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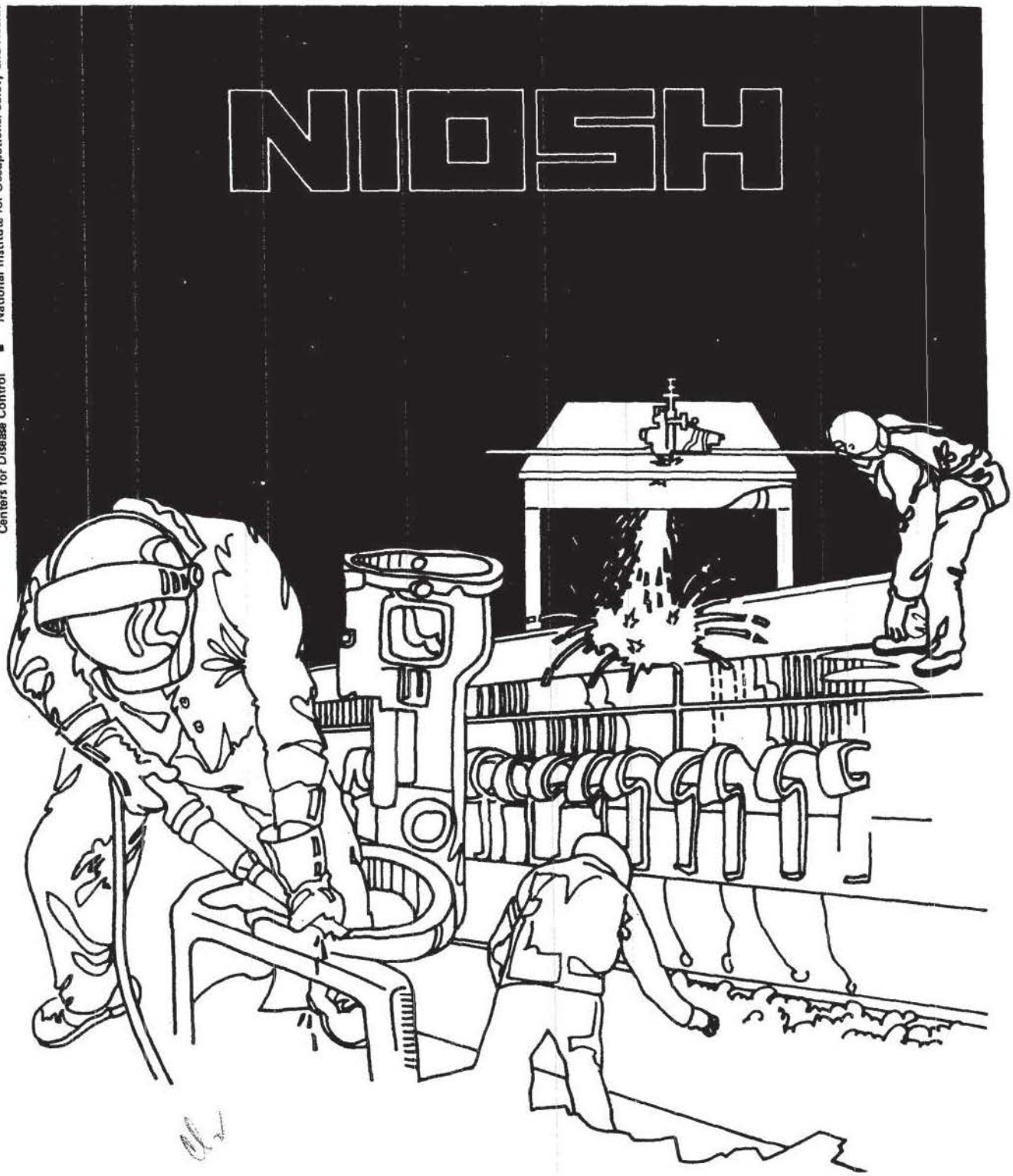

Health Hazard Evaluation Report

HETA 79-040-1381
PENNWALT CORPORATION
PORTLAND, OREGON

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PENNWALT CORPORATION
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I. SUMMARY

The National Institute for Occupational Safety and Health received a request from the International Chemical Workers' Local 109 to evaluate work-related pulmonary diseases and excess mortality and morbidity from cancer and heart disease existing among employees exposed to substances present at the Pennwalt Corporation, Portland, Oregon.

The workers were potentially exposed to chlorine vapors at concentrations which exceeded the criteria of 0.5 ppm for a 15-minute period during the cell changes in the chlorine and chlorate cell room. These workers wore respirators for use with chlorine during these operations. Based on the percentage (17.5%) of times the general area chlorine samples exceeded 0.5 ppm in the chlorate cell room, a worker in this area could have a 15-minute chlorine exposure in excess of 0.5 ppm. The eight-hour time weighted exposure, however, would be less than 0.5 ppm. One worker in chlorine cell repair was exposed to 15 minute airborne asbestos fiber concentrations of 0.71 fibers per cc of air when mixing batches or asbestos. This occurs once or twice a day. During this time, he wears a respirator for use with asbestos. Since asbestos is a carcinogen, exposure should be reduced to the lowest feasible limit. Welding performed by the maintenance department is sometimes performed on stainless steel and on nickel. During an eight-hour period one welder's exposure to chromium fumes was 0.25 mg/cubic meter which is 10 times the criteria of 0.025 mg/cubic meter and his exposure to nickel fume was 0.04 mg/cubic meter which is 2.6 times the criteria of 0.015 mg/cubic meter for nickel. The workers' exposure to other substances evaluated were less than the applicable criteria used in this evaluation.

In the present study no evidence was found of an increased prevalence or of an unusual pattern of occurrence of abnormal chest x-rays, EKG's, or pulmonary function tests (FVC and FEV_1) among employees who participated in the medical surveillance program at Pennwalt. A questionnaire survey of retired workers showed that the majority of their health problems are cardiovascular in origin, conditions which are not uncommon in adult American males. The rate among this group did not seem excessive nor was it suggestive of a work-related health problem.

Nine of the 20 deaths (45%) reviewed were due to cancer; the most common site was the lung. The asbestos exposure and smoking history of this group was not available. This number of cancer deaths may seem more than expected, but there are too few total deaths to detect a statistically significant excess. Another nine out of the 20 deaths were from "heart disease", the most common cause of death among older American males.

Several individuals had "abnormal" pulmonary function values, however, we found no pattern to suggest they were necessarily related to the work environment. In fact, we found no association between pulmonary function and any gross measure of chlorine exposure. By history, employees experience periodic exposure to acute irritating levels ("gassings"), some of these have been severe enough to require treatment and/or hospitalization. Chlorine is known to cause acute pulmonary damage, however, the evidence regarding permanent pulmonary damage from chronic low level chlorine exposure remains inconclusive.

