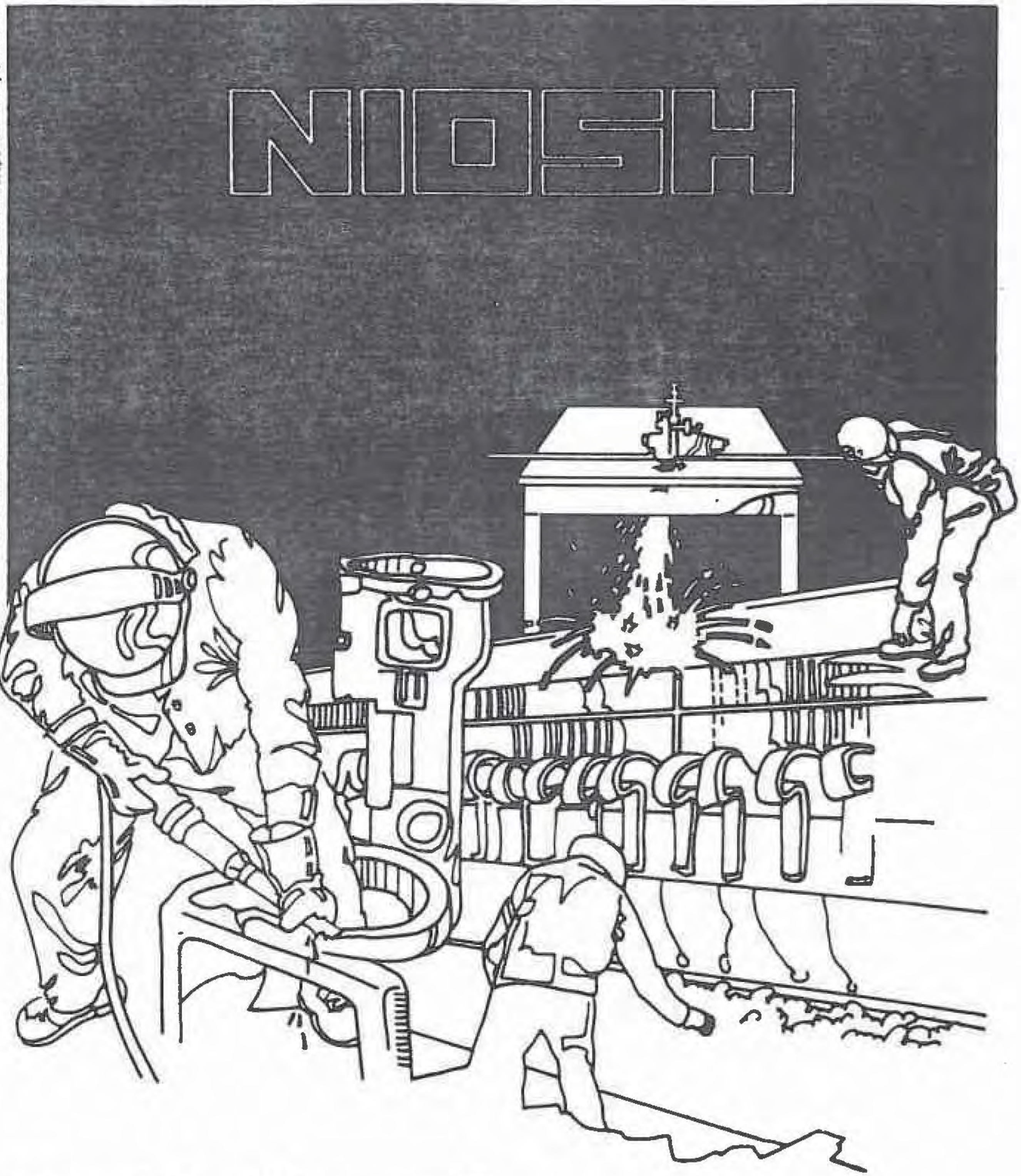
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 82-024-1428
CHEMETCO, INCORPORATED
ALTON, ILLINOIS

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.

HETA 82-024-1428
MARCH 1984
CHEMETCO, INCORPORATED
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I. SUMMARY

In October 1981, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate health concerns including lead exposure, other heavy metal exposures, excessive fatigue and skin problems at the Chemetco Corporation (a secondary copper smelter) in Alton, Illinois. A major concern was the occurrence of a single case of granulomatous lung disease in a 31-year old worker which was diagnosed as sarcoidosis in early 1981. Environmental-medical surveys were conducted in February and November 1982 and April 1983. Personal air samples were obtained to measure arsenic, beryllium, cadmium, lead, nickel and sulfuric acid concentrations. The medical evaluation consisted of a screening questionnaire given to one-third (30) of the work-force and a subsequent evaluation of all tankhouse workers and 16 workers selected to evaluate beryllium exposures. Blood lead levels provided by the Company were also examined to determine if higher levels were associated with fatigue and season.

Lead concentrations in 50 personal samples ranged from 20.8 to 1879 ug/m^3, with 18 values (36%) exceeding 200 ug/m^3, and 26 values (52%) exceeding the OSHA Permissible Exposure Limit PEL of 50 ug/m^3. Arsenic concentrations in 50 personal samples ranged from <1.0 to 3.4 ug/m^3 with 5 values (10%) exceeding the NIOSH recommended standard of 2.0 ug/m^3; the OSHA PEL is 10 ug/m^3. Beryllium levels in 50 personal samples ranged from <0.2 to 0.5 ug/m^3; the NIOSH recommended standard is 0.5 ug/m^3 and the OSHA PEL is 2.0 ug/m^3. Beryllium concentrations measured by Chemetco in 1981 showed that 17% (21 of 127) of the values ranged from 0.5 to 2.0 ug/m^3, exceeding the NIOSH recommended standard. No excessive exposures were found for cadmium, nickel or sulfuric acid.

Results of the medical evaluation demonstrated that the worker initially reported to have sarcoidosis, actually had been sensitized to beryllium. The evaluation of blood lead levels showed higher levels in cold weather months when ventilation in the plant may be reduced. All seven tankhouse workers had nasal symptoms and a high prevalence of skin problems. There was no diagnostic evidence of beryllium disease in the other 16 workers, as demonstrated by chest x-rays and immunological lymphocyte transformation testing (LFT).

