U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
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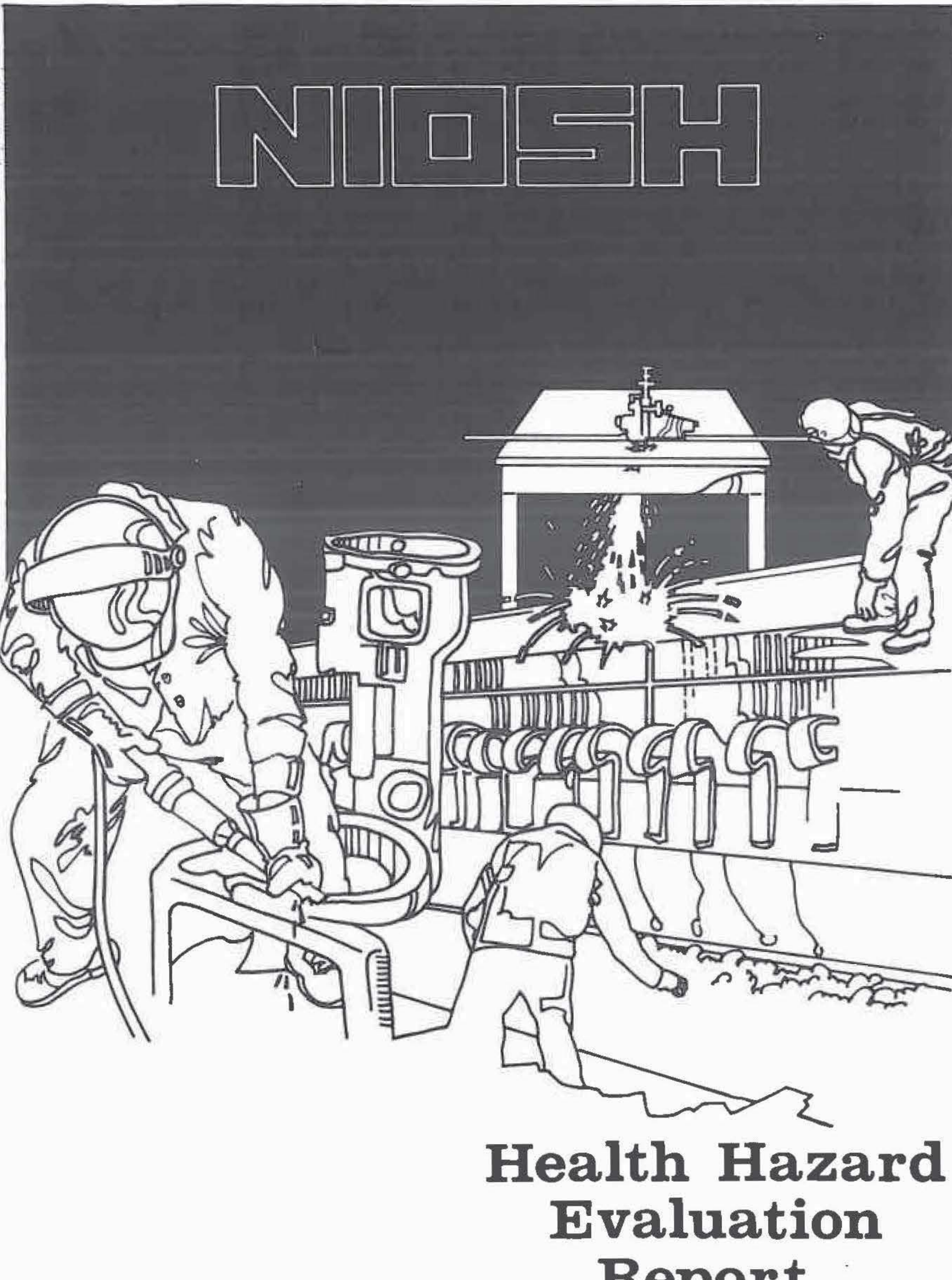

Health Hazard Evaluation Report

78-44-715

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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

HEALTH HAZARD EVALUATION DETERMINATION REPORT
HE 78-44-715 (Revised)

KAISER ALUMINUM AND CHEMICAL CORPORATION
RAVENSWOOD, WEST VIRGINIA 26164

November 1980

I. SUMMARY

On January 1, 1978, the National Institute for Occupational Safety and Health (NIOSH) received a request to "update" environmental conditions and "evaluate" the ventilation systems within the potrooms at the Kaiser Aluminum and Chemical Corporation, Ravenswood, West Virginia. In response to this request, NIOSH conducted environmental and ventilation system assessments at the plant.

Personal and area air samples were obtained for determination of coal tar pitch volatiles (CTPV) (benzene solubles), polynuclear aromatic hydrocarbons (PNA), total particulates, and fluorides. Indicator tube sampling was done for sulfur dioxide, carbon monoxide, and hydrogen fluoride. Bulk samples of anodes and cathodes were analyzed for CTPV's and PNA's, while bulk samples of ore and bath were analyzed for free silica. Twenty-one workers were interviewed using non-directed medical questionnaires. The ventilation assessment was done using observations, air velocity measurements, and company data.

CTPV concentrations in 14 of 46 personal samples exceeded the NIOSH recommendation of 0.10 mg/M^3, while PNA analyses on 27 of the same 46 samples showed PNA's to be present in every instance. Three of 28 personal samples exceeded the Threshold Limit Value of 10.0 mg/M^3 for total particulates although two had concentrations so excessive that their validity may be questionable. None of 25 personal samples for fluorides exceeded the NIOSH recommendation of 2.5 mg/M^3. Of the 99 personal air samples, six (three each for CTPV and total particulates) indicated air concentrations in excess of OSHA standards. Fifteen of 27 indicator tube samples exceeded the NIOSH recommendation of 3 ppm (ceiling) for sulfur dioxide while none of the 12 samples for carbon monoxide or 4 samples for hydrogen fluoride exceeded the NIOSH recommendations of 200 ppm (ceiling) and 5.0 mg/M^3 (15-minute), respectively.

The bulk sample analyses showed the presence of benzene solubles in the "green" anodes and cathodes. The bulk sample analyses of "baked" and "spent", as compared with "green", anodes and cathodes show significant

reductions in both the benzene solubles and PNA's (the PNA's being generally below the lab detection limits). The bulk sample analyses for free silica in the ore and bath indicated concentrations of quartz and cristobalite below the laboratory detection limits.