On the basis of this evaluation, NIOSH determined no evidence was found of an increased prevalence or of an unusual pattern of occurrence of abnormal chest x-rays, EKG's or pulmonary function tests among employees in the medical surveillance program at Pennwalt. Also the number of cancer deaths may seem more than expected; however, the number is too small to detect a statistically significant excess. Recommendations to reduce exposures to chlorine, asbestos and welding fumes are included in this report.

KEYWORDS: SIC 2812 (Chemicals and Allied Products--Alkalies and Chlorine), asbestos, chlorine, chromium, nickel, cancer, heart disease, pulmonary disease.

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.

II INTRODUCTION

In January 1979, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Chemical Workers Union Local 109 to evaluate work-related pulmonary disease and excess morbidity and mortality from cancer and heart disease existing among employees exposed to substances present at the Pennwalt Corporation, Portland, Oregon. An initial survey was conducted in March 1979. The environmental survey was conducted on September 25-27, October 18, 1979 and April 8, 1980. The company and the union were provided the environmental results on April 9, 1980.

III BACKGROUND

The Pennwalt Corporation's main product in its Portland plant is chlorine. Ammonia, sodium orthosilicate and chlorates are also produced. This plant began producing chlorate in 1941, chlorine in 1947, orthosilicate in 1950 and ammonia in 1954.

At the time of this evaluation, the plant employed 186 employees: office 24; laboratory, 6; and hourly (production and maintenance), 156. The work force is very stable with approximately 90 employees having over 25 years service. The evaluation involved six areas: Chlorine Cell Room and Cell Repair; Ammonia Plant; Chlorine Finishing; Chlorate Production; Orthosil Production; Caustic Process and Maintenance Shop. Approximately 80 hourly employees worked (as of 1980) in these six areas. Approximately 40 of the hourly group work in a labor pool and move to various jobs throughout the plant as needed.

The company has used the services of a local occupational health clinic for approximately 20 years which provides such services as pre-employment and periodic physical examinations. Since 1977 the company has offered a multi-phasic health evaluation to all employees which includes a medical history, physical examination, vision and hearing tests, pulmonary function tests, blood work, chest x-ray, electrocardiogram (EKG), and urinalysis. Special "asbestos physicals" consisting of a physical examination, chest x-ray, and pulmonary function test are done [as required by the Occupational Safety and Health Administration (OSHA) standard] only on workers currently exposed to asbestos.

The chlorine cell room contains a series of Diamond Shamrock chlorine cells. In a cell an electric current is passed through a saturated sodium chloride solution to produce chlorine, sodium hydroxide, and hydrogen. A cell contains a diaphragm made of asbestos which separates the anode from the cathode to isolate the chlorine, which forms at the cathode, from the anode since mixing would lead to the formation of sodium hypochlorite instead of chlorine. Periodically, the cells have to be removed from the line and rebuilt in the cell repair area. The workers in the chlorine cell room are exposed to chlorine. The highest concentration occurs during a cell change which takes about 45 minutes a cell and is done twice a day. The workers wear respirators when changing a cell. The cells are rebuilt in the cell room. The asbestos is washed off the diaphragm and new asbestos is applied to the diaphragm by passing a solution of asbestos and cell liquor through it. The asbestos contains a measured quantity of short and long asbestos fibers.

Full bags are cut open and hand dumped into a vat. Less than full bag quantities are shoveled from a bin into buckets, weighed and dumped into the vat. Airborne asbestos fibers are visible during this procedure. The workers doing this wear NIOSH-approved respirators for use with asbestos. There are two employees per shift, three shifts a day, in the cell room and five employees per shift a day in the chlorine cell repair.

Chlorine from the chlorine cell room is purified and piped to chlorine finishing. Here the chlorine gas is cooled, compressed (liquified) and packaged into various size containers. The cylinders are inspected, tested and painted before they are refilled. The workers in the area are exposed to chlorine gas, paint solvent vapors, and paint particles in the overspray. There is one worker for each of three shifts in liquification and six workers on one shift in chlorine packaging.

The chlorate cell room contains a series of electrolytic cells where sodium chlorate is produced. Chlorine can be released into the work area during normal operation and during cell change. Periodically, the cells have to be removed from the line and are rebuilt in the chlorate cell repair area. The workers in the cell repair were concerned about the copper dust exposure they received while cleaning the copper bus bars. There are two workers per shift, three shifts a day in the cell room and four workers on one shift in cell repair.

Sodium hydroxide generated as a by-product in chlorine production is concentrated in the evaporators. There are three employees for each of the three shifts a day.

In the orthosil operation, hot (400° F) sodium hydroxide from the evaporator is mixed with free silica on a continual basis with a paddle mixer to form sodium orthosilicate (orthosil). The orthosil exits the mixer by a screw conveyor, is pressed into a thin sheet, dried, broken up in a hammer mill, screened and piped into 55 gallon drums or 3,500 lb hoppers. There are four employees on each of three shifts in orthosil and one employee for each of three shifts in the evaporator area. The orthosil production was discontinued after the environmental portion of this evaluation was completed.

Ammonia is produced in the ammonia plant. Hydrogen generated in the chlorine production is combined with nitrogen to make ammonia. There are two workers for each of three shifts who monitor this operation.

The maintenance workers perform work throughout the plant. Their concern was their exposure to welding fumes and, in particular, when welding on nickel flanges and on stainless steel.

IV EVALUATION DESIGN AND METHOD

a. Environmental

Environmental breathing zones and general area samples were collected for airborne substances the employees were exposed to in the areas listed in the background section. Listed below are the sampling and analytical methods used:

Substance	Collection Method	Flow Rate	Analytical Method
Ammonia	0.1N H_2SO_4 in impinger	1-1.5 lpm	P&CAM 205
Asbestos	Cellulose membrane filter open face	1.5 lpm	P&CAM 239
Chlorine	Methyl orange in impinger	1 lpm	P&CAM 209
Copper	PVC filter	1.5 lpm	P&CAM S186
Mineral Spirits	Charcoal tube	50-200 cc/min	P&CAM 127
Silica (free)	PVC filter	1.7 lpm	P&CAM 109
Sodium Hydroxide	Cellulose liter membrane filter	1.5 lpm	P&CAM 173
Total particulates	PVC filters	1.5 ppm	electrobalance
Welding fumes (Chrome, iron oxide, manganese, nickel)	PVC filters	1.5 lpm	P&CAM 173
Xylene	Charcoal tube	50-200 cc/min	P&CAM 127

b. Medical

During the initial survey a self-administered nondirected quesionnaire was distributed to 150 hourly production and maintenance workers. The NIOSH physician requested and received detailed information about the medical surveillance program and certain morbidity and mortality data for the employees. Personal interviews were conducted with 14 employees regarding work related symptoms and diseases. The medical records of multi-phasic health examination of the majority of the work force were reviewed. The multi-phasic health examination included a medical history, physical examination, vision and hearing test, pulmonary function test, blood work, chest x-ray, electrocardiogram and urinalysis.

V EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employed environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours

per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U. S. Department of Labor (OSHA) occupational health standards, 4) the Oregon State Standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Substance	NIOSH or ACGIH Recommended Criteria 10-Hr TWA*	OSHA &/or Oregon Standards	Health Effects
Ammonia	50 ppm/5 min ceiling (NIOSH)	25 ppm (Oregon) 50 ppm (OSHA)	Irritation of the the eyes, respiratory track & skin

Substance	NIOSH or ACGIH Recommended Criteria 10-Hr TWA*	OSHA &/or Oregon Standards	Health Effects
Asbestos	Lowest feasible limit	2 million fibers/cu m (10 million fibers/cu m	asbestosis (a chronic lung disease) lung cancer
Chlorine	0.5 ppm 15 min ceiling (NIOSH)	1 ppm ceiling	see paragraph following the table
Copper dust	1.0 mg/cu m (ACGIH)	1 mg/cu m	irritation of mucous membrane pharynx, nasal ulcer perforation, eye irritation, metal taste, dermatitis
Mineral spirits	350 mg/cu m (approx 75 ppm) (NIOSH)	500 ppm	dizziness, drowsy, nausea, irritation of eyes, nose, throat, dry cracked skin
Free silica	50 ug/cu m free SiO_2 in respirable fraction (NIOSH)	10 mg/cu m % free SiO_2+2 of respirable fraction	cough, dryness wheezing, impaired pulmonary function progressive symptoms
Sodium hydroxide	2 mg/cu m 15 min ceiling (NIOSH)	2 mg/cu m	irritation of nose, pneumonitis, burns eyes, skin, temporary loss of hair
Total particulates	10 mg/cu m (ACGIH)	10 mg/cu m	nuisance dust

Substance	NIOSH or ACGIH Recommended Criteria 10-Hr TWA*	OSHA &/or Oregon Standards	Health Effects
Welding fumes Total Particulates	5 mg/m (ACGIH)	None - see individual component of fumes	
Chromium	0.025 mg/cu m (NIOSH)	1 mg/cu m	histologic fibrosis of lungs
Iron oxide	5 mg/cu m (ACGIH)	10 mg/cu m	benign pneumo-coniosis)
Manganese	5 mg/cu m (ceiling) (ACGIH)	10 mg/cu m	metal fume fever, dry throat, cough, tight chest, dyspnia, low back pain, fatigue, vomiting
Nickel	0.015 mg/cu m (NIOSH)	1 mg/cu m	sensitization dermatitis, cancer of lungs, and nasal cavities, pneu-monitis, allergic asthma
Xylene	100 ppm (NIOSH)	100 ppm	dizziness, excite-ment, drowsiness, incoherence, staggering gait, irritation of eyes, nose & throat, nausea vomiting, abdominal pain

Chlorine - Chlorine is extremely irritating to the mucous membranes of the eyes, nose, and throat and the skin.[1] Irritation of the respiratory tract can result in sneezing, coughing, choking and chest pain. In very high concentrations chlorine can cause muscle cramping of the throat and swelling of the linings of air passages resulting in suffocation. Corrosion of the teeth may occur with prolonged exposure at 5 ppm or greater. The TLV is set at a level to minimize chronic changes in the lungs and corrosion of the teeth.[2] Odor thresholds are reported to be 0.03 to 3.5 ppm, however, persons chronically exposed can develop olfactory fatigue.[3]

While it is known that exposure to chlorine causes acute effects on pulmonary function following exposure to high concentrations, whether it causes permanent lung damage is not certain. Several pulmonary function studies in persons exposed to acute heavy concentrations as occurs in accidents such as when a tank of chlorine ruptures. Few studies have been done of workers chronically exposed to low level chlorine and those that have been done report mixed results.[5-9] Available evidence, thus, is insufficient to conclude that chlorine causes permanent lung damage.

VI EVALUATION RESULTS

A. Environmental Results.

The air sample results from the chlorine cell room and cell repair are shown in Tables 1, 2 and 5. Cell room operators A and B had 8-hour TWA chlorine exposures that ranged from 0.01 to 0.07 ppm over a three-day period. The chlorine concentration at the lab bench was 0.01 ppm on these three days. A spot sample taken in the middle of the cell room was 0.12 ppm. There are two cells changed each day. During one cell change a five minute sample collected when the worker was disconnecting the chlorine line was greater than 1.5 ppm. The methyl orange sampling solution bleached out at that time indicating that the concentration was in excess of 1.5 ppm. During this operation on another cell change, the chlorine concentration was 0.23 ppm. This individual wears a respirator for use with chlorine when conducting this operation. The remaining workers on the cell change crew had chlorine exposures of 0.02 to 0.10 ppm. Except for the one sample period, during which time a respirator was worn, all the chlorine sample results were less than the criterion of 0.5 ppm.

Asbestos is handled in the cell repair process. The asbestos sample results are shown in Table 2. The worker who handles and mixes the asbestos had results potential exposures ranging from < 0.15 to 0.71 fibers/cc. During this time, he wears a NIOSH-approved respirator for use with asbestos. All other samples were less than the limits of quantitation.

When a cell is completed, the cell is hand painted. The solvents used in the paint were xylene, mineral spirits, and butyl alcohol. It took 15 minutes to paint a cell. During this time, the worker's exposure to these substances was 64% of the criteria for the mixture (see Table 5). Since there are only one to two cells painted each day, his eight-hour TWA exposure would be less than 5% of the criteria.

The sample results from chlorine finishing are shown in Tables 3, 5 and 6. The worker's chlorine exposures while filling the chlorine cylinders and aspirating the cylinders was 0.01 to 0.05 ppm. When exhausting the chlorine residual from the 150 pound cylinder, the exposure was 0.43 ppm. In the area near the caustic soda chlorine waste tank, the chlorine concentration was 0.25

and 0.29 ppm. Near the 150 pound cylinder filling line the concentration was from 0.01 to 0.04 ppm. In the area near the chlorine cylinder filling line the concentration for a 14.5 minute period ranged from 0.15 to 1.17 ppm with a time weighted average over the period of 0.48 ppm. Near the cylinder wash and steam the chlorine concentration was 0.03 ppm. These concentrations are less than the criteria of 0.5 ppm. Breathing zone samples were collected for each job in chlorine finishing using an experimental charcoal tube method. Due to the erratic results between side-by-side impinger and charcoal samples, the results were not considered reliable and are not reported.

The 150 pound cylinders were hand painted and the 2,000 pound cylinders were spray painted (Table 5). The paint solvent used consisted of a mixture of xylene and mineral spirits. During hand painting, the painter's exposure was 2%, 5%, and 53% of the criteria for the mixture and during spray painting the painter's exposure was 15% and 40% of the criteria. The total particulate concentration during spray painting (Table 6) was 9.73 and 13.8 mg/cubic meter. These were over 50 and 40 minute periods. Since the painting involves only a portion of the day, the time weighted average is less than the criteria of 10 mg/cubic meter. The spray painter wore a respirator for use with dusts only. It did not provide protection for the solvent vapor exposure.

