IN-DEPTH SURVEY REPORT

OF

St. Joe Minerals Corporation
Viburnbum, 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 benefication operation.

EMPLOYER REPRESENTATIVES:

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ANALYSIS PERFORMED BY: DPSE, NIOSH
UBTL - Salt Lake City, Utah

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 St. Joe Minerals Brushy Creek mill in Viburnum, Missouri. The flotation process beneficiates over 5000 tons per day of a complex sulfide ore containing an average of four to five 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 74 per cent with a normal lead recovery of 98 per cent. The rougher, 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 rougher flotation cell covers, covered cleaner and recleaner flotation cells and launders, and the use of a centralized flotation process control room. Environmental concentration results indicated the rougher flotation cell covers were ineffective, the covered cleaner and recleaner flotation cells and launders were moderately effective, and the centralized control room was 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 covers to minimize the quantity of mist escaping into the general work area atmopshere (Figures 3 and 4).

2. Cleaner and recleaner flotation cell and launder covers to minimize the quantity of mist escaping into the general work area atmosphere (Figures3 and 5).

3. 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 1973 at the St. Joe Minerals Corporation's Brushy Creek operation. An average of 5000 tons of ore, averaging four to five per cent lead, is processed per day. The lead flotation process includes a bank of eight 120-inch Wemco rougher cells, four 66-inch cleaner cells, and four 66-inch recleaner 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 163 employees at the Brushy Creek operation, 20 are employed in the mill, with the remaining employees being underground, maintenance, office and staff personnel. The mill or beneficiation operations and supporting functions are housed in a one-floor sheet metal building containing approximately 40,000 square feet of floor space.

PROCESS DESCRIPTION

The Brushy Creek mill abuts a 1,000-ton capacity skip bin housed in the headframe of the ore hoisting shaft. The skip bin then becomes the feed end of the plant in a unique combination of underground primary crushing, ore hoisting, and concentration. Between the skip bin discharge and the secondary crusher, located inside the mill at the grinding bay, there is less than 40 feet of conveyor footage. In the entire mill, there is less than 150 feet of conveyor. Storage capacity for the plant is maintained underground.

The bulk reagent storage and mix room and a truck cargo receiving dock flank one side of the skip bin. The entire arrangement is highly utilitarian, resulting in a compactness of layout that lends itself to ease of supervision