The results of the 21 medical questionnaires indicate that dust and off-gases from the pots (particularly during anode replacement) may be causing some mucous membrane irritation. The ventilation assessment showed the pothood system to be of sound design but that deficiencies in maintenance and housekeeping may be reducing its intrinsic efficiency. Since a portion of the ore fed to the pots is now recycled from air pollution scrubbing units and thus contains fluorides and hydrocarbons, the efficiency of the pothood system has become more critical. Also, the roof ventilators protrude only a few inches above the roof and the possibility exists for downwash and unplanned recirculation of contaminated air.

On the basis of the findings of this investigation, and comparison with NIOSH survey criteria (not necessarily the OSHA standards), it is concluded that potentially hazardous exposures to coal tar pitch volatiles (benzene solubles which contain polynuclear aromatic hydrocarbons), total particulates, and sulfur dioxide exist for certain of the potroom workers. Also, some workers may be experiencing respiratory irritation. The potroom ventilation systems are of basic sound design, but certain deficiencies are reducing the intrinsic effectiveness of these systems. Recommendations directed towards reducing workers' exposures are presented in this report.

II. INTRODUCTION

On January 1, 1978, a union safety and health committeeman, United Steelworkers of America, Local 5668, Ravenswood, West Virginia, requested a health hazard evaluation of the potrooms at the Kaiser Aluminum and Chemical Corporation, Ravenswood, West Virginia. The purpose of the request was to have NIOSH "update" environmental conditions and "evaluate" the exhaust ventilation systems within the potrooms.

Environmental conditions at the Kaiser Ravenswood plant have been evaluated a number of times by federal agencies for industrial hygiene purposes. The Charleston, West Virginia, OSHA office has made several industrial hygiene inspections at the plant during the years 1971 to 1978. In addition, NIOSH has previously conducted two health evaluations at the plant (HE's 74-25-267 and 76-33,34-431). One of these evaluations (HE 76-33,34-431) addressed environmental conditions within the potrooms. Both of these evaluations included medical as well as environmental components.

III. BACKGROUND

A. Process - Materials

In the basic potroom process, alumina (aluminum oxide) is dissolved in in a bath of molten fluorides within a large steel pot. In a reduction plant a number of these pots are connected electrically in series. Such a series of pots constitutes a potline. Carbon electrodes are used as both the anode and cathode. The Ravenswood process is of the "pre-bake variety, that is, the anodes are pre-baked before being used in the reduction pots. The passage of direct current results in molten aluminum sinking to the bottom of the pot (cathode) and oxygen liberation at the anodes (formation of carbon monoxide and carbon dioxide). The molten aluminum is siphoned off into large heated crucibles. Basic raw materials include alumina, cryolite, aluminum fluoride, fluorospar, and soda ash for the molten solution; coal tar pitch, calcined coke, and "remake" (spent anodes) for the anodes; and coal tar pitch and anthracite coal for the cathodes.

The Ravenswood plant has four potlines, each of which has 168 pots arranged in two ("A" & "B") parallel potrooms (84 pots each). Each potline draws about 84,000 amperes at a voltage drop of about 4.7 volts per pot. Each pot measures about 10' x 20' and each potroom about 50' x 1200'. Aluminum production runs about 40,000 tons of aluminum per line-year, or about 160,000 tons for the plant per year.

The amount of ore charged is 220 tons per potline per day. On two of the potlines (2 & 3), the total 440 tons fed per day is the reacted ore used in the dry scrubbers that treat the potroom gases. The reacted ore normally is not blended with virgin ore before being fed to the pots. The other two potlines (1 & 4) are fed with virgin ore, carbon scrubber ore, and crushed bath. Of the 440 tons per day (for Lines 1 & 4) about 20% is reacted ore from carbon scrubbers (carbon plant) and crushed bath.

B. Personnel

The plant operates on a 3-shift per day, 7 days per week basis. Typical shift crews and major duties are (per line):

A. 6 Cell Operators - operate pots
B. 4 Anode Setters - change anodes
C. 2 Crane Men - operate cranes
D. 2 Tappers - syphon aluminum from pots
E. 2 Spares (laborers) - housekeeping
F. 1 Mobile Equipment Operator (MEO) - transports materials, housekeeping
G. 1 Foreman

C. Ventilation Systems

The pots are fully enclosed, but on each side there are six shield plates which can be removed individually to change the anodes or otherwise service the pot. There are also lift-off doors covering openings in the hood at each end of the pot that afford additional access for tapping, etc. Pot gases are drawn off through four slots inside the pot enclosure, two on each side of the centerline. The intake slots cover most of the length of the pot except at the center and the ends, where the pneumatic cylinders that actuate the centerline crustbreaker are located. The exhausts from the four intake hoods join to enter a single exhaust duct. A blast gate in each pot exhaust duct permits adjustment of the air flow.

The pot ventilation system provides a nominal pot exhaust rate of 3000 ft^3/min at 93°C. Each pothood exhaust duct connects directly to a main collector duct running outside the potroom building for its full length. The main collector duct is tapered to maintain a velocity of 3000 ft/min as the number of connected pots increases. The main ducts from four potrooms (two potlines) enter a plenum immediately upstream of four fans so that three fans can provide ventilation for all the potlines if one fan should be out of service. The fans are rated at 250,000 ft^3/min at 93°C and a differential pressure of 19.7 inches of water. Each fan has a separate discharge line. The discharge ducts from the four fans serving two of the potlines join a common header that later splits into two lines, each discharging to a bank of 12 dry scrubbers in parallel. The four fans serving the other two potlines are similarly arranged and eventually discharge to two more banks of 12 dry scrubbers each.

The dry scrubbers treating the potroom gases are essentially the same as those used at the carbon baking plant. Each unit has a nominal capacity of 40,000 ft^3/min and is made up of four modular sections that can be cut out of the line for servicing. Fabric filters are in the same structures as the fluid-bed reactors, with the filter bags directly above the fluid bed. The fluidized bed uses virgin ore (alumina) to "capture" the exhaust gases from the exhaust ventilation system.