The sample results from the chlorate cell room and cell repair are shown in Tables 4 and 5. General area samples were collected for chlorine vapors at various locations in the rows between the cells. Samples were collected for 1010 minutes over three days. The chlorine concentrations ranged from 0.12 ppm to 1.30 ppm. The chlorine concentration exceeded the criteria of 0.5 ppm (15 minute ceiling) during 177 minutes (17.5%) of that time. The worker's chlorine exposure during a cell change ranged from 0.07 to 0.68 ppm. The 0.68 ppm sample occurred when the worker was behind the cell and during cleanup of the equipment.

Airborne total particulate and copper dust samples (Table 6) were collected when the bus bars were cleaned using their regular method and when using a new type of buffing wheel. The total particulate concentrations were 1.05 and 0.80 mg/cubic meter. These are less than the criteria of 10 mg/cubic meter. The copper dust was 0.06 and 0.37 mg/cubic meter, respectively. Both were less than the copper dust criteria of 1 mg/cubic meter. The use of the new type of buffing wheel appears to create a higher copper dust exposure than the old method of grinding the bus bars.

Sample results from the ammonia plant are shown in Table 7. The operator's exposures ranged from 10 to 20 ppm which is less than the Oregon State Standards of 25 ppm.

Sodium hydroxide sample results from the evaporator operators are shown in Table 8. The sodium hydroxide exposures over three shifts were 0.02, 0.03 and 0.05 mg/cubic meter which are less than 3% of the criteria of 2 mg/cubic meter.

Samples were collected in the Orthosil Department for sodium hydroxide mist and particulates, respirable and total particulates, free silica and mineral spirit vapors. The results are shown in Tables 5, 8 and 9.

The pot room operator, "B" deck operator, filler operator, and drum capping worker were exposed to airborne sodium hydroxide mist and/or dust concentrations that ranged from 0.03 to 0.12 mg/cubic meter. These are 6% or less than the criteria of 2 mg/cubic meters. The flaking operator's exposure was 0.33 mg/cubic meters, which is 17% of this criteria. The "B" deck operator's exposure to respirable particulates was 0.04 and 0.26 mg/cubic meter. The free silica portion of these respirable dust samples was less than 40 ug/cubic meter. (The limit of detection for the sample size present was 40 ug/cubic meter.) The criteria used for free silica was 50 ug/cubic meter. The free silica concentration next to the orthosil mixing unit was 460 ug/cubic meter; however, no workers are at that location. The "B" packager and "A" operator were exposed to total particulate concentrations of 0.87 to 1.19 mg/cubic meter. The majority of this is sodium orthosilicate. Due to the high pH, the sodium hydroxide criteria was used and these concentrations are less than 60% of this criteria.

The 55-gallon drums were spray painted in a booth located in the orthosil department. The spray painter's exposure to the mineral spirit vapors present in the paint was 16 mg/cubic meter which is less than 5% of the mineral spirit criteria.

Sample results of the maintenance welder's exposure to welding fumes are shown in Table 10. The total particulate concentration ranged from 0.60 to 3.28 mg/cubic meter. These are less than the criteria for welding fumes of 5 mg/cubic meter. The iron oxide portion of the fume ranged from 0.07 to 0.78 mg/cubic meter and the manganese from 0.01 to 0.07 mg/cubic meter. These concentrations are well below the criteria of 5 mg/cubic meter for these substances. The chrome and nickel exposures were less than detectable limits on all but one sample. This welder had an eight-hour time weighted average exposure to chromium of 0.25 mg/cubic meter which is 10 times the criteria (0.025 mg/cubic meter) for chromium used in this evaluation and an exposure to nickel of 0.04 mg/cubic meter which is 2.6 times the criteria of 0.015/cubic meter for nickel.

B. Medical Results.

During the initial survey a self-administered, non-directed health questionnaire was distributed to the approximately 150 then current hourly production and maintenance workers; 47 (26%) were returned. Sixteen of the 47 respondents reported experiencing work-related health problem(s). The majority of symptoms (9/16) were related to mucous membrane and/or respiratory tract irritation (cough, stuffy nose, nosebleeds, bronchial congestion and/or "colds"). Six persons reported musculoskeletal problems such as back strain, pulled muscles, carpal tunnel syndrome, and/or bruises; and one, facial skin irritation from caustic "fume". Most entries in the OSHA 200 log for the 10-month period, February through December 1978, were for musculoskeletal problems. Two cases of "chlorine inhalation" and one case of "ammonia inhalation" were listed. From this and from conversations with employees it was apparent that there are (were) periodic ammonia and chlorine leaks to which were attributed many of the irritative symptoms.

Detailed information was requested about the medical surveillance program and certain morbidity and mortality data for employees at the Portland facility. The company responded with a letter containing information about the multi-phasic health evaluations and a summary of the findings of the company medical consultant who had recently completed a review of the medical records of Pennwalt employees. This consultant stated in a letter to Pennwalt, dated October 22, 1979, that he was unaware of any "... documented case of silicosis, asbestosis nor mesothelioma..." among Pennwalt employees. Also, in his review of the records of the 21 employees who had died since the plant opened in 1941, he found "...no relationship between occupational exposure and cause of death..." As the information provided to NIOSH contained only summary and no quantitative medical or epidemiologic data, a second visit was arranged to collect data.

During this visit, 14 current employees (those with the most seniority) from the areas of primary concern were interviewed about work-related symptoms and diseases. Nine of these currently worked with chlorine, the remaining five had done so in the past. All were men. Twelve of the 14 reported one or more work-related symptom(s) while at Pennwalt. All 12 reported eye, nose, or throat irritation at some time and all but one associated his symptoms with chlorine exposure; the latter person associated them with caustic exposure. Six of the twelve also reported respiratory symptoms such as cough, difficulty breathing, or wheeze. One reported having difficulty "shaking" a cold. Five reported a skin problem such as a rash or a burn. Two stated that they had been "gassed" with chlorine several times in the past; one had been hospitalized after such an incident. Periodic ammonia and chlorine leaks were reportedly responsible for many of these irritative symptoms.

Based on the findings of the first two visits, the medical investigators focused their investigation on determination of the presence of respiratory symptoms and heart disease among current and retired workers, and upon the number of deaths due to cancer and heart and lung disease among former employees. Accordingly, chest x-ray, electrocardiogram (EKG), and pulmonary function data from 1977, 1979, and 1980 were reviewed to determine if there were any patterns of illness or pulmonary dysfunction which were possibly related to the work environment.

The pulmonary function data was first analyzed descriptively by determining the total number of persons with "abnormal" results. A value was considered "abnormal" if it was below the lower limit of the 95% confidence interval (based on Morris' prediction formula). Since one of the primary concerns was possible health effects from chronic (low-level) exposure to chlorine, workers were then also grouped according to whether or not they worked in an area with potential chlorine exposure as their primary department (area worked in the longest) and the length of time spent there. Mean FVC, FEV_1, and FEV_1/FVC ratio were compared using analysis of variance (ANOVA).