Based on environmental results and clinical evidence, a health hazard from beryllium exposure has existed at Chemetco. Because the sample furnaces were phased out without prior environmental testing, it is impossible to determine whether the source has been eliminated. Foundry workers are exposed to potentially toxic concentrations of lead and arsenic. Tankhouse workers are experiencing irritant exposures to upper respiratory tract and skin. Recommendations to control these exposures are offered in Section VIII of this report.

KEYWORDS: SIC 3340 (Secondary Smelting and Refining of Nonferrous Metals and Alloys), beryllium disease, sarcoidosis, granulomatous disease, lymphocyte transformation test, lead, beryllium, arsenic, sulfuric acid, skin irritation, nasal irritation.

II. INTRODUCTION

On October 26, 1981, the National Institute for Occupational Safety and Health (NIOSH) was requested by the United Steel Workers of America on behalf of Local 7866 to evaluate a variety of health concerns, including lead exposure, fatigue, and skin problems, at the Chemetco Hartford Works in Alton, Illinois. There were also concerns about beryllium exposure and the possibility of work related cause in a case of debilitating lung disease in a young worker, diagnosed as having sarcoidosis in early 1981. Because of a latency between initial recognition of lead problems by Local 7866 and eventual submission of an health hazard evaluation request to NIOSH, by the time NIOSH contacted Chemetco, the company was already under an abatement schedule by the Occupational Safety and Health Administration (OSHA). Therefore, the NIOSH investigation was not principally directed towards the evaluation of health hazards related to lead.

An initial survey in February 1982 was described in a letter report, dated February 23, 1982, and an interim report, dated June 1982. It included results from (a) surface wipe and settled dust samples from the foundry area and adjoining lunchrooms, and (b) a medical screening questionnaire involving a third of the non-salaried work force (30 people). Because of concerns raised in this initial survey, blood lead levels were evaluated for seasonal variations and relationship to fatigue.

Follow-up environmental evaluations were performed on November 10-11, 1982 and April 26-29, 1983. On the basis of a positive diagnosis of beryllium disease in the previously described worker and bulk environmental results indicating the presence of beryllium, potential sensitization to beryllium was further assessed. Sixteen workers were selected for a protocol consisting of (1) a lymphocyte transformation test (LTT), (2) a questionnaire on chest disease and hypersensitivity conditions, and (3) a chest x-ray. Because the screening questionnaire suggested irritant problems among tankhouse workers, a questionnaire and examination of all tankhouses workers was also included.

III. BACKGROUND

A. Description of Process

Chemetco, Inc., is a secondary copper smelting and refining operation, which processes high grade scrap into electrolytic grade cathode plates containing 99.99% elemental copper. Secondary products include reclaimed non-ferrous metals, lead, and metal salts, such as zinc and nickel sulfate.

The process begins with acquisition of recoverable scrap including #2 copper wire, radiators, red brasses, copper and brass shearings, slags, drosses and other assorted copper bearing scrap. A sample from each representative load of scrap is pulled by the Sampling Department and sorted into a melt sample. The melt sample is processed through sampling furnaces and sent to the Assay Laboratory for preliminary analysis for use in sorting and charge blending of the scrap. Sample reduction is currently performed by an outside contractor. Though 1981 this was accomplished on-site by the Sampling Department using two small electric-arc furnaces. These furnaces are reportedly still used about three to four times per month.

The smelting and preliminary refining of the scrap occurs in four centrifugal converter furnaces, each capable of yielding a 70-85 ton tapping, or "heat". The blended scrap is charged to the furnaces by a non-remote crane. The heat-refined product is approximately 98% copper and is known as blister copper. It is tapped into a ladle mounted on a transfer car located beneath the furnace in a pit area. The ladle is then carried by a hot metals crane to the anode casting area, where the blister copper is charged into a 150-ton holding furnace. The holding furnace is tapped into a pre-heated tundish called a "catch box". The liquid metal is then cast into one of approximately 24 copper molds positioned on a continuous casting wheel. The resultant product is a copper anode. The anode cast is approximately 36" long by 36" wide by 2 1/2" thick; it weighs 730 pounds. The freshly cast anodes pass under a cooling hood which uses high pressure fan jets of water to solidify the anodes. The solid (but still red hot) anodes are then lifted from the molds and immersed in a tank of water for final cooling. They are then transported to a yard for temporary storage. The 98-99% copper anodes are eventually transported to the tank house for electrolytic refining resulting in copper cathodes of 99.99% purity.

The tank house consists of several hundred cells arranged in electrical circuits and provided with a piping system to distribute the copper sulfate and sulfuric acid electrolyte. The anodes and titanium starting cathodes are charged to these cells by overhead crane. The copper of the impure anode is dissolved electrolytically, and copper migrates to and is deposited at the cathode. Electrolysis continues until the anode is corroded to about 15% of its original weight.

At the completion of the anode cycle the anode scrap is washed free of adhering slime, pulled by overhead crane, and transferred to the yard to be either sold as scrap or recharged into the furnaces. The impurities in the anode copper are either dissolved in the electrolyte or fall to the bottom of the cells as sludge. The impurity level of the electrolyte is controlled by electrolysis in "liberator cells" which employ insoluble lead anodes. Crude nickel sulfate produced is washed, dewatered, packaged and marketed. The metal sludge is also dewatered, assayed, packaged and marketed.

B. Exposure Controls

Process fume emissions originate in the converter furnaces during meltdown and refining periods. They are controlled by direct evacuation through a closely fitted hood. Process fumes generated in tapping or slagging off of the furnace, and fugitive emmisions resulting from the charging of the materials into the furances, both rise by natural convection into the overhead roof canopies.

All personnel entering the foundry are required to wear a NIOSH-approved high efficiency particulate filter respirator with a one-half facepiece. The workers are quantitatively fit tested semi-annually. The respiratory protection program, targeted at controling exposures to lead, was initiated in 1980.

Downdraft booths are used to remove surface dust from the employees work clothing. Their use is required prior to entering lunchroom and hygiene facilities. Downdraft ventilation is used to collect dust particles which are dislodged from the clothing by a series of air nozzles. Respirators are worn during the process, which takes approximately one minute.

C. Environmental and Medical Surveillance

The Company conducts environmental sampling for airborne lead and beryllium on a quarterly basis.

In addition to the routine laboratory work, the Company performs routine blood monitoring in accordance with the Occupational Safety and Health Administration (OSHA) lead standard protocol. There has been considerable controversy in the past concerning Chemetco's lead program and the Company is currently under an OSHA abatement order. Issues involving lab accuracy have been resolved since Chemetco contracted its blood lead work in 1980 with a laboratory approved by the Centers for Disease Control (CDC).

