U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

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HEALTH HAZARD EVALUATION
PROJECT NO. HE 78-98-710

GLOBE UNION BATTERY PLANT
BENNINGTON, VERMONT

JULY 1980

I. SUMMARY

In May 1978, the National Institute for Occupational Safety and Health (NIOSH) was asked to evaluate possible lead poisoning in lead-acid battery fabricators at the Globe Union Corporation, Bennington, Vermont. To study symptoms and exposures, NIOSH conducted industrial hygiene, control technology and medical evaluations. Personal and area air samples were obtained to measure lead, arsenic, antimony, sulfuric acid, arsine, stibine, and benzene-soluble polynuclear aromatic hydrocarbons (PNAH). Blood lead, erythrocyte protoporphyrin (EP), urine arsenic, and blood urea nitrogen (BUN) concentrations were determined.

Lead concentrations in 35 (10%) of 342 personal (breathing zone) air samples equaled or exceeded the previous OSHA standard of 200 $\mu g/M^3$; 93 (27%) equaled or exceeded the NIOSH recommended standard of 100 $\mu g/M^3$, and 172 (50.3%) equaled or exceeded the new OSHA standard of 50 $\mu g/M^3$. Arsenic concentrations in 5 (1.5%) of 344 samples equaled or exceeded the OSHA standard of 10 $\mu g/M^3$, and 13 (3.8%) equaled or exceeded the NIOSH recommended standard of 2 $\mu g/M^3$. Occupational exposure to PNAH was demonstrated. No excessive exposures were found for any other substances.

Although the installed ventilation met recommended design values, numerous specific flaws in ventilation were detected. Few hazardous personal habits were noted in 135 hours of videotape analysis.

Blood lead concentrations of 60 $\mu g/dl$ or above were found in 19 (13.3%) of 143 workers; 63 (44%) had levels of 40-59 $\mu g/dl$. In workers most heavily exposed, a positive correlation was observed between air and blood lead levels ($r = 0.24$, $p = 0.054$; $n = 44$). EP values above 100 $\mu g/dl$ whole blood were found in 56 (41%) workers and correlated ($r = 0.77$) with blood lead levels.

Urine arsenic concentrations of 50 μg/liter or above were found in 53 (43%) of 122 workers; 11 (9.0%) had concentrations of 100 μg/liter or above. A positive correlation was found between air and urine arsenic concentrations ($r = 0.25$, $p = 0.01$, $n = 86$).

Elevated BUN levels, 22 $\mu g/dl$ or above, were found in 21 (14.7%) of 143 workers. No more than 3 to 4 such values would have been expected. Certain workers may have lead-induced kidney disease.

NIOSH concluded that a hazard of exposure to airborne lead and arsenic existed at the Globe Union Corporation, Bennington, Vermont. Recommendations on ventilation, work practices and medical surveillance to control these hazards are incorporated on pages 37-40. Further evaluations of kidney status and urine arsenic levels may be required in certain workers.

II. INTRODUCTION

On May 20, 1978, the United Automotive, Aerospace, and Agricultural Implement Workers Union (UAW) requested that the National Institute for Occupational Safety and Health (NIOSH) evaluate worker exposure to lead and other substances at the Globe Union lead battery plant, Bennington, Vermont. In response to that request, a NIOSH industrial hygienist, a NIOSH regional program consultant, a Center for Disease Control physician, and a representative of the Vermont Department of Health met in Bennington on August 2-3, 1978 with the Regional International Union Representatives, the local Union President, the Globe Union Manager for Health, Safety, and Environment and local Globe Union Management and conducted an initial walk-through inspection of the facility.* Microfilm copies of pertinent company medical records and informal smoke tests to determine the operational status of engineering control systems were made during this visit. Subsequently, management was asked to furnish additional data concerning plant operations.

Because of the extensive sampling anticipated, a further familiarization meeting was held in Bennington on December 14-15, 1978. NIOSH, UAW, and Globe Union representatives attended. In December 1978, NIOSH developed a draft sampling protocol. Representatives of labor and management met at NIOSH headquarters in Cincinnati, January 10, 1979 to review that protocol and to finalize evaluation plans. On January 26, 1979 a NIOSH representative and the Regional International Union Representative visited Bennington to brief union and management personnel on sampling procedures and to answer general questions.

Environmental and medical sampling, video taping and testing of the ventilation system were conducted at the plant from January 29 - February 2, 1979. Nine Globe Union Health and Safety Specialists, Corporate Personnel and Consultants acted as observers throughout the sampling period. A UAW industrial hygienist reviewed procedures on February 2. A closing conference was held on February 2, 1979 with representatives of labor and management. Results of a previous evaluation of the plant have been released to interested parties via a report published by the Center for Disease Control EPI-78-66-2 (December 14, 1979).[1]

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*Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance in the place of employment might have potentially toxic effects as it is used or found.

III. BACKGROUND

The Bennington Plant has been in operation since 1965 and has approximately 140,000 square feet of production area. It was originally designed to produce 2,000 - 3,000 batteries per day but, with certain process changes, has experienced peak production periods of up to 7,000 batteries per day. The plant employs approximately 230 production workers on three shifts. The process description (Figure 1) is as follows:

Grid Casting - In this 1,900 square foot area, purchased lead, which contains antimony, is fed into six melt furnaces. This area is isolated from the general plant area by swinging doors. The molten lead is poured into grid molds in a localized non-oxidizing atmosphere. The grids are fed out and are manually stacked on pallets to be transferred to the pasting area. Once per shift each machine operator skims the impurities (dross) from the top of the molten lead in his machine.

Remelt - Scrap lead is gathered throughout the plant and fed into a melt furnace. This lead is poured and formed into pigs to be used in grid casting. The furnace is drossed to remove impurities. Also present in the scrap area is a scrap plate reprocessor into which scrap containing lead and lead oxide is fed. The lead and lead oxide are separated and recovered.

Small Parts Casting - Purchased lead, containing antimony, and reclaimed lead is fed into a small furnace. Molten lead is manually poured into molds for production lead pieces to be used in the Tiegel burn area for specific applications.

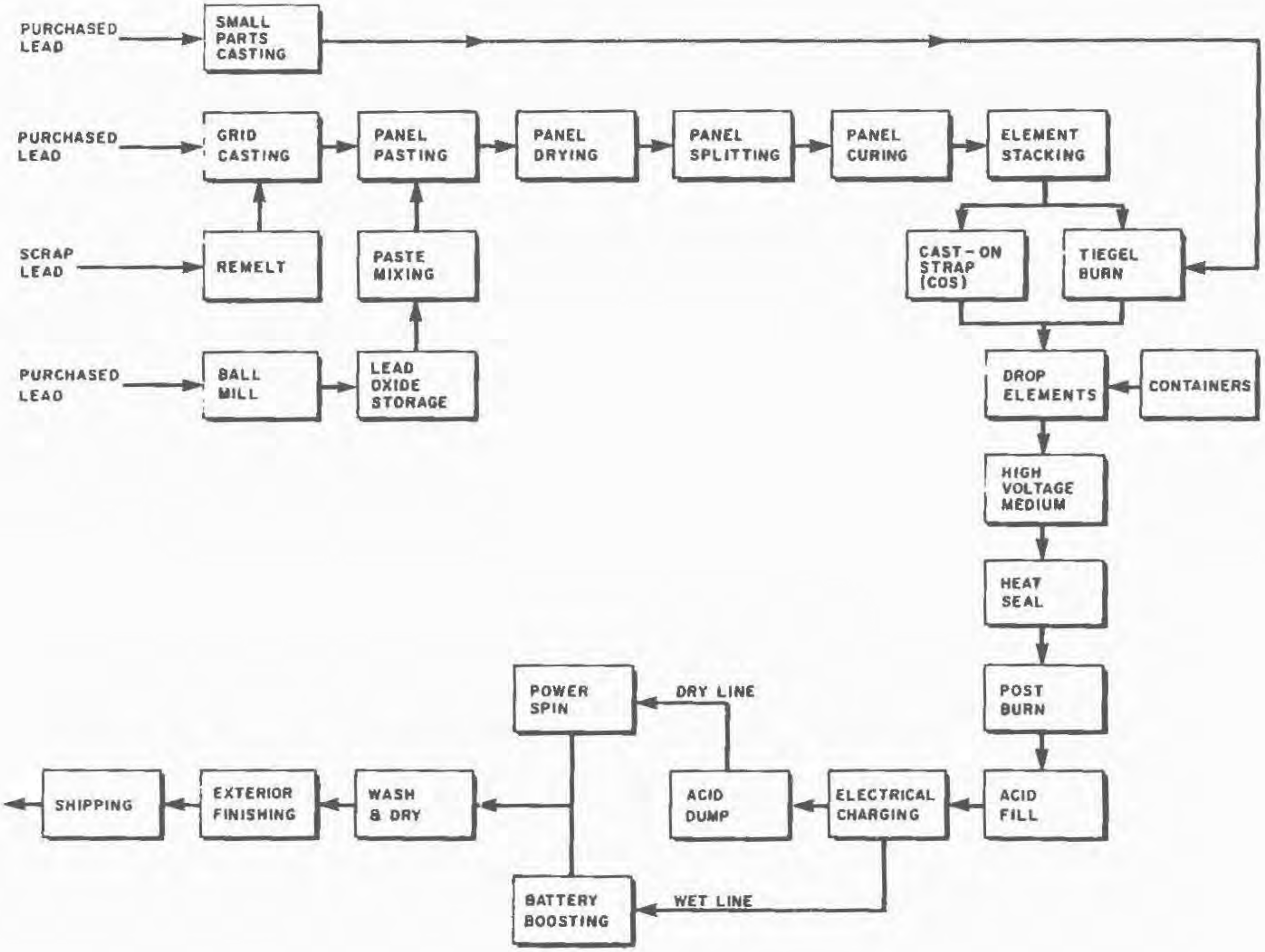
Ball Mill - Purchased lead pigs are fed into a rotating mill. The pigs tumble and break apart from continued impact. The heat generated by friction and the breaking of the lead into smaller and smaller pieces enhances the production of lead oxide. After the oxide is produced, it is transported to a classifier where the larger particles are separated and returned for further milling. The remaining oxide is transported to a cyclone where particles of the desired size are collected and transported by conveyor to storage.

Paste Mixing - Lead oxide is conveyed from storage to two paste mixing machines which are located directly above the pasting lines. The lead oxide is mixed with water, sulfuric acid, carbon black and other constituents to form a paste.

Panel Pasting - Lead grids are fed into one of two feed conveyors and passed under a hopper containing paste which has dropped from the paste mixer. The pasted panels are conveyed through a drying oven. They are subsequently split, stacked on pallets and stored to cure.

FIG. 1 - PROCESS FLOW

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979



Element Assembly - Cured plates may go to either the Cast On Strap (COS) Area for high production batteries or to the Tiegel burn area for specialized batteries. In the COS area the plates are taken from pallets, blocked on a tamping box and placed in a plate-stacking machine. The plates are mechanically stacked, interleaved with separators and then assembled into groups. These groups are conveyed to the COS lead station and loaded into the COS machine. If the groups of plates are being produced faster than the COS machine can handle them, they are stored on a surge table. The COS machine takes six plate groups and dips them in molten lead to form them into battery elements. The Tiegel burn area operates in much the same manner except that the plate groups are stacked in the surge area until a sufficient number have accumulated. The operator then leads the groups into the Tiegel machine and forms elements by burning on small parts. Finished elements from the COS and Tiegel areas are dropped into battery containers.

Welding Elements - The battery containers are conveyed to an intercell welding machine and the elements welded together. The battery is then checked for electrical continuity.

Heat Seal - The battery container and the battery cover are heated and sealed together. The battery is pressure checked. Those batteries which do not have side mounted connections have molds placed in the top and molten lead is poured to form posts. The batteries are then filled with sulfuric acid.

Formation - After batteries are filled with acid they are electrically formed. Those which are to be shipped dry have the acid dumped and are then spun in a centrifuge to remove the remaining acid. Those batteries which are to be shipped wet are electrically boosted. All batteries are then washed and dried, processed by the exterior finishing department if necessary and shipped.

B. Previous Studies

Medical surveillance of workers at the Bennington plant has been maintained for many years by the plant physician. A statistical analysis of all 8,978 blood lead values obtained on workers from February 1971 through Janauary 1978 showed an overall downward trend (Figure 2). Most of this decline occurred between 1971 and 1976. During those same years, there were downward trends in the number of workers who had blood lead levels of either ≥ 80 µg/dl or of 60-79 µg/dl. Highest blood lead levels tended consistently to occur in work orders 13 and 17 (pasting, oxide mixing, ball mill), 16 and 18 (welding), 11 (grid casting), and 14 (cast-on strap [COS]).

In 1977 and in the first seven months of 1978, an increase of 10-12 µg/dl in mean monthly blood lead levels occurred over 1977 values. This increase occurred at a time when air lead levels and the incidence of symptoms in workers were also increasing (Figures 2 and 3)[1].

IV. METHODS

A. Industrial Hygiene Methods

Based on a comprehensive review of plant processes, materials, and available air monitoring data, together with previous NIOSH experience in battery plants and a computer-assisted literature search, the following chemicals in the Bennington plant were chosen for further evaluation: inorganic lead, inorganic arsenic, antimony, arsine gas, stibine gas, benzene soluble polynuclear aromatic hydrocarbons (PNAH) and sulfuric acid. Lead, antimony, and trace quantities of arsenic are grid materials. Carbon black (which may carry PNAH) is a trace additive to paste. Arsine, stibine and sulfuric acid mist are generated during battery forming, and sulfuric acid can be generated by electrolyte filling operations.

The objective of personal breathing zone air sampling was to measure workers' individual exposures to airborne substances. The data from the breathing zone air samples were analyzed for variation by shift, by day of the week, by job category and by individual to examine possible correlations between medical and environmental data. Area air sampling was intended to examine re-entrainment and migration of lead dust in selected areas. The ventilation survey examined the function of control equipment and compared actual function with design values; environmental data were used in conjunction with ventilation survey results to identify requirements for additional mechanical controls. Video tape surveys of job operations were conducted to evaluate work practices and personal hygiene habits.

In the design of the air sampling survey, principal interest was directed to those areas and job categories where high air or blood lead values had been found in previous surveys conducted by OSHA. Workers were divided into 4 exposure groups (A-D), and procedures for obtaining personal breathing zone air samples in the 4 groups were as follows:

Group A: All members of this group on each shift were sampled with one DuPont pump and one MSA pump and AA filters on each of the five sampling days. Exposures evaluated were inorganic lead, arsenic, and antimony. Job categories included janitors, scrap coordinators, maintenance workers, duct and equipment cleaners, oxide mixers, pasters, ball mill workers, quality controllers, pasters and clean-up starters.

Group B: All members of this group on each shift were sampled with two MSA pumps and AA filters on two sampling days. Exposures evaluated were lead, arsenic, and antimony. Job categories included were grid casters, small parts casters, high voltage welders, post burners, and COS personnel.

