

IN-DEPTH SURVEY REPORT

OF

COMINCO AMERICAN, INC.
BLIXBY, MISSOURI

Survey Conducted by:
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National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway
Cincinnati, Ohio 45226

PURPOSE OF SURVEY: To evaluate engineering control technology used in a lead ore beneficiation operation.

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ANALYSIS PERFORMED BY: DPSE, NIOSH
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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 Cominco American Magmont mill in Bixby, Missouri. The flotation process beneficiates over 4600 tons per day of a complex sulfide ore containing an average of seven 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 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 the use of a starch mixing tank ventilation system, covered recleaner, rougher, and scavenger and partially-covered cleaner flotation cells, 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 cleaner and recleaner cell covers were ineffective, the rougher and scavenger cell covers were moderately effective, and the "water spike", mixing tank ventilation system 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. The use of a starch mixing tank ventilation system equipped with a polypropylene lined dump chute to minimize the quantity of total dust escaping into the general work area atmosphere (Figure 7).
2. Rougher, scavenger, and recleaner flotation cell covers and partial cleaner cell covers to minimize the quantity of mist escaping into the general work area atmosphere (Figure 3).
3. The use of a "water spike" in the reagent handling area to empty drums of cyanide and xanthate (Figures 4, 5 and 6).
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).

Lead ore beneficiation operations started in 1968 at Cominco American, Inc.'s Magmont operation. An average of 4600 tons of ore, averaging seven per cent lead, is processed per day. The lead flotation process includes four banks of flotation cells with each bank consisting of eleven cells. The first six cells in each bank are rougher cells and the last five in each bank are scavenger cells. The first stage of cleaning consists of five flotation cells and the second or recleaner stage consists 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 five days per week, 24 hours per day, to produce lead, copper, and zinc concentrates. Of the total 200 employees at the Magmont operation, 26 are employed in the mill, 30 of the 60 maintenance employee crew work on the surface, with the remaining employees being underground, office and staff personnel. The mill or beneficiation operations and supporting functions are housed in a four-story sheet metal building containing approximately 80,000 square feet of floor space.

PROCESS DESCRIPTION

Once the ore is skipped to the surface it is dumped from the skip into the coarse-ore bin. The coarse-ore bin is located above the crusher building (Figure 2).