Additional medical monitoring consists of pre-employment chest and lumbar spine x-rays and pulmonary function tests. These are administered by a contract medical services company. The pulmonary function testing program has been introduced within the past two years as a screening procedure for respirator use. At the time of the NIOSH initial survey, 72 workers had been screened. It is the stated policy of Chemetco to repeat these tests on a yearly basis.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Air sampling was conducted to characterize exposures to arsenic, beryllium, cadmium, lead and nickel. The metals were collected on 0.8 um pore size, 37-mm diameter, mixed cellulose ester membrane filters contained in a 3-piece closed-faced cassette using calibrated constant flow sampling pumps operating at 2.0 liters per minute (L/min). The filters were analyzed using inductively coupled plasma-atomic emission spectroscopy (ICP-AES). Samples of settled dust were obtained from the second and third levels of the foundry for quantitative assays of arsenic, beryllium, cadmium, lead and nickel. The samples were also analyzed by ICP-AES. The settled dust samples were obtained from surfaces, selected to represent the accumulation of dust over an extended period of time.

Surface wipe samples were obtained in the north and south foundry lunch rooms to determine the potential for ingestion of lead. Wipe samples of horizontal surfaces were collected to determine the presence of lead. The samples were obtained by wiping an area of approximately 100 square centimeters using a smear tab moistened with distilled water. Vinyl gloves were worn by the industrial hygienist during surface sampling and changed after each sample was taken. The wipe sample was immediately placed into a glass vial with a polyethylene-lined cap for shipment to the laboratory for analysis. The samples were treated with 2:1 concentrated nitric and perchloric acids and analyzed using atomic absorption spectrophotometry according to NIOSH Method S-341.[1]

Air sampling was conducted to evaluate exposures to tank house workers from sulfuric acid. The sulfuric acid was collected on 0.8 um pore size, 37-mm diameter, mixed cellulose ester filters contained in a 3-piece closed-faced cassette using a constant flow sampling pump operating at 2.0 L/min. The samples were analyzed using ion chromatography according to NIOSH Method P&CAM 339. [2]

B. Medical

1. Cross-Sectional Analysis -- Screening Questionnaire

During the February 1982 initial survey, an interviewer-administered medical screening questionnaire was given to 30 Chemetco employees. Workers were selected by the NIOSH physician, as a one in three sample of the full non-salaried workforce, using a random numbers table. Questions were directed towards obtaining information on present and previous occupational experience, medical history and habits, and current general medical symptoms, with particular attention to respiratory symptoms.

2. Analysis of Blood Lead Monitoring Data

There was a recurrent concern among Chemetco workers that although blood lead levels had generally declined, there remained a seasonal variation with higher levels in cold weather, occurring as a consequence of reduced ventilation. A statistical model was set-up to measure seasonal effects on blood lead levels. A simple comparison or matched pair comparison of weighted mean blood leads drawn during cold and warm weather months did not offer an entirely suitable solution because of the interaction between high blood lead levels, work site, and frequency of blood drawing. Because frequency of blood drawing for lead would increase with higher levels, given OSHA requirements and voluntary requests, and assumedly decrease to a lower level as a consequency of intervention, independent of season, an adjustment has been made for job site and frequency of blood tests. These pooled weighted mean blood lead levels are presented according to season and by job category. October-March are classified as cold weather months; April-September are classified as warm weather months.

3. Evaluation of Case of Beryllium Disease

Hospital and out-patient medical records on the worker affected with a granulomatous lung disease were reviewed. Open lung biopsy paraffin sections were received and reviewed by a NIOSH pathologist. Biopsy specimens were also reviewed by the pathology departments of the medical schools at Washington University, the University of North Carolina, the University of New Hampshire and the Unviersity of California at San Diego. A lymphocyte transformation test (LTT) on peripheral blood was conducted at the Cleveland Clinic, using an irradiated thymidine uptake method, described by Deodhar at al. [3,4]

4. Cross-Sectional Study of Tankhouse Workers

Seven of 23 tankhouse workers were included in the random sample of the 30 non-salaried members of the workforce. Based on reported nasal and skin symptoms and a potential risk of dermatitis from nickel sulfate in the reclamation area of the tankhouse, a follow-up questionnaire and physical examination were developed. The questionnaire was directed to occupational history, work and work practices, and conditions affecting the skin, eyes, nose and throat. The physical examination included an examination of exposed skin on the hands, arms and face; an examination of the conjunctivae; and a speculum examination of the nose.

5. Cross-Sectional Study of Beryllium Sensitization

In order to assess the presence of sub-clinical disease in other workers with potential past or current exposures to beryllium, 16 workers were selected for further study. Selection was made by the NIOSH medical investigator without randomization. Workers were selected from all areas with the exception of the tankhouse, where the exposure potential was minimal. The study consisted of a chest x-ray, medical history questionnaire, and a lymphocyte transformation blood test. The chest films were standard 11" x 17" posterior-anterior and lateral. They were interpreted by a single radiologist's reading at the University of Cincinnati. The questionnaire emphasized symptoms of hypersensitivity pneumonitis. The lymphocyte transformation test (LTT) for beryllium sensitization, involved shipping uncentrifuged samples from St. Louis to the Cleveland Clinic. All specimens for LTT arrived with 24 hours of drawing and were found acceptable for testing.

V. EVALUATION CRITERIA

A. Environmental

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ 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. 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.

The environmental criteria for the substances evaluated are presented in Appendix A.

B. Toxicological

1. Lead [5]

Inhalation of lead dust and fumes is the major route of lead exposure in industry. A secondary source of exposure may be from lead dust contamination on food, cigarettes, or other objects. Once absorbed lead is excreted from the body very slowly. The absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/100 ml whole blood are considered to be normal levels which may result from daily environmental exposure. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/100 ml. Lead levels between 40-60 ug/100 ml in lead exposed workers indicate excessive absorption of lead may result in some adverse health effects. Levels of 60 to 100 ug/100 ml represent unaccetable elevations which may cause serious adverse health effects. Levels over 100 ug/100 ml are considered dangerous and often require hospitalization and medical treatment.

The new Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/m^3 calculated as an 8-hour time-weighted average for daily exposure.[5] The standard also dictates that workers with blood lead levels greater than 50 ug/100 ml must be immediately removed from further lead exposure and, in some circumstances, workers with lead levels of less than 50 ug/100 ml must also be removed. At present medical removal of workers is necessary at blood lead levels of 60 ug/100 ml or greater. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 50 ug/deciliter and they can return to lead exposure areas.