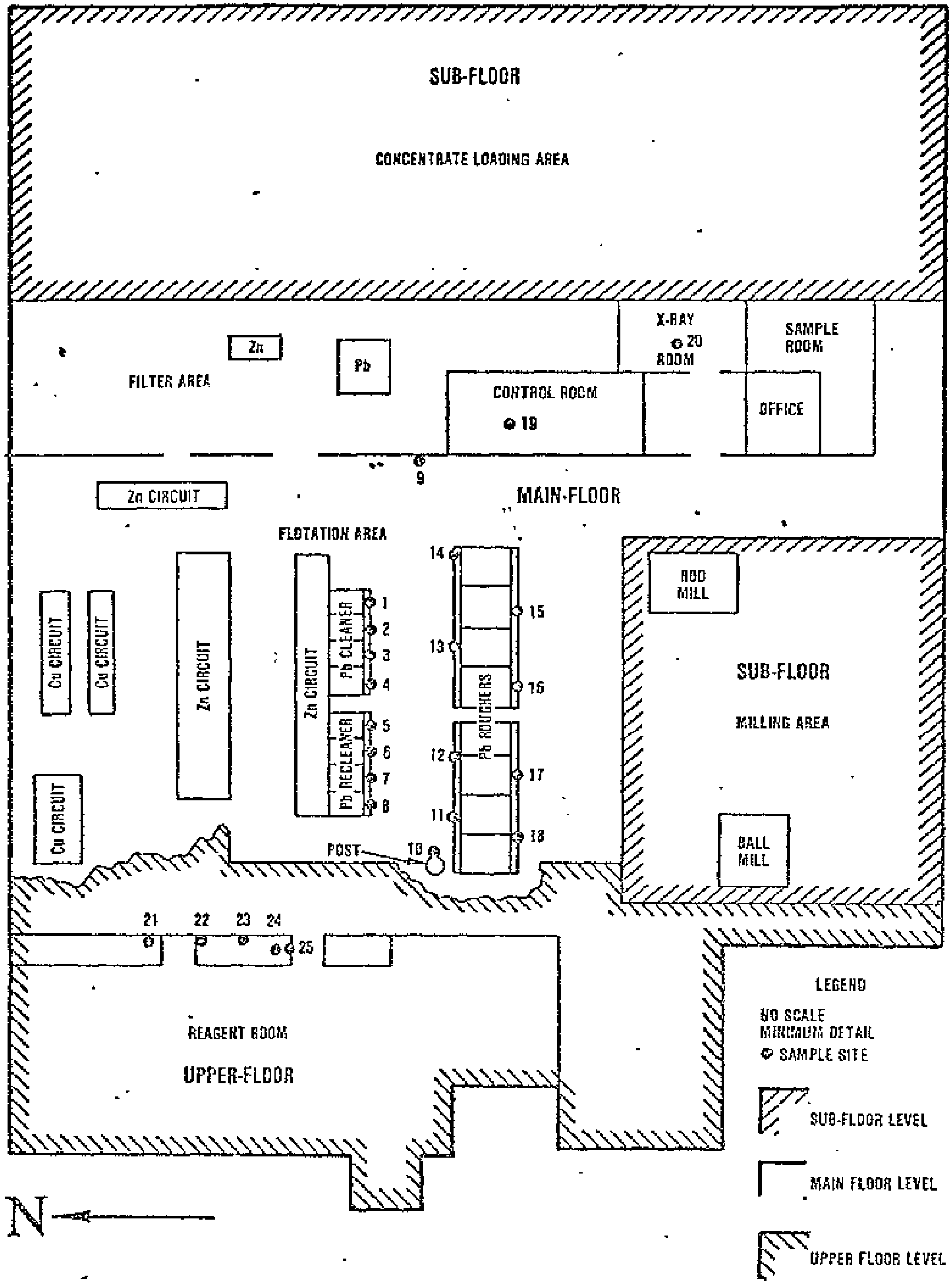

Figure 1 - Floor Plan of the Beneficiation Operations

and control by mill operators. The secondary screening and crushing, rod and ball milling, and all flotation circuits are grouped on a single floor. The central control room and console are positioned to provide operators with a panoramic view of the system, from secondary screening and crushing through filtration (Figure 1).

Ore from the skip bin is crushed to minus one inch by a Allis Chalmers 1084 "Hydrocone" crusher, then conveyed directly to the open-circuit 11 by 16 foot, Allis Chalmers rod mill and mixed with water to form a 73 per cent solids slurry (Figure 2). The rod mill discharge is then pumped to a battery of four Krebs D2 OL cyclones, where the underflow is routed to a Allis Chalmers 13 by 14 foot ball mill operating in closed circuit with the cyclones. The product of the grinding circuit is a slurry containing 50 per cent minus 200-mesh and 5 per cent plus 48-mesh ore.

The grinding circuit product flows by gravity to a bank of eight 120-inch Wemco roughers to bulk-float the lead and copper while depressing the zinc and gangue. These rougher cells are equipped with covers to minimize the quantity of mist escaping into the general work area atmopshere (Figures 3 and 4). The lead-copper rougher froth is pumped to two further banks of four-cell, 66-inch cleaners, then to a lead-copper separation circuit, where lead is depressed and copper is recovered as froth. These cleaner and recleaner cells are equipped with cell and launder covers to minimize the quantity of mist escaping into the general work area atmosphere (Figures 3 and 5). The lead concentrate is pumped to a thickener, then to a 10-foot 6-inch-diameter, 8-disc vacuum filters, before it is conveyed to 10-ton containers on automatic indexing turntables. The lead concentrate, containing about 5 per cent water at this point, is transported by truck to St. Joe's Herculaneum smelter.

The flotation circuits produce approximately a 74 per cent lead concentrate with 98 per cent total lead recovery. Flotation parameters are adjusted in accordance with the readout of the mill's onstream ARL X-ray analyzer, working with a 2114B analog computer. The analyzer continuously monitors seven different sample streams for data on the composition of the feed, concentrates, and tailings.

The Brushy Creek mill uses a variety of reagents in the flotation process to recover the valuable minerals. 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:

Xanthate 343	-	Promoter for copper, lead and zinc sulfide minerals.
Frother 71	-	Frothing agent used to create stable bubbles capable of carrying the sulfide mineral to the surface.
Sodium Cyanide	-	Depressant for iron sulfide minerals.
Zinc Sulfate	-	Depressant for sphalerite.