FIG. 2 ANNUAL MEAN BLOOD LEAD VALUES BY WORK AREA, BENNINGTON BATTERY PLANT, 1971-1978

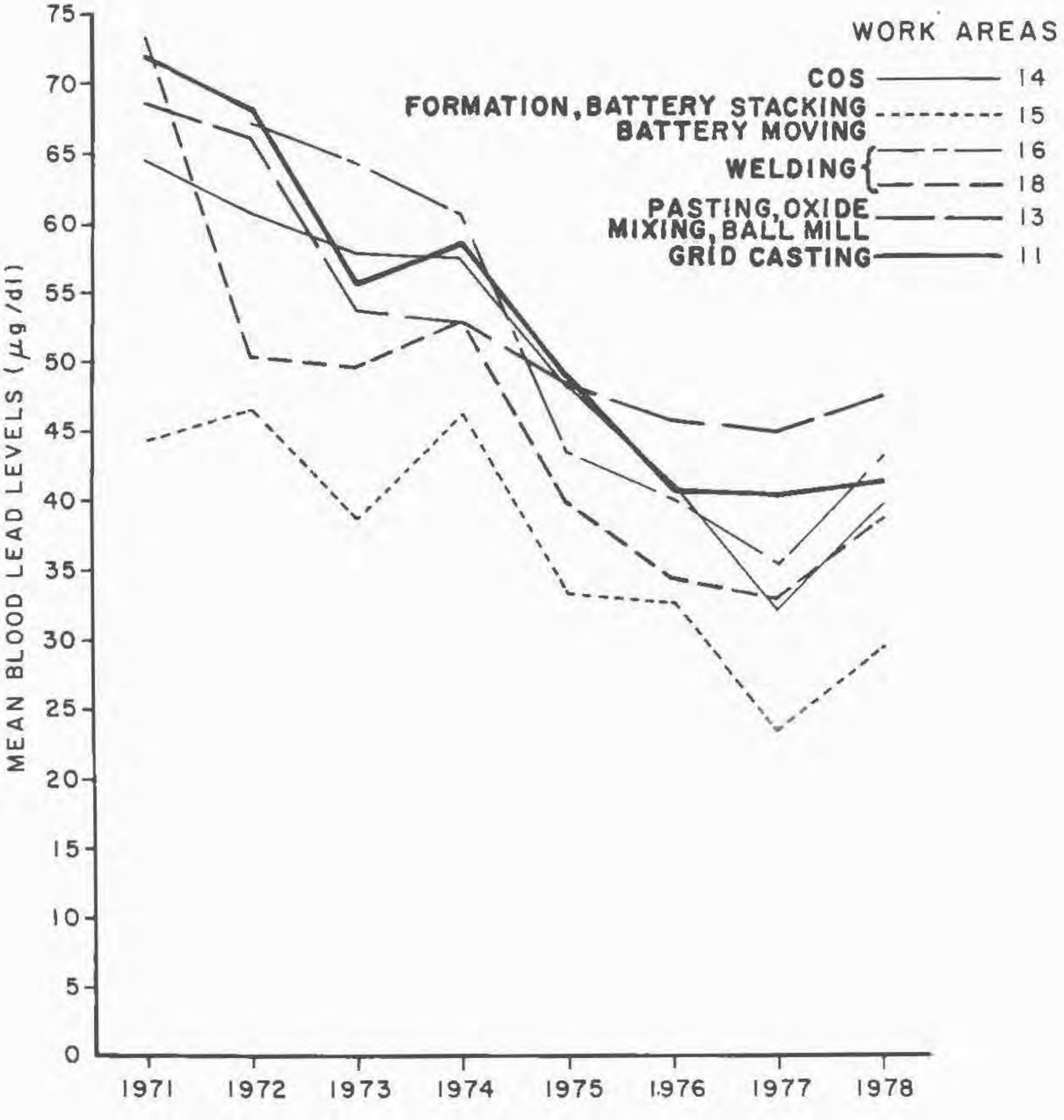
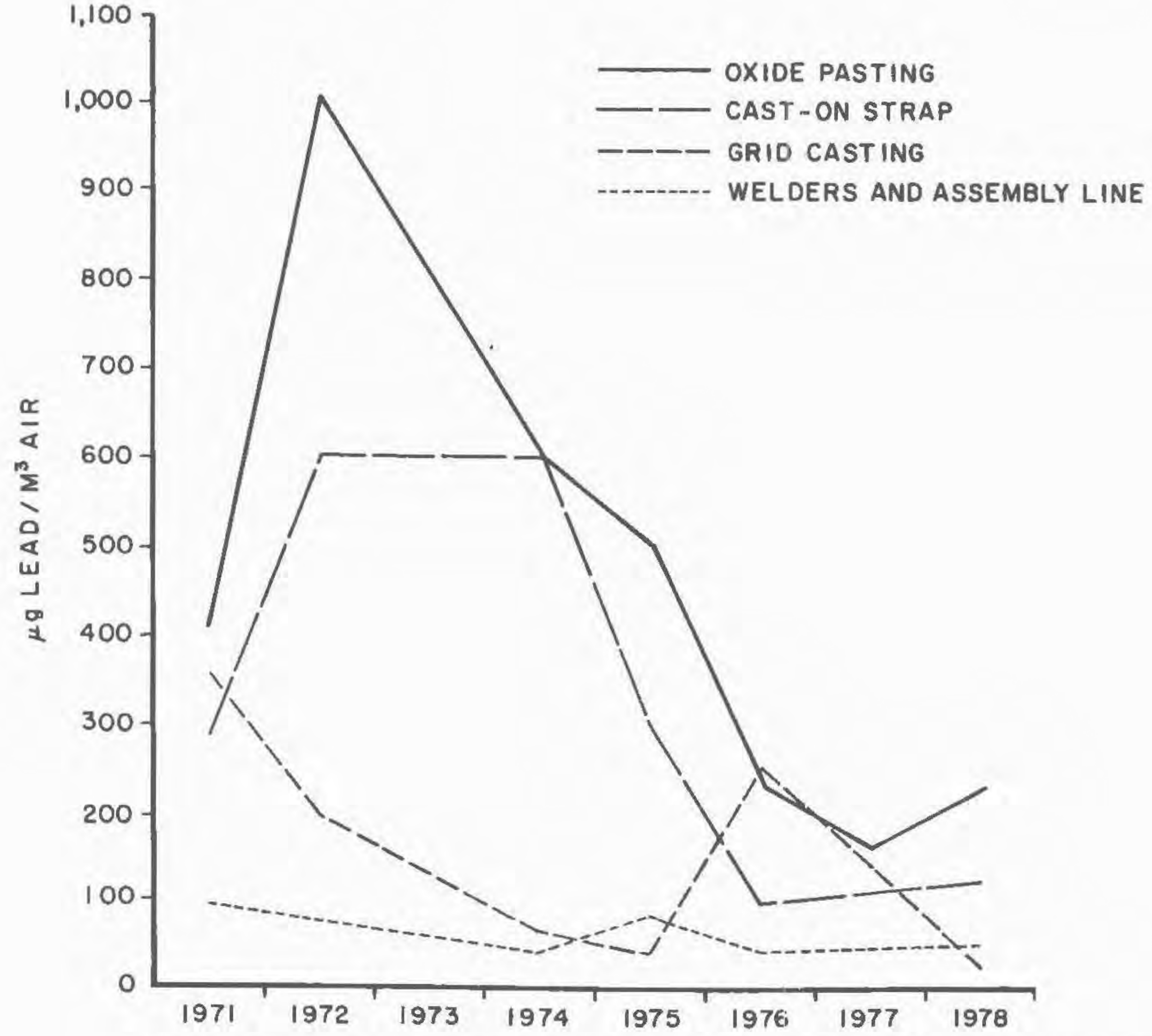


FIG. 3 MEAN BREATHING ZONE AIR LEAD LEVELS AT A BATTERY PLANT, BY WORK AREA AND YEAR, BENNINGTON, VERMONT, 1971-1978*



*DATA FROM VERMONT OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

Group C: All members of this group on each shift were sampled with one MSA pump and one Sipin pump and AA filter and a charcoal tube on two sampling days. Exposures evaluated were sulfuric acid mist, arsine, and stibine. The job categories included in Group C were: immersion fillers, process attendants (forming area), power spin operators and acid levelers.

Group D: This group was comprised of relatively unexposed controls, primarily Globe Union office personnel. No breathing zone air samples were obtained for Group D.

In the statistical design of the breathing zone air sampling survey, it was anticipated, on the basis of data from previous surveys of airborne lead and arsenic, that the intensive sampling conducted in Group A would yield results on air lead and arsenic concentrations that would be accurate, with 95% confidence, within 10-20% of actual mean values. Such estimates were not possible for antimony, sulfuric acid, arsine, or stibine, since past measurements were inadequate or unavailable. It was anticipated that, in general, exposure estimates in Groups B and C would be less precise than those in Group A, because sampling was conducted for 2 days rather than for 5 days. Because observed variability for lead and arsenic measurements was greater than anticipated, the resulting confidence intervals were wider than expected.

Area air samples were collected in the following locations: for carbon black which may carry PNAH in pasting and mixing areas; for lead at floor level and at an elevated location in the polypunch and storage areas, on forklifts, at floor level and at elevated levels along forklift routes, in the cured plate storage area, as well as in office, cafeteria, and locker room locations; locker room samples were taken during shift change.

Detailed air sampling and analytical methodologies for the substances evaluated are shown in Appendix I. All determinations were performed at the Utah Biomedical Test Laboratory, Salt Lake City, Utah.

In the ventilation survey, smoke tubes were used to observe airflow patterns surrounding local exhaust hoods in the plant. A velometer was used to determine average face velocities for exhaust hoods.

In the video tape survey, multiple video recording units were used to document housekeeping, work practices, and control equipment function. Fixed and mobile equipment was employed. Fixed shots observed a work area from two angles, except in the locker room and oxide mixing area. Mobile operations were conducted using a battery-operated cart to transport batteries and inverter for the mobile camera. Areas observed included pasting, casting, COS, oxide mixing, and locker facilities. Individual jobs observed were janitors, scrap coordinators, maintenance workers, duct and equipment cleaners and quality controllers. Two fixed cameras were used in the pasting, casting and COS areas. Some of the smoke tube/smoke candle tests of the mechanical control equipment were video tape recorded. The use of video tape was an experimental technique intended to permit uniform review of identical work practice materials by all parties. Representatives of management and labor were invited to review the tapes at NIOSH facilities in Cincinnati.

Video tapes were analyzed using 2 NEC Model VC-7505 time lapse cassette recorders and multiple monitors. Real time, 9 times real speed and still-framing modes were used. Evaluation was subjective and based on the experience and background of the reviewers.

B. Medical Methods

After signed, informed consent had been obtained from each participant, venous blood samples were obtained for blood lead, erythrocyte protoporphyrin (EP) and blood urea nitrogen (BUN) determinations. Blood lead determinations were performed at the Center for Disease Control (CDC) by modified Delves' cup atomic absorption spectrophotometry.[2] EP levels were determined by a micromethod.[3] BUN levels were determined at CDC by an auto-analytic technique.[4] In addition, urine samples for arsenic determination were obtained on all cooperating workers in Groups A and B. Arsenic determinations were performed at Utah Biomedical Test Laboratories, Salt Lake City, Utah by the method of Pierce et al.[5] A brief history was obtained on each worker; the history obtained demographic information, data on occupational exposure, on source of drinking water, and on recent seafood consumption.

C. Statistical Procedures

Analysis of variance techniques (ANOVA) were used to test for significant differences within sampling days, shifts, and job categories. The results of both one-way and multiple ANOVA were in agreement. Any differences described in the text are present when adjustment is made for the effects of each of the variables examined. Duncan's Multiple Range Test ($\propto$.05) was used to evaluate differences within each variable, e.g., to determine which job categories were different from others. Where appropriate, environmental samples were transformed using base ten logarithms, zero values being replaced by a small constant.

V. EVALUATION CRITERIA

A. Environmental

The environmental evaluation criteria used for this study are presented in Appendix II. Listed for each substance are the recommended environmental limit, the source of the recommended limit and the current OSHA standard.

There are four lead-in-air concentrations currently available as evaluation criteria.

(1) The previous OSHA Standard: The previous OSHA standard for exposure to lead and its inorganic compounds in air was adopted in 1971 and is 200 µg/M^3, as determined on the basis of an 8-hour time-weighted average (TWA). This OSHA standard was based on the national consensus standard of the American National Standards Institute (Z37.11-1969). No rationale was provided for selection of the 200 µg/M^3 level.[6] This was the OSHA Standard in force at the time of this investigation.

(2) The New OSHA Standard: In the light of new information on the toxicity of lead, the OSHA air lead standard has been lowered. The final standard will limit occupational exposure to lead to 50 µg/M^3 based on an 8-hour time-weighted average. It specified an effective date of February 1, 1979 and allowed 150 days from the effective date for compliance with the permissible exposure limits (PEL).[7]

Initially, respirators may be used for compliance with the PEL. However, industries other than primary lead production, secondary lead production, lead acid battery manufacturing, nonferrous foundries, and lead pigment manufacturing must also implement engineering and work practice controls (including administrative controls) to reduce and maintain employee exposure to lead to 50 µg/M^3 within one year of the effective date. The five named industries have longer compliance times.[7] The new standard is currently under challenge in the Federal Courts. In the interim, OSHA continues to enforce the previous 200 µg/M^3 standard.

(3) The NIOSH Recommended Lead Standard states that occupational exposure to inorganic lead shall be controlled, so that workers shall not be exposed to inorganic lead at a concentration greater than 100 µg/M^3 determined as a time-weighted average (TWA) exposure for a 10-hour workday, 40-hour workweek.[8]

(4) The Threshold Limit Values for Chemical Substances in Workroom Air adopted by ACGIH for 1979 lists a time-weighted average value for lead, inorganic fumes and dusts (as Pb) as 0.15 mg/M^3 (150 µg/M^3).[9]

B. Medical

Lead is a toxic heavy metal. It may enter the body either by inhalation into the lungs or as a result of being swallowed. Numerous studies have shown that inhalation is the major route of exposure to lead in the workplace.[8]

The average blood lead level in adults in the United States is approximately 20-25 µg/dl and 99% of unexposed American adults have lead levels below 40 µg/dl. Levels above 40 µg/dl may be associated with symptoms and early signs of lead poisoning. As levels rise above 60-80 µg/dl, the likelihood of serious poisoning increases.[7]

Lead may damage developing red blood cells in the bone marrow and may also injure the nervous system (brain and nerves), and the kidneys. Red cell damage first causes elevation of the erythrocyte protoporphyrin (EP) level; EP levels above 100 μg/dl whole blood in lead workers indicate that lead has caused red cell damage. At higher levels of exposure, the red blood cell damage caused by lead can produce anemia. In the nervous system, lead can damage the nerves of the limbs to cause slowed (or absent) reflexes, slowed reaction time, and at high doses can cause paralysis of the wrist or ankle muscles. At very high levels of exposure, lead can damage the brain to cause coma, convulsions, and death. In the kidneys, lead can cause a slow destruction of the working units (the nephrons) which clear the blood of poisonous substances and produce urine. Kidney damage caused by lead (lead nephropathy) causes elevation of the blood urea nitrogen (BUN) level. Serious, prolonged lead nephropathy can cause kidney failure.

<u>Arsenic</u>[10,30] is a toxic metal which is used as an alloy with lead in making batteries and whose poisonous properties have been recognized since ancient times. It may enter the body by inhalation or by swallowing. It is best measured in the urine, and the normal urinary arsenic excretion is less than 50 μg/liter.[16-22]

Cancer is the most serious hazard of long-term exposure to arsenic. Arsenic can cause cancer of the skin, lungs, and liver. Spots (like warts) may appear on the skin of workers exposed to arsenic long before cancer develops (arsenical kerotosis). Any worker who notices a suspicious spot on his skin should go at once to his/her doctor.

Arsenic can also cause irritation of the membranes of the eyes, nose, and throat, perforation of the nasal septum, nerve damage, and liver damage.

<u>Antimony</u>[11] is another metal which is alloyed with lead in battery making. Exposure may be by inahalation or by swallowing. Irritation of the skin and of the membranes of the eyes, nose, and throat are the major toxic effects of exposure to antimony. Spots may develop on exposed skin areas, and chronic irritation of the eyes, nose, and throat have been seen in workers exposed to dusts and fumes containing antimony.

<u>Arsine</u> and <u>Stibine</u>[12] are colorless poisonous gases which are odorless at low levels and, at higher levels, have an irritating or garlic-like odor. They can form when either arsenic or antimony comes into contact with acid or with other sources of hydrogen. In the battery industry, both of these gases can be formed when batteries containing either arsenic or antimony alloys are charged.[13]

Exposure to arsine and stibine is by inhalation. Both gases are very highly poisonous and both act by causing a very rapid breakdown of the red blood cells (intra-vascular hemolysis). The destroyed red blood cell products are passed out through the urine, and the urine may turn dark red or brown and muddy. The appearance of dark urine in a worker exposed to arsine or stibine is an emergency and the worker must be seen by a doctor immediately. Untreated exposure can lead to permanent damage of the kidneys or liver.

