.320	3.718	1.702	2.913
Flotation	18	"	0.664	0.740	1.220	0.875
Cells	19	"	0.959	2.549	0.117	1.208
	20	"	3.835	1.042	0.415	1.764
Mean			2.194	2.012	0.864	1.690
Recleaner	15	Lead	0.139	0.100	0.119	0.119
Flotation	16	"	0.265	0.353	0.436	0.351
Cells	21	"	0.339	0.099	0.106	0.181
	22	"	0.162	0.098	0.213	0.158
Mean			0.226	0.162	0.218	0.202
General	10	Lead	0.134	0.156	0.138	0.143
Flotation	11	"	0.065	0.104	0.067	0.079
Cell Area						
Mean			0.099	0.130	0.102	0.111
Sampler Room	23	Lead	0.029	0.020	0.027	0.025
Mean			0.029	0.020	0.027	0.025
Control Room	24	Lead	0.014	0.019	0.025	0.019
Mean			0.014	0.019	0.025	0.019
Reagent Area	25	Total Dust	0.30	0.32	0.23	0.28
Mean			0.30	0.32	0.23	0.28
Cyanide Water	26	Cyanide	0.008	0.005	0.005	0.006
Spike	27	"	0.008	0.005	0.005	0.006
Mean			0.008	0.005	0.005	0.006
Xanthate Water	28	Carbon Disulfide	2.56	4.38	1.50	2.81
Spike	29	" "	0.88	0.88	0.89	0.88
Mean			1.72	2.63	1.19	1.84

cyanide at the cyanide water spike averaged 0.006 mg/m^3 and were well below the MSHA Standard of 5 mg/m^3. Area samples collected for carbon disulfide at the xanthate water spike ranged in concentration from 0.88 mg/m^3 at site 29 to 4.38 mg/m^3 at site 28 with an average concentration for the six samples collected over the three-day period of 1.84 mg/m^3. All six of the samples were well below the MSHA Standard of 60 mg/m^3 and five were below the NIOSH recommended level of 3 mg/m^3.

DISCUSSION

The widened rougher flotation cell launders are not effective in reducing the quantity of lead-containing mist generated to an acceptable level. Only 3 of 24 samples taken at the rougher launders were below the MSHA Standard and only one was below the NIOSH recommended level. The average concentrations for all eight sites were above the MSHA Standard for each of the three days sampled. The average concentration for the 24 samples taken over a three-day period of 1.324 mg/m^3 is approximately 9 times the MSHA Standard and 13 times the NIOSH recommended level. The validity of the above conclusion appears to be further supported by a comparison of the cleaner flotation cell total sample mean with the rougher flotation cell total sample mean. Since the cleaner flotation cell launders are of the narrow type (9 inches) and the solution contains a greater lead concentrate the total sample mean should show a greater difference than 0.366 mg/m^3 (1.69 mg/m^3 - 1.324 mg/m^3).

The recleaner flotation cell launder covers are moderately effective in minimizing the quantity of mist escaping into the general work area atmosphere. Six of the 12 samples taken at the recleaner launders were below the MSHA Standard and three were within the NIOSH recommended level. The average concentraion for the 12 samples of 0.202 mg/m^3 is approximately 135 per cent of the MSHA Standard and 202 per cent of the NIOSH recommended level. The launders covers effectiveness can be further illustrated by a comparison of the total sample mean of the uncovered, less concentrated, cleaner flotation cells (1.69 mg/m^3) with the covered, more concentrated, recleaner flotation cell results (0.202 mg/m^3). This comparison, excluding the difference in concentration, indicates an eight-fold reduction in the quantity of mist escaping into the general work area atmosphere.

The use of "water spikes" in the reagent handling area to empty drums of cyanide and xanthate is effective in preventing harmful exposure to employees. The Flotation Operator working in the reagent area had an average carbon disulfide (xanthate decomposition product) exposure of 1.41 mg/m^3 and an average cyanide exposure of 0.007 mg/m^3 for the three days sampled. This concentration for carbon disulfide is two per cent of the MSHA Standard and 47 per cent of the NIOSH recommended level and for cyanide is less than one per cent for the MSHA Standard. The six area samples collected for particulate cyanide at the cyanide "water spike" averaged 0.006 mg/m^3 and were well below the MSHA Standard of 5 mg/m^3. Area samples collected for carbon disulfide at the xanthate "Water spike" averaged 1.84 mg/m^3 and were well below the MSHA Standard of 60 mg/m^3 and NIOSH recommended level of 3 mg/m^3.

The use of an isolated, enclosed, air-conditioned flotation cell control room is effective in reducing the potentially harmful lead exposure levels for the Mill Operator. The three area samples collected for lead in the control room averaged 0.019 mg/m^3 which is 13 and 19 per cent respectively of the MSHA Standard and NIOSH recommended level. The Mill Operator working in the control room and flotation cell area had an average lead exposure of 0.041 mg/m^3 for the three days sampled. This concentration is 27 per cent of the MSHA Standard and 41 per cent of the NIOSH recommended level.