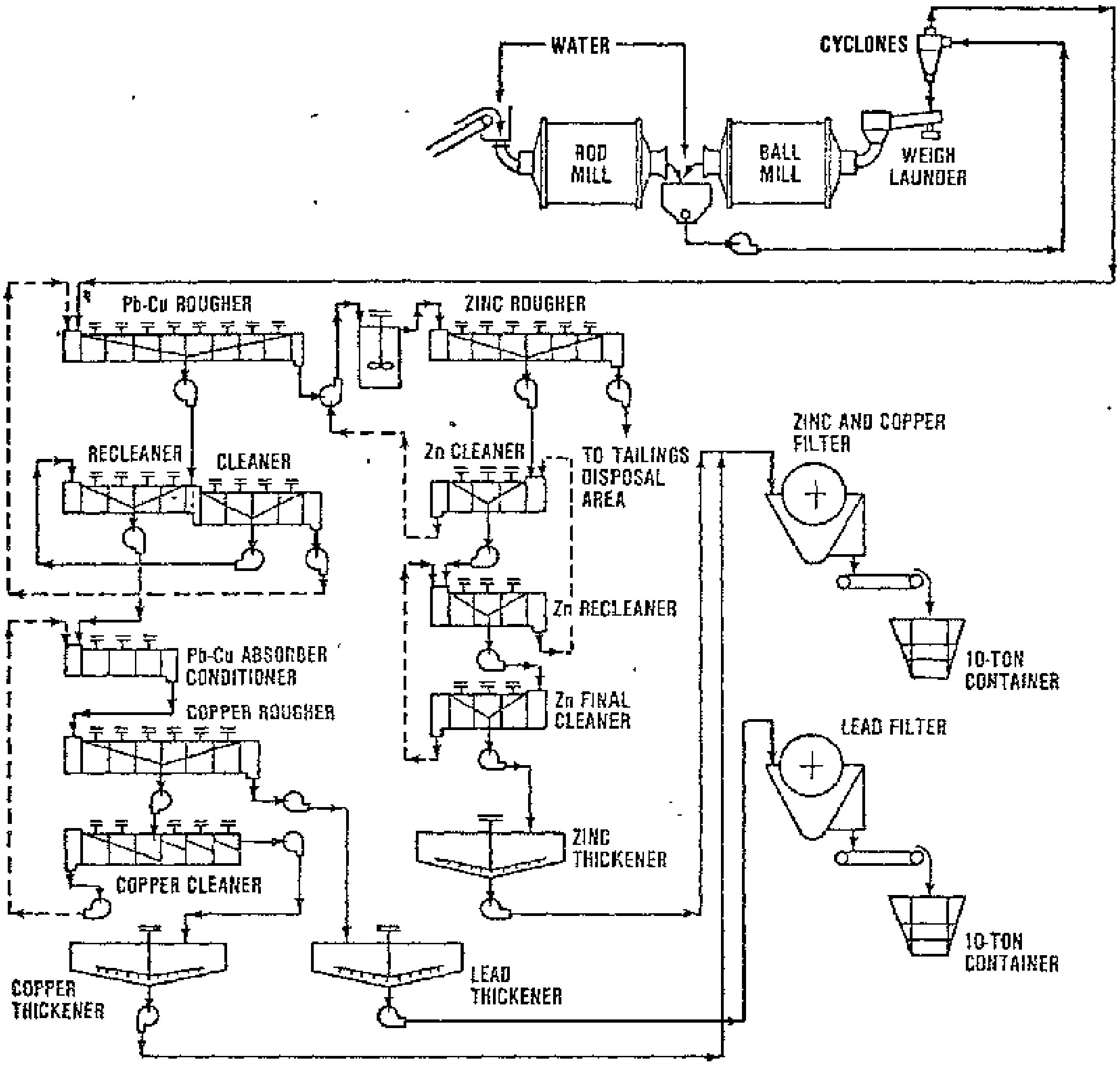

Figure 2 - Ore Beneficiation Process Flow

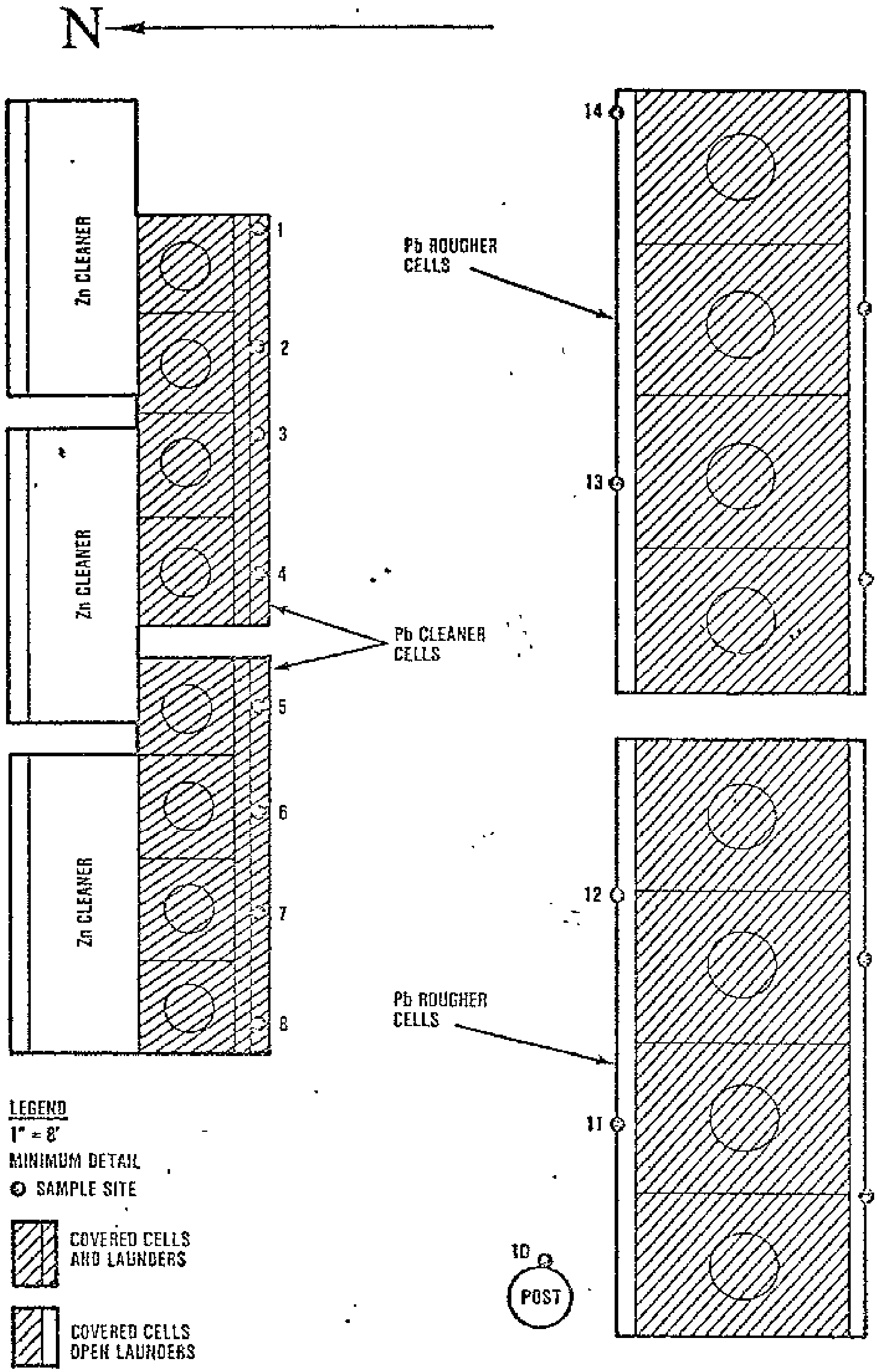

Figure 3 - Flotation Cell and Launder Covers

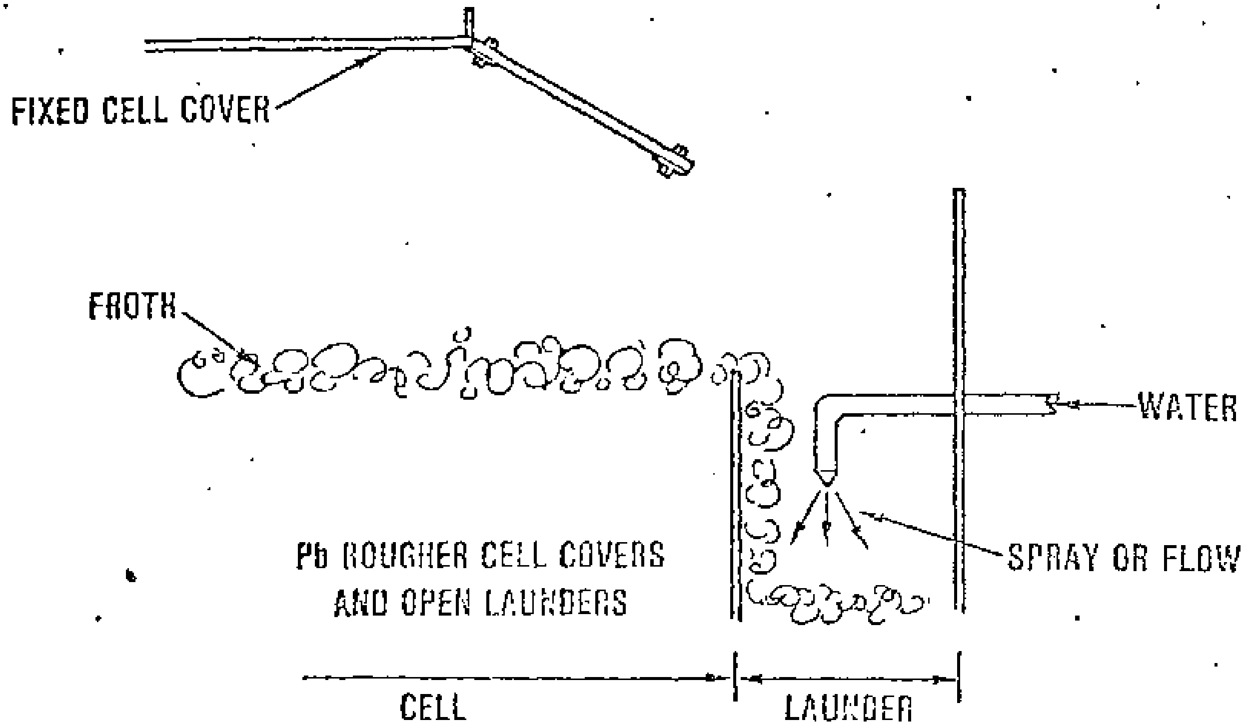

Figure 4 - Rougher Cell Covers

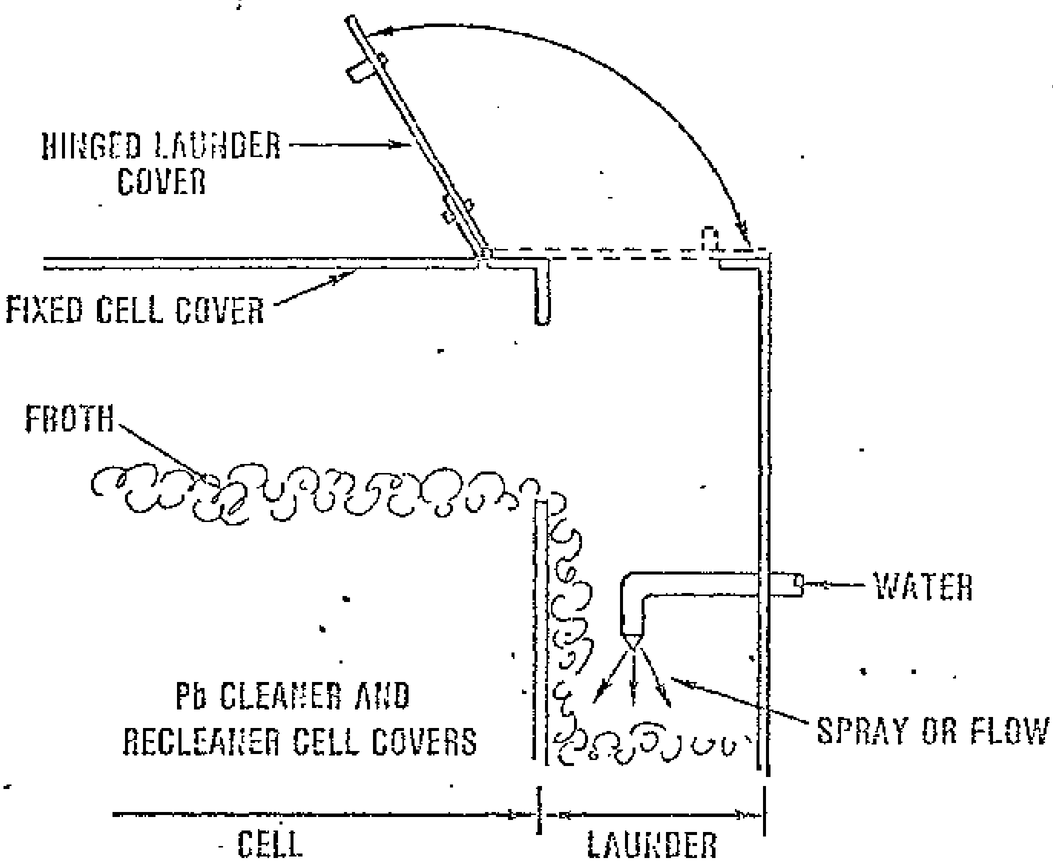

Figure 5 - Cleaner and Recleaner Cell and Launder Covers

Starch	-	A depressant used to control slime lead in the copper-lead separation.
Sulfur Dioxide	-	Used in copper-lead separation. Copper activator and lead depressant.
Sodium Dichromate	-	A depressant of lead used in the copper cleaners.
Caustic Soda	-	A dispersant used for preparation fo the starch in the copper-lead separation.
Sulfuric Acid	-	A leaching agent to remove dolomite from the copper-lead concentrate.
Copper Sulfate	-	Activator of sphalerite used in the zinc circuit.
Alkyl Sulfonate (Aerodi 104)	-	A drying aid used to control the moisture content of the concentrates.

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. 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 the workshift on three shifts in two days. Breathing zone samples for lead were collected on the Sampler, Concentrator Operator, Concentrator