To evaluate the possibility of excess cancer and heart and lung disease among older workers, a health status questionnaire was sent to all former hourly retired employees. An attempt was made to contact all non-respondents by telephone. To evaluate possible excess cancer deaths or deaths due to heart disease among former workers, NIOSH investigators reviewed available death certificates and/or insurance records of the employees who had died since the plant opened in 1951. The list of all deceased employes was generated by the company from records of insurance claims.

Electrocardiogram (EKG)

During 1977, 1979, and 1980, 111 employees participated in one or more of the multi-phasic health evaluations. Sixty-one of these had had EKG's performed, eight of which were read as "abnormal" or possibly abnormal. These eight individuals, ages 49 to 60 and all males, worked in diverse areas of the plant. Two, ages 54 an 58, showed signs suggestive of past myocardial infarction (heart attack). The remainder showed less serious changes. Two, ages 54 and 60, showed left axis deviation (a sign usually caused by a conduction defect in the AV area), one of whom also had primary atrio-ventricular (AV) block. Two showed poor R wave progression and one showed possible left atrial enlargement. Most of these changes are the result of decreased blood circulation to the heart. These findings are not uncommon in American men in the 5th decade of life and their pattern of occurrence at Pennwalt did not appear unusual.

Chest x-rays

Eighty-four chest x-rays were reviewed, 12 of which were interpreted as "abnormal" or possibly abnormal by a radiologist as follows: 1) hilar calcifications (5 cases); 2) peripheral lung calcifications (3); blunting of the costophrenic angle (1); and tortuous aorta (3). Only one individual, age 41, with five years seniority at Pennwalt, showed signs of (upper lobe) fibrosis. (Pulmonary function tests were normal.) The records indicated that his employment at Pennwalt had been in an area without asbestos or chlorine exposure and that he had had a previous job that may have contributed to this medical finding.

A NIOSH physician reviewed each chest x-ray and found none with evidence of pneumoconiosis. There was no evidence of any unusual patterns among those x-rays that were abnormal.

Pulmonary Function Tests

NIOSH investigators had planned to analyze individual changes in pulmonary function over the four-year period, 1977-80, however, the data from 1977 had inconsistencies which made its validity questionable thus precluding such a comparison. The most recent pulmonary function test from 1979 or 1980 (results which appeared to be consistent) were used in subsequent analyses. Enough data were available to calculate predicted values on 81 employees. As we were looking for chronic pulmonary effects, those with less than one year's seniority at Pennwalt (5) were excluded leaving 76 for analysis.

Twelve of 76 (16%) were "abnormal" i.e., were below the lower limit of normal as determined by the 95% confidence interval. Six of the 12 (50%) had an "obstructive" pattern (reduced FEV_1 and/or FEV_1/FVC ratio); four of which were smokers. All worked in different areas of the plant. The remaining six people had a "restrictive" pattern, i.e., a reduced FVC and/or FEV_1 with a normal FEV_1/FVC ratio. Their years of service at Pennwalt ranged from 2.9 to 13 years and they worked in several different areas of the plant. None had known exposure to asbestos and none were presently working in an area with potential chlorine exposure. (Two had previously worked in a chlorine area for a year or less.)

A primary concern which prompted the health hazard evaluation request was the possibility of adverse pulmonary effects from chronic chlorine exposure. Pulmonary function, therefore, was also analyzed as a function of chlorine exposure. Workers were classified by current and primary chlorine exposure. Mean percent predicted FVC, FEV_1 values and the FEV/FVC ratio were calculated. Twenty-two workers were excluded because they had either mixed or unknown exposures. The mean percent predicted FVC, FEV_1, and FEV_1/FVC± S.D. of the remaining 54 perons was as follows:

	Current Exposure		Primary Exposure	
	Chlorine Exposed* (20 workers)	Not Chlorine Exposed (34 workers)	Chlorine Exposed (20 workers)	Not Chlorine Exposed (34 workers)
FVC	96.5±11.8	95.7±16.2	94.6±12.7	95.7±15.8
FEV_1	98.0±15.7	94.8±15.7	97.4±15.1	95.4±16.7
FEV_1/FVC	75.5±14.5	75.8±9.0	76.5±14.2	76.1±9.0

*Areas with potential chlorine exposure: Chlorine Finishing, Chlorine Cell or Chlorate Process

We found no statistically significant difference (p less than .05) in any pulmonary function parameter in any group, i.e., we found no association between these pulmonary function parameters and any gross measure of chlorine exposure.

Other Health Concerns

Forty-three (90%) of the 48 retired workers who were mailed health questionnaires returned them. Eighteen reported having cancer, respiratory or lung disease.

Retired Workers with Cancer, Heart and/or Lung Disease

Cancer	4
Colon	2
Prostate	1
Skin	1
Lung "disease"	2
Tuberculosis	1
Productive cough with wheezing	1
"Heart disease"	12
Hypertension	4
Coronary by-pass	4
Myocardial infarction	4

Several workers volunteered that they had experienced periodic respiratory symptoms such as cough while at Pennwalt related to such things as duty conditions or to being "gassed" with chlorine.

As of 1980 24 deaths were recorded, 20 of which had available death certificates or other official records of cause of death. The following causes of death were noted:

Cardiovascular disease	9	
Stroke		1
Myocardial infarction		5
Congestive heart failure		1
Dissecting aortic aneurysm		1
Arteriosclerotic heart disease		1
Cancer	9	
Lung		5
Pancreas		2
Breast		1
Acute lymphocytic leukemia		1
Other	2	
Pneumonia		1
Liver and kidney failure		1

The average age of those who died from cardiovascular disease was 62.5 years, range 54-72; all were men. The average age at death of those dying from cancer was 56.4 years (range, 28-76). Nine cancer deaths out of a total of 20 may seem more than expected, but there are too few total deaths to discern a statistically significant excess.

VII CONCLUSIONS

In the present study no evidence was found of an increased prevalence or of an unusual pattern of occurrence of abnormal chest x-rays, EKG's, or pulmonary function tests (FVC and FEV_1) among employees who participated in the medical surveillance program at Pennwalt. A questionnaire survey of retired workers showed that the majority of their health problems are cardiovascular in origin, conditions which are not uncommon in adult American males. The rate among this group did not seem excessive nor was it suggestive of a work-related health problem.

Forty-five percent of the deaths reviewed were due to cancer; the most common site (5/9), was the lung. The asbestos exposure and smoking history of this group was not available. (Chlorine is not known to be a carcinogen.) This number of cancer deaths may seem more than expected, but there are too few total deaths to detect a statistically significant excess. Nine out of the 20 deaths were from "heart disease", the most common cause of death among older American males.