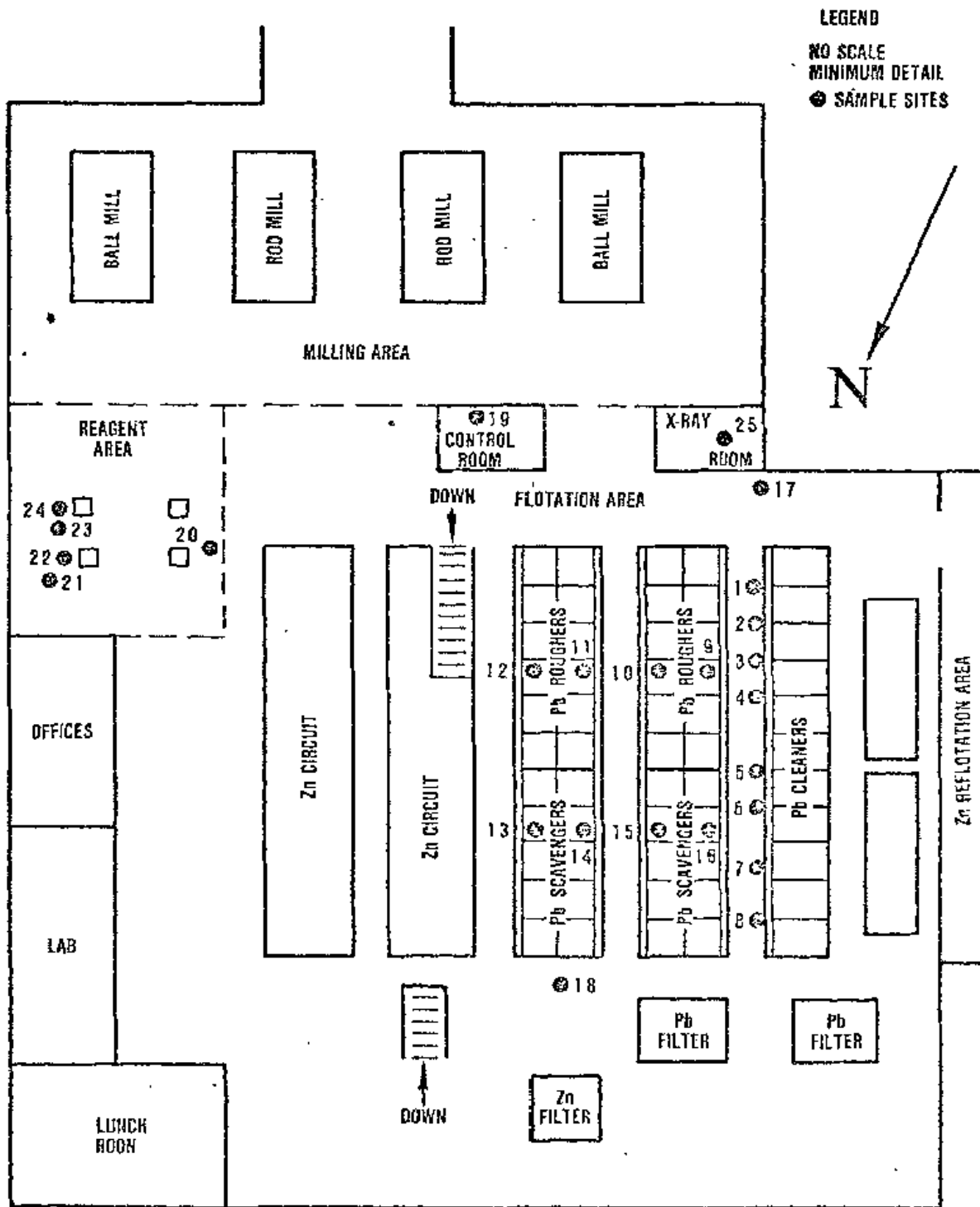


Figure 1 - Floor Plan of the Beneficiation Operations

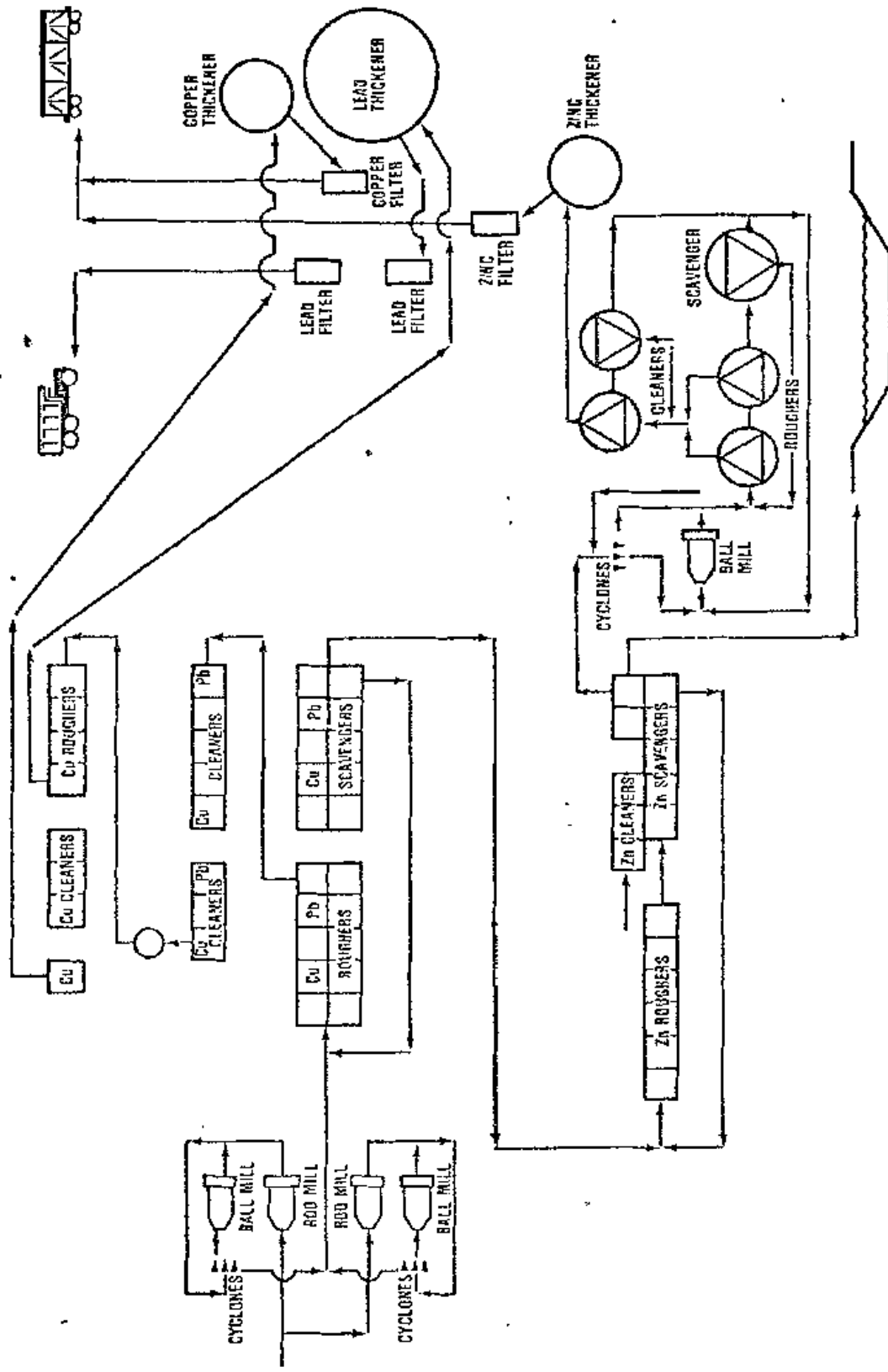


Figure 2 - Ore Beneficiation Process Flow

There are two stages of crushing on the surface. A variable speed apron feeder controls the ore flow from the coarse-ore bin to a 5 1/2 foot standard cone secondary crusher set at about 2 1/2 inch. The ore then passes to a 7-foot short-head tertiary crusher set at 3/4 inch.

Discharge from this crusher is conveyed to two 2000-ton fine-ore bins fed by a reversible shuttle belt. The shuttle belt is wheel-mounted on rails so that it can be moved to a forward position to discharge crushed waste, or stockpile ore, outside the plant.

Because of fluctuations in ore composition and as protection against production stoppages, two grinding circuits are installed. Each circuit consists of a 9 1/2 by 12 foot rod mill and a 10 1/2 by 12 foot ball mill. The rod mills are in open circuit while the ball mills are in closed circuit with 20-inch cyclone classifiers. Mill steel consumption is 0.153 pounds of 3-inch rods and 0.234 pounds of 2-inch balls per ton of mill feed.

Each fine-ore bin has two slot feeders, one to each grinding circuit. One of the feeder belts to each circuit is adjusted manually while the other is static controlled from the belt scales. In practice, one belt feeds at a constant speed while the other floats to maintain the preset tonnage.

There are three cyclones for each grinding circuit with two normally in use and the third as a stand-by. The cyclones are mounted 30 degrees from horizontal and are pressurized at about 4 1/2 psi from a steady-head tank. The steady-head tank compensates for feed variations as well as assuring deaeration without requiring precise pump-speed control. The cyclone overflows are pumped to the flotation circuit through vertical pipes equipped with radiation density gauges.

The slurries from the two grinding circuits are combined and then distributed into four rows, each row containing 11 flotation machines. The galena and chalcopryrite are floated together in a bulk concentrate. The eleven 61 cubic foot cells in each row are divided into six roughers and five scavengers. Concentrate is then pumped to an 11-cell cleaner circuit. The bulk concentrate is cleaned once or twice, depending on the throughput quantity. The cleaner tails and scavenger concentrates are returned to the distributor ahead of the rougher circuits. The rougher, scavenger, and recleaner cells are equipped with full cell covers and the cleaner cells are equipped with partial covers to minimize the quantity of mist escaping into the general work area atmosphere (Figure 3).

The cleaned bulk concentrates are then fed to the copper separation circuit. They are treated with sulfur dioxide and starch to depress the galena, and the chalcopryrite is floated in four 150 cubic foot cells. The tailings from these cells is the final lead concentrate and is pumped to the lead thickener. The copper-bearing froth is cleaned four times to produce the final copper concentrate. The cleaner tailings are returned to the copper circuit feed.

The tailings from all four rows of copper-lead scavenger machines go to a 1200 cubic foot final scavenger flotation machine. The tailings from the scavenger