Sulfuric acid[14] is one of the strongest acids known. It can cause serious burns to skin and eyes. If skin contact does occur, burns can be reduced by rinsing immediately with running water. If sulfuric acid splashes into the eyes, they should be rinsed immediately for 15 minutes. Face shield, goggles, boots, apron, and gloves should always be worn when working with sulfuric acid. Contact lenses should never be worn by workers handling acid because acid can get under the lenses.

Carbon black[15], which is used to make lead oxide paste, may contain carcinogenic chemicals called the polynuclear aromatic hydrocarbons (PNAH). Similar components are found in pitch, tar, and soot. The PNAH have little acute toxicity, but prolonged day-to-day contact can cause cancer. Workers exposed to airborne PNAH, such as coke oven workers in the steel industry, develop lung cancer as a result of their PNAH exposure. In the battery industry, where most carbon black exposure is on the skin, there may be a risk of skin cancer. Careful showering and hand washing at the end of each shift should reduce any skin cancer risk associated with exposure to carbon black and its components.

VI. RESULTS

A. Environmental

1. Lead

A total of 342 personal breathing zone air samples were collected for lead analysis. Thirty-five values (10.2%) were equal to or greater than 200 $\mu g/M^3$; 58 (16.9%) were between 100 and 199 $\mu g/M^3$; 79 (23.1%) were between 50 and 99 $\mu g/M^3$; and 170 (49.7%) were less than 50 $\mu g/M^3$ (Table 1; Figure 4). Salvage and remelt operators had the highest average air lead exposures (278 $\mu g/M^3$), followed by wet down operators (175 $\mu g/M^3$), and by ball mill operators (168 $\mu g/M^3$) (Table 2). No differences were found by day of sampling or by shift ($p>0.05$). Mean differences between job assignments persisted whether raw or mathematically adjusted (logarithmic transformation) data were used.

2. Arsenic

A total of 344 breathing zone air samples were collected for arsenic analysis. Arsenic concentrations ranged from zero to 61.7 $\mu g/M^3$. Eight values (2.3%) were between 2 and 10 $\mu g/M^3$; 5 (1.5%) were greater than 10 $\mu g/M^3$ (Table 3; Figure 5). Highest average exposures to airborne arsenic were found in Tiegel operators (26.02 $\mu g/M^3$), followed by element repair personnel (3.20 $\mu g/M^3$), and by salvage and remelt operators (1.84 $\mu g/M^3$) (Table 4). Those mean differences between job categories persisted whether raw or mathematically adjusted data were used. Additionally, differences in arsenic exposure between shifts and between days of sampling became evident when raw data were examined. Shift one was found to have higher exposures than either of the other two shifts, and January 30 and February 1 had higher levels than any of the other 3 days; those differences were not evident in the transformed data (Appendix IV).

3. Antimony

A total of 344 breathing zone air samples for antimony were collected. No antimony concentrations exceeded the OSHA or NIOSH recommended standard (Figure 6). There were differences in antimony exposure between groups, day of sampling and job assignment ($p>0.05$). Exposure levels on January 30 and February 1 were different from those on January 29 and 31 and February 2. Salvage and remelt workers were exposed to the highest antimony levels. There was no difference in exposure between shifts.

4. Sulfuric Acid

A total of 47 breathing zone air samples for sulfuric acid were collected. No sulfuric acid concentrations exceeded the OSHA or NIOSH Recommended Standard (Figure 7). There was no difference between average sulfuric acid exposures by day of sampling or job assignment ($p<0.05$). Shift one was exposed to less sulfuric acid than were shifts two or three.

5. Arsine

A total of 47 breathing zone air samples for arsine were collected. No arsine concentrations exceeded the OSHA standard (Figure 8). Arsine levels on January 29 were lower than those of January 31 and February 1. There were no differences between shifts or job assignments ($p<0.05$).

6. Stibine

A total of 47 breathing zone air samples for stibine were collected. No stibine concentration exceeded the OSHA Standard (Figure 9). No combination of arsine and stibine exposure together exceeded recognized health standards. The stibine levels were different on different days. Shift one was exposed to less stibine than were shifts two or three. There were no differences between job assignments.

TABLE 1
AIRBORNE LEAD EXPOSURES
(PERSONAL BREATHING ZONE SAMPLES)
HE 78-98
GLOBE UNION BATTERY PLANT
BENNINGTON, VERMONT
29 Jan - 2 Feb 1979

Job Categories	No. of Workers	No. of Samples	DISTRIBUTION OF CONCENTRATIONS ($\mu g/M^3$) 0 - 49		50-99		100-199		200 +	
			n	(%)	n	(%)	n	(%)	n	(%)
Ball Mill Operator	4	16	3	(19)	3	(19)	4	(25)	6	(38)
Caster (#11 & Grid)	14	28	21	(75)	7	(25)	0	(0)	0	(0)
COS Reed Stacker	10	18	3	(17)	11	(61)	3	(17)	1	(6)
COS Loader	9	16	4	(25)	5	(31)	6	(38)	1	(6)
COS Unloader	10	18	12	(67)	4	(22)	2	(11)	0	(0)
Ductwork & Equip. Cleaner	2	10	6	(60)	1	(10)	0	(0)	3	(30)
Element Battery Repair	2	4	2	(50)	2	(50)	0	(0)	0	(0)
Janitor	11	52	45	(87)	6	(12)	1	(2)	0	(0)
Maintenance	14	61	46	(75)	6	(10)	4	(7)	5	(8)
Paster Mixer	2	9	0	(0)	2	(22)	5	(56)	2	(22)
Paster Operator, Paster	4	20	1	(5)	11	(55)	8	(40)	0	(0)
Plate Stacker	2	10	0	(0)	3	(30)	5	(50)	2	(20)
Post Builder	5	9	6	(67)	1	(11)	1	(11)	1	(11)
Q.C. Auditor	3	15	5	(33)	4	(27)	4	(27)	2	(13)
Salvage & Remelt	3	14	1	(7)	0	(0)	5	(36)	8	(57)
Scrap Coordinator	3	14	7	(50)	2	(14)	3	(21)	2	(14)
Tiegel Operator	2	4	1	(25)	2	(50)	1	(25)	0	(0)
Welder, H.V. Welder	9	17	5	(29)	9	(53)	2	(12)	1	(6)
Small Parts	1	2	2	(100)	0	(0)	0	(0)	0	(0)
Wet Down W.O.B.	1	5	0	(0)	0	(0)	4	(80)	1	(20)
TOTAL	111	342	170	(51.1)	79	(22.4)	58	(16.5)	35	(10.0)

FIG. 4 - DISTRIBUTION OF LEAD IN AIR CONCENTRATIONS - PERSONAL SAMPLES

HE 78-98

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979

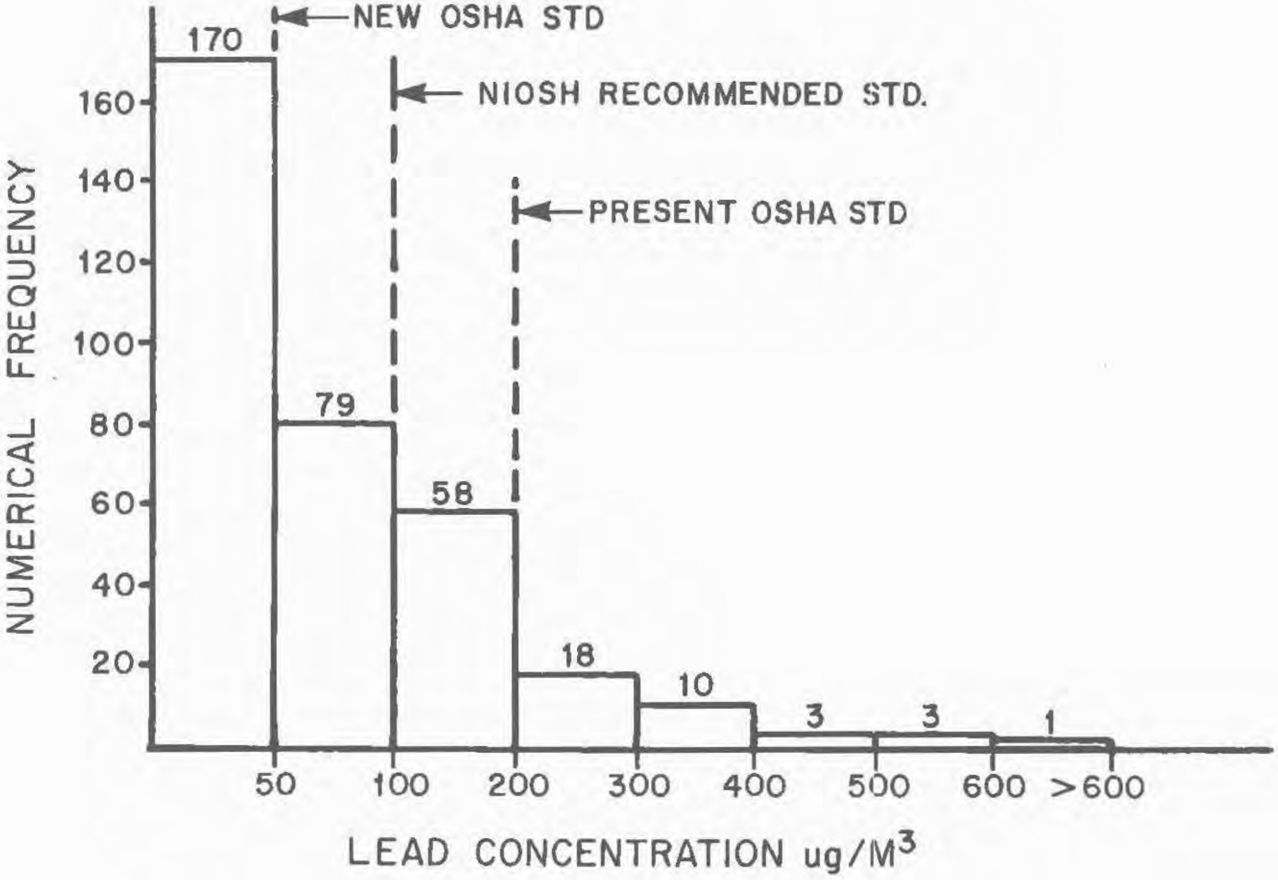


TABLE 2

AIRBORNE LEAD EXPOSURE BY JOB CATEGORY
(PERSONAL BREATHING ZONE SAMPLES)
AND BLOOD LEAD LEVELS

HE 78-98
GLOBE UNION BATTERY PLANT
BENNINGTON, VERMONT
Jan 29 - Feb 2, 1979

JOB CATEGORY	AIR LEAD ($\mu g/M^3$)			BLOOD LEAD ($\mu g/dl$)		
	# SAMPLES	MEAN	S.D.*	# SAMPLES	MEAN	S.D.*
Salvage, Remelt	14	279	178	1	58.0	----
Wet Down	5	176	43	1	50.0	----
Ball Mill	16	168	127	5	40.4	9.3
Paste Mixer	9	166	71	1	47.0	----
Plate Stacker	10	151	69	2	58.5	6.4
Duct. & Equip. Cleaner	10	125	132	3	34.3	2.5
Scrap Coordinator	14	107	100	4	50.0	9.5
COS Loader	16	99	69	8	50.6	14.2
Post Builder	9	85	113	6	31.5	6.3
Q.C. Auditor	15	91	79	3	51.0	5.6
Paster Operator	20	91	38	3	57.3	13.1
Welder, HV Welder	17	79	64	6	53.0	13.5
COS Reed Stacker	18	84	46	10	48.8	13.1
Maintenance	61	65	104	14	50.4	14.6
Tiegel Operator	4	73	54	3	47.3	3.8
Element Battery Repair	4	46	21	2	54.5	16.3
COS Unloader	18	54	35	9	46.1	5.0
Caster (Grid & #11)	28	41	20	15	50.6	10.7
Janitor	52	32	25	10	46.7	10.0
Small Parts	2	23	11	1	36.0	----
Assembly Line	--	--	--	1	45.0	----
Battery Mover	--	--	--	3	41.0	3.5
Work Order 21	--	--	--	4	40.0	10.5
Battery Forming Handler	--	--	--	2	35.0	9.9
Acid Leveler	--	--	--	2	31.5	5.0
High Rate Operator	--	--	--	1	31.0	----
Battery Stacker	--	--	--	4	30.0	2.2
Immersion Fill	--	--	--	3	27.0	2.7
Process Attendant	--	--	--	5	24.6	6.9
Carton Maker	--	--	--	3	23.7	9.1

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[*] S.D. = Standard Deviation

TABLE 3

AIRBORNE ARSENIC EXPOSURES
(PERSONAL BREATHING ZONE SAMPLES)
HE 78-98
GLOBE UNION BATTERY PLANT
BENNINGTON, VERMONT

29 Jan - 1 Feb 1979

			DISTRIBUTION OF CONCENTRATIONS ($\mu g/M^3$)					
Job Categories	No. of Workers	No. of Samples	0 - 1.99		2.00-9.99		10.00 +	
			n	(%)	n	(%)	n	(%)
Ball Mill Operator	4	16	16	(100)	0	(0)	0	(0)
Caster (#11 & Grid)	14	28	28	(100)	0	(0)	0	(0)
COS Reed Stacker	10	18	18	(100)	0	(0)	0	(0)
COS Loader	9	16	16	(100)	0	(0)	0	(0)
COS Unloader	10	18	18	(100)	0	(0)	0	(0)
Ductwork & Equip. Cleaner	2	10	10	(100)	0	(0)	0	(0)
Element Battery Repair	2	4	3	(75)	0	(0)	1	(25)
Janitor	11	52	51	(98)	0	(0)	1	(2)
Maintenance	14	63	63	(100)	0	(0)	0	(0)
Paster Mixer	2	9	9	(100)	0	(0)	0	(0)
Paster Operator, Paster	4	20	20	(100)	0	(0)	0	(0)
Plate Stacker	2	10	10	(100)	0	(0)	0	(0)
Post Builder	5	9	7	(78)	2	(22)	0	(0)
Q.C. Auditor	3	15	15	(100)	0	(0)	0	(0)
Salvage & Remelt	3	14	10	(71)	4	(29)	0	(0)
Scrap Coordinator	3	14	13	(93)	1	(7)	0	(0)
Tiegel Operator	2	4	0	(0)	1	(25)	3	(75)
Welder, H.V. Welder	9	17	17	(100)	0	(0)	0	(0)
Small Parts	1	2	2	(100)	0	(0)	0	(0)
Wet Down W.O.B.	1	5	5	(100)	0	(0)	0	(0)
TOTAL	111	344	331	(96.2)	8	(2.3)	5	(1.5)