Operator Helper and General 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 and cleaner flotation cells, in the general flotation 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 0.114 mg/m^3 for lead, 2.14 mg/m^3 for carbon disulfide, and 0.007 mg/m^3 for cyanide. Flotation cell, reagent area and general area sampling sites are shown in Figures 6, 7, and 8.

The Sampler employee working in the sample room and collecting samples from various locations throughout the beneficiation operation had an average lead exposure of 0.105 mg/m^3 for the two shifts sampled. This concentration is 70 per cent of the MSHA Standard of 0.15 mg/m^3 and 105 per cent of the NIOSH recommended level of 0.1 mg/m^3. The Concentrator Operator working in the control room and flotation cell area had an average lead exposure of 0.045 mg/m^3 for the three shifts sampled. This concentration is 30 per cent of the MSHA Standard and 45 per cent of the NIOSH recommended level. The Concentrator Operator Helper working in the control room and flotation cell area had an average lead exposure of 0.149 mg/m^3 for the three shifts sampled. This concentration is equal to the MSHA Standard and 149 per cent of the NIOSH recommended level. This employee's exposure ranged up to 0.269 mg/m^3 or 180 and 269 per cent respectively, of the MSHA Standard and NIOSH recommendation. The General Helper working throughout the beneficiation operation had an average lead exposure of 0.230 mg/m^3 for the three shifts sampled. This concentration is 153 per cent of the MSHA Standard and 230 per cent of the NIOSH recommended level. The Reagent Operator working in the reagent area had an average carbon disulfide exposure of 2.14 mg/m^3 and an average cyanide expousre of 0.007 mg/m^3 for the three shifts sampled. This concentration for carbon disulfide is 4 per cent of the MSHA Standard and 71 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	Cyanide
Sampler	2-09-82	0.079		
	2-10-82	0.130		
Mean		0.105		
Concentrator Operator	2-09-82	0.028		
	*2-09-82	0.046		
	2-10-82	0.062		
Mean		0.045		
Concentrator Operator Helper	2-09-82	0.053		
	*2-09-82	0.269		
	2-10-82	0.126		
Mean		0.149		
General Helper	*2-09-82	0.230		
Reagent Operator	2-09-82		2.40	0.007
	2-10-82		1.87	0.006
Mean			2.14	0.007
Grand Mean		0.114	2.14	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