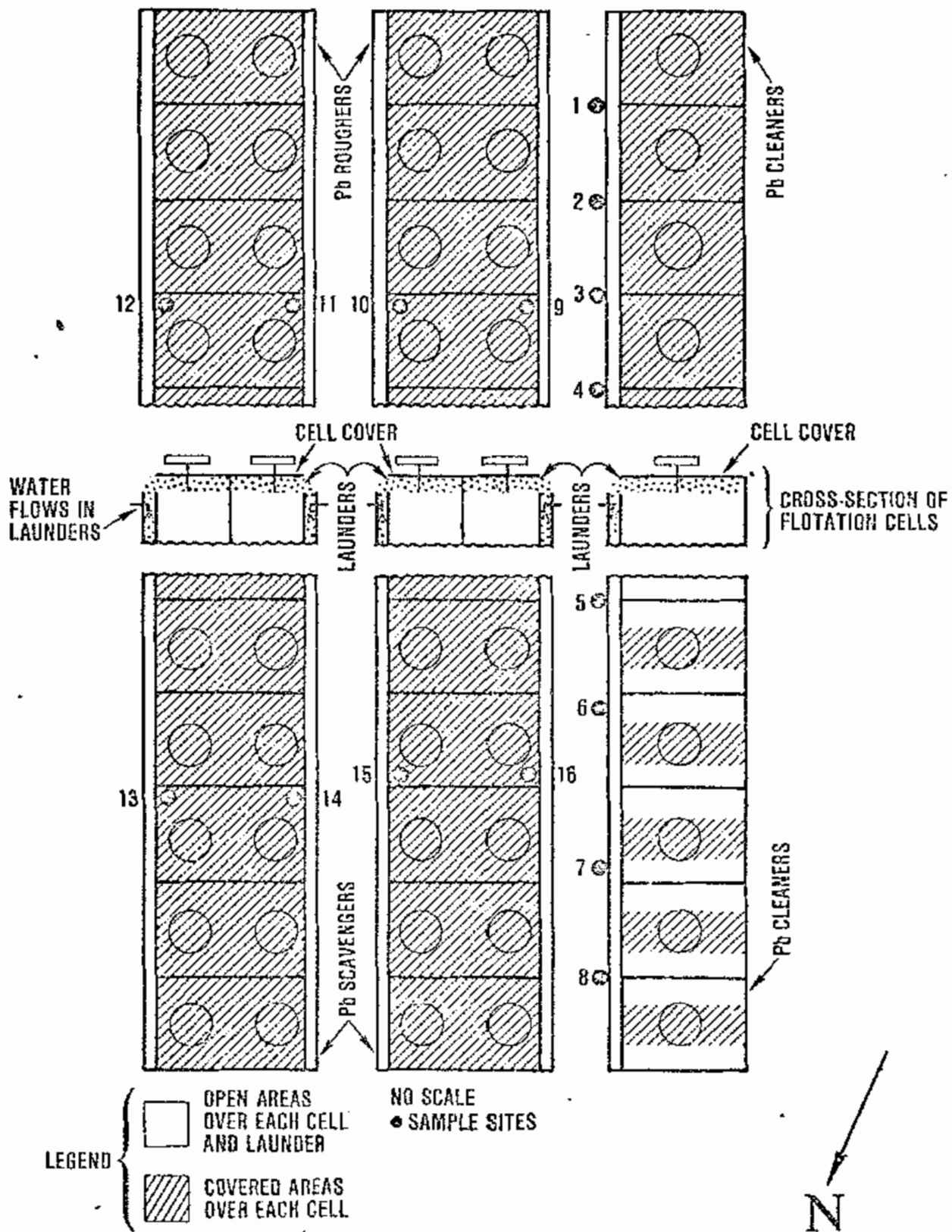


Figure 3 ~ Flotation Cell Covers

cell go to the zinc conditioner and then are distributed to three rows of 61 cubic foot flotation machines. The froth from the six roughers in each row goes to one stage of cleaning then to a zinc regrind circuit to produce the final zinc concentrate. The feed consumption in the regrind mill is 0.015 pounds of 1-inch balls per ton of mill feed. The concentrate from the scavengers returns to the zinc conditioner.

Lead concentrate is thickened in a 60-foot diameter thickener. Copper and zinc concentrates are thickened in 35-foot diameter thickeners. The rakes rise automatically when thrust exceeds the set amount, but must be lowered manually by the reversible motors on the lifting mechanisms. The thickener tanks are supported on concrete columns and located outside of the mill building.

Lead concentrate is filtered on two 8-foot diameter by 12-foot long drum filters. Zinc and copper concentrates are filtered on 8 by 8 foot drum filters.

Cake moistures are satisfactory in both zinc and copper concentrates, usually 8 to 10 percent. The lead concentrate is sticky unless a filter aid is used. Aerodri 104, a surface tension modifier, is used in the lead filters at the rate of 0.8 to 0.9 pound per ton of concentrate. This lowers the cake moisture by 2 to 3 per cent which gives a final moisture of 6.5 to 8.5 per cent.

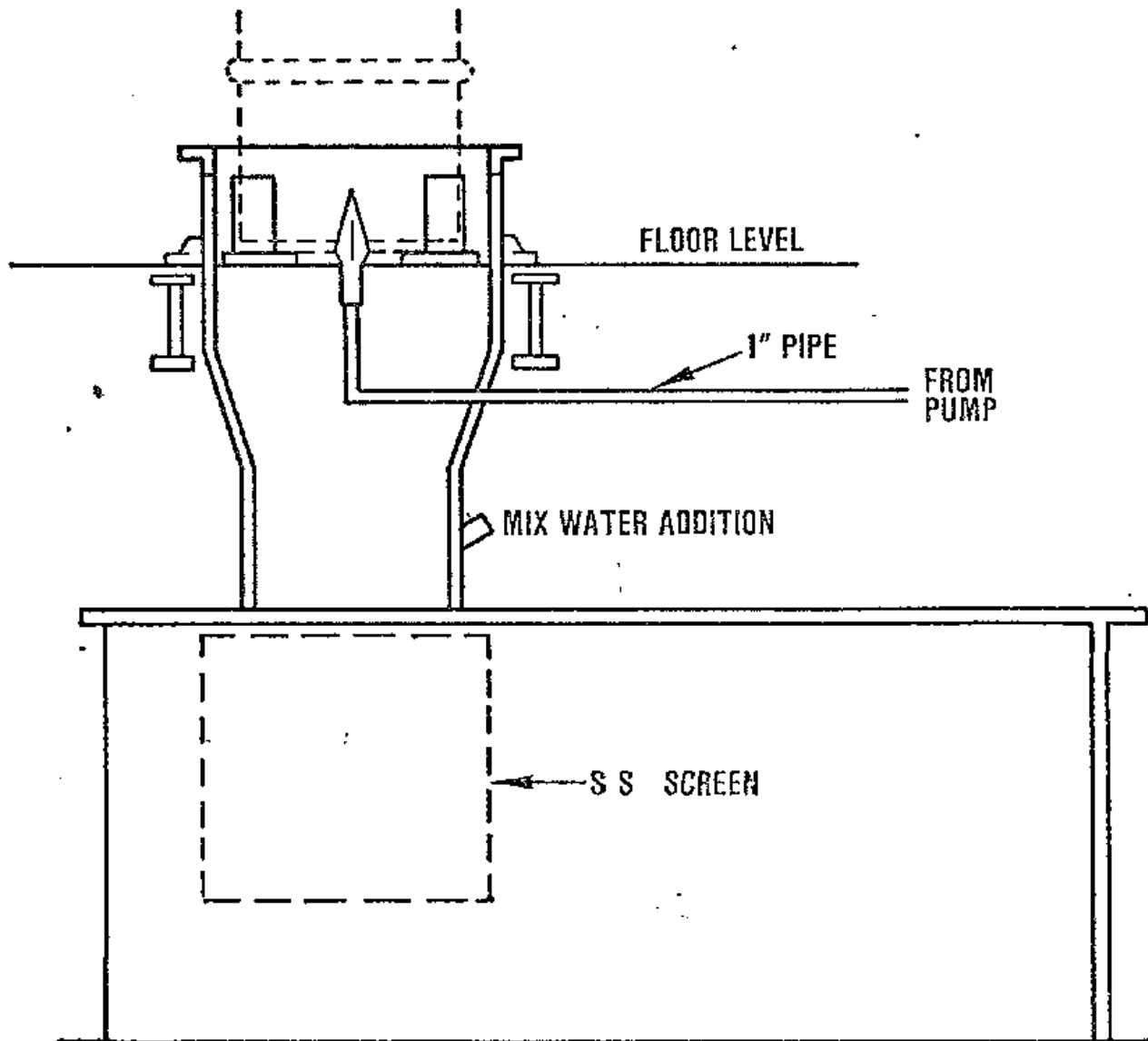
Concentrates are conveyed by belts to a concentrate-storage building that is partitioned for the three concentrates. A combination truck and railroad scale is in front of the loading dock, and trucks or rail cars are loaded by a front-end loader to the desired weight as shown by a digital display.

Most of the lead concentrates are hauled to a smelter one-half mile away by truck. Other concentrates are shipped in open gondola rail cars. All control operations for the grinding and flotation circuits are performed from a centralized control room located between the grinding and flotation sections (Figure 1).

The Magmont Mine uses a variety of reagents in the flotation process to recover the valuable minerals. These reagents are prepared in the reagent area where a "water spike," is used in the emptying of xanthate and cyanide drums (Figure 4, 5, and 6) and a ventilated mixing tank is used for mixing starch (Figure 7). These reagents have varying degrees of hazard potential. They are stored in the mill. The following is a list of these reagents with their functions and approximate usage:

Potassium Amyl Xanthate - Promoter for copper, lead and zinc sulfide minerals. Approximate usage: 150,000 lbs./yr. Storage container: 300 lb./bbl.