The potrooms are ventilated by natural draft. The roof of a potroom is constructed with a row of natural draft ventilators that run the length of the building. The ventilators are supplemented by two rows of evenly spaced rectangular vents, one on each side of the roof ridge. There are air intake openings at the bottom of each side wall of a potroom, and these openings run the entire length of the building. The top-hinged doors covering these slide openings can be raised as much as necessary to afford the ventilation required. The ventilation system nominally provides 12 air changes per hour under winter conditions (ambient temperature 10°C) and 74 air changes per hour under summer conditions (ambient temperature 35°C). Under summer conditions, the velocity of the air entering the side doors was estimated to be 330 ft/min and the exit velocity through the roof monitors was estimated to be 500 ft/min.

IV. METHODS

A. Sequence

5/25/78	The OSHA area office in Charleston, West Virginia, was visited in order to review records and obtain environmental data from OSHA potroom surveys of 1978.
7/18-20/78	NIOSH conducted an environmental survey at the plant followed by an interim report.
2/21/79	Kaiser and NIOSH representatives discussed the environmental data for survey of July 18-20, 1978. NIOSH (with union concurrence) decided to "resample" the potrooms for specific PNA's (not done during the first survey).
4/3-5/79	NIOSH conducted a second environmental survey at the plant. The results were distributed by letter.
6/11-14/79	NIOSH conducted control technology assessment at the plant and the draft report dated October 1979 was reviewed.

B. Environmental

Based upon the potroom process and classical potroom exposures, air samples were collected for CTPV's, PNA's, total particulates, fluorides, sulfur dioxide, carbon monoxide, and hydrogen fluoride. The air sampling and analytical methodologies for the different types of air samples are shown in Table 1. Included in Table 1 are, for each substance evaluated, the collection device, the pump flow rate, the range of sample durations, the analysis method, the analytical detection limit, and where applicable, the reference for the detailed sampling and analytical method. Personal air samples are those for which the worker actually wears the air sampler with the collection device pinned to shirt lapel or collar so as to obtain an air sample representative of what he/she is breathing.

Several fixed location samples were collected for qualitative purposes only so the results are not presented in this report. Also, a number of air samples were collected for oil mist. Because of laboratory interferences, the oil mist sample results were not meaningful and consequently are not included in this report. Bulk samples were collected for polynuclear aromatic hydrocarbon and free silica analyses---the analytical methods are given on Tables 13 and 14.

C. Evaluation Criteria

The environmental evaluation criteria used for this study are presented in Table 2. Listed in Table 2, for each substance, are the recommended environmental limit, the source of the recommended limit, the principal or primary health effects underlying each recommended limit, and the current OSHA legal standard. NIOSH recommendations are often lower than OSHA standards because they incorporate newer information and are mainly based on occupational health considerations rather than technical feasibility and/or economic factors.

D. Employee Interviews

During the survey of April 3-5, 1979, twenty-one employees in several job categories were interviewed using non-directed questionnaires.

V. RESULTS-DISCUSSION

A. Environmental

Table 3 summarizes the results of the personal air samples for CTPV's (benzene soluble fraction). These results show that the air concentrations were generally lower for the April 1979 survey (mean of 0.06 mg/M^3) than for the July 1978 survey (mean of 0.11 mg/M^3) even though porus polymer tubes were not included in the sampling trains of July 1978. The 27 sample results of 1979 ranged from non-detectable to 0.14 mg/M^3 with a mean of 0.06 mg/M^3. Eight of the 27 samples (30%) from the 1979 survey exceeded the NIOSH recommendation of 0.10 mg/M^3 (normal workday average). Therefore, as judged by the NIOSH recommendation, it is concluded that hazardous exposures to CTPV were occurring in the potrooms at the time of the April 1979 survey (recognizing that minor alterations to the data might be necessary to determine true workday average exposures). None of the air samples for the April 1979 survey exceeded the OSHA standard of 0.20 mg/M^3.

Table 4 summarizes the results of the 27 personal air sample analyses for specific PNA's (benzo(a)pyrene, chrysene, pyrene, benzo(a)anthracene, and fluoranthene). Exposures ranged from "none-detected" (N.D.) to 3.80 ug/M^3 (mean of 0.29 ug/M^3) for benzo(a)pyrene, from N.D. to 4.90 ug/M^3 (mean of 0.43 ug/M) for chrysene, from N.D. to 32.0 ug/M^3 (mean of 1.6 ug/M^3) for pyrene, from N.D. to 28.0 ug/M^3 (mean of 1.7 ug/M^3) for benzo(a)anthracene, and from 0.07 to 48.0 ug/M^3 (mean of 3.0 ug/M^3) for fluoranthene. These results show the exposure of the potroom workers to PNA's. Also, as compared to National Air Surveillance Data,[1] the mean potroom benzo(a)pyrene level is several hundred fold higher than what one would expect in the ambient environment.

1. Environmental Protection Agency: Annual Benzo(a)pyrene Averages for 1977, National Aerometric Data Bank, Mail Drop 14, Research Triangle Park, No. Car. 27711

Table 5 summarizes the results of the personal air samples for total particulates (28 samples) and fluorides (24 samples). With the exception of three samples for total particulates (two MEO's and one spare) all of these results show air concentrations below the evaluation criteria of 10 mg/M^3 (total particulates) and 2.5 mg/M^3 (total fluorides). Two of these three air sample results (55.9 and 177 mg/M^3) are so high that their validity might be questioned. However, observations at the time of the surveys, showed that the MEO and spare jobs were potentially very dusty. Air concentrations for total particulates ranged from 0.3 to 177.0 mg/M^3 with a mean of 11.9 mg/M^3, while air concentrations for total fluorides ranged from 0.07 to 2.47 mg/M^3 with a mean of 0.51 mg/M^3. Excluding the two cited air sample results, air concentrations for total particulates would range from 0.3 to 20.6 mg/M^3 with a mean of 3.83 mg/M^3 while air concentrations for total fluorides would range from 0.07 to 0.81 mg/M^3 with a mean of 0.35 mg/M^3. Judging on the basis of the survey criteria (10.0 mg/M^3 for total particulates and 2.5 mg/M^3 for fluorides) and survey observations, it is concluded that the above data show over exposures (or potential of) to total airborne particulates for the MEO's and spares.