TABLE 4

AIRBORNE ARSENIC EXPOSURES (BREATHING ZONE SAMPLES) AND URINE ARSENIC CONCENTRATIONS (24-HOUR SAMPLES) BY JOB CATEGORY

HE 78-98
GLOBE UNION BATTERY PLANT
BENNINGTON, VERMONT
29 Jan - 2 Feb 1979

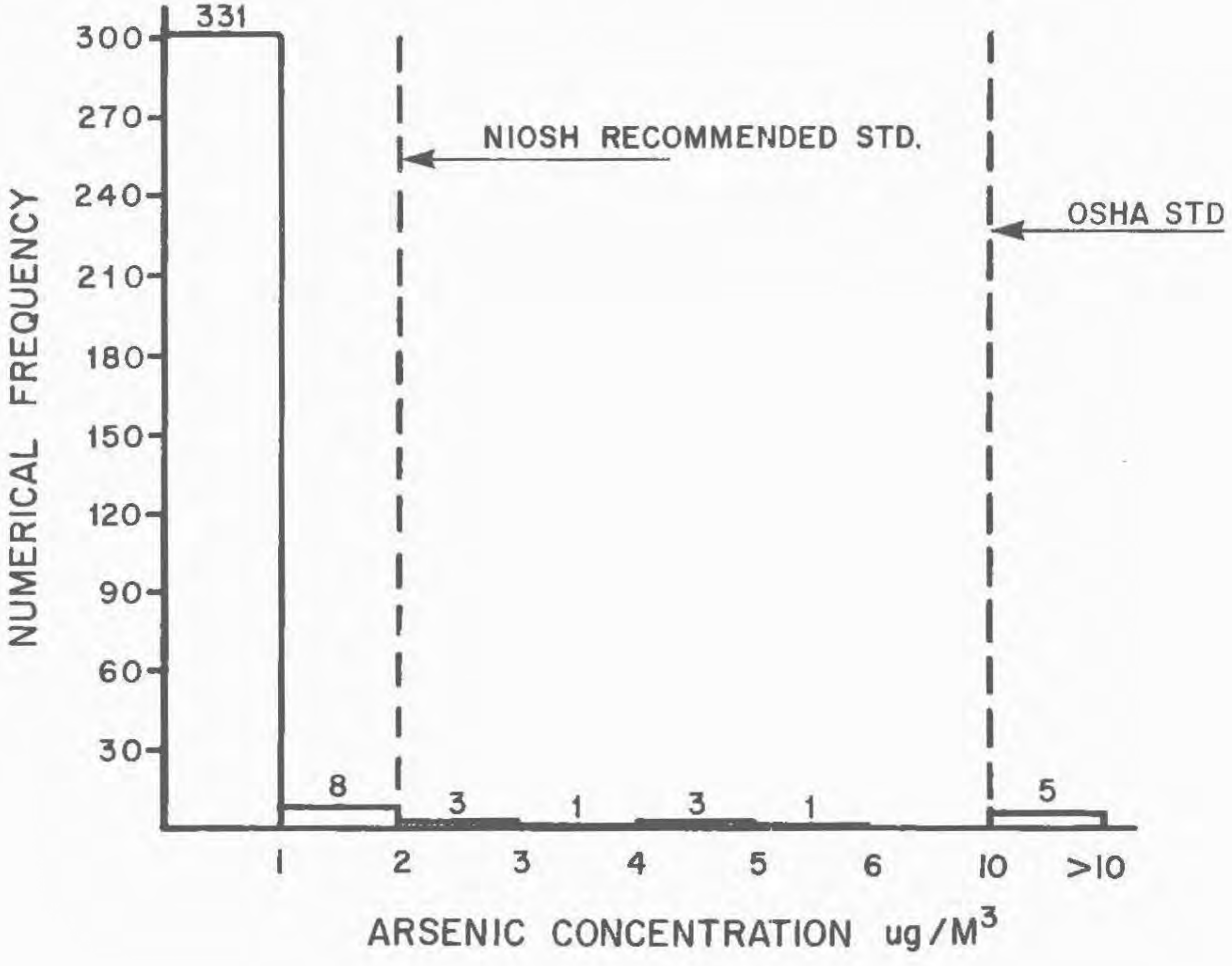
	AIR ARSENIC (µg/M^3)			URINE ARSENIC (µg/l)		
Job Category	No. of Samples	Mean	S.D.*	No. of Samples	Mean	S.D.*
Tiegel Operator	4	26.02	15.80	1	76.0	-----
Element Battery Repair	4	3.20	5.06	2	82.0	21.2
Salvage & Remelt	14	1.84	2.72	-	----	-----
Post Builder	9	1.60	1.60	4	54.0	10.7
Janitor	52	1.23	8.56	10	27.7	12.6
Scrap Coordinator	14	0.38	1.11	3	54.7	34.9
Caster (Grid & #11)	28	0.34	0.23	9	17.7	14.1
Welder, HV Welder	17	0.25	0.27	4	77.5	11.1
Duct & Equipt. Cleaner	10	0.18	0.28	2	45.5	19.1
C.O.S. Loader	16	0.15	0.06	7	57.1	26.3
C.O.S. Reed Stacker	18	0.14	0.07	8	64.0	24.1
C.O.S. Unloader	18	0.14	0.08	8	48.3	26.0
Small Parts	2	0.14	0.01	1	8.4	---
Maintenance	63	0.09	0.11	13	42.2	19.3
Paster Operator	20	0.07	0.08	3	44.0	37.2
Ball Mill Operator	16	0.06	0.67	4	48.5	15.6
Q.C. Auditor	15	0.04	0.05	3	49.3	22.7
Paste Mixer	9	0.03	0.05	-	----	-----
Wet Down	5	0.03	0.04	1	13.0	-----
Plate Stacker	10	0.01	0.04	2	61.0	21.2
Battery Forming Handler	--	----	----	2	206.5	174.7
Battery Stacker	--	----	----	3	166.0	67.7
Process Attendant	--	----	----	4	163.5	64.9
Assembly Line	--	----	----	1	150.0	-----
Immersion Fill	--	----	----	2	84.5	36.1
Acid Leveler	--	----	----	2	81.5	68.6
Battery Mover	--	----	----	2	63.5	51.6
Carton Maker	--	----	----	2	60.0	26.9
Work Order #21	--	----	----	3	51.0	4.4
High Rate Operator	--	----	----	1	16.0	-----

* S.D. = Standard Deviation

FIG. 5 - DISTRIBUTION OF ARSENIC IN AIR CONCENTRATIONS - PERSONAL SAMPLES

HE 78-98

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979



7. Area Samples

A total of 93 area air samples were collected for lead analysis (Table 5). The cafeteria and locker room results (mean 10.4 and 20.7 µg/M^{3}, respectively) indicate migration of lead from production areas to those nonproduction areas. By contrast, no airborne lead was detected in the office despite frequent use of this space by NIOSH and company personnel associated with the survey.

The results of area samples at Columns 7 (mean, 18.8 µg/M^{3}) and G-10 (mean, 6.9 µg/M^{3}) of the mobile samples taken on the forklifts (mean, 21.0 µg/M^{3}) may reflect re-entrainment of lead dust from pedestrian and vehicular traffic, since no other source of lead dust was apparent in these areas.

The samples in the polypunch (mean, 2.6 µg/M^{3}) area were taken where a high air lead level had been found on a previous survey.

The pasting line samples in the plate stacking area were elevated (mean, 47.2 µg/M^{3}) even after elimination of two values known to be due to an upset in the mechanical ventilation system. These residual elevated values may be partially due to the airflow from the Ball Mill to the stacking area discussed on page 33, but read together with the personal sample results indicate a definite need for additional engineering control of lead emissions in this area including elimination of migration of lead from the ball mill.

The bulk sample of carbon black contained 1.6% benzene solubles. This level of benzene solubles indicates occupational exposure to PNAH. Area samples analyzed for benzene soluble-fraction were higher in pasting (0.11 mg/M^{3} and 0.06 mg/M^{3}) than in paste mixing (0.03 mg/M^{3} and 0.03 mg/M^{3}). The 0.11 mg/M^{3} sample exceeds the NIOSH recommended environmental standards of 0.1 mg/M^{3}.(15) Analyses for specific PNA's were negative at the limits of detection for the method used. There are, however, so many potentially carcinogenic PNAH's that it is not possible to test for each one individually.

C. Medical Results

1. Blood Lead and EP Data

Blood lead determinations were performed on 143 workers; for the 14 on whom duplicate determinations were performed, the mean of the two values was used in expressing results. Blood lead concentrations ranged from 8.0 to 72.0 µg/dl. Nineteen (19%) of the 100 workers examined in Groups A and B had blood lead levels ≥60 µg/dl, and another 56 (56%) had levels between 40 and 60 µg/dl. By contrast, no worker in Groups C or D had levels ≥60 µg/dl, and 7 (20%) of 35 workers in those groups had levels between 40 and 60 µg/dl (Figure 10).

FIG. 6 - DISTRIBUTION OF ANTIMONY IN AIR CONCENTRATIONS - PERSONAL SAMPLES

HE 78-98

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2,1979

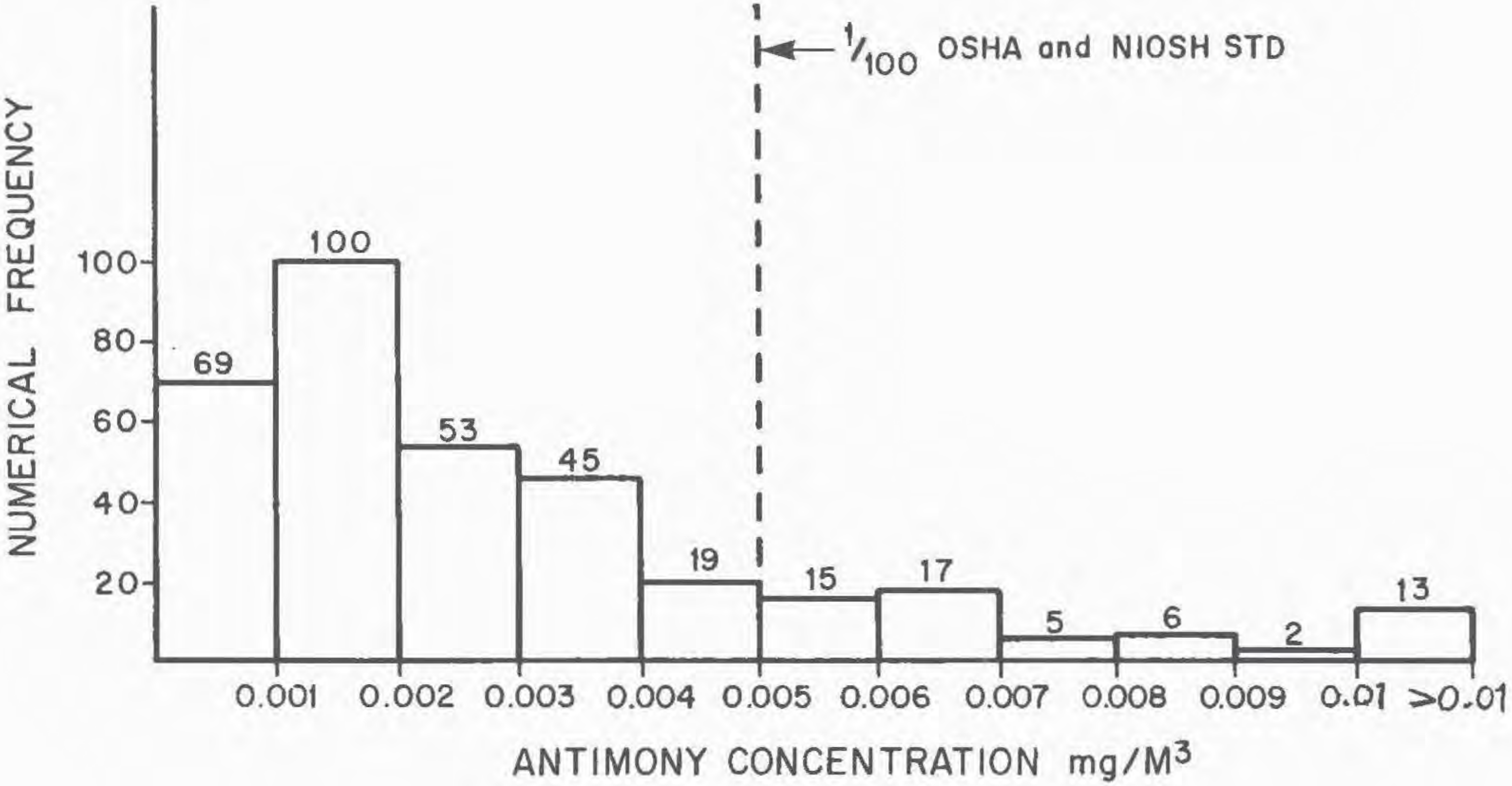


FIG. 7 - SULFURIC ACID IN AIR CONCENTRATIONS - PERSONAL SAMPLES

HE 78-98

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979

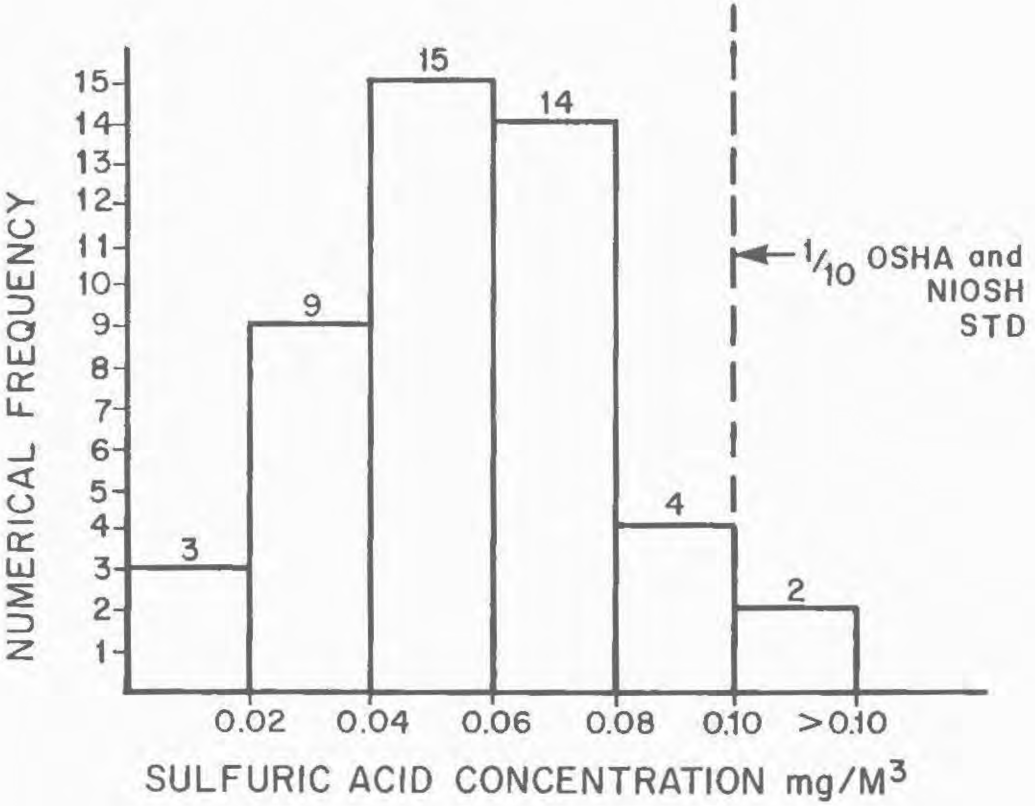


FIG. 8 - ARSINE IN AIR CONCENTRATIONS - PERSONAL SAMPLES
HE 78-98
GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979