Frothers (MIBC and Dowfroth 250) - Frothing agents used to create stable bubbles capable of carrying the sulfide mineral to the surface. Approximate usage: 20,000 lbs/yr. Storage container: MIBC 371 lbs./bbl. Dowfroth 250 - 450 lbs./bbl.



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 4 - Xanthate and Cyanide "Water Spike" Assembly

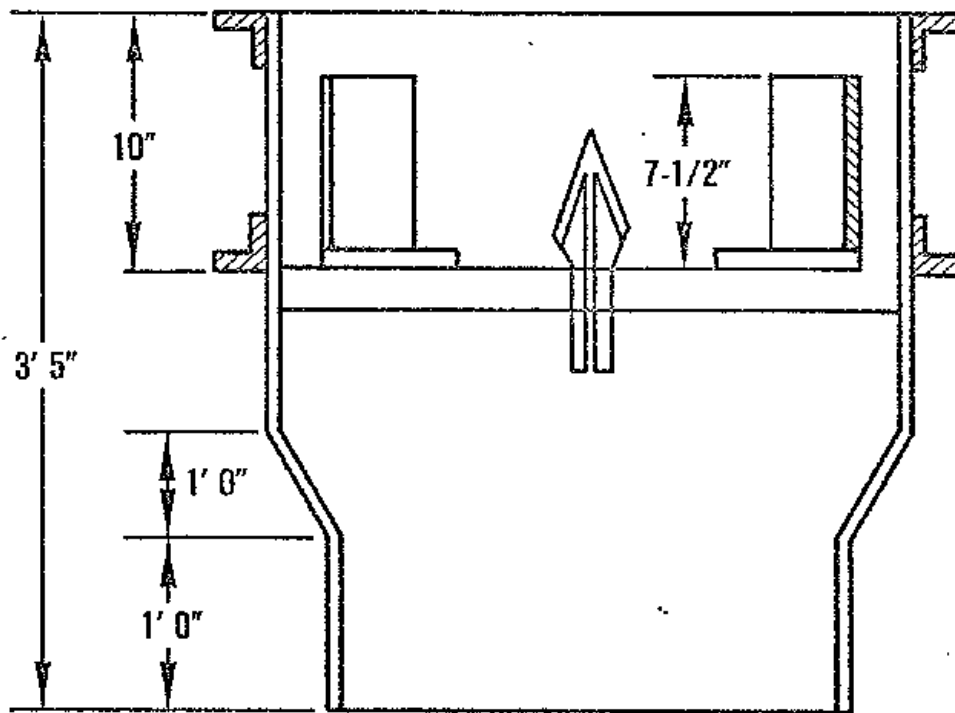
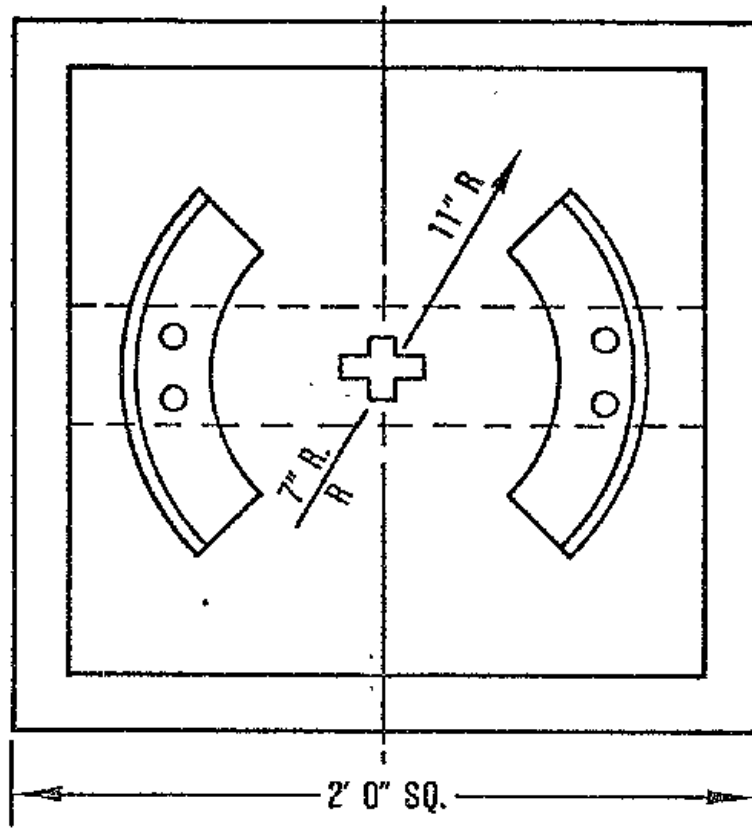