*Second Shift
**Ceiling averaged over a 10-minute period

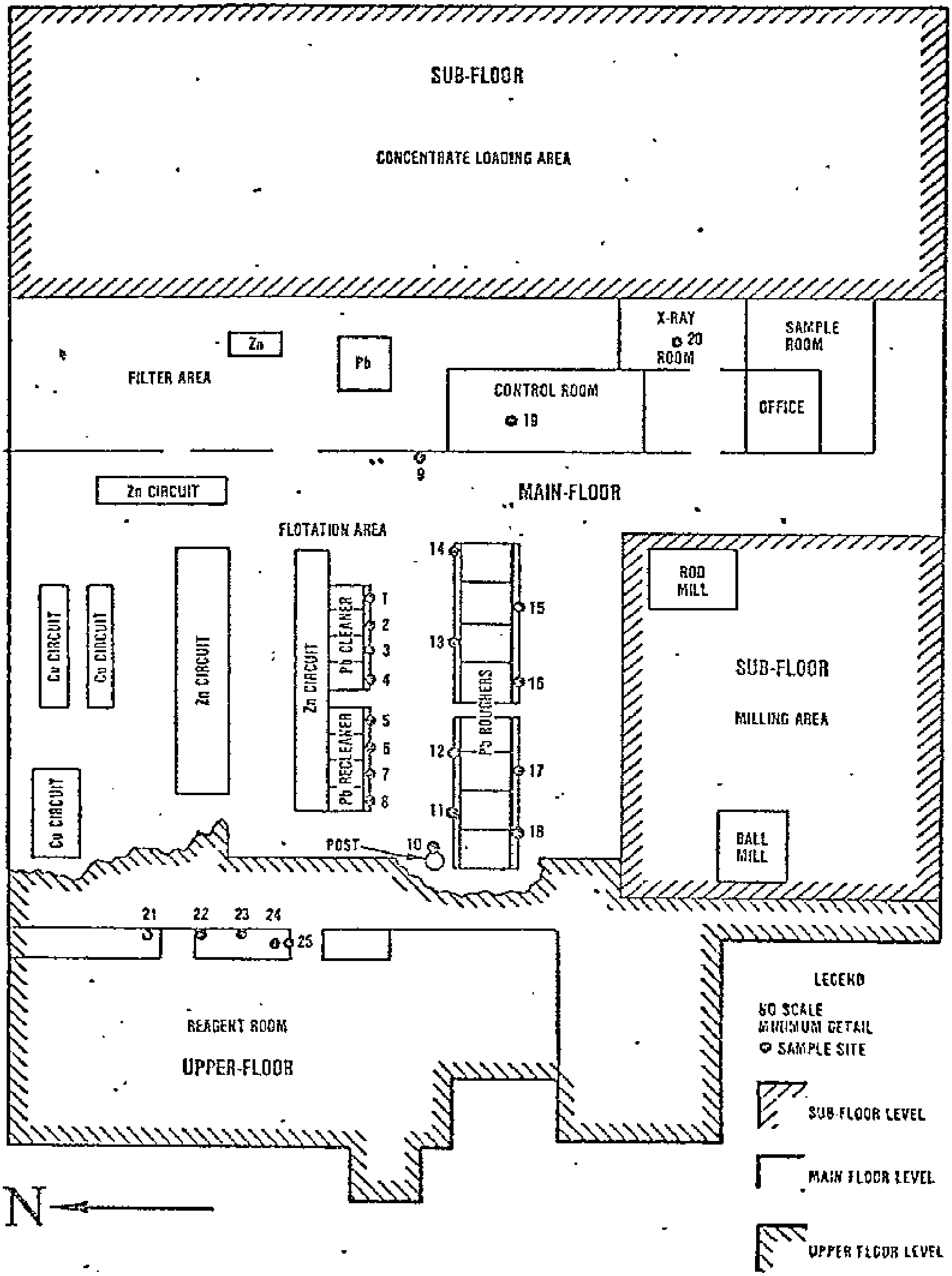

Figure 6 - Total Area Sampling Sites

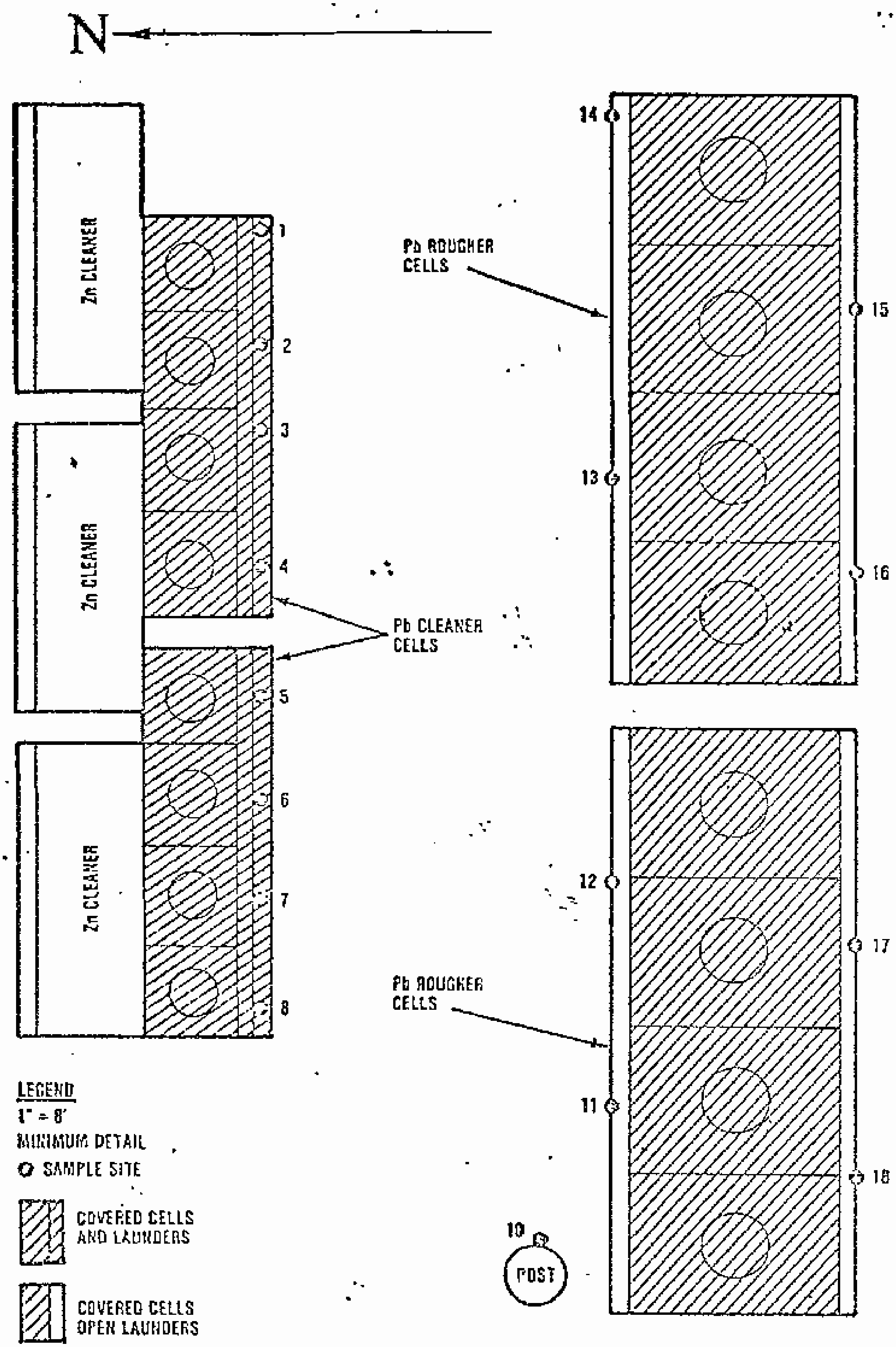

Figure 7 - Flotation Cell Sampling Sites

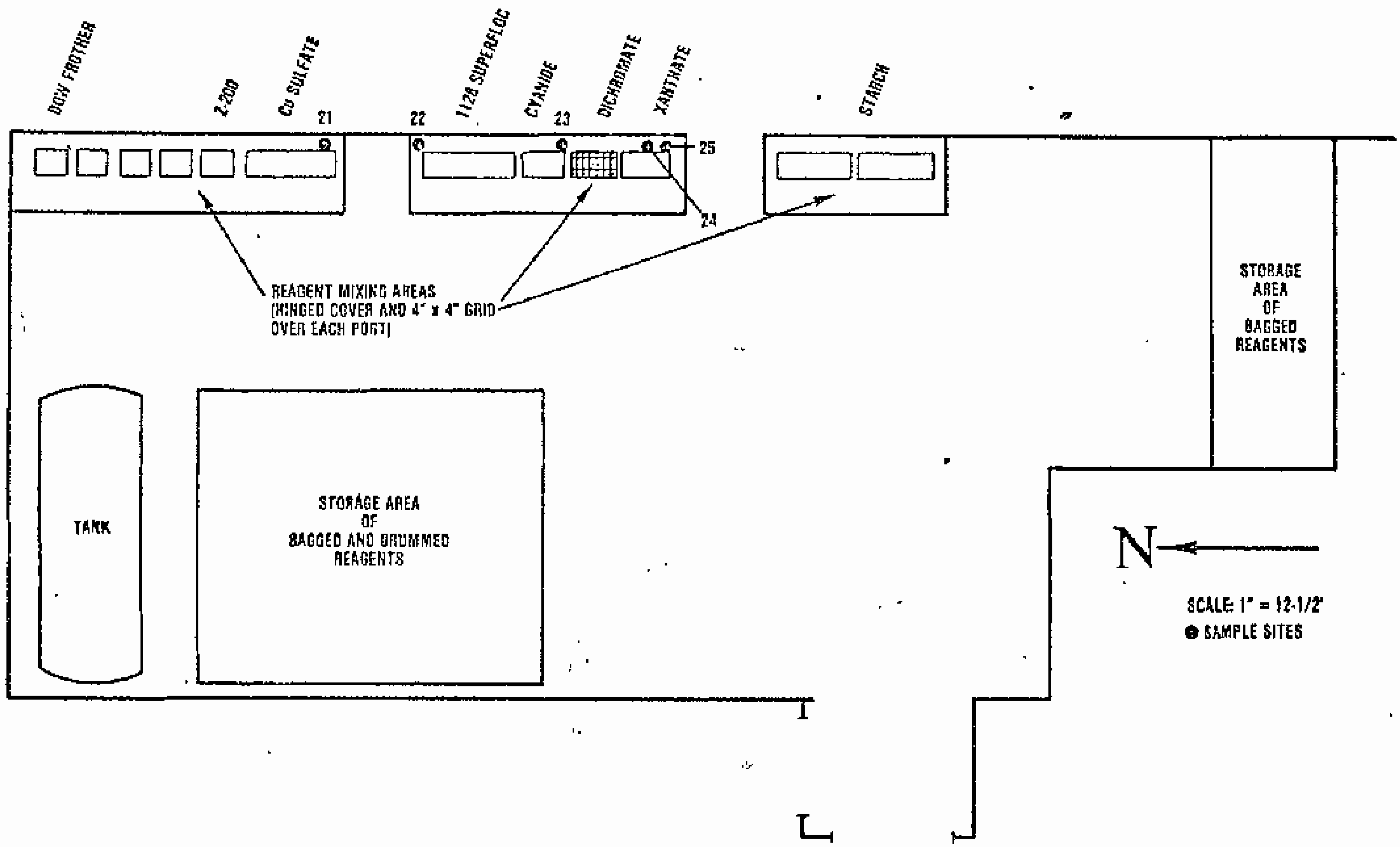

Figure 8 - Reagent Area Sampling Sites

Area samples are shown in Table 2 for lead collected near the rougher, cleaner, and recleaner flotation cells, general flotation cell area, assay room, and control room, total dust collected in the reagent area, cyanide collected in the cyanide handling area, and carbon disulfide collected in the xanthate handling area. Concentrations of samples collected at the rougher flotation cells ranged from 0.124 mg/m^3 at site 14 to 2.022 mg/m^3 at site 12 with an average concentration for the 24 samples of 0.493 mg/m^3. Only 1 of 24 samples was below the MSHA Standard of 0.15 mg/m^3 and none of the samples were 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 shifts sampled. The average concentration for the 24 samples of 0.493 mg/m^3 is approximately 3 times the MSHA Standard and 5 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 cleaner flotation cells ranged in concentration from 0.107 mg/m^3 at site 1 to 0.250 mg/m^3 at site 4 with an average concentration for the 12 samples collected over the three-shift period of 0.177 mg/m^3. Only three of the twelve samples were below the MSHA Standard and none being below the NIOSH recommended level. The average concentration for 12 samples of 0.177 mg/m^3 is approximately 118 per cent of the MSHA Standard and 177 per cent of the NIOSH recommended level. Area samples collected for lead at the recleaner flotation cells ranged in concentration from 0.131 mg/m^3 at site 7 to 0.545 mg/m^3 at site 5 with an average concentration for the 12 samples collected over the three-shift period of 0.253 mg/m^3. Three of the 12 samples were below the MSHA Standard and none were within the NIOSH recommended level. The average concentration for the 12 samples of 0.253 mg/m^3 is approximately 169 per cent of the MSHA Standard and 253 per cent of the NIOSH recommended level. Area samples