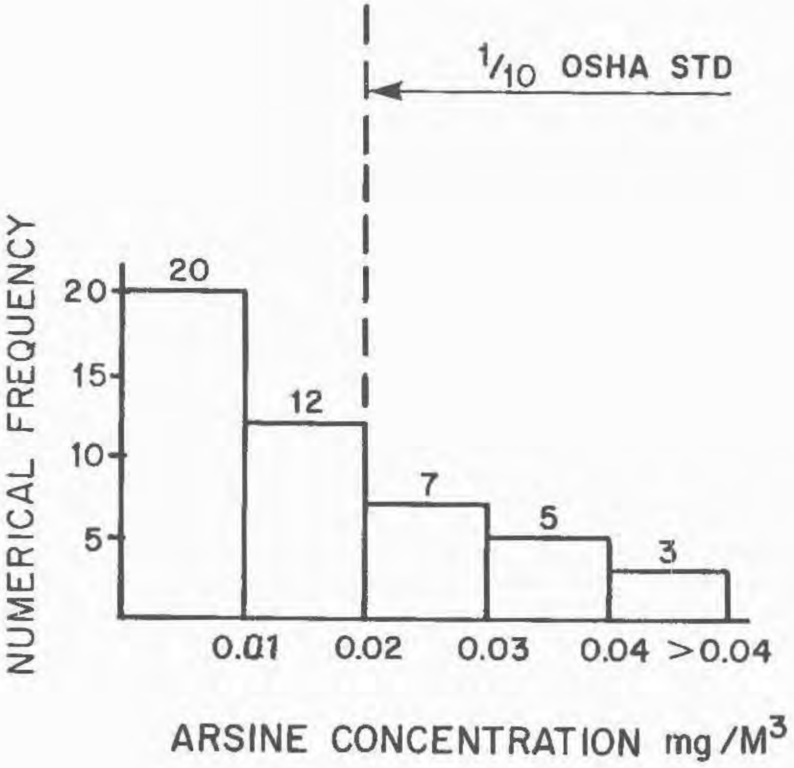


FIG. 9 - STIBINE IN AIR CONCENTRATIONS - PERSONAL SAMPLES

HE 78-98

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979

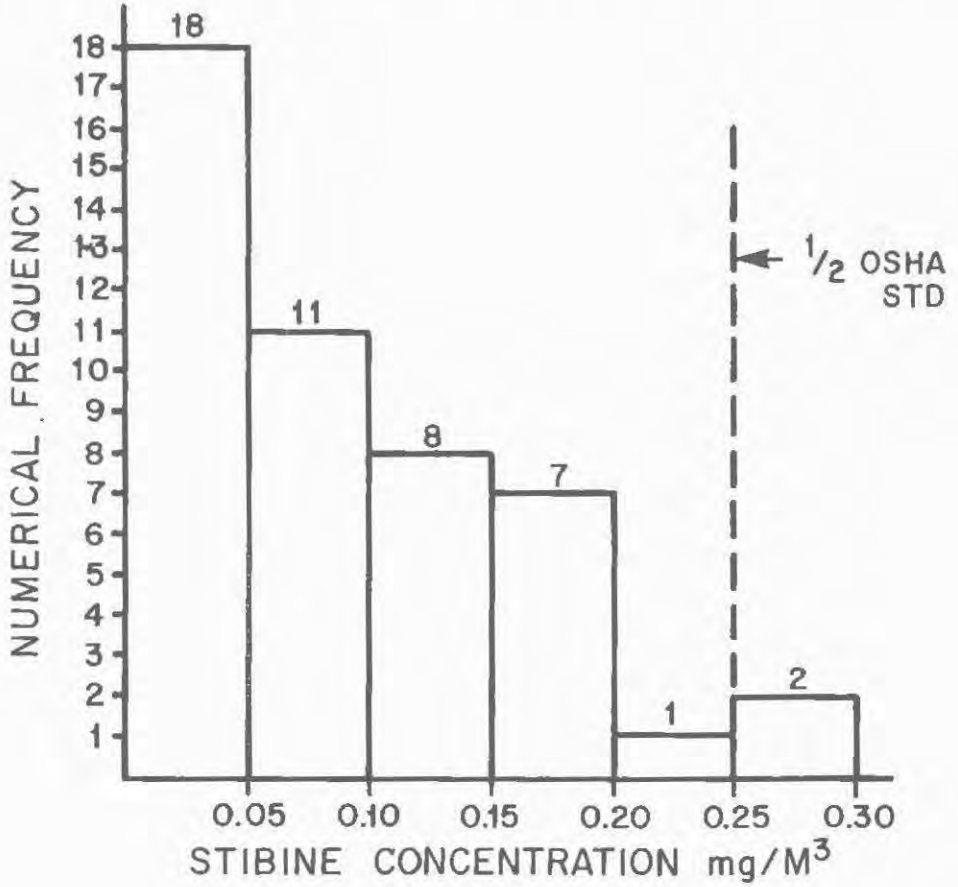


TABLE 5
AIRBORNE LEAD CONCENTRATION
AREA SAMPLES
HHE 78-98
GLOBE UNION CORPORATION
BENNINGTON, VT
Jan 29 - Feb 2, 79

Location	Cafeteria	Pasting Line Plate Stacking	Pasting Line Plate Stacking	Column K-7	Column G-10	Polypunch Area	Forklift	Locker Room	Office	Total
Number of Samples	7	13 *	11	15	12	16	8	9	2	93
Arithmetic Mean ($\mu g/M^3$)	10.4	151.0	47.2	18.8	6.9	2.6	21.0	20.7	0.0	
Arithmetic Standard deviation	3.4	160.5	68.0	14.3	3.5	2.8	11.8	4.6	-	
Maximum concentration ($\mu g/M^3$)	15.0	791.7	236.4	66.1	14.0	9.9	43.3	28.0	-	
Minimum concentration ($\mu g/M^3$)	5.7	5.8	5.8	4.9	0.0	0.0	8.9	15.0	-	

* Include samples taken during incident of known mechanical ventilation upset.

By job category, highest blood lead levels were seen in plate stackers (mean, 58.5 μg/dl), salvage and remelt operators (58.0 μg/dl), and pasters (57.3 μg/dl) (Table 2).

Erythrocyte protoporphyrin (EP) results were obtained on 136 workers. Fifty-six (41%) had EP values of 100 μg/dl whole blood or higher. Highest mean EP values were found in Groups A (152.3 μg/dl) and B (135.6 μg/dl), and significantly lower values were found in Groups C (73.0 μg/dl) and D (48.1 μg/dl). A high degree of correlation was found between blood lead and EP values (correlation coefficient, r = 0.77, p 0.0001, n = 136). As was the case with blood lead, EP values tended to increase with duration of employment at the plant (r = 0.49, p 0.0001, n = 135).

Evidence for a positive relationship between breathing zone air lead exposures and concentrations of lead in blood was sought among workers in each of the two study groups (A and B) in which breathing zone air lead determinations were performed. Although no significant correlations were observed in the two groups combined or in Group B workers alone, a possibly significant positive correlation was found in Group A, the group most heavily exposed to lead, between workers' blood lead concentrations and the logarithms of their personal breathing zone air lead exposures (correlation coefficient, r = 0.24; p one-tailed = 0.054; n = 44).

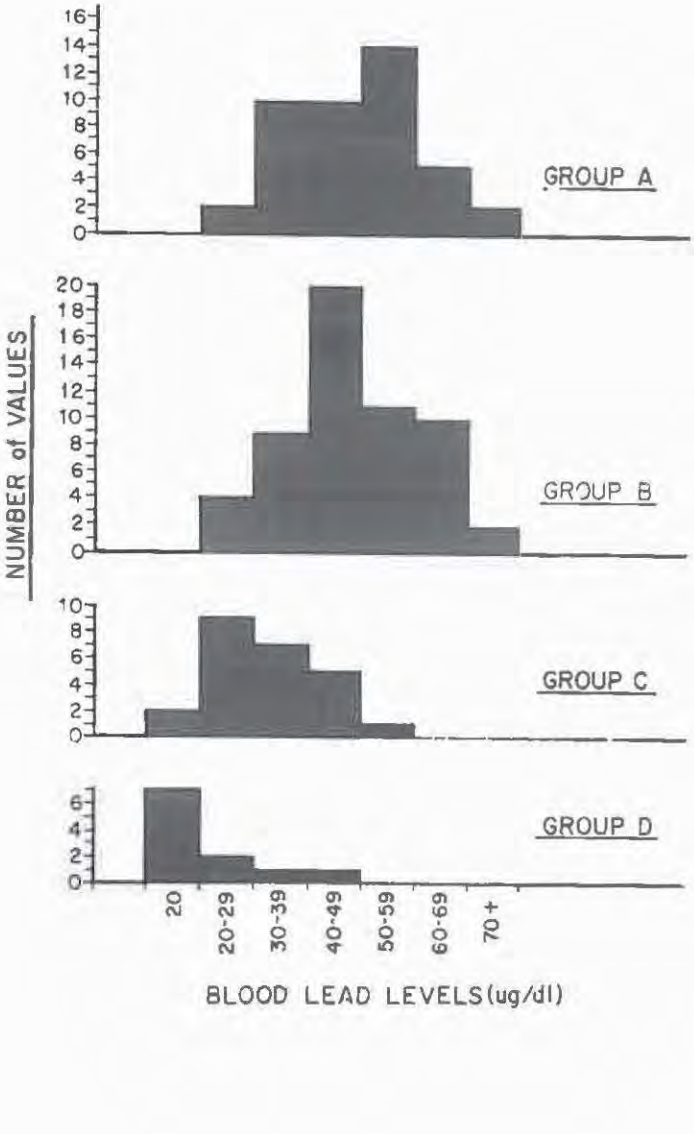
2. Urine Arsenic Data

Urine arsenic determinations were performed on 122 workers; for each worker on whom more than one such analysis was performed, the average value was used in expressing results. Concentrations ranged from 2.50 to 330 μg/l, with a mean of 55.1 μg/l. Sixty-nine workers had values less than 50 μg/l; 42 had 50-99 μg/l; 11 had 100 μg/l or above. The highest mean urine arsenic concentration (116.5 μg/l) was found in the 21 workers in Group C. Their average concentration was significantly higher than those in Group A (40.6 μg/l), Group B (50.7 μg/l) or above Group D (15.7 μg/l) ($p<0.05$ by Duncan's Multiple Range Test) (Figure 11). Twelve workers reported that they had eaten seafood in the week preceding the evaluation. The 12 were distributed across the 4 study groups, and only one of three fish-eaters in Group C had a urine arsenic concentration above 50 μg/l (91 μg/l).

By job category, the highest urine arsenic concentrations were found in battery-forming handlers (206.5 μg/l), battery stackers (166.0 μg/l), process attendants in the forming area (163.5 μg/l), and assembly line workers (150.0 μg/l) (Table 4).

Evidence for a positive relationship between concentrations of arsenic in air and in urine was sought among workers in the two study groups (A and B) in which personal breathing zone airborne arsenic determination was performed. Although no positive correlation was observed among workers in either group examined separately, a significant positive correlation was found between workers' urine arsenic concentrations and the logarithms of their airborne arsenic exposures, when the two groups were combined (r = 0.25; p one-tail = 0.01, n = 86) (Figure 12).

FIG. 10 - BLOOD LEAD LEVELS
by STUDY GROUP
GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979



3. Blood Urea Nitrogen Data

Blood urea nitrogen (BUN) determinations were performed on 143 workers. Any values above 21 mg/dl were more than 2 standard deviations above the usual mean value at the CDC laboratories and were considered indicative of possibly abnormal renal function. Twenty-one workers (14.7%) had BUN values above 21 mg/dl. The highest value was 27.9 mg/dl (Figure 13).

Neither the mean BUN value nor the proportion of workers with BUN values greater than 21 mg/dl varied significantly among the four study groups. Also, the correlation coefficient between blood lead and BUN levels was of only marginal significance ($r = 0.17$, $p = 0.046$, $n = 143$). A stronger correlation was, however, found between EP and BUN concentrations ($r = 0.38$, $p = 0.0001$, $n = 136$). Only a moderate correlation was found between BUN levels and duration of employment at the plant ($r = 0.22$, $p = 0.0095$, $n = 142$), and there was no increase in the prevalence rate of BUN elevation in workers with longer employment. There was no indication from any source that chelation therapy had ever been administered at the Bennington plant.

D. Video Tapes

The video records were reviewed by NIOSH and Globe Union representatives in Cincinnati March 13-15, 1979. General observations confirmed the absence of eating, smoking, and nail biting in the approximately 135 hours of tape observed. Respirator use appeared appropriate except for individuals observed breaking the mask face seal to speak; some of those working also wore dirty gloves. The locker room films suggested that more attention should be given to hand, face and neck washing prior to meals/breaks. Due to the use of only one camera in the locker room area and because of shooting difficulties, it could not be definitely determined that all personnel with shower time actually used shower facilities.

Review of the films from the oxide mixing, pasting, and salvage and remelt areas indicated some instances of dry floor conditions which could lead to temporarily elevated dust levels. This condition differed significantly from shift to shift.

Review of tapes in the paster take-off/paster area indicated that lead exposure may occur when jammed plates are freed from the interior of machines, from emptying clean-out drawers, and due to what appeared to be dry-brushing of the conveyor surface. Review of tapes taken in the salvage and remelt area showed repeated non-use of a movable hood in the vicinity of the lead pump and repeated dropping and banging of uncovered dry waste barrels in the scrap processor feed area, which could be eliminated by use of dust covers or an inclined ramp from lead area to the floor. Some evidence of throwing of leaded materials was observed. This could be eliminated in most cases by repositioning ventilated scrap containers.

Except in the locker room and take-off end of the paster line sequences there was no apparent deviation from normal procedures due either to camera shyness or boldness.

FIG. 11 - URINE ARSENIC CONCENTRATIONS by STUDY GROUPS

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979

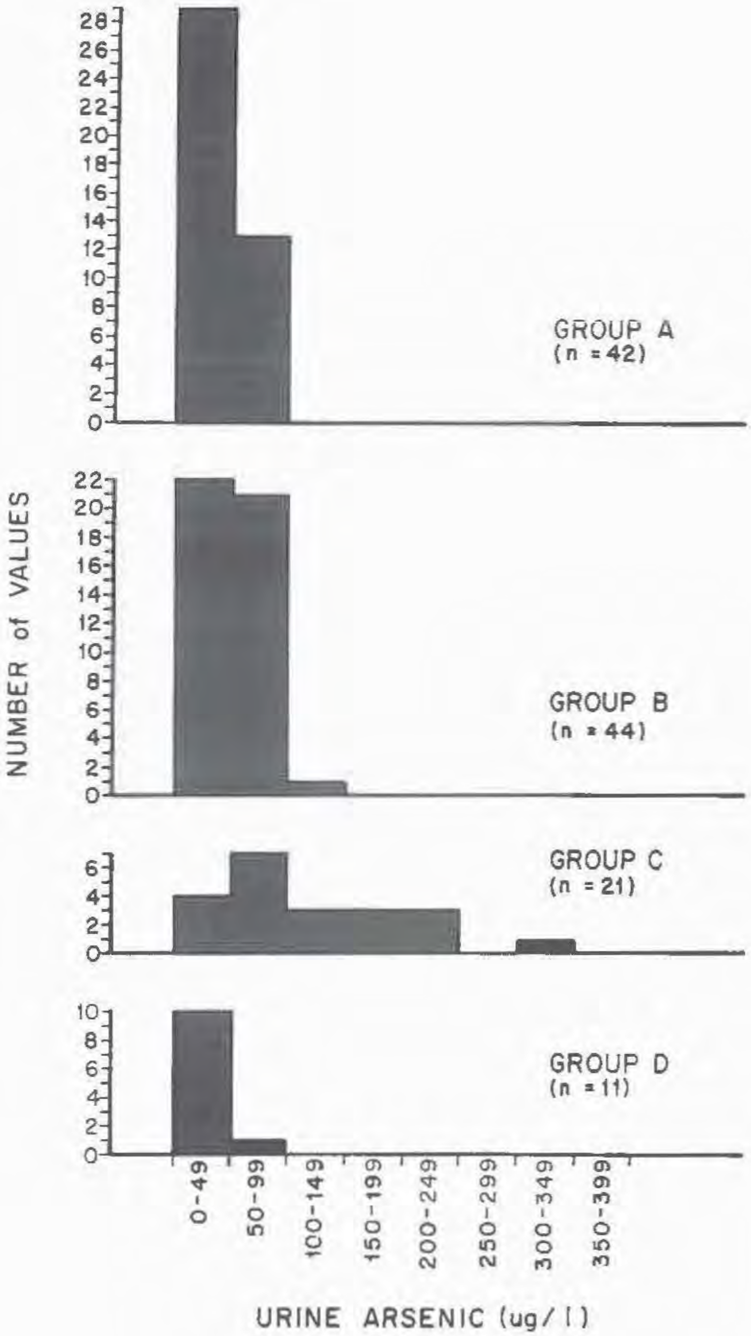
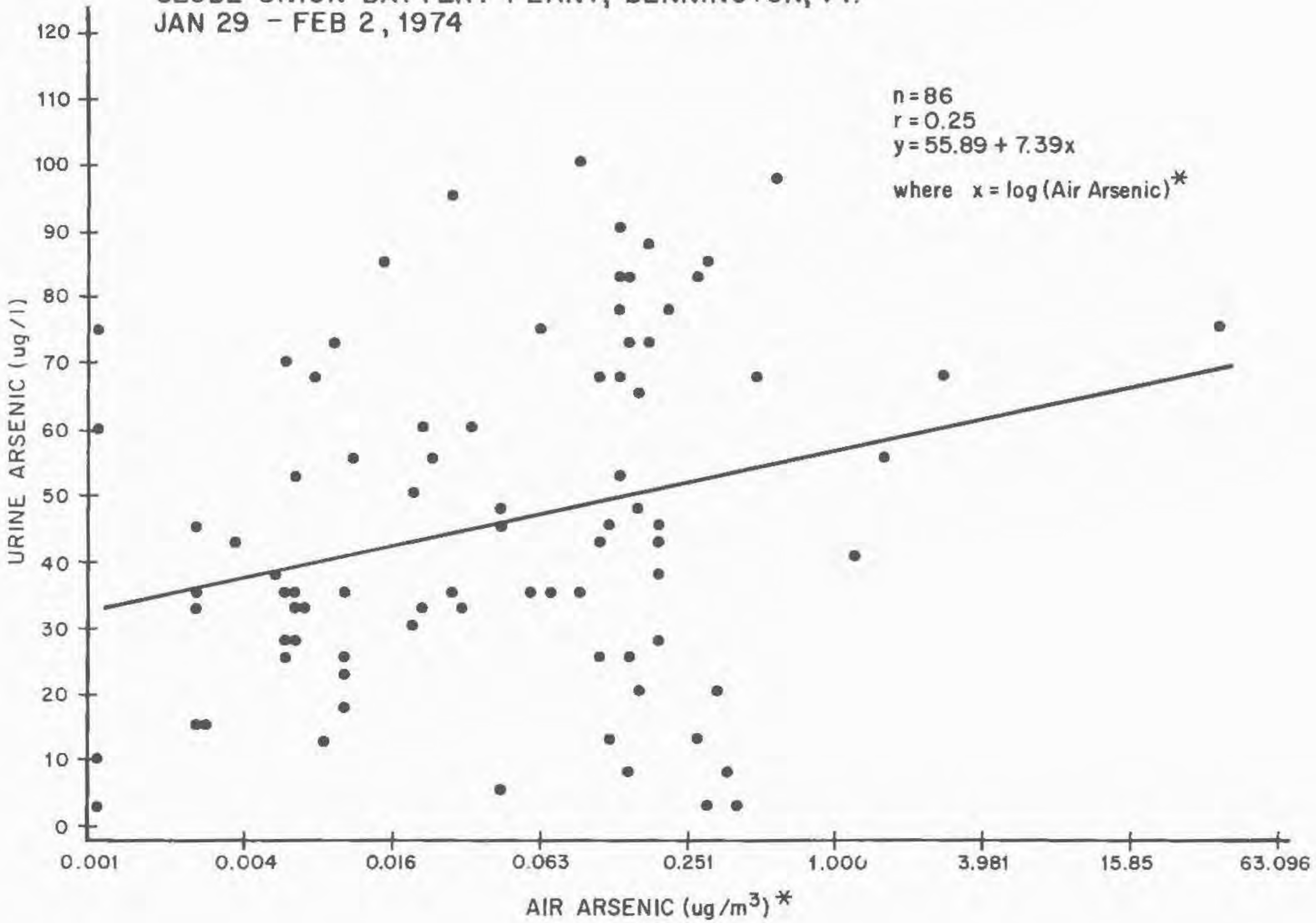