Figure 5 - "Water Spike" in Drum Basket

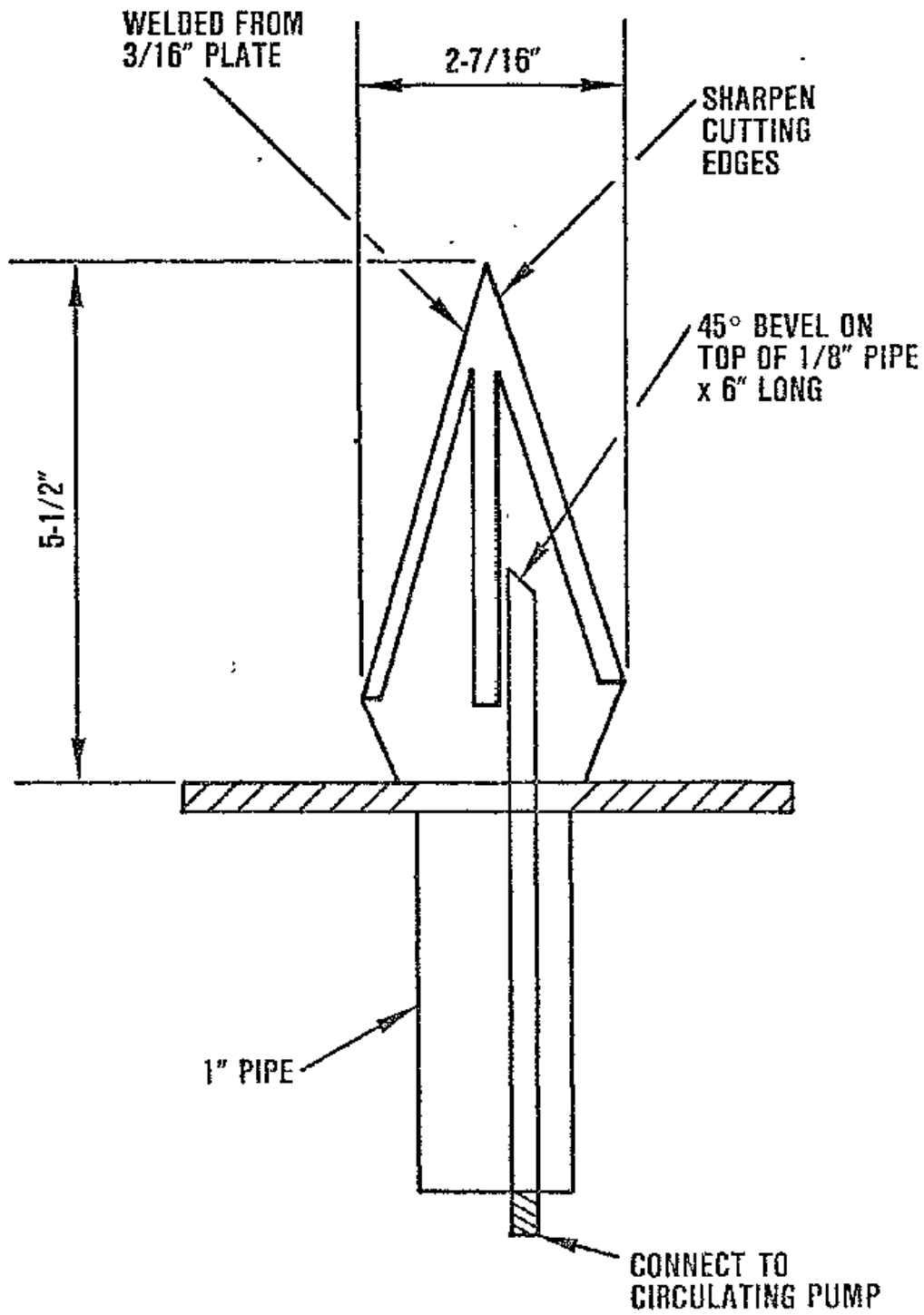


Figure 6 - "Water Spike" Detail

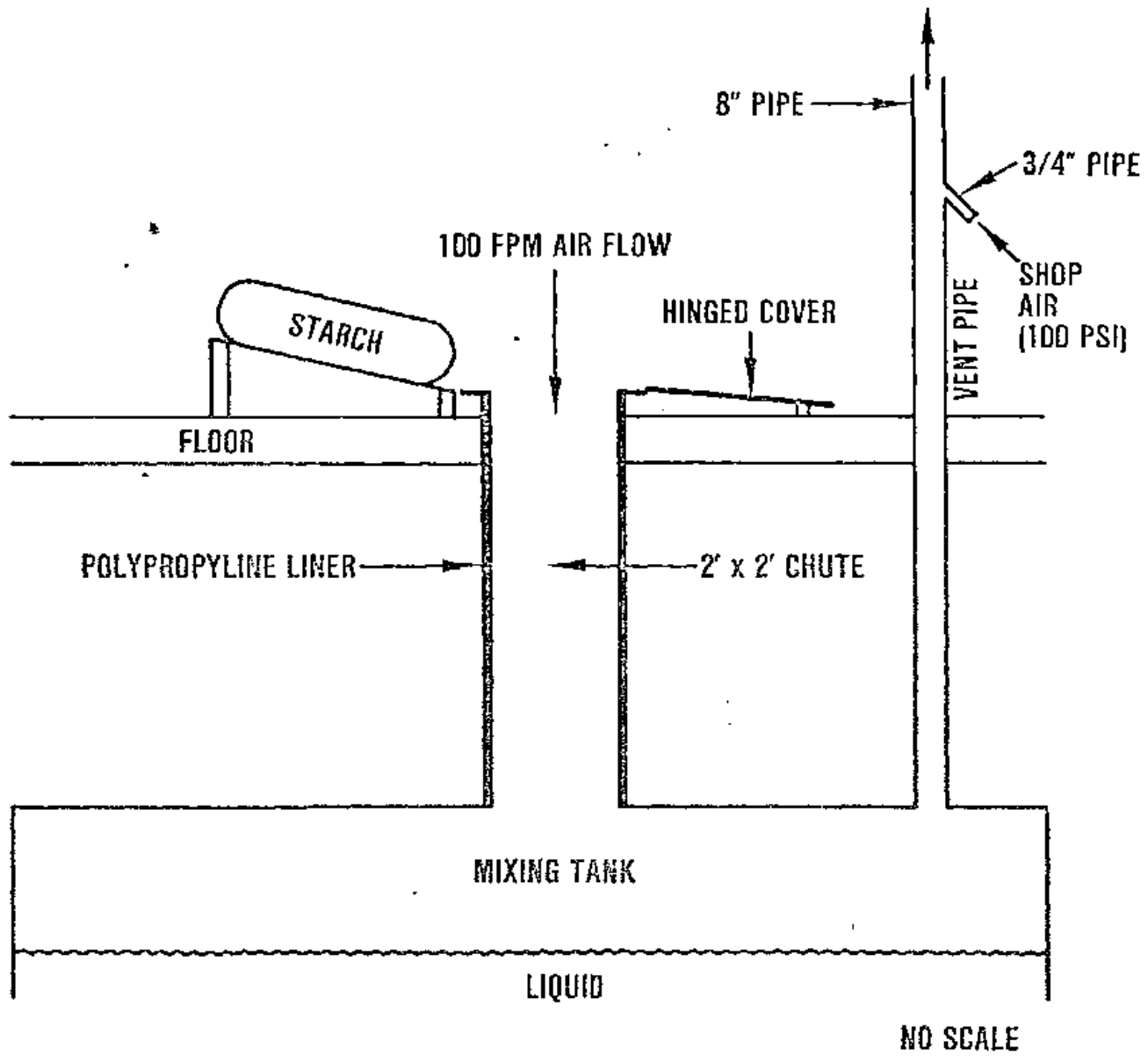


Figure 7 - Starch Mixing Tank Ventilation System

Sodium Cyanide - Depressant for iron sulfide minerals. Approximate usage: 20,000 lbs./yr. Storage container: 200 lbs./bbl.

Zinc Sulfate - Depressant for sphalerite. Approximate usage: 65,000 lbs/yr. Storage container: Bulk tank 20 tons.

Starch - A depressant used to control slime lead in the copper-lead separation. Approximate usage: 150,000 lbs./yr. Storage container: 100 lbs./bag.

Sulfur Dioxide - Used in copper-lead separation. Copper activator and lead depressant. Approximately usage: 1,000,000 lbs./yr. Storage container: Bulk tank 80 tons.

Sodium Bichromate - A depressant of lead used in the copper cleaners. Approximate usage: 70,000 lbs./yr. Storage container: 100 lbs./bag.

Caustic Soda - A dispersant used for preparation of the starch in the copper-lead separation. Approximate usage: 50,000 lbs./yr. Storage container: 500 lbs./bbl.

Sulfuric Acid - A leaching agent to remove dolomite from the copper-lead concentrate. Approximate usage: 900,000 lbs./yr. Storage container: Bulk tank 25 tons.

Lime - pH regulator used in the copper-lead circuit and zinc circuit. Approximate usage: 350,000 lbs./yr. Storage container: Bulk tank 30 tons.

Copper Sulfate - Activator of sphalerite used in the zinc circuit. Approximate usage: 250,000 lbs./yr. Storage container: Bulk tank 20 tons.

Alkyl Sulfonate (Aerodri 104) - A drying aid used to control the moisture content of the concentrates. Approximate usage: 90,000 lbs./yr. Storage container: 450 lbs./bbl.

Sodium Aerofloat - Secondary promoter for sphalerite in zinc circuit. Approximate usage: 4,000 lbs./yr. Storage container: 525 lbs./bbl.

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, neuro-muscular, 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/m³). 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, hepatotoxin, nephrotoxin, and primary irritant of the skin. Massive, short-term exposure to concentrations of about 10,000 mg/m³ 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/m³ accompanied by predominantly psychiatric and neurological symptoms such as extreme irritability, uncontrolled anger, rapid mood changes, euphoria, hallucinations, paranoid 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 paresthesia 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/m³ 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/m³ 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. Appropriately, some exposure criteria are average concentrations currently considered acceptable for lifetime occupational 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 three workshifts in two days. Breathing zone samples for lead were collected on the Sampler, Mill Operator, Assistant Mill Operator, and Mill Helper and for cyanide and carbon disulfide on the Reagent 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, recleaner and cleaner flotation cells, in the general flotation area, in the reagent area, in the control room, and in the assay room. 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 0.158 mg/m³ for lead, 1.31 mg/m³ for carbon disulfide, and 0.007 mg/m³ for cyanide. Flotation cell, reagent area and general area sampling sites are shown in Figures 8, 9, and 10.