collected for lead in the general flotation cell area ranged in concentration from 0.082 mg/m^3 at site 10 to 0.167 mg/m^3 at site 9 with an average concentration for the 6 samples collected over the three-shift period of 0.122 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 6 samples of 0.122 mg/m^3 is approximately 81 per cent of the MSHA Standard and 122 per cent of the NIOSH recommended level. The three area samples collected for lead in the assay room averaged 0.008 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 0.014 mg/m^3 and were well below the MSHA Standard and NIOSH recommended level. The two area samples collected for total dust in the reagent area averaged 0.41 mg/m^3 and were well below the MSHA Standard. The four area samples collected for particulate cyanide in the cyanide handling area averaged 0.006 mg/m^3 and were well below the MSHA Standard of 5 mg/m^3. Area samples collected for carbon disulfide in the xanthate handling area had an average concentration for the 2 samples collected during one shift of 1.92 mg/m^3. Both samples were well below the MSHA Standard of 60 mg/m^3 and the NIOSH recommended level of 3 mg/m^3.

Table 2

Area Samples - Air Concentration (mg/m3)

Area	Sample Site	Contaminant	1st Shift 2-09-82	2nd Shift *2-09-82	1st Shift 2-10-82	Mean
Cleaner	1	Lead	0.107	0.107	0.205	0.140
Flotation	2	"	0.164	0.148	0.193	0.168
Cells	3	"	0.152	0.231	0.193	0.192
	4	"	0.177	0.200	0.250	0.209
Mean			0.150	0.172	0.210	0.177
Recleaner	5	Lead	0.290	0.522	0.545	0.452
Flotation	6	"	0.132	0.156	0.366	0.218
Cells	7	"	0.131	0.178	0.215	0.175
	8	"	0.135	0.156	0.205	0.165
Mean			0.172	0.253	0.333	0.253
Rougher	11	Lead	0.152	0.167	0.225	0.181
Flotation	12	"	1.613	0.679	2.022	1.444
Cells	13	"	0.323	0.384	0.472	0.393
	14	"	0.124	0.156	0.202	0.161
	15	"	0.222	0.292	0.444	0.319
	16	"	0.734	0.955	0.270	0.653
	17	"	0.359	0.377	0.555	0.430
	18	"	0.453	0.443	0.222	0.373
Mean			0.495	0.434	0.551	0.493
General	9	Lead	0.122	0.125	0.167	0.138
Flotation	10	"	0.082	0.144	0.093	0.106
Cell Area						
Mean			0.102	0.134	0.130	0.122
Control Room	19	Lead	0.006	0.016	0.019	0.014
Assay Room	20	Lead	0.006	0.011	0.008	0.008