FIG. 12 - URINE ARSENIC CONCENTRATION COMPARED WITH LOG AIRBORNE ARSENIC EXPOSURE (BREATHING ZONE SAMPLES)

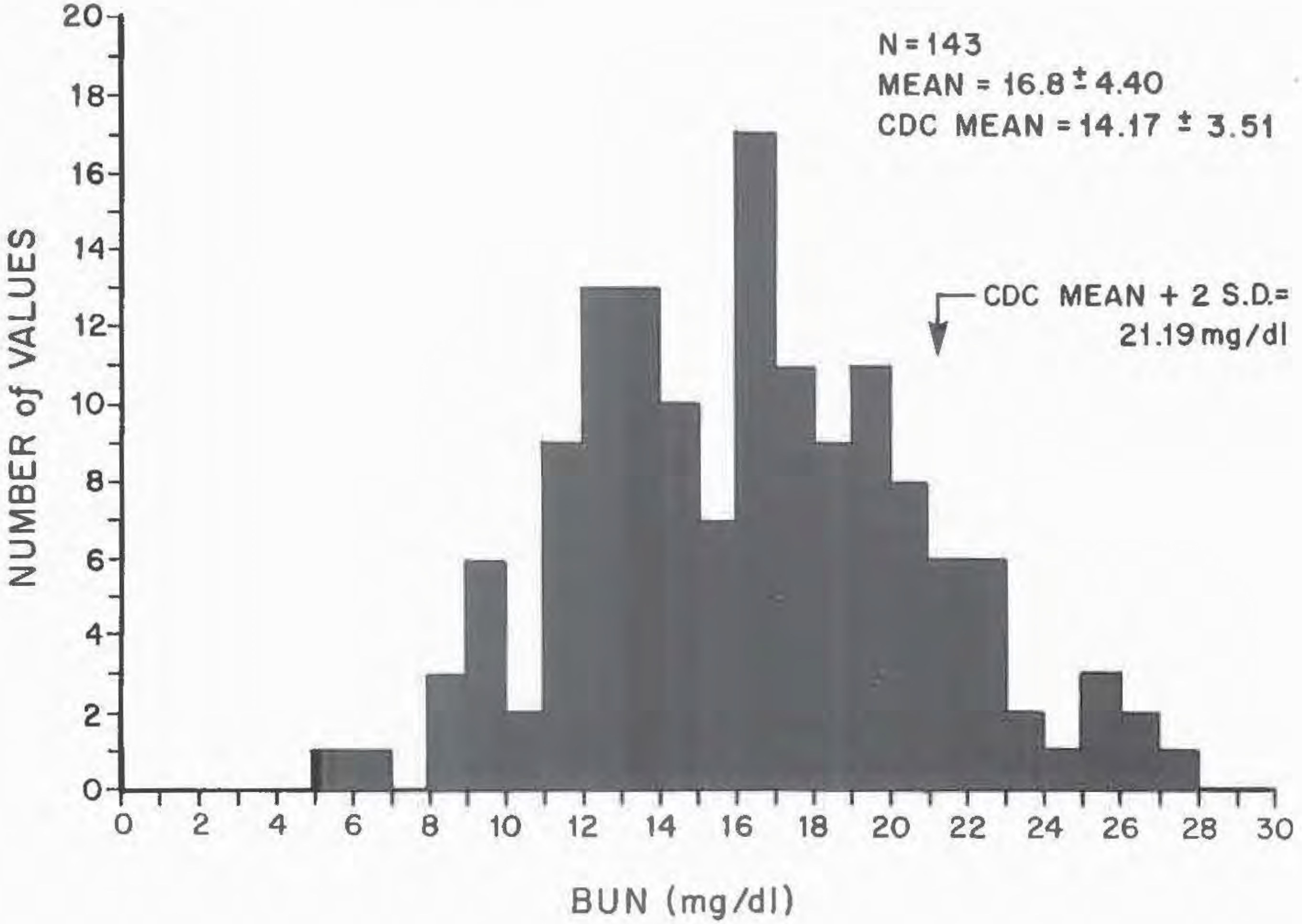
GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1974



*NOTE: "X" COORDINATES AS GIVEN IN THE FIGURE MUST BE TRANSFORMED TO LOG_{10} BEFORE SUBSTITUTION INTO THE REGRESSION EQUATION.

FIG. 13 - DISTRIBUTION OF BLOOD UREA NITROGEN (BUN) VALUES

GLOBE UNION BATTERY PLANT, BENNINGTON, VT.
JAN 29 - FEB 2, 1979



E. Ventilation Survey Results (Appendix V)

In general, the installed ventilation at the Bennington plant met recommended engineering design values. Capture velocities were appropriate and smoke-tube observations indicated generally good airflow patterns. Specific problems were, however, noted and are detailed below.

One make-up air unit in the Grid Casting area was down for a maintenance problem during a portion of the time observations were being made. This condition created a deficit of supply air to the area causing migration of air from outdoors or from other plant locations.

The Ball Mill area was isolated and under a supply air deficit. A common practice used to supply air was to open a door to the panel pasting and parting area. At one point smoke was observed flowing to the Ball Mill room from the pasting area but when a door on the opposite side of the room was also opened, smoke flowed from the ball mill to the pasting area. This situation of air flowing to the pasting area from the ball mill is unacceptable.

Also in the Ball Mill, leaks were noted in the conveying system moving oxide through the collection system and from the mill to the holding area. These are areas where the oxide may plug the lines of movement. These build-ups must be manually freed at which time the oxide may be emitted to the room air.

It was noted that the Ball Mill operator had a control room separate from the mill and that this room was under a positive pressure. The operator was, however, required to wear personal protective equipment when entering the mill area.

The paste mixers were enclosed and displayed a good positive air velocity inward when the access doors were open. The outlets of the mixers and inlets to the hoppers were open. A draft upward in this area might carry some dry materials possibly containing PNAH that had not been fully mixed; therefore, consideration should be given to enclosing that small area. The sulfuric acid feed tank in the paste mix area was uncovered and escaping mist was observed.

The mixers were located directly above the dispensing hoppers which is good practice for limiting the transport of oxide. There was no exhaust ventilation from the dispensing hoppers to the drying ovens. The pasting lines were ventilated. On January 31 the local exhaust at the take-off end of the pasting line began to act as an air supply rather than exhaust. This occurred at the time of day when the baghouses went through their shake cleaning cycle. This was reported by plant personnel not to be a common occurrence, but conditions were right for this malfunction.

The COS lines displayed good control ventilation. However, the air connection to the ferris wheel hood on Reed Stacker #1 was clogged.

The Tiegel burn and post building areas were generally well controlled. However, the hood under which the actual burning in the Tiegel burn area was occurring was not ideally placed in relation to the source of emission. In addition, the air supply unit located above the polypunch area was directed toward the Tiegel burn area and was disruptive to the airflow around the exhaust hoods in that area.

Smoke tube observations were conducted in and around the cafeteria, locker room, and office area. Smoke that was discharged at the doors of the cafeteria flowed out to the adjoining areas. Cigarette smoke generated in the cafeteria during break and lunch periods became quite heavy and was slow to dissipate. Smoke generated at locations connecting the office areas to the production area had positive movement from the office area to the production area. This is a desirable flow pattern. Smoke generated at the access doors to the locker room displayed movement into the locker room area. This is not a desirable flow pattern.

Smoke bomb and candle testing were performed and video taped. In general, the smoke testing results indicated good control at local exhaust points and positive flows towards roof exhaust fans and provided a permanent record of many of the observations.

None of the respirators observed were NIOSH certified. The ball mill area was the only one where the use of a respirator was required. There was no provision for quantitative fit testing, but the safety and health coordinator had responsibility for qualitative fitting of respirators and instruction on their proper use.

VII. CONCLUSIONS

The major conclusion to be drawn from this evaluation is that a serious hazard of exposure to airborne lead existed in January and February 1979 at the Globe Union lead battery plant in Bennington, Vermont. Although air lead concentrations in the plant had decreased substantially over the preceding decade (Figure 2), and the installed ventilation was generally effective, a number of uncontrolled sources of airborne lead emission continued to exist. It was found that 10% of personal breathing zone air samples still exceeded the previous OSHA air lead standard of 200 $\mu g/M^3$, that 27% exceeded the NIOSH recommended standard of 100 $\mu g/M^3$, and that 50.3% exceeded the new OSHA standard of 50 $\mu g/M^3$. Mean breathing zone airborne lead exposures in 7 of 20 job categories were in excess of 100 $\mu g/M^3$.

Blood lead levels in workers were also found to be elevated. Nineteen workers (13.3%) of the 143 examined had blood lead levels ≥60 µg/dl, and 82 (57%) had levels ≥40 µg/dl; it is the opinion of OSHA that above a blood lead level of 40 µg/dl there exists an increased risk of hematologic, neurologic, and renal impairment in adult lead workers.[8,23] A positive correlation was found among workers in Group A, the group with highest exposure to airborne lead, between breathing zone air lead exposures and blood lead levels.

An arsenic exposure hazard was also found at the Bennington plant. Thirteen (3.8%) of 344 breathing zone air samples contained arsenic in concentrations at or above the NIOSH recommended standard of 2 µg/M^3, and 5 (1.5%) of those samples had concentrations which were at or above the OSHA standard of 10 µg/M^3 (Table 3). It should be noted that no air samples for arsenic analysis were collected on workers in Group C, the group with the highest mean urine arsenic concentration (Table 4). It seems likely that additional exposures to airborne arsenic in concentrations above standards must have existed in Group C job categories.

Increased absorption of arsenic was noted in workers; 42 had urine arsenic concentrations of 50-99 µg/l, and 11 had concentrations of 100 µg/l or more, with the highest being 330 µg/l (Figure 11). Previous evaluations of urine arsenic concentrations in persons without unusual exposure to arsenic indicate that most such persons excrete less than 50 µg arsenic/l of urine.[16-22] In the present study, office workers (Group D) had a mean urinary arsenic excretion of 15.7 µg/l and 10 of 11 workers in that group excreted less than 50 µg/l. In this study of Groups A and B, a positive correlation was noted between log airborne arsenic exposure and urinary arsenic excretion ($r = 0.25$; p (one-tail) $= 0.01$; $n = 86$). This correlation extended to an exposure level well below the current OSHA standard (Figure 12).

The major medical problem identified in this study was the finding of elevated blood urea nitrogen (BUN) values (≥22 mg/dl) in 21 (14.7%) of 143 workers. At the Center for Disease Control, where those determinations were performed, the average BUN value in 650 adults aged 30-64 years was found to be 14.17 mg/dl; the standard deviation was 3.51 mg/dl (J. Donahue, personal communication, 1979). Given that distribution, no more than 2.5% of BUN values would be expected in a normally healthy population to be greater than 21.19 mg/dl(24). Thus in the Bennington group of 143 workers, no more than 3 or 4 would have been expected to show BUN values ≥22 mg/dl. The finding of 21 workers in this plant with elevated BUN concentrations represents a 6 to 7-fold excess prevalence over expected. In addition, it must be noted that BUN is a relatively insensitive indicator of kidney damage and that a large fraction (30-40%)

of the functional units in the kidneys, the nephrons, must be damaged before elevation in BUN begins to occur.[25] The finding of elevated BUN values in this large group of workers suggests that certain members of the group may have kidney impairment caused by lead, lead nephropathy. That serious diagnostic possibility must be evaluated further.[26]

The suggestion that poor personal hygiene or improper work practices may have contributed to workers' lead exposure at the Bennington plant was evaluated through the relatively novel technique of video tape analysis. Although several less than satisfactory work practices and personal habits were seen on the tapes, they were not common, and none of those practices were likely by themselves to have caused excessive lead absorption or to have accounted for the widespread pattern of lead absorption seen at the Bennington Plant.

There is a need for additional lead control measures at the Bennington battery plant to approach an airborne level of 50 $\mu g/M^3$, and one of the means of affecting the control would be improvement and addition of ventilation. It should be noted that not only additional local exhaust ventilation is needed, but proper utilization and directive control of supply air and within-plant air currents are important. Detailed recommendations for engineering improvements will follow in the recommendations section.

Subsequent to the survey, the United Auto Workers (UAW) submitted to NIOSH a memorandum describing new lead control technology observed at a GM Delco-Remy battery plant. A copy of this memorandum is included in this report as Appendix VI. The Delco-Remy plant was visited by NIOSH personnel to observe the operations in light of the UAW memorandum. Most of the operations in the Delco-Remy plant were highly automated and heavily ventilated, and are unique to the way Delco-Remy produces its batteries. Some of the control measures employed in the Delco-Remy plant may have retrofit capability to existing plants, but many would encounter problems when not originally implemented. To be more specific, the plastic coating used on the plant floor in the Delco-Remy plant was difficult to apply and keep on when used on a floor which was new and had not been exposed to dirt and oil. It would be far more difficult to utilize this coating in a plant with old flooring. The method of plate production, pasting and parting is so different from what is done at Bennington that there would have to be major changes to utilize the control techniques.