Table 6 summarizes the results of the indicator tube samples for sulfur dioxide (27 samples), carbon monoxide (12 samples), and hydrogen fluoride (4 samples). Sample results for sulfur dioxide (SO_2) ranged from none detected (<1 ppm) to 25+ ppm with a mean of 7+ ppm. NIOSH currently recommends that the SO_2 occupational exposure limit be a time weighted average of 0.5 ppm for up to a 10-hour workday, 40 hour workweek and anticipates that adherence to this limit will confine excursions to about 2 or 3 ppm. A simple calculation for the breathing zone data of April 4, 1979, assuming a sample time of 3.7 minutes per sample (with no other exposures), would yield a TWA concentration of 0.8 ppm, for the anode setters, which is in excess of the 0.5 ppm recommendation. The data of April 4, 1979, also show excursions greater than 2 or 3 ppm. It is therefore concluded, based on the survey data, and judged by NIOSH recommendations, that certain anode setters were over-exposed to SO_2 at the time of the survey. The limitations of indicator tube sampling (e.g. specificivity, sample duration, accuracy) are recognized. The SO_2 data do not indicate that the OSHA legal standard (average exposure) of 5.0 ppm was exceeded.

Sample results for carbon monoxide ranged from 0 to 15 ppm with a mean of 7 ppm. For hydrogen fluoride the results were all nondetectable. None of these sample results were in excess of the NIOSH recommendations for carbon monoxide and hydrogen fluoride on either the time-weighted average or short term exposure concepts.

All individual air sample results for CTPV's, PNA's, total particulates, fluorides, sulfur dioxide, carbon monoxide, and hydrogen fluoride, for both the July 1978 and April 1979 surveys are presented in Tables 7-12.

Table 13 presents the results of the bulk sample analyses for benzene solubles and specific PNA's. These results show the presence of benzene solubles and PNA's in the green anodes and cathodes. The results for the "baked" and "spent" anodes and cathodes as compared with "green" anodes and cathodes, show significant reductions in both the benzene solubles and PNA's (the PNA's being generally below the laboratory's detection limits).

Table 14 presents the results of bulk sample analyses for quartz and cristobolite. These results indicate non-detectable concentrations of quartz and cristobolite in the ore and bath.

B. Ventilation Systems

Despite its age (over 20 years), the pot ventilation system is of sound design and not essentially different from a number of plants recently constructed, either in basic design or--in most cases--in details of construction. The gas collecting slots inside the pothoods appear well positioned to provide necessary ventilation. However, observations indicated that the probable contaminant collection efficiencies of the pot ventilation systems are below the intrinsic potentials of the basic systems used. This results from operating practices and deficiencies in maintenance and housekeeping. The side shield plates of the pots were either poorly placed or were in such condition that they could not be properly placed. Part of the problem was associated with the accumulations of spilled ore on the deck plate next to the rim of the pot. These accumulations were frequently high enough to prevent proper seating of the side shields. Such paths for air leakage decreases the collection efficiency of the pot ventilation systems. Presumably, if maintenance, housekeeping, and work practices in the potrooms improved, worker exposure to pot emissions would be measurably reduced.

The plant has no data to indicate what percentages of the fluoride emissions from the pots are captured by the pot exhaust systems and what percentages are lost into the potroom atmosphere and escape to the atmosphere through the roof monitors. The efficiency of well designed and maintained pothoods is commonly estimated to be about 95% to 99%. The efficiencies of the potroom ventilation systems appear to be below that level.

The dry scrubber systems installed in recent years to treat the potroom gases provide capabilities for control of fluorides, particulates, and hydrocarbons that were previously lacking. However, now that part of the ore is reacted and contains aluminum fluoride or carries adsorbed hydrocarbons, the pot emissions may present a greater hazard for inhalation or ingestion than emissions from virgin ore. Prevention of emissions into the potroom atmosphere has therefore become more important.

The use of reacted ore from the carbon bake plant dry scrubbers introduces an additional source of hydrocarbons into the potline exhaust systems. As the ore is fed to the pots, some of the hydrocarbons adsorbed on the ore are burned; however, a portion of the hydrocarbons are revaporized and are collected by the potline exhaust systems. These fumes are trapped on the alumina used in the potline dry scrubbers, and the hydrocarbons are returned to the pots with the reacted ore. Whether this contributes significantly to the levels of hydrocarbons in the potrooms is dependent upon the efficiency of the individual pothoods. Calcining the hydrocarbon-laden ore to burn off the hydrocarbons before the ore is fed to the potlines would reduce hydrocarbons recycled to the potlines.

The evolution of emissions from a cell was particularly noticeable during the baking in of a rebuilt pot. In such an operation, the green cathode is placed on line with the anodes resting directly on the cathode lining of the pot shell, and current flow is continued for 24 hours while the cathode is baked. The hydrocarbon emissions from the pitch were highly visible and their escape from the pothood, as well as from other openings in the cell, was obvious.

The roof ventilators project only a short distance above the roof, and the possibility exists for downwash of contaminated air during crosswinds and subsequent unplanned recirculation of contaminated air into the intakes of the same or adjacent buildings. The extent of the problem posed by such recirculation is primarily related to the meteorology as well as the degree to which gases and fumes are contained within the pothoods and are removed by the primary gas collection and treatment system.

C. Employee Interviews

The average age of the 21 interviewed workers was 34 years with a range of 23-63 years. Age distribution was skewed towards the younger age groups with the median age being 28 years. The average length of employment was 10.2 years with a range of 2-21 years. Again, the distribution was skewed towards a shorter period of employment with the median being six years. Nine of the 21 workers (43%) stated that they did not feel they had any health problems related to their work. However, only one had no complaints on further questioning. The anode setters and spares working as anode setters identified emissions during anode replacement as being the source of their symptoms, which included burning of the eyes, nose, and throat; cough; and a choking sensation. These symptoms were mentioned less frequently by the other workers, whose major complaints concerned the dust which tended to clog up the nose, and cause respiratory tract irritation and cough. Workers generally reported that their symptoms improved when away from the job over weekends or particularly when on vacation. Two of the workers mentioned the heat. It thus appears that both the dust and off-gases from anode replacement cause mucous membrane irritation.

It must be noted that this hazard evaluation did not address chronic health effects. Also, two recent studies examined mortality patterns of workers in the aluminum reduction industry. One showed a dose-response relationship between lung cancer mortality and a cumulative exposure index.[2] Although the Gibb's study,[2] apparently included a reduction plant with Soderberg cells, and consequently worker exposure to CTPV (PNA's) would have been higher than in a "pre-bake" plant, the carcinogenic potential of CTPV (PNA's) is none-the-less indicated. The other study suggested that excess deaths from lymphatic and hematopoietic cancers observed in prebake smelter workers are related to occupational exposures that included CTPV.[3] Consequently, NIOSH reaffirms its previous conclusions that CTPV are carcinogenic and recommends that exposures be minimized.