Several individuals had "abnormal" pulmonary function values, however, we found no pattern to suggest they were necessarily related to the work environment. In fact, we found no association between pulmonary function and any gross measure of chlorine exposure. By history, employees experience periodic exposure to acute irritating levels ("gassings"), some of these have been severe enough to require treatment and/or hospitalization. Chlorine is known to cause acute pulmonary damage, however, the evidence regarding permanent pulmonary damage from chronic low level chlorine exposure remains inconclusive.

The workers' exposure to chlorine vapors exceeded the criteria of 0.5 ppm for a 15-minute period during the cell changes in the chlorine and chlorate cell room. These workers wore respirators for use with chlorine during these operations. Based on the percentage (17.5%) of times the general area chlorine samples exceeded 0.5 ppm in the chlorate cell room, a worker in this area could have a 15-minute chlorine exposure in excess of 0.5 ppm. The eight-hour time weighted exposure, however, would be less than 0.5 ppm. One worker in chlorine cell repair was exposed to 15 minute airborne asbestos fiber concentrations of 0.71 fibers per cc of air when mixing batches or asbestos. This occurs once or twice a day. During this time, he wears a respirator for use with asbestos. Welding performed by the maintenance department is sometimes performed on stainless steel and on nickel. During an eight-hour period one welder's exposure to chromium fumes was 0.25 mg/cubic meter which is 10 times the criteria of 0.025 mg/cubic meter and his exposure to nickel fume was 0.04 mg/cubic meter which is 2.6 times the criteria of 0.015 mg/cubic meter for nickel.

The workers' exposure to other substances evaluated were less than the applicable criteria used in this evaluation.

VIII RECOMMENDATIONS

1. Avoid handling loose asbestos fibers. Prepackaged asbestos fibers of the quantity needed for each batch mixed could be obtained. The fibers can then be wetted before the packages are opened.

2. Use wet clean up methods or vacuum spilled asbestos fibers.

3. NIOSH-approved cartridge type respirators for use with organic vapors and paint mist should be used instead of dust respirators when spray painting 2,000 pound chlorine cylinders.

4. All welding on stainless steel material and nickel flanges should be conducted using local exhaust ventilation. When welding is conducted in plant locations where local exhaust ventilation cannot be provided, the welder should wear a respirator approved for use with welding fumes.

IX REFERENCES

1. NIOSH, Recommended Standard for Occupational Exposure to Chlorine, Publication No. 76-170.

2. US DHHS (NIOSH), US DOL (OSHA), Occupational Health Guidelines for Chlorine, September 1978, p 1-4.

3. Proctor, N.H. and J.P. Hughes, Chemical Hazards of the Workplace, J.B. Lippincott Co, Phila. 1978, p 156-157.

4. Kaufman, J. and D. Burkons, Clinical, Roentgenologic, and Physiologic Effects of Acute Chlorine Exposure. ARCH ENV HEALTH 12: 29-34, 1971.

5. Capadaglio, E., G. Pezzagno, G.C. Bobbio, F. Cazzoli. Investigation Regarding Respiratory Function of Workers Assigned to the Electrolytic Production of Chlorine and Sodium. Med Lav 60: 192-202, 1970.

6. Chester, E. H., D.G., Gillespie, and F.D. Krause. The Prevalence of Chronic Obstructive Pulmonary Disease in Chlorine Gas Workers. Amer Rev Resp Dis 99:365-373, 1969.

7. Patil, L.R.S., R.G. Smith, A.J. Vorwald and T.F. Mooney. The Health of Diaphragm All Workers Exposed to Chlorine AIHAJ 31: 678-86, 1970.

8. Will, H.R. George, Z.M., Schwarz, Late evaluation of pulmonary function after acute exposure to chlorine gas. Amer Rev Resp Dis 99: 374, 1969.

9. Kowitz, T.A., R.C. Reba, R.T. Parker, Spicer, W.S. Effects of Chlorine Gas upon respiratory function. Arch. Envir Health 14: 545-558, 1967.

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X DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Pennwalt Corporation, Portland, Oregon.

2. International Chemical Workers' Union Local 109, Portland, Oregon.

3. Oregon State Accident Prevention Division, Salem, Oregon.

4. U. S. Department of Labor, Occupational Safety and Health Agency (OSHA), Region X, Seattle, Washington.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

CHLORINE AIR CONCENTRATIONS
CHLORINE CELL ROOM

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

LOCATION	DATE	SAMPLE NUMBER	SAMPLE TIME (MINS)	SAMPLE VOLUME LITERS	CHLORINE CONCENTRATION PPM
GA at lab bench	9/25/79	11	365	365	0.01
GA at lab bench	9/26/79	22	435	335	<0.01
GA at lab bench	9/27/79	31	420	420	0.01
GA middle of cell room	9/27/79	10	20	20	0.12
BZ cell change (disconnecting chlorine line)	9/27/79	32	5	5	>1.5
BZ cell change (disconnecting chlorine line operate hoist)	4/08/80	1	18	18	0.23
BZ worked on bus bar and around cell	4/08/80	2	20	20	0.05
BZ. worked around cell	4/08/80	3	25	25	0.10
BZ. changing dog legs and connecting new cell	4/08/80	5	22	22	0.02
GA. on shunt cart, cell being filled with chlorine	4/08/80	4	35	35	0.04
GA. cell repair wash room when used cell was first taken apart	4/08/80	6	30	30	0.06

The following samples were collected using an experimental charcoal tube method. The results are considered to be approximate values.

BZ Operator A	9/25/79	112	405	75	0.07
BZ Operator B	9/25/79	113	405	76	0.02
BZ Operator A	9/26/79	123	205	44	0.06
BZ Operator B	9/26/79	123	420	77	0.01
BZ Operator A	9/27/79	132	405	82	0.03
BZ Operator B	9/27/79	133	415	93	0.02

TABLE 2

ASBESTOS AIR CONCENTRATIONS
CHLORINE CELL REPAIR

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

JOB	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOL LITERS	*ASBESTOS CONCENTRATION FIBERS/cc
BZ worker mixes asbestos, time before asbestos mixing	9/25/79	A-4	120	180	<0.03
Mixing one batch of asbestos	9/25/79	A-3	20	30	<0.15
Time between mixing of asbestos batches	9/25/79	A-2	160	240	<0.02
Mixing of second batch	9/25/79	A-6	15	22.5	<0.20
Time weighted average for 9/25/79	9/25/79	A-4,3,2 & 6	315	472	<0.04
Area sample - near asbestos mixing area	9/25/79	A-14	405	608	<0.01
BZ worker mixing asbestos, time before asbestos mixing	9/26/79	A-9	315	473	<0.01
Mixing of first batch	9/26/79	A-10	15	22.5	0.71
Time between mixing of asbestos batches	9/26/79	A-8	100	150	<0.03
Mixing of second batch	9/26/79	A-17	15	22.5	<0.71
Time weighted average for 9/26/79	9/26/79	A-9,10,8 & 17	445	668	<0.05
Area sample near asbestos mixing area	9/26/79	A-12	450	675	<0.01
BZ worker who mixes asbestos, time before mixing asbestos	9/27/79	A-35	335	503	<0.01
Mixing only batch of day	9/27/79	A-11	12	18	<0.28
Time weighted average for 9/27/79	9/27/79	A-35, 11	347	521	<0.02
Area sample - near asbestos mixing area	9/27/79	A-20	420	630	<0.01

* Values noted as < (less than) concentrations are none detected; limit of quantitation varies as the volume of air sampled.