The Sampler employee working in the sample room and collecting samples from various locations throughout the beneficiation operation had an average lead exposure of 0.136 mg/m³ for the two shifts sampled. This concentration is 91 per cent of the MSHA Standard of 0.15 mg/m³ and 136 per cent of the NIOSH recommended level of 0.1 mg/m³. The Mill Operator working in the control room and flotation cell area had an average lead exposure of 0.100 mg/m³ for the three shifts sampled. This concentration is 67 per cent of the MSHA Standard and equal to the NIOSH recommended level. The Assistant Mill Operator working in the control room and flotation cell area had an average lead exposure of 0.266 mg/m³ for the two shifts sampled. This concentration is 177 per cent of the MSHA Standard and 266 per cent of the NIOSH recommended level. The Mill Helper working throughout the beneficiation operation had an average lead exposure of 0.158 mg/m³ for the three shifts sampled. This concentration is 105 per cent of the MSHA Standard and 158 per cent of the NIOSH recommended level. The Reagent Operator working in the reagent area had an average carbon disulfide exposure of 1.31 mg/m³ and an average cyanide exposure of 0.007 mg/m³ for the two shifts sampled. This concentration for carbon disulfide is 2 per cent of the MSHA Standard and 44 per cent of the NIOSH recommended level and for cyanide is less than 1 percent of the MSHA Standard.

Area samples are shown in Table 2 for lead collected near the rougher, scavenger, cleaner, and recleaner flotation cells, general flotation cell area, assay 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 0.166 mg/m³ at site 9 to 0.935 mg/m³ at site 12 with an average concentration for the 12 samples of 0.354 mg/m³. None of the samples were below the MSHA Standard of 0.15 mg/m³ or the NIOSH recommended level of 0.10 mg/m³. The average concentrations for all four sites were above the MSHA Standard for each of the three shifts sampled. The average concentration for the 12 samples of 0.354 mg/m³ is approximately 236 per cent of the MSHA Standard and 354 per cent of 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 0.004 mg/m³ at site 15 to 0.315 mg/m³ at site 13 with an average concentration for the 12 samples collected over the three-shift period of 0.159 mg/m³. Five of the twelve samples were below the MSHA Standard and two were below the NIOSH recommended level. The average concentration for one of the four sites was slightly below the MSHA Standard with the other three being slightly above. The average concentration for the 12 samples of 0.159 mg/m³ is approximately 106 per cent of the MSHA Standard and 159 per cent of the NIOSH recommended

Table 1
Employee Exposure (mg/m³)

Job Description	Date	Lead	Carbon Disulfide	Cyamide
Sampler	2-11-82	0.123		
	2-12-82	0.149		
	Mean	0.136		
Mill Operator	2-11-82	0.050		
	*2-11-82	0.097		
	2-12-82	0.153		
	Mean	0.100		
Assistant Mill Operator	2-11-82	0.012		
	2-12-82	0.521		
	Mean	0.266		
Mill Helper	2-11-82	0.096		
	*2-11-82	0.174		
	2-12-82	0.204		
	Mean	0.158		
Reagent Operator	2-11-82		1.35	0.007
	2-12-82		1.27	0.006
	Mean		1.31	0.007
Grand Mean		0.158	1.31	0.007
Limit of Detection		0.003	0.002	0.005
MSHA Standard		0.15	60.0	5.0
ACGIH (TLV (1981/TLV Book)		0.15	30.0	5.0
NIOSH Rec.(NIOSH/OSHA Pocketguide)		0.10	3.0	**5.0