2. Arsenic [6-8]

The major route of exposure to arsenic is through inhalation, although skin absorption and ingestion are other important modes. Since arsenic's toxic effect is at the specific site of absorption, as well as systemic, the chemical form of the exposure -- metal, salt, chloride, oxide -- combined with the exposure site can produce very different etiologies of disease.

Irritant and Sensitization Effects. Arsenic compounds are irritants of the skin, mucous membranes, and eyes. Hyperpigmentation and hyperkeratoses are also associated with occupational exposure to arsenic compounds. The dermatitis associated with arsenic may involve either primary irritation or allergic sensitization. Ulceration and a sometimes painless perforation of the nasal septum are classical stigmata of arsenic trioxide exposure.

Neurological Effects. Peripheral neuropathies have been described with environmental exposure to arsenic compounds. Some organic arsenicals have a selective effect on the optic nerve, including blindness.

Systemic Effects. Arsenic's notoriety as a cumulative systemic poison is appreciated in its wide range of adverse symptoms, which include weakness, anorexia, and gastrointestinal disorders. There are selective actions on the liver, and on the other blood forming organs, and on the cardiovascular system. Impairment of the peripheral circulation has lead to gangrenous conditions of the extremities ("blackfoot disease"), although this has not been reported through occupational exposure.

Cancer. Arsenic has been related to skin cancers at the site of exposure. Much more serious is an elevated rate of lung cancer. Several studies of smelter workers have shown a three to five fold increase in lung cancer mortality among smelter workers.

3. Beryllium [9-11]

The main route of exposure of beryllium and beryllium compounds is through the lung. Local contact has produced a granulomatous and scarring skin reaction and can produce a systemic sensitization, aggravating the effects of inhalation.

Under current conditions of exposure, skin reactions are no longer seen in the United States among workers exposed to beryllium. The most serious effect is a granulomatous lung disease, which can produce symptoms of shortness of breath, weight loss, anorexia, and cough. The disease is associated with alterations in immunity and clinical anergy. Before the advent of steroids, and when exposures were higher, one-third of all cases died from the chronic form of the disease. In the classical presentation of the disease, there is no remission and steroid dependency is lifelong. There is an acute form of beryllium disease, a chemical pneumonitis, which was common before industrial regulations. There have been no reported cases of the acute disease in the United States in more than 20 years.

Although beryllium disease is generally regarded as an intrathoracic process, liver granulomata to are common and there is at least one case report in the Beryllium Case Registry (BCR) of an exclusively neurological manifestation of the disease.

Beryllium is a potent animal carcinogen. Its status as a human carcinogen is still undetermined although several studies have associated its occupational use with increased rates of lung cancer.

VI. RESULTS AND DISCUSSION

A. Environmental

Metal assays were completed on 19 settled dust samples obtained from the second and third levels of the foundry (Table I). The samples contained (by weight) an average of 3.9% (+S.D. 1.1, range 2.4 to 6.1) lead, 0.5% (+S.D. 0.1, range 0.3 to 0.63) nickel, 0.07% (+S.D. 0.07, range <0.01 to 0.30) arsenic, 0.06% (+S.D. 0.04, range 0.05 to 0.16) cadmium, and 0.01% (+S.D. 0.01, range <0.006 to 0.032) beryllium.

Tables II and III presents the analysis of 50 personal air samples for lead, beryllium, arsenic, cadmium and nickel. The lead concentrations ranged from 20.8 to 1879 ug/m^3. Eighteen values (36%) exceed 200 ug/m^3; 16 values (32%) were between 100 to 199 ug/m^3; 10 values (20%) were between 50 to 99 ug/m^3; and 6 values (12%) were less than 50 ug/m^3 (Table IV). The OSHA Permissable Exposure Limit PEL is 50 ug/m^3. The average airborne lead concentrations by the nine categories evaluated (Figure 1) are: furnace operators (966, S.D. + 632), furnace helpers - lab (329; S.D. + 231), bricklayers (276, S.D. + 254), laborer sweeping inside of foundry (234, S.D. + 244), hot metal crane operators (176; S.D. + 79), furnace helper (161, S.D. + 116), laborer sweeping inside and outside of foundry (115, S.D. + 38), sampling fork truck operators (75, S.D. + 21), and sampling mobile equipment operators (56; S.D. + 41). The wide range of standard deviations for each of the nine job categories suggests a wide variability in exposure to be found at the smelter from job-to-job and day-to-day.

The surface contamination levels in the lunch rooms ranged from 17 to 68 ug/100 cm^2 (mean 41.3, S.D. + 21.4)(Table V), demonstrating a potential for exposure to lead by ingestion.

Beryllium was detected in five of the 50 personal samples (Tables II and III). The concentrations ranged from 0.2 to 0.5 ug/m^3 (mean 0.32, S.D. + 0.11); the NIOSH recommended standard is 0.5 ug/m^3 and the OSHA PEL is 2.0 ug/m^3. These exposure concentrations are lower than those previously measured by Chemetco, Inc. The analyses of 1 airborne beryllium samples obtained by the Company during 1981 ran in concentration from <0.1 to 2.0 ug/m^3. Seventeen percent (21 of 127) of the values exceeded the NIOSH recommended standard of 0.5 ug/m^3.

Arsenic was detected in 31 of 50 personal samples (Tables II and I The concentrations ranged from 1.0 to 3.4 ug/m^3 (mean 1.6, S.D. + 0.58). Ten percent (5 of 50) of the values exceeded the NIOSH recommended standard of 2.0 ug/m^3; the OSHA PEL is 10 ug/m^3.

Cadmium was detected in 45 of 50 personal samples (Tables II and III). The concentrations ranged from 0.5 to 18 ug/m^3 (mean 3.7, S.D. $\pm$ 4.1). None of the values exceeded the NIOSH recommended standard of 40 ug/m^3 or OSHA PEL of 100 ug/m^3.

Nickel was detected in 48 of 50 samples (Tables II and III). The concentrations ranged from 1.0 to 14.2 ug/m^3 (mean 5.8, S.D. $\pm$ 4.2). None of the values exceeded the NIOSH recommended standard of 15 ug/m^3 or OSHA PEL of 1000 ug/m^3.