VI. RECOMMENDATIONS

On the basis of the survey findings, the following recommendations are made:

1. General maintenance and housekeeping should be improved (e.g., broken crane cab windows should be immediately replaced).

2. The potroom ventilation systems must be carefully maintained and frequently inspected. These systems should be modified or other steps considered (i.e., process change) to keep CTPV and/or PNA exposures as low as possible.

3. The MEO's and spares (and any other employees) must use appropriate respiratory protection when environmental conditions warrant it until permanent engineering controls (if feasible) are installed and operating properly.

4. The anode setters should be carefully studied for pot emission exposures (particularly for SO_2 using more precise sampling methods than indicator tubes). If the anode setters are exposed to emissions in excess of NIOSH recommendations, additional engineering and/or administrative controls should be considered. A respiratory protection program may be appropriate on an interim basis if excessive exposures are found.

It is recognized that the company has comprehensive health and safety programs. All aspects of these programs should continue.

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2. Gibbs, G.W., and I. Horowitz: Lung Cancer Mortality in Aluminum Reduction Plant Workers, J. Occup. Med. 21 (5): 347-353 (1979).

3. Milham S.: Mortality in Aluminum Reduction Plant Workers, J. Occup. Med. 21 (7): 475-480 (1979).

VII. AUTHORSHIP/ACKNOWLEDGMENT

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VIII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this 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 from the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH at the Cincinnati address.

This report (copies) has been sent to:

1. Kaiser Aluminum and Chemical Corporation
2. Local Union 5668, United Steelworkers of America
3. National Office, United Steelworkers of America
4. OSHA, Region II
5. NIOSH, Region II

For purposes of informing the potroom employees, the employer shall promptly post this report in a prominent place(s) near or in the potrooms for a period of 30 calendar days.

Table 1
Air Sampling and Analysis Methodology

Substance	Collection Device	Flow Rate (Lpm)	Duration	Analysis	Detection Limit	Reference
Coal Tar Pitch Volatiles (Benzene Soluble)	Glass Fiber Filter Silver Membrane Filter Porous Polymer Tube*	2.0	6-8 hours	Benzene Extraction	0.02 mg/sample	NIOSH P&CAM No. 217
Polynuclear Aromatics (PNA)	" " "	2.0	"	High Pressure Liquid Chromatography, U-V Detector	1-10 μg/sample***	NIOSH P&CAM No. 217
Total Particulates	PVC Filter (DM-800)	2.0	"	Electrobalance	0.01 mg	------
Fluorides	PVC Filter (DM-800)	2.0	"	Ion Specific Electrode	2.5-3 μg/sample	NIOSH P&CAM No. 212
Sulfur Dioxide	Indicator Tube	0.27	1.0 L sample	Indicator Tube	1.0 ppm**	Drager Ind. Tubes
Carbon Monoxide	"	0.27	1.0 L sample	"	5.0 ppm**	"
Hydrogen Fluoride	"	1.5	2.0 L sample	"	1.0 ppm**	"

* Porous polymer tubes not used for survey of July 1978
** Lower end of measuring range (by mfg.)

*** Detection limit based on a 1.0 ul injection. The samples were analyzed using larger injection volumes to increase sensitivity.

Table 2
Environmental Evaluation Criteria

Substance	Recommended Environmental Limit	Source	Primary Health Effects	OSHA Standard
Coal Tar Pitch Volatiles (Benzene Soluble)	0.1 mg/m^3	NIOSH	Lung and Skin Cancer	0.2 mg/m^3
Polynuclear Aromatics (PNA's)	Certain PNA's are carcinogenic and exposures should be minimized.			
Total Particulates	10 mg/m^3	ACGIH	Respiratory Effects	15 mg/m^3
Fluorides	2.5 mg F/m^3	NIOSH	Kidney and Bone Effects	2.5 mg/m^3
Sulfur Dioxide	0.5 ppm 3.0-ceiling	NIOSH	Respiratory Effects	5 ppm
Carbon Monoxide	35 ppm	NIOSH	Heart Effects	50 ppm
Hydrogen Fluoride	2.5 mg F/m^3 5.0 mg F/m^3 (15-min sample)	NIOSH	Irritation, Bone Effects	3 ppm

All air concentrations are time weighted average (TWA) exposures for a normal (8 to 10 hour) work day of a 40 hour work week unless designated "ceiling"
A ceiling limit is one which should not be exceeded at any time.

Table
Summary of Personal Air Sample Results for
Coal Tar Pitch Volatiles (Benzene Soluble Fraction)*

Job	Survey of 7/18-20/78 No. of Samples	Air Conc. Mean	Air Conc. Range	Survey of 4/3-5/79 No. of Samples	Air Conc. Mean	Air Conc. Range
Crane Operator	3	0.10	0.07-0.15	4	0.08	N.D.-0.14
Anode Setter	5	0.09	0.02-0.29	6	0.05	N.D.-0.14
Tapper	3	0.14	0.02-0.37	6	0.07	0.03-0.12
Cell Operator	3	0.12	0.05-0.26	7	0.05	N.D.-0.14
Spare	2	0.07	0.05-0.08	1	0.11	------
Foreman	3	0.11	0.04-0.15	3	0.04	N.D.-0.10
Total No. of Samples	19	0.11	0.02-0.37	27	0.06	N.D.-0.14
Number of Samples exceeding 0.10 mg/m^3 (NIOSH recommended standard)	6 (32%)			8 (30%)		
Number of samples exceeding 0.20 mg/m^3 (OSHA legal standard)	3 (16%)			0 (0%)		

* Air concentrations in mg/m^3

Table 4
Summary of Personal Air Sample Results for Specific Polynuclear Aromatic Hydrocarbons*
April 3-5, 1979