TABLE 3

CHLORINE AIR CONCENTRATIONS
CHLORINE FINISHING
PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

JOB OR LOCATION	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOLUME LITERS	CHLORINE CONCENTRATION PPM
BZ chlorine cylinder operator	9-25-79	301	20	30	0.01
BZ filling chlorine cylinders	9-25-79	303	19	285	0.02
GA by caustic soda chlorine waste tank	9-25-79	304	5	7.5	0.29
GA above caustic sodia chlorine waste tank	9-25-79	305	6	9	0.25
GA 150 lb cylinder filling line	9-25-79	306	18	18	0.01
GA 150 lb cylinder filling line	9-25-79	307	18	17	0.01
GA 150 lb cylinder filling line	9-25-79	308	17	18	0.04
GA near chlorine cylinder filling	9-26-79	309	2	2	1.00
GA near chlorine cylinder filling	9-26-79	310	3	3	0.53
GA near chlorine cylinder filling	9-26-79	311	1	1	1.17
GA near chlorine cylinder filling	9-26-79	312	1.5	1.5	0.71
GA near chlorine cylinder filling	9-26-79	313	7	7	0.15
TWA for # 309-313	9-26-79		14.5	14.5	0.48
BZ filling 2000 lb cylinders	9-27-82	314	17	17	0.05
BZ exhausting residual chlorine from 150 lb cylinders	9-27-82	316	5	5	0.43
BZ aspirating chlorine cylinders	9-27-79	317	17	17	0.05
GA 5° from cylinder wash and steam	9-27-79	318	15	15	0.03

TABLE 4

CHLORINE AIR CONCENTRATIONS
CHLORATE CELL ROOM

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

LOCATION	DATE	SAMPLE NUMBER	SAMPLE TIME (MINS)	CHLORINE VOLUME LITERS	CONCENTRATION PPM
		402	5	6.0	0.53
Middle of G series	9/25/79	403	18	14.4	0.46
		404	22	17.6	0.39
		405	32	25.6	0.28
Middle of F series	9/25/79	406	32	25.6	0.29
		407	41	32.8	0.18
		408	38	30.4	0.28
Middle of E series	9/25/79	409	45	36.0	0.15
		410	44	35.2	0.12
Middle of G series	9/26/79	411	27	8.1	0.72
		413	41	12.3	0.31
		414	38	11.4	0.43
		415	38	11.4	0.60
Middle of F series	9/26/79	417	59	17.7	0.32
		418	30	9.0	0.67
		420	66	19.8	0.31
Middle of E series	9/26/79	421	18	5.4	0.90
		423	40	12.0	0.51
By Cell G 39 during cell change		416	15	9.0	0.28
End of G series		419	25	15.0	0.36
Middle of G series	9/27/79	424	40	13.2	0.37
		425	30	9.9	0.48
		427	30	9.9	0.38
		428	30	15.0	0.34
Rear end of G series	9/27/79	429	30	15.0	0.48
Walkway by F-G series	9/27/79	430	30	15.0	0.34
		431	30	15.0	0.38
Walkway by E-F series	9/27/79	432	31	15.3	0.14
		434	30	15.0	0.15
Rear end of G series	9/27/79	435	13	13.0	0.54
		436	6	4.5	1.30
		437	16	12.0	0.56
Middle of F series	9/27/79	438	20	15.0	0.27
BZ cell change (on on top of cell)	4/08/80	7	28	19.6	0.34
BZ cell change (on front side of cell)	4/08/80	8	21	21	0.07
BZ cell change (behind cell)	4/08/80	9	21	21	0.13
BZ cell change (front of cell and clean up of equipment)	4/08/80	11	11	11	0.06
BZ cell change (back of cell and clean up of equipment)	4/08/80	12	11	11	0.68

TABLE 5
XYLENE AND MINERAL SPIRITS AIR CONCENTRATION
CHLORINE FINISHING, ORTHOSIL, CHLORINE CELL REPAIR

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

LOCATION	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOLUME LITERS	XYLENE* CONC. mg/cu m	MINERAL SPIRITS** CONC. mg/cu m	EVALUATION+ CRITERIA OF THE MIXTURE IN EACH SAMPLE mg/cu m	TOTAL EXPOSURE mg/cu m	RATIO-TOTAL EXPOSURE/ EVALUATION CRITERIA OF MIXTURE
BZ Hand Painting 150 lb Cylinders Chlorine Finishing	9-25-79	C-309	63	12.2	<1	<8	365	<9	0.02
BZ Hand Painting 150 lb Cylinders Chlorine Finishing	9-25-79	C-302	168	29.2	3	17	368	20	0.05
BZ Hand Painting 150 lb Cylinders Chlorine Finishing	9-26-79	C-313	124	24.8	85	121	389	206	0.53
BZ Spray Painting 2000 lb Cylinders Chlorine Finishing	9-27-79	C-314	65	10.9	22	37	393	59	0.15
BZ Spray Painting 2000 lb Cylinders Chlorine Finishing	9-27-79	C-320	40	8.7	49	103	380	152	0.40
BZ Spray Painting in Spray Booth 55 Gallon Drums Orthosil Dept.	9-25-79	C-500	140	6.4	-	16	-	-	-
BZ Hand Painting Cathodes Chlorine Cell Repair	9-27-79	C-152	15	3.5	37	198	373	239	0.64
BZ Hand Painting Cathodes Chlorine Cell Repair	9-27-79	C-151	15	2.9	Butyl Alcohol was not detectable				

\+ When there are two or more substances present that have similar health effects, the exposure levels are combined and an equivalent permissible exposure level determined. When the ratio of the total exposure/the evaluation criteria exceeds 1.0, the evaluation criteria was exceeded.