Reagent Area	21	Total Dust	0.43	-	0.39	0.41
Cyanide	22	Cyanide	0.007	-	0.006	0.006
Handling Area	23	"	0.007	-	0.006	0.006
Mean			0.007	-	0.006	0.006
Xanthate	24	Carbon Disulfide	1.57	-	-	1.57
Handling Area	25	" "	2.28	-	-	2.28
Mean			1.92	-	-	1.92

*Second Shift

DISCUSSION

The rougher flotation cell covers are not effective in reducing the quantity of lead-containing mist generated to an acceptable level. Only one of 24 samples taken at the rougher cells were below the MSHA Standard and none were below the 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 24 samples taken over a three-shift period of 0.493 mg/m^3 is approximately 3 times the MSHA standard of 0.15 mg/m^3 and 5 times the NIOSH recommended level of 0.10 mg/m^3.

The cleaner and recleaner flotation cell and launder covers are moderately effective in minimizing the quantity of mist escaping into the general work area atmosphere. Three of the 12 samples taken at the cleaner cells and three of the 12 samples taken at the recleaner cells were below the MSHA Standard. The average concentration for the 12 cleaner cell samples was 0.177 mg/m^3 which is 118 per cent of the MSHA Standard and 177 per cent of the NIOSH recommended level. The average concentration for the 12 recleaner cell samples was 0.253 mg/m^3 which is 169 per cent of the MSHA Standard and 253 per cent of the NIOSH recommended level. The greater average concentration in the recleaner cell samples may be attributable to the higher pulp lead level in these cells.

The use of an isolated, enclosed, air-conditioned flotation cell control room is effective in reducing the potentially harmful lead exposure levels for the Concentrator Operator. The three area samples collected for lead in the control room averaged 0.014 mg/m^3 which is 9 and 14 per cent respectively of the MSHA Standard and NIOSH recommended level. The Concentrator Operator working in the control room and flotation cell area had an average lead exposure of 0.045 mg/m^3 for the three shifts sampled. This concentration is 30 per cent of the MSHA Standard and 45 per cent of the NIOSH recommended level.