Seven personal and two work area samples were collected to evaluate exposures to sulfuric acid by persons working in the tank house (Table VI). The maximum airborne concentration of sulfuric acid was less than 20% (range 30.7 to 191 ug/m^3, mean 79.5, S.D. $\pm$ 46.2) of the OSHA PEL and NIOSH recommended standard of 1000 ug/m^3. These samples were collected during a maintenance day. Therefore, the exposure concentrations might be lower than during operating periods.

B. Medical

1. Cross-Sectional Analysis -- Screening Questionnaire

The frequency of recent symptoms as reported on the medical screening questionnaire are presented in Table VII. The most common symptom complaints involve organs of respiration, mucosal surfaces (eyes, nose and throat), and skin. Symptoms occurring among more than 20% of respondents are further analyzed in Table VIII, by comparing tankhouse to non-tankhouse workers. Irritant symptoms to the eyes, nose and throat were concentrated among tankhouse workers, among whom sulfuric acid exposures are ubiquitous but lead exposures are relatively low.

Because fatigue and peripheral numbness were reported more commonly among workers employed outside of the tankhouse, and both are symptoms associated with lead exposure, the mean blood lead levels of calendar year 1981 were compared between workers reporting and denying these symptoms. Because fatigue is a highly descriptive category, a more thorough index of tiredness was derived on the basis of more specific symptoms, i.e. hours of customary nighttime sleep, and need for post-work naps. Fifty percent (15 workers) of the interviewed group indicated symptoms of excess fatigue. Workers reporting fatigue had a mean blood lead level (36.8 mcg/dl) which was not significantly different than that of workers without fatigue (39.6 mcg/dl). Workers reporting peripheral numbness also had marginally lower mean blood lead levels -- 36.4 vs. 38.3 mcg/dl. Neither of these results is of statistical or practical significance.

2. Analysis of Blood Lead Monitoring Data

Pooled weighted mean blood lead samples levels are presented according to season and job category in Table IX. There appeared to be seasonal differences among workers in the anode casting and tankhouse areas.In Table X, the same data is presented with an additional accounting for frequency of blood drawing. There is a statistically significant difference between cold and warm weather blood lead levels for all groups, although the actual overall difference -- 1.67 mcg/dl -- is probably not medically significant. However, certain groups -- the anode casters and the tankhouse operators -- did have seasonal differences which probably are biologically significant: that is, consistent with adverse health effects. The seasonal difference was greatest for tankhouse operators.

3. Evaluation of the Case of Beryllium Disease

A 31-year-old male who was first hospitalized in December, 1980, with a one-year history of dyspnea on exertion, progressive shortness of breath, and an approximate 60 pound weight loss. On admission he patient was hypoxic at rest with a PO2 of 50 mm Hg. Pulmonary function tests indicated a restrictive disorder -- FVC of 3.5 liters: 55% of predicted -- and a diffusion capacity which was 50% of the predicted normal. The chest x-ray was consistent with interstitial lung disease. An open lung biopsy showed non-caseating granulomatous lung disease with frequent asteroid bodies and infiltration of the interstitium. In the Freiman and Hardy classification system, based on the Beryllium Case Registry, this would have been a type IB.[12] Specimens of lung tissue were analyzed with scanning electron microscopy and by ion beam detection. Both results were non-diagnostic for tissue beryllium, but both techniques are of limited applicability in the detection of beryllium in the lung. There was inadequate tissue for a more definitive quantitative analysis. In May 1982, a lumphocyte transformation test was highly positive for beryllium sensitization, with a 4+ (maximum) blast response.

The patient's occupational history was employed for 9 1/2 years at Chemetco, primarily as a sample furnace operator, a job involving the charging of small quantities of various metal scrap. This was not a respirator-assigned job, and the worker did not use a respirator.

The patient had a rapid response to steroid therapy with improvements in pulmonary function and blood gasses. He remains steriod dependent.

4. Follow-up Study of Tankhouse Workers

A follow-up study of tankhouse workers based on the previous findings on the screening questionnaire was hindered by poor compliance: only 9 of 21 workers elected to participate. Results are therefore implicative only, and symptom frequencies should not be intrepreted as cross-sectional prevalence. Skin and nasal irritation and shortness of breath were most commonly reported symptoms (Table XI). The most common skin problem was fissuring of the hands related to acid exposure. There was no evidence of nasal polyps, or other work related eye, nose, or throat findings.

5. Cross-Sectional Study of Beryllium Sensitization

Sixteen workers participated in the three part protocol. All had a negative LTT from peripheral blood. Workers were scheduled to have their chest films taken offsite. Twelve participated and four did not. Of the 12 films, eight were completely negative; four had evidence of calcified granumomas which are probably old histoplasmosis infections and are most likely unrelated to beryllium exposure. Questionnaire results are summarized in Table XII. Although two men (#2 and #7) had symptom patterns consistent with hypersensitivity syndromes -- a pattern of fevers, chills and muscular aches, with a chronic pulmonary complaint -- the negative chest film precludes a diagnosis of active lung disease.

VII. CONCLUSIONS

Airborne exposures to arsenic, beryllium, cadmium, lead and nickel were evaluated for nine job categories associated with the foundry. The mean personal exposure concentrations to lead (range 56 to 966 ug/m^3) exceeded the OSHA PEL of 50 ug/m^3. Although respirators were worn by the workers to comply with the OSHA PEL, the mean exposure concentration reported for the furnace operators (966 ug/m^3) exceeded the maximum use concentration (500 ug/m^3) designated for a high efficiency particulate filter respirator with one-half facepiece.[13] Thus, the respiratory protection worn by these workers may not be providing adequate protection against the airborne lead concentrations measured. The presence of lead on eating surfaces in the north and south foundry lunch rooms establishes a potential for further exposure via ingestion.

The airborne beryllium concentrations measured by NIOSH did not exceed the NIOSH recommended standard. Conversely, the airborne concentrations reported by Chemetco for personal samples collected in 1981 showed that 17% (21 of 127) of the values exceeded the NIOSH recommended standard. These two data sets show that there is variability in exposure concentrations, which is due to a variety of factors. Most notably, it is due to the beryllium content of the furnace charge. The Chemetco data demonstrates that past airborne beryllium concentrations were higher than current levels, and that the levels exceeded recognized occupational health criteria.

Ten percent (5 of 50) of the personal samples showed arsenic concentrations in excess of the NIOSH recommended standard. These samples were generally distributed over several job categories evaluated and did not indicate an increased exposure risk for any one job category.