Job	No. of Samples	Benzo(a)pyrene		Chrysene		Pyrene		Benzo(a)anthracene		Fluoranthene	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Crane Operator	4	0.21	N.D.-0.63	0.21	N.D.-0.71	0.40	N.D.-0.40	0.77	N.D.-0.77	1.22	0.07-3.60
Anode Setter	6	0.13	N.D.-0.32	0.31	N.D.-0.84	0.24	N.D.-0.95	0.63	0.13-1.80	0.86	0.18-1.80
Tapper	6	0.05	N.D.-0.16	0.08	N.D.-0.19	0.14	N.D.-0.82	0.23	N.D.-0.77	0.64	0.25-1.50
Cell Operator	7	0.63	N.D.-3.80	0.90	N.D.-4.90	4.70	N.D.-32.0	4.20	N.D.-28.0	7.30	0.14-48.0
Spare	1	N.D.	-----	0.13	-----	0.59	-----	0.41	-----	0.16	-----
Foreman	3	0.51	N.D.-1.50	0.63	N.D.-1.90	2.30	N.D.-6.90	2.50	N.D.-7.40	4.90	0.24-14.0

* Air concentrations in $\mu g/m^3$

Table 5
Summary of Personal Air Sample Results for Total Particulates and Fluorides *

Surveys of July 18-20, 1978 and April 3-5, 1979

Job	Total Particulates			Total Fluorides		
	No. of Samples	Air Conc. Mean	Air Conc. Range	No. of Samples	Air Conc. Mean	Air Conc. Range
Crane Operator	4	3.2	0.5-9.8	4	0.38	0.11-0.81
Anode Setter	3	2.8	2.1-3.8	3	0.42	0.36-0.48
Tapper	3	1.7	0.3-2.8	3	0.31	0.07-0.58
Cell Operator	6	3.10	1.1-3.8	5	0.35	0.14-0.47
Spare	6	32.0	1.0-177.0	4	0.81	0.26-2.15
MEO	5	18.9	5.0-55.9	4	0.87	0.25-2.47
Foreman	1	0.9	----	1	0.19	----
Evaluation Criteria (ACGIH, NIOSH)		10.0			2.5	
OSHA Standard		15.0			2.5	
Total No. of Samples	28			25		
No. of Samples exceeding Survey Criteria	3 (11%)			0 (0%)		
No. of Samples exceeding OSHA Standard	3 (11%)			0 (0%)		

* Air concentrations in mg/m^3

Tab

Summary of Air Sample Results by Indicator Tube*

Surveys for July 18-20, 1978 and April 3-5, 1979

Location	Substance	No. of Samples	Air Conc. Mean (ppm)	Air Conc. Range (ppm)
Crane Cabs	Sulfur Dioxide	5	N.D.	
	Carbon Monoxide	6	9	N.D. - 15
	Hydrogen Fluoride	2	N.D.	
Anode Setting	Sulfur Dioxide	19	10	1 - 25+
	Carbon Monoxide	2	5	0 - 10
	Hydrogen Fluoride	1	N.D.	
Other Areas	Sulfur Dioxide	3	N.D.	
	Carbon Monoxide	4	4	0 - 10
	Hydrogen Fluoride	1	N.D.	

Environmental Criteria: (all by NIOSH and in ppm)

	Average Exposure	Short Term Exposure
Sulfur Dioxide	0.5	3 ceiling
Carbon Monoxide	35	200 ceiling
Hydrogen Fluoride	6	12 (15-min)

* Indicator tube results should be compared with applicable short term exposure criteria.

Table 1

Results of Personal Air Sampling for Coal Tar Pitch Volatiles
(Benzene Soluble Fraction)

Date	Time	Line	Job	Benzene Solubles (mg/m^3)
7/18/78	0802-1456	2 B	Crane Operator	0.07
7/18/78	0808-1533	2 A & B	Anode Setter	0.02
7/18/78	0829-1514	2 A	Tapper	0.37
7/18/78	0851-1540	2 A	Cell Operator - 3rd Section	0.05
7/18/78	0901-1545	2 A & B	Foreman	0.15
7/19/78	0759-1437	1 B	Crane Operator	0.15
7/19/78	0804-1439	1 A & B	Anode Setter	0.05
7/19/78	0857-1439	1 A & B	Anode Setter	0.03
7/19/78	0840-1447	1 B	Cell Operator - 1st Section	0.05
7/19/78	0811-1446	1 B.	Spare	0.08
7/19/78	1008-1432	1 A & B	Foreman	0.04
7/19/78	0822-1447	1 A	Tapper	0.02
7/20/78	0804-1445	3 B	Crane Operator	0.07
7/20/78	0825-1445	3 A & B	Anode Setter	0.08
7/20/78	0835-0945	3 A & B	Anode Setter	0.29
7/20/78	0818-1511	3 A	Tapper	0.02
7/20/78	0806-1445	3 B	Spare	0.05
7/20/78	0902-1445	4 B	Cell Operator - 2nd Section	0.26
7/20/78	0901-1430	4 A & B	Foreman	0.15
Environmental Criteria (NIOSH)				0.10
Legal Standard (OSHA)				0.20

RESULTS OF AIR SAMPLING FOR COAL TAR PITCH VOLATILES
(BENZENE SOLUBLE FRACTION) AND SPE POLYNUCLEAR AROMATIC HYDROCARBONS