The automatic stackers, group assembly, burning, and sinking were very well ventilated. In addition, encapsulating positive plates in envelopes of separating material lessened the chance of dusting from those plates during assembly. These controls would entail major modification to an existing facility. The formation room displayed control which would provide a good opportunity for retrofit. The canopy-type enclosure with side draft exhaust appeared to be working well.

The Delco-Remy plant is an excellent model for new plant construction with some features which could be retrofitted; however, close examination and judgement should be used before attempting to retrofit many of the controls in place there.

RECOMMENDATIONS

1. Efforts to control lead exposure at the Bennington plant should focus initially on the 7 job categories where mean airborne lead levels in the industrial hygiene survey were found to exceed 100 $\mu g/M^3$.

a. Ball Mill Operator - now wears a respirator when he tends the mill; wore a respirator that was not NIOSH-approved. The measures of his exposure do not take air mask use into account. Further control measures would be required to eliminate the need for respirators. It is recognized that current ball mill technology at Bennington may be state-of-the-art.[27,28] Migration of air from ball mill to other plant areas must be reduced or eliminated.

b. Duct Work and Equipment Cleaner - these workers vacuum off the duct work, but major potential exposure is probably associated with cleaning dust collectors. Respirators may be appropriate protection when cleaning dust collectors.

c. Paste Mixer - this operation needs improved technology to contain lead oxide dust during transfer of litharge into mixer. Airflow back through the local exhaust during baghouse cleaning requires further investigation and must be remedied.

d. Plate Stacker - lead exposure in this job needs reduction. Possible solution could entail use of an automatic stacking machine, improved ventilation on stacking table, and elimination of lead migration from the ball mill.

e. Salvage & Remelt - needs additional controls and further study.

f. Scrap Coordinator - operator empties ventilated scrap cans, also counts scrap plates by hand. This latter practice should be discontinued.

g. Wet Down - wets down floors, but really a general utility man who does numerous tasks as needed. Job needs further study to determine how exposures can be reduced.

2. Additional specific industrial hygiene and ventilation improvements that should be undertaken at the Bennington plant are as follows:

a. The air balance in the grid casting area should be checked to assure it remains slightly positive to prevent air migration from other plant areas. The supply air to the room should be free of contamination from the exhaust air leaving other areas.

b. The procedure of manually opening and closing the door joining the parting area and ball mill to satisfy air supply requirements should be changed.

c. The reason for the reverse flow through the local exhaust in the parting area during baghouse cleaning should be documented and provisions made to eliminate the problem. Although cleaning occurs during worker break times, the emissions added to the housekeeping problem in the area.

d. Consideration should be given to installing manometers on ducts in proximity to exhaust hoods to monitor static pressure. A change in the static pressure reading from a normal setting could be easily recognized by the workers in the area and reported to the plant engineer. Also, a plant-wide plan to regularly monitor static pressure and capture velocity should be instituted. These procedures would help detect an exhaust malfunction.

e. Air make-up units should be monitored to assure that they are effectively helping to maintain the air balance desired. The supply air from these units should be distributed so as not to cause disruption in the airflow patterns around local exhaust control sites.

f. COS lines should be checked frequently to ensure that hoods are functioning properly and that exhaust ducts are not clogged.

g. The positioning of hoods in the Tiegel burn area should be reevaluated.

h. The airflow from an air supply unit above the polypunch area was directed toward the Tiegel burn area, where it disrupted airflow patterns. This situation needs to be remedied.

i. Scrap barrels should be covered when being stored or transported to minimize dust release. Also, pallets should be washed down after use so as to remove any residual lead oxide.

3. In addition to those specific recommendations, some of the methodology used in controlling toxic dusts to microgram levels in other industries that may be applicable to battery plants in reaching the 50 μg Pb/M^3 standard is as follows:

(a) Locker Change Rooms & Clothes - all workers who come in contact with lead should each day be issued clean clothing from the skin out. The worker should come into the locker room, draw clean work clothes, don work clothes, and shower clogs from locker in which he stores street clothes and proceed to the shoe locker room, don his plant shoes and exit through door leading into plant. At end of shift, the process is reversed.

They enter the shoe locker room, put shoes in shoe locker, don shower clogs, put clothes into hamper which has a mist spraying on it, then go through the shower to a drying area adjacent to locker room. Used clothes should be washed at the inplant laundry. No company clothes should leave the plant site.

(b) Lunch Room - it is preferable to build a lunch room at least 10 to 20 feet away from the main building. A gravel walkway should be provided that will clean shoes as one goes to lunch room. Lunch room must be near or convenient to a wash room.

(c) Plant Floors - these are usually concrete. They should be smooth, and equipment must be maintained so that liquor or lead oxide from the pasting operation or from the pasted plates does not drop onto it. These concrete floors should be covered with a plastic coating such as polyurethane varnish and they should be washed each shift with a mechanical sweeper which puts down a detergent solution, then scrubs and picks up the contaminated liquor by vacuum. Area under the equipment that cannot be reached with the sweeper should be cleaned with the house vacuum system using appropriate pick up tools. Because of adhesion difficulties this may be more applicable to new plants than to older ones.

(d) Pasting - pasting machine should be fed from a vertical pneumatic system. (There should be no bucketing into pasting machine.) Such a system is not in use at Bennington.

(e) Racks (stacking boards) should be plastic and washed each time they are used.

(f) Plate stacking should be automated so that pasted plates do not have to be manually handled.

(g) Stacked plates stored around the plant should have local exhaust ventilation.[28]

(h) Area air samples at Bennington showed concentrations of approximately 20 µg lead/M^3 air in several areas where airborne lead appeared to have been re-entrained from mud on the floor by forklift trucks. Although a prior report[27] suggests that dust raised by forklift trucks contains insufficient lead to interfere with meeting a 100 µg/M^3 air lead standard, the present experience suggests that such reentrainment might hinder achievement of a 50 µg/M^3 standard. These observations support the need for vigorous floor care (3.c., above).

4. The discovery of high arsenic concentrations in air and urine samples in certain plant areas, and in the battery formation area, was unanticipated. Arsenic is a known carcinogen (cancer-causing agent), and exposure to arsenic must be reduced to the lowest level possible. Air and urine samples in plant areas found on this survey to have high exposures to arsenic must be monitored periodically in accordance with OSHA regulations[30], and NIOSH recommendations.[10] Also, all workers must be informed of the danger of working with arsenic, and hazardous areas must be posted.[10]

IX. FUTURE PLANS

1. NIOSH plans to do follow-up air sampling to assess the current arsenic hazard.

2. To investigate further the finding of elevated BUN levels in 21 Bennington workers, NIOSH plans to conduct detailed evaluations of kidney function in certain workers. Details will follow by letter.

X. REFERENCES

1. Center for Disease Control, Bureau of Epidemiology, EPI 78-66-2, Occupational Lead Exposure - Vermont, December 14, 1979.
2. Barthel, W.F., Smrek, A.L., and Angel, G.P., et al : Modified Delves' Cup Atomic Absorption Determination of Lead in Blood. *J. Amer. Off. Analytical Chem.* 56:1252-1256, 1973.
3. Piomelli, S.: A Micromethod for Erythrocyte Porphyrins: The FEP Test. *J. Lab Clin. Med.* 81:923-940, 1973.
4. Technicon Auto-Analyzer Methodology: Technicon Laboratory Method File, NB-1, Urea Nitrogen, General Description.
5. Pierce, F.D. et al: "Automated Technique for the Submicrogram Determination of Selenium and Arsenic in Surface Waters by Atomic Absorption Applied 30:28-42, 1976.
6. Occupational Safety and Health Standards, Subpart Z - Toxic and Hazardous Substances ... 29 CFR 1000 Table Z1.
7. Occupational Safety and Health Standards, Subpart Z - Toxic and Hazardous Substances: Lead ... 29 CFR 1910.1025.
8. NIOSH Criteria for a Recommended Standard ... Occupational Exposure to Inorganic Lead, Revised 1978.
9. American Conference of Governmental Industrial Hygienists, *Documentation of the Threshold Limit Values for Substances in Workroom Air*, 3rd Edition, 1971.

10. NIOSH Criteria for a Recommended Standard ... Occupational Exposure to Inorganic Arsenic, Revised 1975.

11. NIOSH Criteria for a Recommended Standard ... Occupational Exposure to Antimony.

12. NIOSH Current Intelligence Bulletin 32: Arsine (Arsenic Hydride) Poisoning in the Workplace, April 3, 1979.

13. National Institute for Occupational Safety and Health: Health and Safety Guide for Storage Battery Manufacturers. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1977.

14. NIOSH Criteria for a Recommended Standard ... Occupational Exposure to Sulfuric Acid.

15. NIOSH Criteria for a Recommended Standard ... Occupational Exposure to Carbon Black.

16. Harrington, J.M., Middaugh, J.P., and Morse, D.L., et al: A Survey of a Population Exposed to High Concentrations of Arsenic in Well Water in Fairbanks, Alaska. Amer. J. Epidem. 108:377-385, 1978.

17. Rosenberg, M.J., Landrigan, P.J., and Crowley, S.: Low-level Arsenic Exposure in Wood Processing Plants. Arch. Environ. Health, in press.

18. Baker, E.L. Jr., Hayes, C.G., and Landrigan, P.J., et al: A Nationwide Survey of Heavy Metal Absorption in Children Living Near Primary Copper Lead and Zinc Smelters. Amer. J. Epidem. 106:261-273.

19. Milham, S. Jr., and Strong, T.: Human Arsenic Exposure in Relation to a Copper Smelter. Environ. Res. 7:176-182, 1974.

20. Webster, S.H.: The Lead and Arsenic Content of Urine From 46 Persons With No Known Exposure to Lead or Arsenic. Public Health Rep. 53:1953-1961, 1941.

21. Browning, E.E.: Toxicity of Industrial Metals. Second Edition. New York, Elsevier, 1969.

22. Dinman, B.D.: Arsenic - Chronic Human Intoxication. J. Occup. Med. 2:137-141, 1960.

23. Baker, E.L. Jr., Landrigan, P.J., and Barbour, A.G., et al: Occupational Lead Poisoning in the United States: Clinical and Biochemical Findings Related to Blood Lead Levels. Brit. J. Industr. Med. 36:315-322, 1979.

24. Colton, T.: Statistics in Medicine. Boston, Little, Brown and Co., 1974.

25. Page, L.B. and Culver, P.J.: A Syllabus of Laboratory Examinations in Clinical Diagnosis, Rev. Ed., Cambridge: Harvard University Press, 1962.

26. Wedeen, R.P., Maesaka, J.K., and Weiner, B., et al: Occupational Lead Nephropathy. American Journal of Medicine 59:630, 1975.

27. Caplan, Knowlton. Engineering Cost and Feasibility Study of Lead Standard for Proposed OSHA. International, Inc., Battery Council, July, 1976.

28. Caplan, K.J. and Knutson, G.W.: Experimental Analysis of Lead in Air Sources in Lead-Acid Battery Manufacturers. Amer. Ind. Hyg. Assoc. J. 40:7, July 1979.

29. NIOSH Manual of Analytical Methods, 2nd Edition, 1977.

30. Occupational Safety and Health Standard, Subpart Z - Toxic and Hazardous Substances: Arsenic ... 29 CFR 1910.1018.

XI. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By:

Richard J. Costello, P.E., C.I.H.
Industrial Hygienist
Industrial Hygiene Section
Hazard Evaluations and Technical Assistance Branch
Cincinnati, Ohio

Philip J. Landrigan, M.D., M.Sc.
Director
Division of Surveillance, Hazard Evaluations and Field Studies
Cincinnati, Ohio

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies
Cincinnati, Ohio

Acknowledgements

Initial Survey:

Wesley E. Straub
Regional Consultant, Region I
NIOSH, CDC, PHS, HEW
JFK Federal Building Room 1401
Boston, Massachusetts 02203

	Ray Stroman, P.A. Medical Section Hazard Evaluations and Technical Assistance Branch Cincinnati, Ohio
Medical Survey:	Richard Vogt, M.D. State Epidemiologist State of Vermont Agency for Human Services Department of Health Barre, Vermont 05641
	Michael T. Donohue, P.A. Medical Section Hazard Evaluations and Technical Assistance Branch Cincinnati, Ohio
Environmental Survey/Control Recommendations	Harry Donaldson Research Industrial Hygienist Industry-Wide Studies Branch Division of Surveillance, Hazard Evaluations and Field Studies Cincinnati, Ohio
Environmental Survey:	Ray Ruhe Jim McGlothlin Paul Johnson John Kominsky Industrial Hygienists Industrial Hygiene Section Hazard Evaluations and Technical Assistance Branch Cincinnati, Ohio
	David Peter Richard Duncan Co-Op Students Industrial Hygiene Section Hazard Evaluations and Technical Assistance Branch Cincinnati, Ohio
	Jerry Newman Program Analyst Division of Technical Services

Ventilation Survey:	Alfred Amendola Environmental Engineer Division of Physical Sciences and Engineering
Video Survey:	Roger Wheeler Electronics Technician Division of Training and Manpower Development
	Paul Day Safety Specialist Division of Technical Services
Statistics:	William T. Stringer Statistician Support Services Branch Division of Surveillance, Hazard Evaluations and Field Studies Cincinnati, Ohio
	Shiu T. Lee Statistician Support Services Branch Division of Surveillance, Hazard Evaluations and Field Studies Cincinnati, Ohio
Report Typed By:	Sandra Kerdolff Clerk Typist Industrial Hygiene Section

XII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report have been sent to:

1. International Representatives, United Auto Workers, 179 Allyn Street, Hartford, Connecticut 06103.
2. Globe Union Corporation, 900 East Kerfe Avenue, Milwaukee, Wisconsin 53201.
3. United Auto Workers, Social Security Department, 8000 East Jefferson Avenue, Detroit, Michigan 48214.
4. Director, State of Vermont - Division of Occupational and Radiological Health, 10 Baldwin Street-Administration Building, Montpelier, Vermont 05602.
5. NIOSH, Region I
6. OSHA, Region I

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

For the purpose of informing the affected employees the employer shall promptly post for a period of 30 calendar days this determination report in a prominent place(s) near where the exposed employees work.

APPENDIX I

SAMPLING AND ANALYSIS METHODOLOGY
GLOBE UNION BATTERY PLANT
BENNINGTON, VT

January 29 - February 2, 1979

Substance	Collection Device	Flow Rate	Duration	Analysis	Limit of Detection	References
Lead	AA filter	1.5 l/min	7-8 hrs.	Atomic absorption	2 μg	28
Arsenic	AA filter	1.5 l/min	7-8 hours	Wet ashing - method of Pierce	50 ng	5
Antimony	AA filter	1.5 l/min	7-8 hours	" " "	50 ng	5
Sulfuric Acid	AA filter	1.5 l/min	7-8 hours	ion chromatography	4 μg	28
Arsine	Charcoal tube (150 mg)	100 cc/min	7-8 hours	Wet ashing - method of Pierce	50 ng	5
Stibine	Charcoal tube (150 mg)	100 cc/min	7-8 hours	" " "	50 ng	5
Polynuclear Aromatic Hydrocarbons	Silver Membrane Filter	1.5 l/min	7-8 hours	Benzene extraction	0.02 mg	28

Note - the same methodology applies to both area and personal samples.