No excessive exposure concentrations were measured for cadmium and nickel.

The medical survey focused on three questions: (1) the role of environmental lead on seasonal blood lead levels (2) chemical irritation and injury to tankhouse workers, and (3) the risk to current workers from low-level beryllium exposure.

The findings of a cold weather effect on higher blood lead levels, particularly for tankhouse workers and anode casters, underlines the importance of the interior climate in occupational exposure. However, small elevations of this type, at least in the group sense, are not of clinical significance. However, since there are a range of values and individual variation, there is a potential for significant seasonal elevation in individual cases.

Because of inadequate participation, it is not possible to formally grade the seriousness of occupational exposures to tankhouse workers. However, both the plant-wide cross-sectional study and the limited study of tankhouse workers, confirmed a high prevalence of irritation to the face, eyes, nose and throat of workers. Skin fissures of the hands were probably due to direct acid exposure. Although the nickel sulfate operation was considered from the point of view of potential sensitization, there was no evidence of a resultant dermatitis in the workers examined.

The finding of a single case of beryllium disease is a cause for significant public health concern, since (1) there is a prevailing, although incorrect, opinion that beryllium exposures are completely controlled in modern industry [14], and (2) beryllium disease is an extremely serious disorder with a dismal prognosis for complete recovery.[15] Although diagnosis of beryllium disease must rest on natural history of the disease and documented exposure, the Lymphocyte Transformation Test has a virtual 100% specificity in the reported literature, and it is diagnostic for immune responses of this 4+ magnitude. [16]

The negative LTT results and negative chest films for asymptomatic workers are reassuring but do not, by themselves, rule out the presence of a continuing hazard. Although there are a few reports in the literature of borderline positive tests in exposed asymptomatic workers [16,17], the test has been shown to be conclusively positive only in the presence of active disease.[3] At the present time, the serial chest film remains the most reliable technique for detecting interstitial lung disease.

VIII. RECOMMENDATIONS

1. The respiratory protection program should ensure that exposure concentrations do not exceed the maximum use concentration for the assigned respirator. This is particularly relevant to workers in the foundry. The maximum use concentration for a respirator is generally determined by multiplying a contaminant's permissible exposure limit by the protection factor assigned to the respirator. The maximum use concentration for a high efficiency particulate filter respirator with one-half facepiece used to protect against lead is 500 ug/m^3. The respirator's fit factor (an estimate of fit of a respirator to a particular individual, determined by a quantitative fit test) is generally not equivalent to the respirator's assigned protection factor (an estimate of the minimum anticipated level of protection provided by a respirator to a large percentage of the user population).[18] The use of the fit factor, however, may be appropriate if a reliable correlation between the workplace protection factors (a measure of the protection provided by a respirator during a work shift when it is worn for only some fraction of the total work shift period) and fit factors can be demonstrated.[18]

Unless a reliable workplace protection factor can be determined (and use of such would probably require a variance from OSHA), an alternate type of respirator should be issued to the furnace opertors. Alternate types of respirators include high efficiency particulate filter respirator with full-facepiece or a powered air purifying respirator. The latter type is equipped with a helmet and face shield that complies with OSHA regulations 29 CFR 1910.133 (a)(6) and 1910.135 as specified by the American National Standards Institute (ANSI Z89.1-1969 and Z87.1-1968). These recommendations relating to respiratory protection should not delay control of the lead exposures by engineering controls.

2. Of 127 airborne beryllium samples obtained by Chemetco during 1981, 61 results (48%) were reported as <1.0 ug/m^3, which is assumed to be the volume-adjusted limit of detection. This is twice the NIOSH recommended standard. If these levels were taken as actual values, they would exceed the NIOSH recommended standard. In view of the severe toxicity associated with beryllium, it is recommended that a sampling and analytical method capable of detection of less than 0.5 ug/m^3 be used. Three such methods with adequate sensitivity are NIOSH P&CAM Methods 121, 351 and S339-1.[1,19,20]

3. The eating surfaces in the foundry lunchrooms should be washed as often as necessary to assure that they are not contaminated with lead, thus, minimizing the possibility of lead exposure via ingestion in these areas. The downdraft ventilation chamber should be evaluated to ensure that it is operating according to the design specifications. In addition, union and management should ensure that all employees properly use the downdraft chamber prior to entering the lunchrooms.

4. The occurrence of beryllium disease in a sample furnace operator is a sentinel event which suggests a more general risk. Because a transient batch/pulse exposure remains a possible etiology, the sampling process would best be phased out altogether. If sporadic use is to continue, beryllium concentrations should be thoroughly quantified on a worst case basis and operators should have appropriate respiratory protection.

5. Unless adequate steps can be taken to minimize beryllium exposures, Chemetco should establish a policy in its purchasing department to refuse all scrap, in which the possibility of beryllium contamination persists. This would include sparkless copper products and beryllium-copper scrap, and components used in the electronics industry.

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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 NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Chemetco, Incorporated, Alton, Illinois
2. United Steel Workers of America, Local Union 7866
3. International Headquarters of the United Steel Workers of America, Pittsburgh, Pennsylvania
4. NIOSH, Region V
5. OSHA, Region V