DATE	TIME	LINE	JOB	BENZENE SOLUBLES (mg/M3)	B(a)P (μg/M3)	CHRYSENE (μg/M3)	PYRENE (μg/M3)	B(a)A (μg/M3)	FLUORANTHENE (μg/M3)
4/3/79	0744-1437	4	Crane Operator	0.05	0.05	N.D.	N.D.	0.12	0.45
"	0746-1440	4	Crane Operator	0.14	0.63	0.71	1.6	2.6	3.6
"	0751-1400	4	Anode Setter	0.05	0.08	N.D.	N.D.	0.31	0.22
"	0801-1400	4	" "	0.14	0.15	0.36	N.D.	0.31	0.74
"	0753-1435	4	Tapper	0.07	0.05	0.16	N.D.	0.16	0.34
"	0755-1436	4	"	0.05	0.16	0.19	0.82	0.77	1.5
"	0756-1438	4B	Cell Operator	0.02	0.10	0.21	N.D.	0.27	0.78
"	0815-1445	4A	" "	0.03	0.15	0.40	N.D.	0.45	0.17
"	0829-1439	4B	" "	0.14	3.8	4.9	32.0	28.0	48.0
"	0803-1441	4	Foreman	0.10	1.50	1.90	6.9	7.4	14.0
"	0845-1455	4B	Crane (Area Sample)	0.03	0.43	0.84	1.1	0.96	3.1
4/4/79	0817-1450	2	Anode Setter	N.D.	0.11	0.43	N.D.	0.79	1.1
"	0805-1450	2	" "	0.02	0.09	0.25	0.48	0.46	1.1
"	0803-1451	2	Tapper	0.12	N.D.	N.D.	N.D.	N.D.	0.34
"	0801-1427	2	"	0.03	N.D.	N.D.	N.D.	0.13	0.43
"	0757-1438	2	Cell Operator	N.D.	0.10	0.35	N.D.	0.31	0.79
"	0747-1454	2	Cell Operator	N.D.	N.D.	N.D.	N.D.	0.06	0.21
"	0757-1452	2	Foreman	0.02	N.D.	N.D.	N.D.	0.08	0.24
"	0900-1425	2A	Crane (Area Sample)	N.D.	N.D.	0.10	N.D.	N.D.	0.85
"	0844-1425	2B	" (Area Sample)	N.D.	N.D.	N.D.	N.D.	0.07	0.45
4/5/79	0800-1240	1B	Crane Operator	N.D.	N.D.	N.D.	N.D.	N.D.	0.07
"	0830-1355	1A	" "	0.12	0.14	0.11	N.D.	0.37	0.75
"	0819-1421	1	Anode Setter	0.06	0.32	0.84	0.95	1.8	1.8
"	0820-1425	1	" "	0.05	N.D.	N.D.	N.D	0.13	0.18
"	0826-1421	1	Tapper	0.06	N.D.	N.D.	N.D.	0.09	0.25
"	0828-1421	1	"	0.08	0.10	0.10	N.D.	0.24	1.0
"	0822-1444	1A	Cell Operator	N.D.	N.D.	N.D.	N.D.	N.D.	0.14
"	0829-1448	1A	Cell Operator	0.13	0.24	0.42	0.62	0.58	1.30
"	0821-0912, 1037-1427	1	Spare	0.11	N.D.	0.13	0.59	0.41	0.16
"	0746-1450	1	Foreman	N.D.	0.04	N.D.	N.D.	0.13	0.39
"	0814-1350	1	NIOSH Investigator	0.06	0.33	0.39	0.40	1.7	0.98

Environmental Criteria (NIOSH)	0.10
Legal Standard (OSHA)	0.20

Table 9

Results of Personal Air Sampling for Total Particulates and Fluorides

Date	Time	Line	Job	Total Particulate (mg/m^3)	Fluorides Soluble (mg/m^3)	Fluorides Insoluble (mg/m^3)	Fluorides Total (mg/m^3)
7/18/78	0802-1456	2 A	Crane Operator	1.6	0.25	0.17	0.42
7/18/78	0811-1531	2 A & B	Anode Setter	2.5	0.15	0.21	0.36
7/18/78	0821-1457	2 B	Tapper	2.8	0.14	0.44	0.58
7/18/78	0836-1515	2 B	Cell Operator - 1st Section	3.3	0.14	0.33	0.47
7/18/78	0845-1421	2 B	Cell Operator - 3rd Section	3.5	0.14	0.16	0.30
7/18/78	0856-1533	2 A & B	Spare	2.3	0.12	0.20	0.32
7/18/78	0907-1525	2 A & B	Upgraded MEO	55.9	0.36	2.11	2.47
7/19/78	0819-1442	1 A	Crane Operator	1.0	0.12	0.05	0.17
7/19/78	0803-1445	1 A & B	Anode Setter	3.8	0.12	0.30	0.42
7/19/78	0829-1435	1 A	Tapper	2.0	0.11	0.17	0.28
7/19/78	1002-1433	1 A	Cell Operator - 1st Section	3.8	0.12	0.27	0.39
7/19/78	0845-1445	1 A	Cell Operator - 3rd Section	1.1	0.08	0.06	0.14
7/19/78	0813-1325	1 A	Spare	4.3	0.13	0.36	0.49
7/19/78	0836-1106	1 A	NIOSH Investigator	0.8	0.06	0.07	0.13
7/20/78	0805-1445	3 A	Crane Operator	0.5	0.07	0.04	0.11
7/20/78	0911-1525	1 & 4	Crane Operator	9.8	0.31	0.50	0.81
7/20/78	0848-1445	3 A & B	Anode Setter	2.1	0.19	0.29	0.48
7/20/78	0822-1445	3 B	Tapper	0.3	0.03	0.04	0.07
7/20/78	0836-1445	3 A	Cell Operator - 1st Section	3.4	0.08	0.35	0.43
7/20/78	0836-1445	3	Foreman	0.9	0.09	0.10	0.19
7/20/78	0839-1445	3	Spare	177.0	0.52	1.63	2.15

Environmental Criteria (ACGIH, NIOSH)	10.0	2.5
Legal Standard (OSHA)	15.0	2.5

TABLE

RESULTS OF PERSONAL AIR SAMPLING FOR TO PARTICULATES AND FLUORIDES (mg/M3)

DATE	TIME	LINE	JOB	TOTAL PARTICULATES	FLUORIDES SOLUBLE	FLUORIDES INSOLUBLE	FLUORIDES TOTAL
4/3/79	0810-1400	4	Spare	6.5	0.05	0.21	0.26
"	0820-1530	3-4	MEO	20.6	----	----	----
4/4/79	0827-1402	1-2	MEO	5.0	0.05	0.34	0.39
"	0847-1505	2	Spare	1.0	----	----	----
4/5/79	0802-1431	3-4	MEO	7.1	0.09	0.27	0.36
"	0805-1427	1	Spare	1.1	----	----	----
"	0808-0930, 1040-1505	1-2	MEO	5.9	0.05	0.20	0.25
"	0815-1444	1A	Cell Operator - 3rd Section	3.5	----	----	----
Environmental Criteria (ACGIH, NIOSH)				10.0			2.5
Legal Standard (OSHA)				15.0			2.5

Table 11

Results of Indicator Tube Air Samples *

Date	Time	Location	Substance	Air Concentration (ppm)
7/18/78	1215	Crane cab - line 2 B	Sulfur Dioxide	N.D.
7/18/78	1240	Crane cab - line 2 B	Carbon Monoxide	10-15
7/18/78	1255	Crane cab - line 2 B	Hydrogen Fluoride	N.D.
7/18/78	1405	Crane cab - line 2 B	Carbon Monoxide	10-15
7/18/78	1355	Crane cab - line 2 B	Sulfur Dioxide	N.D.
7/19/78	1350	Between pots 65 & 66 - Line A	Carbon Monoxide	Trace
7/20/78	1230	Crane cab**- line 3 B	Carbon Monoxide	5
7/20/78	1240	Crane cab - line 3 B	Sulfur Dioxide	N.D.
7/20/78	1255	Crane cab - line 3 B	Sulfur Dioxide	N.D.
7/20/78	1305	Crane cab - line 3 B	Carbon Monoxide	10

Environmental Criteria: (all by NIOSH and in ppm)

	Average Exposure	Short Term Exposure
Sulfur Dioxide	0.5	3 ceiling
Carbon Monoxide	35	200 ceiling
Hydrogen Fluoride	6	12 (15-min.)