* Evaluation Criteria 435 mg/cu m

** Evaluation Criteria 350 mg/cu m

TABLE 5
XYLENE AND MINERAL SPIRITS AIR CONCENTRATION
CHLORINE FINISHING, ORTHOSIL, CHLORINE CELL REPAIR

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

LOCATION	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOLUME LITERS	XYLENE* CONC. mg/cu m	MINERAL SPIRITS** CONC. mg/cu m	EVALUATION+ CRITERIA OF THE MIXTURE IN EACH SAMPLE mg/cu m	TOTAL EXPOSURE mg/cu m	RATIO-TOTAL EXPOSURE/ EVALUATION CRITERIA OF MIXTURE
BZ Hand Painting 150 lb Cylinders Chlorine Finishing	9-25-79	C-309	63	12.2	<1	<8	365	<9	0.02
BZ Hand Painting 150 lb Cylinders Chlorine Finishing	9-25-79	C-302	168	29.2	3	17	368	20	0.05
BZ Hand Painting 150 lb Cylinders Chlorine Finishing	9-26-79	C-313	124	24.8	85	121	389	206	0.53
BZ Spray Painting 2000 lb Cylinders Chlorine Finishing	9-27-79	C-314	65	10.9	22	37	393	59	0.15
BZ Spray Painting 2000 lb Cylinders Chlorine Finishing	9-27-79	C-320	40	8.7	49	103	380	152	0.40
BZ Spray Painting in Spray Booth 55 Gallon Drums Orthosil Dept.	9-25-79	C-500	140	6.4	-	16	-	-	-
BZ Hand Painting Cathodes Chlorine Cell Repair	9-27-79	C-152	15	3.5	37	198	373	239	0.64
BZ Hand Painting Cathodes Chlorine Cell Repair	9-27-79	C-151	15	2.9	Butyl Alcohol was not detectable				

\+ When there are two or more substances present that have similar health effects, the exposure levels are combined and an equivalent permissible exposure level determined. When the ratio of the total exposure/the evaluation criteria exceeds 1.0, the evaluation criteria was exceeded.

* Evaluation Criteria 435 mg/cu m

** Evaluation Criteria 350 mg/cu m

TABLE 6

COPPER AND TOTAL PARTICULATE AIR CONCENTRATIONS
CHLORATE CELL REPAIR, CHLORINE FINISHING

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

JOB	AREA	DATE	NUMBER	SAMPLE TIME MINUTE	SAMPLE VOL LITERS	SUBSTANCE	CONCENTRATION
Grinding Bus Bars (BZ) (Used Regular Method)	Chlorate Cell Repair	9-25-79	D 2386	222	333	Copper	0.06 mg/cu m
						Total Particulates	1.05 mg/cu m
Grinding Bus Bars (BZ) (Used New Type Buffing Wheel)	Chlorate Cell Repair	9-27-79	D 2405	376	564	Copper	0.37 mg/cu m
						Total Particulates	0.80 mg/cu m
Spray Painting 2000 lb Cylinders (BZ) (Operator Wore a Dust Respirator)	Chlorine Finishing	9-26-79	D 2389	50	75	Total Particulates (Paint Overspray)	9.73 mg/cu m
Spray Painting 2000 lb Cylinders (BZ) (Operator Wore a Dust Respirator)	Chlorine Finishing	9-27-79	D 2400	40	40	Total Particulates	13.8 mg/cu m

TABLE 7

AMMONIA AIR CONCENTRATIONS
AMMONIA PLANT

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

JOB	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOLUME LITERS	AMMONIA CONCENTRATION PPM
A Operator	9-27-79	3	116	6.0	20
B Operator	9-27-79	1	120	4.2	10
BZ Lubricating Compressors	9-27-79	231	5	7.5	18
BZ Lubrication Compressors	9-27-79	232	5	7.5	20

NOTE: A 2 hour sample from each operator was voided because the flow rate used exceeded the manufacturer rate by a factor of 10.

TABLE 8

SODIUM HYDROXIDE AIR CONCENTRATIONS
EVAPORATOR AND ORTHOSIL AREA

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

JOB	AREA	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOL LITERS	SUBSTANCE	CONCENTRATION mg/cu m
"A" Operator	Evaporator Area	9-25-79	A-16	413	620	Sodium Hydroxide	0.03
"B" Operator	Evaporator Area	9-26-79	A-15	427	641	Sodium Hydroxide	0.02
"C" Operator	Evaporator Area	9-27-79	A-33	390	585	Sodium Hydroxide	0.05
Flaking Operator	Orthosil Area	9-25-79	A-18	135	203	Sodium Hydroxide	0.33
Pot Room Operator	Orthosil Area	9-26-79	A-19	382	573	Sodium Hydroxide	0.03
"B" Deck Operator	Orthosil Area	9-26-79	A-1	140	210	Caustic Substances As Sodium Hydroxide	0.05
Filler Operator	Orthosil Area	9-27-79	A-34	347	570	Caustic Substances As Sodium Hydroxide	0.07
Capping the Drums	Orthosil Area	9-27-79	A-37	353	530	Caustic Substances As Sodium Hydroxide	0.07
"B" Deck Operator	Orthosil Area	10-18-79	A-20	428	642	Caustic Substances As Sodium Hydroxide	0.12

TABLE 9

FREE SILICA AND TOTAL OR RESPIRABLE
PARTICULATE AIR CONCENTRATIONS
ORTHOSIL AREA

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

JOB	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOLUME LITERS	SUBSTANCE	CONCENTRATION mg/cu m
"B" Deck Operator	9-26-79	FW-404	143	243	Respirable Particulates Free Silica	<0.04 <0.04
"B" Deck Operator	10-18-79	FW-4265	428	728	Respirable Particulates Free Silica	0.26 <0.04
Area Sample by Orthosil mixing unit	10-18-79	FW-4015	426	714	Respirable Particulates Free Silica	0.14 0.04
Area Sample by Orthosil mixing unit	10-18-79	FW-4226	408	612	Total Particulates Free Silica % Free Silica in Total Particulates	0.65 0.46 71%
Orthosil Packaging	9-26-79	D2-446	130	195	Total Particulates (Sodium Orthosilicate)	0.87
Orthosil Packaging "B" Packager	10-18-79	D-2447	415	623	Total Particulates	0.71
"A" Operator	10-18-79	D-2387	431	647	Total Particulates	1.19

TABLE 10

WELDING FUME AIR CONCENTRATIONS
MAINTENANCE DEPARTMENT

PENNWALT CORPORATION
PORTLAND, OREGON
HHE 79-40

JOB	AREA	DATE	SAMPLE NUMBER	SAMPLE TIME MINUTE	SAMPLE VOLUME LITERS	SUBSTANCE	CONCENTRATION mg/cu m
Welder	Maintenance Shop	9-28-79	D-2321	418	627	Iron Oxide	0.59
						Manganese	0.06
						Total Particulates	3.28
Welder	Maintenance orthosil Area	9-25-79	D-2322	342	513	Iron Oxide	0.07
						Manganese	<0.01
						Total Particulates	0.60
Welder	Maintenance Shop	9-26-79	D-2452	424	636	Iron Oxide	0.78
						Manganese	0.02
						Total Particulates	1.72
Welder	Maintenance Shop	9-26-79	D-2334	403	605	Iron Oxide	0.76
						Manganese	0.07
						Chromium	0.25
						Nickel	0.04
						Total Particulates	3.00
Welder	Maintenance Shop	9-27-79	D-2392	322	483	Iron Oxide	0.53
						Manganese	0.01
						Total Particulates	1.55

Note: All samples were analyzed for chrome and nickel and they contained less than 5u and 3u respectively per filter except # D2334.