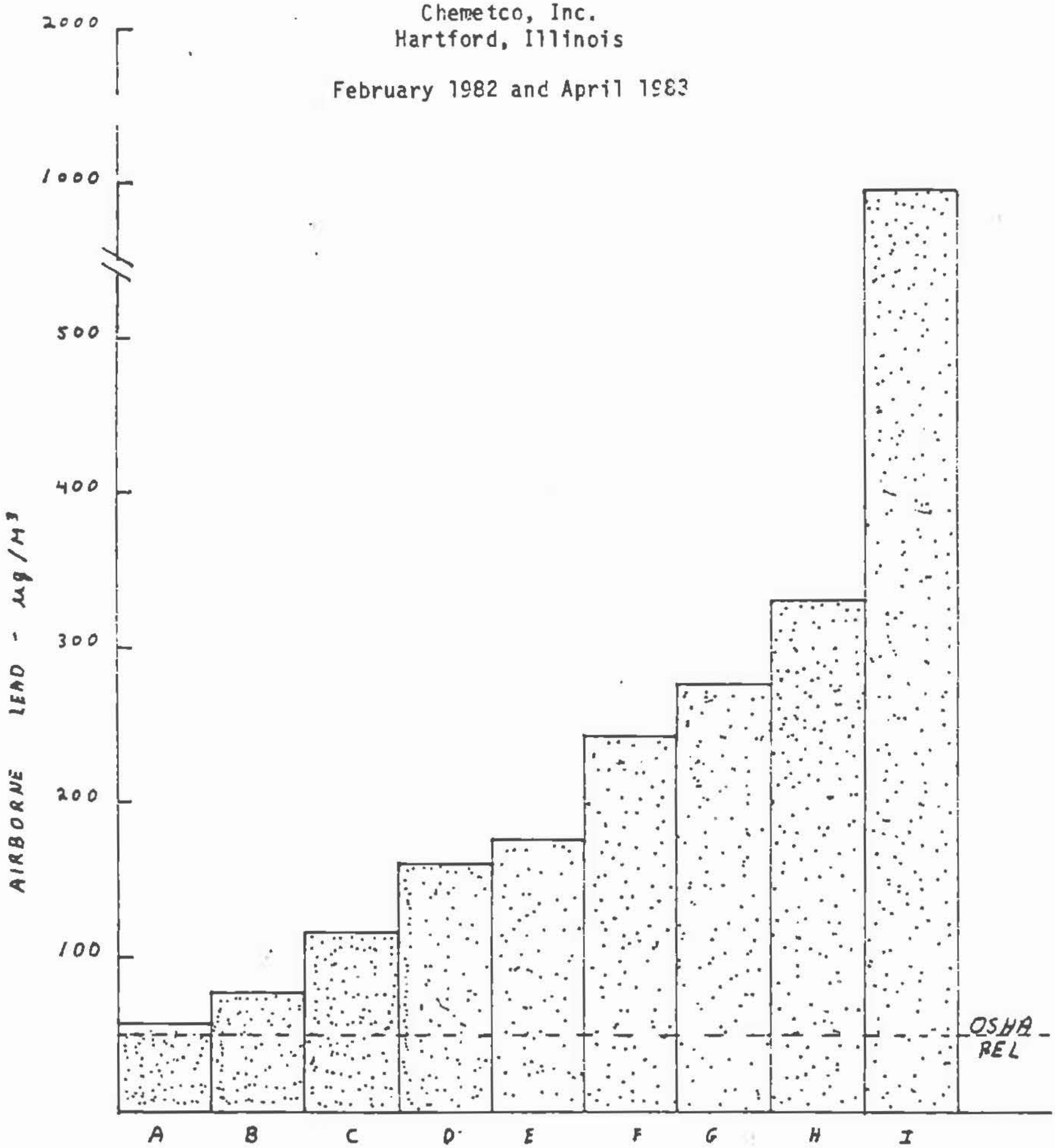
For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Figure 1

AVERAGE AIRBORNE LEAD EXPOSURES VS JOB CLASS

Chemetco, Inc.
Hartford, Illinois

February 1982 and April 1983



Job Classification

Legend:

A - Sampling Mobile Equip. Opera.
B - Sampling Fork Truck Opera.
C - Laborer Sweep in/Outside Foundry
D - Furnace Helper
E - Hot Metals Crane Oper.
F - Laborer Sweep Inside Foundry
G - Bricklayer
H - Furnace Helper Lab
J - Furnace Opera.

Table I

Metals Assay of Settled Dust Samples Obtained in the Foundry

Chemetco, Incorporated
Alton, Illinois

February 1982 and April 1983

Date	Sample Description	Percent by Weight Arsenic	Beryllium	Cadmium	Nickel	Lead
02-04-82	3rd Level - above furnace 1	0.070	0.005	0.08	0.5	3.9
04-27-83	3rd Level - above furnace 1	<0.01	0.011	0.026	0.484	3.93
02-04-82	3rd Level - above furnace 2	0.070	0.003	0.12	0.6	5.5
04-27-83	3rd Level - above furnace 2	<0.03	0.011	0.027	0.627	4.40
02-04-82	3rd Level - above furnace 3	0.15	0.004	0.16	0.5	3.4
04-27-83	3rd Level - above furnace 3	0.17	0.015	0.029	0.456	3.22
04-27-83	3rd Level - above furnace 4	0.03	0.032	0.033	0.530	5.98
04-27-83	2nd Level - roof of furnace 1 aide desk	<0.02	0.016	0.037	0.431	3.53
04-27-83	2nd Level - roof of furnace 2 aide desk	<0.01	0.010	0.028	0.531	3.69
02-04-82	2nd Level - roof of furnace 2 aide desk	0.032	0.01	0.06	0.6	5.0
04-27-83	2nd Level - roof of furnace 3 aide desk	<0.01	0.017	0.021	0.426	3.51
04-27-83	2nd Level - roof of furnace 4 aide desk	0.30*	<0.006	0.011	0.486	2.49
02-04-82	2nd Level - cross member at furnace 3	0.029	0.01	0.07	0.4	6.1
02-04-82	2nd Level - electrical panel box between furnaces 3 & 1	0.12	0.003	0.10	0.4	2.7
02-04-82	2nd Level - electrical panel box between furnaces 2 & 1	0.051	0.01	0.08	0.4	3.9
02-04-82	2nd Level - cross member east wall at anode furnace	0.078	0.01	0.09	0.3	3.4
02-04-82	Hot metals crane - structural member N end	0.085	0.01	0.11	0.3	3.0
02-04-82	Hot metals crane - structural member S end	0.043	0.005	0.05	0.3	2.4
02-04-82	Hot metals crane - 3rd level access platform	0.045	0.01	0.07	0.3	4.8
	Mean**	0.07	0.01	0.06	0.5	3.9
	±S.D.	0.07	0.01	0.04	0.1	1.1

* This value is suspect because of large quantity of phosphorous present.
** The less than values were treated by L/2 approximation method.