*Indicator tube results should be compared with the short term criteria
**Crane cab had a broken window

Table 12

Results of Indicator Tube Air Samples*

Date	Time	Location	Substance	Air Concentration (ppm)
4/3/79	0900	Crane cab - line 4 B	Sulfur Dioxide	<1.0
4/3/79	0920	Crane cab - line 4 B	Carbon Monoxide	15
4/3/79	0923	Crane cab - line 4 B	Hydrogen Fluoride	N.D.
			Carbon Monoxide	N.D.
4/3/79	1000	By pots - line 4 B	Carbon Monoxide	10
4/3/79	1013	By foremans office - line 4	Sulfur Dioxide	N.D.
4/3/79	1300	Potroom aisle - line 4	Sulfur Dioxide	N.D.
4/3/79	1303	Anode Setting - line 4	Carbon Monoxide	10
4/3/79	1310	Anode Setter (BZ)** - line 4	Sulfur Dioxide	2.5-5.0
4/3/79	1330	Anode Setter (BZ) - line 4	Sulfur Dioxide	1.0
4/3/79	1335	Anode Setter (BZ) - line 4	Hydrogen Fluoride	N.D.
			Carbon Monoxide	N.D.
4/4/79	1030	By pots - line 2 B	Carbon Monoxide	5
4/4/79	1035	By pots - line 2 B	Sulfur Dioxide	N.D.
4/4/79	1040	By pots - line 2 B	Hydrogen Fluoride	N.D.
			Carbon Monoxide	N.D.
4/4/79	1229	Anode Setter (BZ) - line 2 A	Sulfur Dioxide	1.0-2.5
4/4/79	1241	Anode Setter (BZ) - line 2 A	Sulfur Dioxide	7-10
4/4/79	1250	Anode Setter (BZ) - line 2 A	Sulfur Dioxide	25+
4/4/79	1300	Anode Setter (BZ) - line 2 A	Sulfur Dioxide	25+
4/4/79	1307	Anode Setter (BZ) - line 2 A	Sulfur Dioxide	12
4/4/79	1314	Anode Setter (BZ) - line 2 A	Sulfur Dioxide	12-15
4/4/79	1318	Anode Setter (BZ) - line 2 A	Sulfur Dioxide	12-15
4/5/79	0855	Anode Setter (BZ) - line 1 B	Sulfur Dioxide	15
4/5/79	0905	Anode Setter (BZ) - line 1 B	Sulfur Dioxide	17
4/5/79	0915	Anode Setter (BZ) - line 1 B	Sulfur Dioxide	10
4/5/79	0925	Anode Setter (BZ) - line 1 B	Sulfur Dioxide	5
4/5/79	0928	Anode Setter (BZ) - line 1 B	Sulfur Dioxide	1-2.5
4/5/79	1250	Anode Setter (BZ) - line 1 A	Sulfur Dioxide	8-10
4/5/79	1300	Anode Setter (BZ) - line 1 A	Sulfur Dioxide	20

Table 12
Results of Indicator Tube Air Samples*
(cont'd)

Date	Time	Location	Substance	Air Concentration (ppm)
4/5/79	1311	Anode Setter (BZ) - line 1 A	Sulfur Dioxide	3-5
4/5/79	1318	Anode Setter (BZ) - line 1 A	Sulfur Dioxide	3-5
4/5/79	1325	Anode Setter (BZ) - line 1 A	Sulfur Dioxide	2.5-3

Environmental Criteria: (all by NIOSH and in ppm)

	Average Exposure	Short Term Exposure
Sulfur Dioxide	0.5	3 ceiling
Carbon Monoxide	35	200 ceiling
Hydrogen Fluoride	6	12 (15-min.)

* Indicator tube results should be compared with the short term criteria

** Breathing zone (BZ) samples of anode setters were taken at BZ height within 3 feet of the anode setter. The Drager tubes were shielded from heat with a wet towel.

TABLE 13

RESULTS OF BULK SAMPLE ANALYSES FOR BENZENE SOLUBLES AND SPECIFIC POLYNUCLEAR AROMATIC HYDROCARBONS *

Bulk Sample	Benzene Soluble (mg/g)	B(a)P (ug/g)	Chrysene (ug/g)	Pyrene (ug/g)	B(a)A (ug/g)	Fluoranthene (ug/g)
Green Anode	89.7	2670	1060	1610	2390	1610
Baked Anode	11.8	<9.8	<24.6	<78.7	<19.7	<14.8
	5.7	<11.4	<28.5	<91.2	<22.8	<17.1
	3.6	< 4.5	<11.3	<35.9	< 9.0	< 6.8
Spent Anode	4.0	22.1	<12.5	<39.5	< 9.4	< 7.5
	3.9	<4.9	<12.3	<39.1	< 9.8	< 7.4
	15.4	<19.2	<48.1	<154	<38.5	<28.8
	12.0	<20.0	<50.0	<160	<40.0	<30.0
Green Cathode	90.9	4280	1960	5730	4840	5530
Spent Cathode	11.6	21.0	<24.3	<77.7	<19.4	<14.6
	11.9	<19.8	<49.6	<159	<39.7	<29.8

* Analysis for benzene solubles was by benzene extraction and gravimetric determination.

Analysis for specific polynuclear aromatic hydrocarbons was by high pressure liquid chromatography and UV detection.

TABLE 14

RESULTS OF BULK SAMPLE ANALYSES FOR QUARTZ AND CRISTOBALITE *

April 4, 1979

Line	Sample	Quartz (%)	Cristobalite (%)
2B	Ore	< 0.9	< 0.9
2B	Bath and Sweepings	< 1.0	< 1.0
2B	Bath	< 0.9	< 0.9

* Samples were analyzed by X-ray diffraction. All results were below the analytical detection limits.