*Second Shift

**Ceiling averaged over a 10-minute period

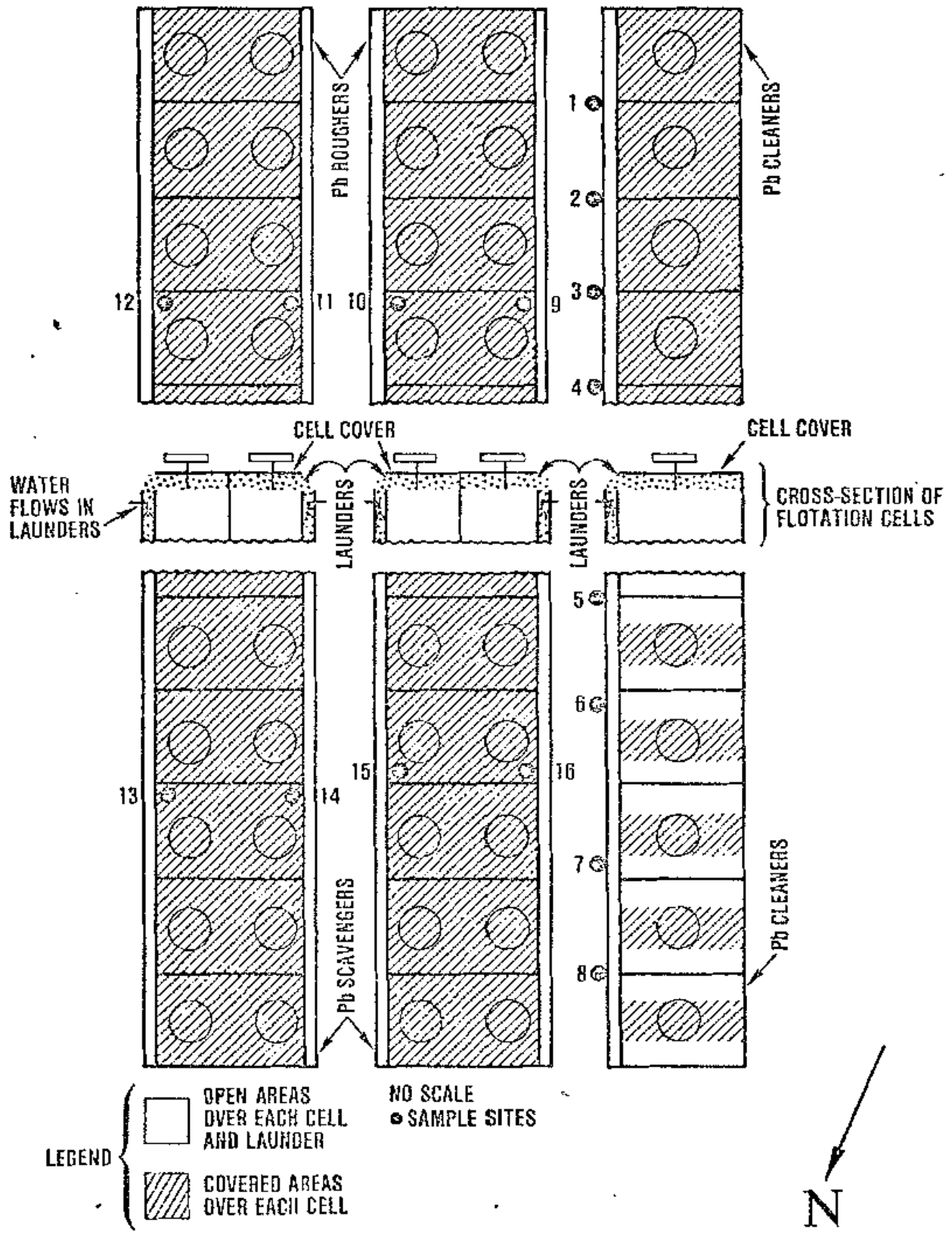


Figure 8 - Flotation Cell Sampling Sites

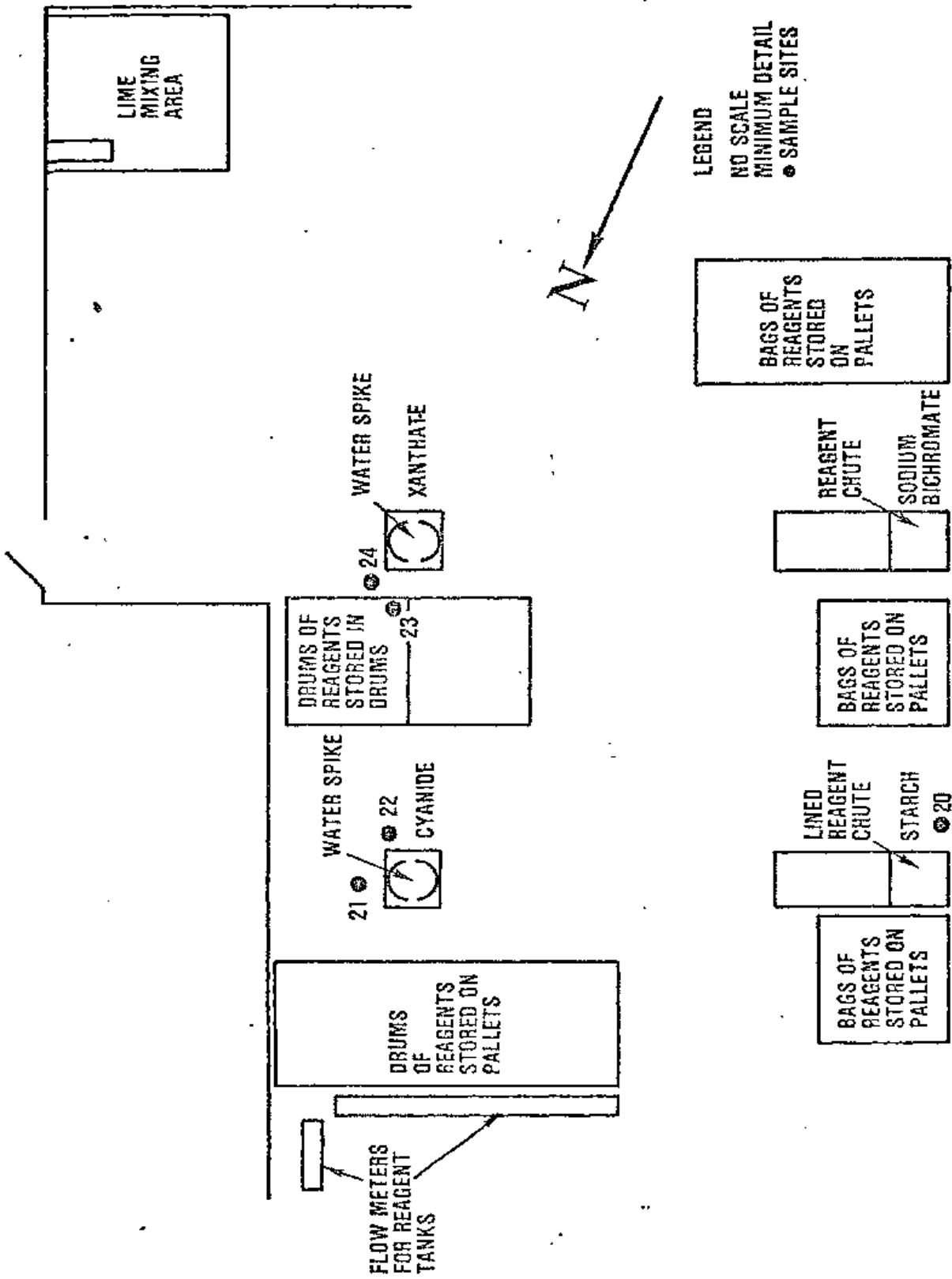


Figure 9 - Reagent Area Sampling Sites

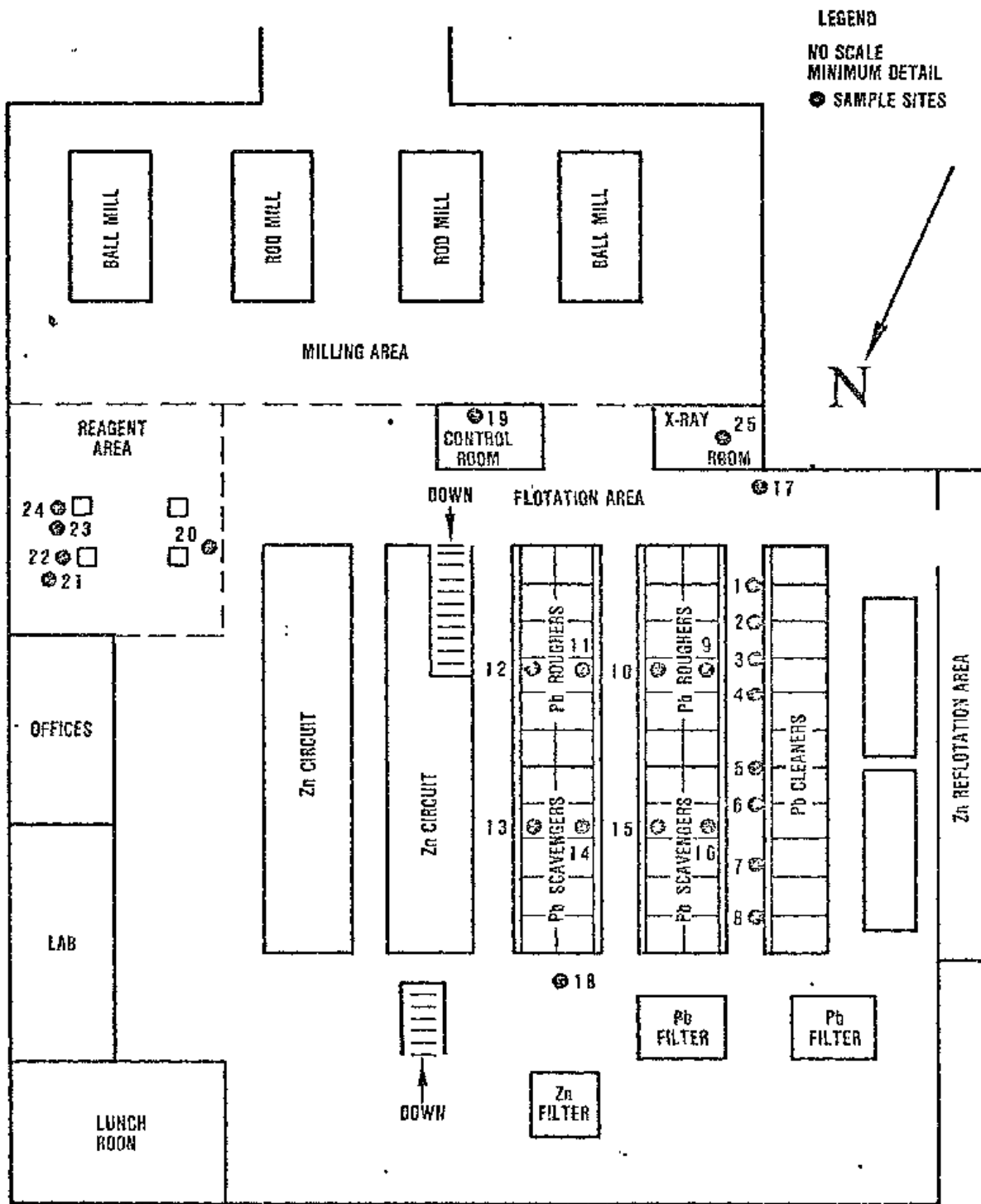


Table 2
Area Samples - Air Concentration (mg/m³)