APPENDIX II

ENVIRONMENTAL EVALUATION CRITERIA
GLOBE UNION BATTERY PLANT
BENNINGTON, VT
HE 78-98

January 29 - February 2, 1979

Substance	NIOSH Recommended Standard	Source	Primary Health Effects	OSHA Standard	
Inorganic Lead	100 $\mu g/M^3$	Reference 8	Damage to blood forming organs, CNS impairment, peripheral neuropathy, renal damage, reproductive abnormalities	50-200 $\mu g/M^3$	Reference 7
Inorganic Arsenic	2 $\mu g/M^3$(C-15 min)	Reference 10	Nausea, vomiting, diarrhea, hyperpigmentation, hyperkeratosis, lung cancer, possible lymphatic cancer, sensory neuropathy, liver cancer	10 $\mu g/M^3$	Reference 30
Antimony	0.5 mg/M^3	Reference 11	Abnormal ECG's, pneumoconiosis, dermatitis, mucous membrane irritation	0.5 mg/M^3	Reference 6
Polynuclear Aromatic Hydrocarbons	0.1 mg/M^3	Reference 15	Possible carcinogen	-------	--------
Arsine		Reference 12	Hemolytic agent - kidney & liver damage	0.2 mg/M^3	Reference 6
Stibine		Reference 12	Hemolytic agent - kidney & liver damage - lung irritant	0.5 mg/M^3	Reference 6
Sulfuric Acid	1.0 mg/M^3	Reference 14	Throat tickling, cough, alteration of respiration, pulmonary edema, fibrosis and emphysema, caries of exposed dental surfaces	1.0 mg/M^3	Reference 6

APPENDIX III LEAD
SUMMARY OF DESCRIPTIVE STATISTICS
COMBINED ENVIRONMENTAL DATA
HE 78-98
GLOBE UNION CORPORATION
BENNINGTON, VT
Jan 29 - Feb 2, 1979

Group/Day/Shift	n	x	STD	MIN	MAX
Lead (overall)	342	0.09	0.10	0.01	0.61
	342	- 1.26	0.40	-2.01	-0.21
Group A	226	0.10	0.11	0.01	0.62
	226	- 1.24	0.45	-2.01	-0.21
Group B	116	0.07	0.06	0.01	0.37
	116	- 1.28	0.30	-1.91	-0.43
1/29/79	40	0.12	0.11	0.01	0.52
	40	- 1.14	0.44	-1.84	-0.28
1/30/79	104	0.08	0.09	0.01	0.44
	104	- 1.28	0.39	-2.01	-0.35
1/31/79	46	0.10	0.12	0.01	0.62
	46	- 1.20	0.44	-1.90	-0.21
2/1/79	102	0.08	0.09	0.01	0.57
	102	- 1.24	0.35	-1.91	-0.24
2/2/79	50	0.08	0.09	0.01	0.40
	50	- 1.37	0.45	-2.01	-0.39
1	117	0.08	0.08	0.01	0.44
	117	- 1.27	0.38	-1.95	-0.35
2	132	0.08	0.10	0.01	0.62
	132	- 1.28	0.39	-2.01	-0.21
3	93	0.10	0.12	0.01	0.53
	93	- 1.20	0.45	-2.01	- 0.28

* Note: Lead (1st line) and Log (Lead) (2nd Line). Concentrations are in mg/M^3

APPENDIX IV ARSENIC

SUMMARY OF DESCRIPTIVE STATISTICS
COMBINED ENVIRONMENTAL DATA
HE 78-98
GLOBE UNION CORPORATION
BENNINGTON, VT
Jan 29 - Feb 2, 1979

Group/Day/Shift	n	$\bar{x}$	STD	MIN	MAX
Overall	344 344	0.75 -1.51	4.65 1.20	0.00 -3.00	61.76 - 1.79
Group A	228 228	0.47 -1.92	4.16 1.18	0.00 -3.00	61.76 1.79
Group B	116 116	1.31 -0.69	5.46 0.75	0.00 -3.00	43.54 1.64
1/29/79	41 41	0.32 -2.12	1.53 1.17	0.00 -3.00	9.75 0.99
1/30/79	104 104	1.59 -0.88	7.74 0.93	0.00 -3.00	61.76 1.79
1/31/79	47 47	0.15 -1.84	0.43 1.13	0.00 -3.00	2.58 0.41
2/1/79	102 102	0.69 -1.11	3.16 1.03	0.00 -3.00	29.49 1.47
2/2/79	50 50	0.05 -2.80	0.31 0.69	0.00 -3.00	2.18 0.34
1	117 117	1.48 -1.21	7.48 1.15	0.00 -3.00	61.76 1.79
2	133 133	0.38 -1.71	2.27 1.20	0.00 -3.00	25.75 1.41
3	94 94	0.38 -1.59	1.26 1.21	0.00 -3.00	9.75 0.99

* Note: Very small value was used to replace zero so log transformation can be done.

Arsenic (1st line) Log (Arsenic) (2nd line). Concentrations are in μg/M^3

APPENDIX V

AIR VELOCITY SUMMARY
HE 78-98
GLOVE UNION INC.
BENNINGTON, VT
Jan 29 - Feb 2, 1979

Location of Hood	Description of Hood	Smoke Tube Observation	Capture Velocity - fpm (location)
Remelt furnace	enclosed canopy with openings for drossing & conveyor	good control	a) access door - 400 (space under door) b) dross opening - 600 (face) c) conveyor opening - 700 (face)
Dross Barrel	enclosed with slot from dross opening to barrel	good control	450 (along slot)
Beside conveyor	side draft slot	poor control	150 (face) too far from capture point
Small parts melt furance	partially enclosed canopy	good control	50 - 100 (along outer edge of furnace)
Paste Mixing			
a) quality control table	down draft (11" x 29")	good control	150 (face)
b) trash containers	enclosed top with opening for trash	good control	250 (inside opening)
c) Mixer A	enclosed with closable access door (7" x 18½")	good control	300 (at door opening)
d) Mixer B	enclosure with closable access door (approximately 22" x 17")	good control	700 (at flanged hood)
#1 Pasting Line - conveyor	(3) side draft slot hood	good control	50 - 100 (at outside edge of plate conveyor)
	downdraft		350 (at plate height)

APPENDIX V
AIR VELOCITY SUMMARY (cont'd)

Location of Hood	Description of Hood	Smoke Tube Observation	Capture Velocity - fpm (location)
#2 Pasting Line - conveyor	(3) side draft slot hood	good control	100 (at outside edge of plant conveyor)
	down draft	good control	450 (at plate height)
#1 and #2 MAC parter	enclosed with openings for panel movement through	good control	150 (at face of openings)
#1 Pasting Line take-off	dust box - downdraft below conveyor	fair control	less than 50 (at conveyor height)
a) North side	tamping box - downdraft	good control	175 (at plate height)
b) South side	" " "	good control	
	downdraft hood with 3¼" x 32" perforated top	good control	
#2 Pasting Line take-off	dust box - downdraft below conveyor	good control	100 (at conveyor height)
a) North side	tamping box - downdraft	good control	150 (at plate height)
b) South side	tamping box - downdraft	good control	150 (at plate height)
	downdraft hood with 3¼ x 32" perforated top	good control	
#1 Stacking machine			
a) scrap barrel	enclosed top with opening for scrap	good control	50 - 100 (inside opening)
b) scrap table	downdraft	good control	100 (face)
c) tamping box	downdraft - tamping box downdraft hood	good control	100 (at plate height)
d) stacking machine	downdraft hood	good control	50 (at plate height)

APPENDIX V
AIR VELOCITY SUMMARY (cont'd)

Location of Hood	Description of Hood	Smoke Tube Observation	Capture Velocity - fpm (location)
e) conveyor exhaust	exhaust manifold with (2) 13" x 2" slots	good control	200 (at base of conveyor)
f) before COS	ferris wheel-enclosed except openings for conveying -	*poor control/ good control	50 (at face of opening)
#2 Stacking machine			
a) scrap barrel	enclosed top with opening for trash	good control	100 (inside openings)
b) scrap table	downdraft	good control	150 (face)
c) tamping box	tamping box downdraft hood	good control	175 (plate height)
d) stacking machine feed	downdraft hood	fair control	less than 50 (at plate height
e) conveyor exhaust	exhaust manifold with (2) 13" x 2" slots	good control	250 (at base of conveyor)
f) before GOX		good control	75 (at face of opening)
#3 Stacking machine			
a) scrap barrel	enclosed top with opening for trash	good control	75 (inside opening)
b) scrap table	downdraft	good control	200 (face)
c) tamping box	tamping box downdraft hood	good control	75 (plate height)
d) walking beam	downdraft hood	good control	75 (plate height)
e) conveyor exhaust	exhaust manifold with (2) 13" x 2" slots	good control	150 (at base of conveyor)

* Initially exhaust duct was blocked. Velocity readings were taken after clearing the obstruction.

APPENDIX V
AIR VELOCITY SUMMARY (cont'd)

Location of Hood	Description of Hood	Smoke Tube Observation	Capture Velocity - fpm (location)
f) before COS	canopy hood enclosure with openings for conveyor to pass through	good control	75 (at face of opening)
#2 COS Unload			
a) tamping surface	downdraft hood with 12" x 22" perforated top	good control	150 (at plate height)
b) repair table	downdraft hood with 18" x 30" perforated top	good control	200 (at plate height)
c) battery case loading	sidedraft hood with 2" x 36"	good control	150 (at case height far end of case)
#3 COS Unload			
a) tamping surface	downdraft hood with 12" x 22" perforated top	good control	125 (at plate height)
b) repair table	downdraft hood with 18" x 30" perforated top	good control	75 (at plate height)
c) battery case loading	sidedraft hood with 2" x 36" slot	good control	300 (at case height far end of case)
Tiegel Burn/Stacking Machine			
a) tamping surface	downdraft hood with 11" x 32" perforated top exhausted at each end	good control	150 (at plate height)
b) conveyor exhaust	exhaust manifold with (2) 13" x 2" slots	good control	100 (at base of conveyor)
c) stacker ferris	canopy hood enclosure with openings for a conveyor to pass through	good control	100 (at openings)

APPENDIX V
AIR VELOCITY SUMMARY (cont'd)

Location of Hood	Description of Hood	Smoke Tube Observation	Capture Velocity - fpm (location)
d) repair table	downdraft	good control	125 (at plate height)
e) surge table	canopy hood enclosure with 32" x 12" access opening	good control	100 (at opening)
f) Tiegel burn tamping box	downdraft hood with 8" x 8" perforated top	good control	100 (at plate height)
g) Tiegel burn tamping box	downdraft hood with 7" x 17" perforated top	good control	100 (at plate height)
h) Tiegel burn	elevated slot 48" x 1"	*fair control	*650 (at slot face)
i) battery case	sidedraft hood with 2" x 36" slot	good control	100 (at battery case height)
j) repair table	downdraft	good control	150 (at plate height)
#1 H-V Welder	downdraft repair hood	good control	150 (at battery top)
#2 H-V Welder	downdraft repair hood	good control	200 (at battery top)
#3 H-V Welder	downdraft repair hood	good control	100 (at battery top)
Post Building			
a) before melt pot	side draft slot (48" x 3")	good control	50 (at face of opening)
b) melt pot	enclosed canopy with 12" x 14" opening	good control	75 (at face of opening)
c) after melt pot	side draft slot (39" x 1")	good control	50 (at furthest post)

* See discussion section.

APPENDIX V
AIR VELOCITY SUMMARY (cont'd)

Location of Hood	Description of Hood	Smoke Tube Observation	Capture Velocity - fpm (location)
#1 COS Loader			
a) surge table	canopy hood enclosure with 32" x 12" access opening	good control	150 (at opening)
b) tamping surface	hood with 7" x 24" perforated top (downdraft) and side with (2) 24" x 3/4" slots	good control	150 (at plate height)
c) repair table	downdraft hood with 18" x 30" perforated top	fair control	less than 50 (at plate height)
#2 COS Loader			
a) surge table	canopy hood enclosure with 32" x 12" access opening	good control	150 (at opening)
b) tamping surface	hood with 7" x 24" perforated top (downdraft) and side with (2) 24" x 3/4" slots	good control	100 (at plate height)
c) repair table	downdraft hood with 18" x 30" perforated top	good control	75 (at plate height)
#3 COS Loader			
a) surge table	canopy hood enclosure with 32" x 12" access opening	good control	150 (at opening)
b) tamping surface	hood with 7" x 24" perforated top (downdraft) and side with (2) 24" x 3/4" slots	good control	75 (at plate height)
c) repair table	downdraft hood with 18" x 30" perforated top	good control	75 (at plate height)

APPENDIX V
AIR VELOCITY SUMMARY (cont'd)

Location of Hood	Description of Hood	Smoke Tube Observation	Capture Velocity - fpm (location)
#1 COS Unload			
a) tamping surface	downdraft hood with 12" x 22" perforated top	good control	175 (at plate height)
b) repair table	downdraft hood with 18" x 30" perforated top	good control	75 (at plate height)
c) battery case loading	sidedraft hood with 2" x 36" slot	good control	300 (at case height far end of case)

APPENDIX VI

Inter-Office Communication

February 21, 1979

To International Executive Board and International Staff Servicing Battery Plants

From Melvin A. Glasser

Subject Lead Control Techniques in Battery Plants

One of my staff recently toured GM-Delco-Remy's new lead-acid battery manufacturing plant in Muncie, Indiana. The lead control techniques should interest you.

This plant is virtually meeting the new OSHA standard for lead-in-air. Records show air levels occasionally exceed the 50 microgram level, but most of the time are within the limit. A number of air samples are even within the 5-10 microgram range.

The new plant started operations in June 1977. The old plant was completely phased out in January 1978. The new plant currently has 580 workers with production at about 14,000 batteries per day.

The plant is undoubtedly the cleanest battery plant surveyed by the UAW Health and Safety Staff. Production is heavily automated compared to other companies where UAW members work. Many innovations in equipment and ventilation design have been instituted here which have improved health conditions markedly. The plant now serves as a model for other battery plants.

There are a few sources of exposure yet to be completely controlled, but it appears that plant management is committed to reducing the exposure in these areas as much as possible.

Techniques Used

The following is a brief description of some of the techniques used. Most of these techniques could be used in existing battery plants to improve conditions. Although, it would be easier to add all these ideas during the construction of a new plant, it is not necessary to build a new plant to make the improvements.

Floor

The floor was cement with a special plastic coating which highlighted any oxide dust that fell to the floor and which facilitated easy cleaning. Because of the other controls, however, very little dust was on the floor, even in some traditionally dusty operations.

Scrap Containers were all well enclosed and fitted with exhaust ventilation.

Plate Making

GM has developed a new method of making plates which eliminates the old grid casting process. Because of the new process, the pasting operation inherently is less dusty. No "oversmear" of paste on grids was made, which thus eliminated the accumulation of lead oxide chips normally found around pasting machines and ovens. Furthermore, there was no more need to brush off the plates at the Off Bear Station, which is traditionally one of the most dangerous operations in a battery plant.

Additionally, the GM process involves putting a tissue paper covering on each plate, which serves to reduce dust coming from the handling and transportation of plates and groups.

The conveyors leading from the ovens to the Off Bear Stations were all fitted with downdraft ventilation.

It was also my impression that the new process was more productive than the old, although I have no data on this.

Plate Transportation

Plates were transported in open skids, which would be a source of dust exposure in most battery plants. Here the problem appeared minimal (although still potentially a source of exposure) because of the smooth floor (less jarring of the plates from the lift truck) and because of the tissue covering on the plates. Skids were vacuumed after each use.

Automatic Stackers

The stackers had built-in exhaust ventilation. Conveyors leading from the stackers were fitted with downdraft ventilation. The loaders had vacuum hoses at their immediate disposal to clean spills. The table which held the plate skids had exhaust ventilation on the edges.

Group Assembly, Burning, and Sinking

GM processes here differed from other battery plants and was more automated. Exhaust ventilation was built into the machines. Locations where dust was created had local exhaust ventilation. All surfaces where plates or groups rested or were handled had downdraft exhaust. Lead oxide dust observed on these machines were much less than found on equivalent machines in other companies.

Man-Cooling Air

This plant was air-conditioned, which eliminated the need for pedestal fans which plague most battery plants because they create so much air turbulence that they defeat the capture of the exhaust systems.

Formation Room

The GM process had downdraft ventilation on each formation tank. Additionally, steel canopies covered each tank. The sides of the canopy could be lifted up for access to the tanks. There was virtually no sulfuric acid mist in the air.

Oxide Mill

All oxide was mechanically conveyed to the mixers. There was no continuing exposure to lead oxide dust such as is found when barrels, elevators, and such are used. Occasional leaks in the system presented the only source of exposure.

Housekeeping

Vacuum systems were used wherever lead oxide dust was likely to be created. The effectiveness of the exhaust ventilation minimized the need for additional housekeeping. The clean plant and the efforts of management to control the dust has contributed to a better consciousness among the workers to keep the plant clean.

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cc: Local Union Representatives from Battery Plants