Area	Sample Site	Contaminant	2-11-82	*2-11-82	2-12-82	Mean
Recleaner	1	Lead	0.333	0.698	0.380	0.470
Flotation	2	"	0.536	0.769	0.707	0.670
Cells	3	"	-	4.260	3.913	4.086
	4	"	0.298	0.583	0.989	0.623
Mean			0.389	1.577	1.497	1.224
Cleaner	5	Lead	0.952	1.354	0.924	1.077
Flotation	6	"	0.405	0.689	2.935	1.343
Cells	7	"	4.488	3.995	0.696	3.060
	8	"	3.372	2.766	0.826	2.321
Mean			2.304	2.201	1.345	1.950
Rougher	9	Lead	0.198	0.166	0.262	0.209
Flotation	10	"	0.209	0.223	0.283	0.238
Cells	11	"	0.302	0.389	0.870	0.520
	12	"	0.198	0.213	0.935	0.449
Mean			0.227	0.248	0.588	0.354
Scavenger	13	Lead	0.114	0.155	0.315	0.195
Flotation	14	"	0.128	0.106	0.261	0.165
Cells	15	"	0.078	0.168	0.004	0.083
	16	"	0.198	0.170	0.207	0.192
Mean			0.129	0.150	0.197	0.159
General	17	Lead	0.114	0.191	0.141	0.149
Flotation	18	"	0.102	0.106	0.118	0.109
Cell Area						
Mean			0.108	0.148	0.129	0.129
Control Room	19	Lead	0.025	0.024	0.059	0.036
Assay Room	25	Lead	0.007	0.024	0.020	0.014
Reagent Area	20	Total Dust	0.42	-	0.47	0.45
Cyanide Water	21	Cyanide	0.006	-	0.006	0.006
Spike	22	"	0.006	-	0.006	0.006
Mean			0.006	-	0.006	0.006
Xanthate Water	23	Carbon Disulfide	0.92	-	1.23	1.08
Spike	24	" "	1.16	-	1.25	1.22
Mean			1.04	-	1.24	1.14

*Second Shift

level. Area samples collected for lead at the cleaner flotation cells ranged in concentration from 0.405 mg/m³ at site 6 to 4.488 mg/m³ at site 7 with an average concentration for the 12 samples collected over the three-shift period of 1.95 mg/m³. None of the 12 samples were below the MSHA Standard or the NIOSH recommended level. The average concentration for the 12 samples of 1.95 mg/m³ is approximately 13 times the MSHA Standard and 19 times the NIOSH recommended level. Area samples collected for lead at the recleaner flotation cells ranged in concentration from 0.298 mg/m³ at site 4 to 4.260 mg/m³ at site 3 with an average concentration for the 11 samples collected over the three-shift period of 1.224 mg/m³. None of the 11 samples were below the MSHA Standard or NIOSH recommended level. The average concentration for the 11 samples of 1.224 mg/m³ is approximately 8 times the MSHA Standard and 12 times the NIOSH recommended level. Area samples collected for lead in the general flotation cell area ranged in concentration from 0.102 mg/m³ at site 18 to 0.191 mg/m³ at site 17 with an average concentration for the 6 samples collected over the three-shift period of 0.129 mg/m³. Five of the six samples were below the MSHA Standard and none were below the NIOSH recommended level. The average concentration for the 6 samples of 0.129 mg/m³ is approximately 86 per cent of the MSHA Standard and 129 per cent of the NIOSH recommended level. The two area samples collected for lead in the assay room averaged 0.014 mg/m³ and were well below the MSHA Standard and the NIOSH recommended level. The three area samples collected for lead in the control room averaged 0.036 mg/m³ and were well below the MSHA Standard and NIOSH recommended level. The two area samples collected for total dust in the reagent area averaged 0.45 mg/m³ and were well below the MSHA Standard. The four area samples collected for particulate cyanide at the cyanide "water spike" averaged 0.006 mg/m³ and were well below the MSHA Standard of 5 mg/m³. Area samples collected for carbon disulfide at the xanthate "water spike" ranged in concentration from 0.92 mg/m³ at site 23 to 1.25 mg/m³ at site 24 with an average concentration for the 4 samples collected over the three-shift period of 1.14 mg/m³. All 4 of the samples were well below the MSHA Standard of 60 mg/m³ and the NIOSH recommended level of 3 mg/m³.

DISCUSSION

The use of a ventilated starch mixing tank equipped with a polypropylene lined dump chute to minimize the quantity of total dust escaping into the general work area atmosphere is effective in preventing harmful exposure levels. The two area samples collected for total dust at the starch mixing tank chute opening averaged 0.45 mg/m³ and were well below the MSHA Standard. The cleaner and recleaner flotation cell covers were not effective in reducing the quantity of mist escaping into the general work area atmosphere to an acceptable level. None of the 24 samples taken at the edge of the covers were below the MSHA Standard or NIOSH recommended level. The average concentrations for all eight sites were above the MSHA Standard for each of the three shifts sampled. The average concentration for the 12 cleaner cell samples taken over a three-shift period of 1.95 mg/m³ is approximately 13 times the MSHA Standard of 0.15 mg/m³ and 19 times the NIOSH recommended level of 0.10 mg/m³. The average concentration for the 12 recleaner cell samples taken over a three-shift period of 1.224 mg/m³ is approximately 8 times the MSHA

Standard and 12 times the NIOSH recommended level. Although neither the cleaner nor the recleaner cell covers were effective in preventing unacceptable lead levels the sampling results indicate the full cell cover (recleaner) is more effective than the partial cell cover (cleaner). Even with the pulp lead percentage at 75-76 in the recleaner cells and 72-74 in the cleaner cells the average concentration for all recleaner samples was 1.224 mg/m³ compared to 1.95 mg/m³ for the cleaner samples. The rougher and scavenger flotation cell covers were moderately effective in reducing the quantity of mist escaping into the general work area atmosphere. The average concentration for the 12 rougher cell samples was 0.354 mg/m³ compared to the 12 recleaner cell samples 1.224 mg/m³. This can be partially attributed to the pulp lead level of 70-72 per cent in the rougher cells and 75-76 per cent in the recleaner cells. The average concentration for the 12 scavenger cell samples was 0.159 mg/m³ or 106 per cent of the MSHA Standard and 159 per cent of the NIOSH recommended level. Five of the 12 samples were below the MSHA Standard and two were below the NIOSH recommended level.

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 Reagent Operator working in the reagent area had an average carbon disulfide (xanthate decomposition product) exposure of 1.31 mg/m³ and an average cyanide exposure of 0.007 mg/m³ for the two shifts sampled. This concentration for carbon disulfide is two per cent of the MSHA Standard and 44 per cent of the NIOSH recommended level and for cyanide is less than one per cent of the MSHA Standard. The 4 area samples collected for particulate cyanide at the cyanide "water spike" averaged 0.006 mg/m³ and were well below the MSHA Standard of 5 mg/m³. Area samples collected for carbon disulfide at the xanthate "water spike" averaged 1.14 mg/m³ and were well below the MSHA Standard of 60 mg/m³ and NIOSH recommended level of 3 mg/m³.

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 0.036 mg/m³ which is 24 and 36 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 0.100 mg/m³ for the three shifts sampled. This concentration is 67 per cent of the MSHA Standard and equal to the NIOSH recommended level.