Table II

Personal Exposure Concentrations to Airborne Inorganic Metals

Chemetco, Incorporated
Alton, Illinois

November 1982 and April 1983

Date	Sample Description	Sampling Period	Sample Volume Liters	Airborne Concentration - ug/m3 Arsenic	Beryllium	Cadmium	Lead	Nickel
11-10-82	Furnace Operator	0640-1445	970	1.4	0.3	10.4	1556	9.7
11-10-82	Furnace Operator	1446-2220	908	LLD*	LLD	1.9	125	1.7
11-11-82	Furnace Operator	0650-1458	976	1.7	LLD	4.8	577	12.8
11-11-82	Furnace Operator	1444-2220	912	2.5	LLD	8.7	802	11.5
04-27-83	Furnace Operator	0643-1455	984	LLD	LLD	14.6	1838	3.7
04-28-83	Furnace Operator	0639-1457	996	1.0	LLD	18.0	896	3.6
11-10-82	Furnace Helper - Lab	0649-1410	882	LLD	LLD	1.13	337	10.5
11-10-82	Furnace Helper - Lab	1420-2200	920	1.2	LLD	LLD	102	6.4
11-11-82	Furnace Helper - Lab	0631-1429	956	1.7	LLD	1.1	305	14.2
11-11-82	Furnace Helper - Lab	1428-2215	934	1.3	LLD	4.6	420	6.9
04-26-83	Furnace Helper - Lab	1429-2223	948	LLD	LLD	1.1	192	9.7
04-27-83	Furnace Helper - Lab	0626-1431	970	LLD	LLD	4.1	789	12.9
04-28-83	Furnace Helper - Lab	0643-1445	964	LLD	LLD	1.8	157	9.3
11-10-82	Furnace Helper	0645-1410	890	LLD	LLD	1.2	198	6.0
11-10-82	Furnace Helper	1421-2210	938	LLD	LLD	LLD	108	3.1
11-11-82	Furnace Helper	0639-1431	944	1.5	LLD	1.4	347	8.6
04-27-83	Furnace Helper	0629-1432	966	LLD	LLD	3.1	56	1.0
04-28-83	Furnace Helper	0641-1431	940	LLD	LLD	3.5	96.9	3.7
11-10-82	Hot Metals Crane Operator	0625-1429	968	1.2	LLD	3.0	188	1.1
11-10-82	Hot Metals Crane Operator	1424-2217	946	1.5	LLD	4.0	229	1.3
11-11-82	Hot Metals Crane Operator	0630-1435	970	1.3	LLD	2.4	267	1.3
11-11-82	Hot Metals Crane Operator	1428-2232	968	2.4	LLD	3.1	256	1.6
04-26-83	Hot Metals Crane Operator	1430-2224	948	LLD	LLD	0.8	63.5	1.2
04-27-83	Hot Metals Crane Operator	0632-1432	960	1.1	LLD	13.9	113	1.2
04-28-83	Hot Metals Crane Operator	0637-1437	960	LLD	LLD	8.0	117	1.1
Environmental Criteria				2	0.5	40	50	15

* Denotes lower limit of detection. LLD's for arsenic, beryllium and cadmium are <1, <0.2 and <0.5 ug/sample, respectively.

Personal Exposure Concentrations to Airborne Inorganic Metals

Chemetco, Incorporated
Alton, Illinois

November 1982 and April 1983

Date	Sample Description	Sampling Period	Sample Volume Liters	Airborne Concentration - ug/m^3 Arsenic	Beryllium	Cadmium	Lead	Nickel
11-10-82	Bricklayer	0722-1525	966	1.6	LLD	1.2	115	10.6
11-11-82	Bricklayer	0740-1527	934	2.5	LLD	1.9	247	7.9
04-27-83	Bricklayer	0758-1548	940	LLD*	0.3	6.0	211	14.3
11-10-82	Bricklayer	0641-1519	1,036	1.5	LLD	1.0	101	5.2
11-11-82	Bricklayer	0640-1523	1,046	1.8	LLD	1.7	199	8.4
04-27-83	Bricklayer	0758-1548	914	LLD	LLD	4.8	78.1	3.3
11-10-82	Laborer - Sweeper Inside Foundry	0643-1515	1,024	2.7	0.5	4.1	606	3.1
11-11-82	Laborer - Sweeper Inside Foundry	0700-1522	1,004	1.0	LLD	0.5	60.0	4.5
11-11-82	Laborer - Sweeper Inside Foundry	0703-1515	984	3.4	0.2	3.6	383	12.9
04-27-83	Laborer - Sweeper Inside Foundry	0656-1513	994	LLD	LLD	5.9	125	2.9
04-27-83	Laborer - Sweeper Inside Foundry	0658-1503	970	LLD	LLD	0.8	44.0	3.1
11-10-82	Laborer, Sweeper In/Outside Foundry	0644-1522	1,042	1.0	LLD	1.2	150	4.9
11-10-82	Laborer, Sweeper In/Outside Foundry	0720-1258	676	1.8	LLD	0.7	74.0	8.9
11-11-82	Laborer, Sweeper In/Outside Foundry	0647-1520	1,026	1.8	LLD	0.8	122	3.1
11-10-82	Sampling, Fork Truck Operator (Laborer)	0645-1525	1,040	1.2	LLD	5.1	60.4	6.2
04-27-82	Sampling, Fork Truck Operator (Laborer)	0657-1525	1,016	1.0	0.3	5.2	90.1	6.3
11-10-82	Sampling - Shipping - SMBE	0647-1526	1,038	1.0	LLD	0.6	105	2.6
11-11-82	Sampling - Shipping - SMBE	0642-1530	1,056	LLD	LLD	LLD	83.1	1.7
11-10-82	Sampling - Inside/Outside - SMBE	0656-1536	1,040	1.5	LLD	0.5	4.8	13.1
11-10-82	Sampling - Inside/Outside - SMBE	0659-1536	1,034	LLD	LLD	0.6	119	2.4
11-10-82	Sampling - Inside/Outside - SMBE	0702-1511	978	1.6	LLD	0.5	24.4	1.1
11-11-82	Sampling - Inside/Outside - SMBE	0715-1415	840	1.2	LLD	LLD	20.8	1.0
11-11-82	Sampling - Inside/Outside - SMBE	0720-1530	980	1.9	LLD	LLD	25.9	4.0
11-10-82	Sampling - Outside - SMBE	0655-1528	1,026	LLD	LLD	0.5	71.6	2.8
11-11-82	Sampling - Outside - SMBE	0710-1530	1,000	1.0	LLD	LLD	49.5	1.3
Environmental Criteria				2	0.5	40	50	15

* Denotes lower limit of detection. LLD's for arsenic, beryllium and cadmium are <1, <0.2 and <0.5 ug/sample, respectively.

Table IV

Personal Exposures to Airborne Inorganic Lead

Chemetco, Incorporated
Alton, Illinois

November 1982 and April 1983

Sample Description	No. of Samples	0 - 49		50 - 99		100 - 199		200+	
		n	(%)	n	(%)	n	(%)	n	(%)
Furnace Operator	6							6	(100)
Furnace Helper - Lab	7					3	(43)	4	(57)
Furnace Helper	5			2	(40)	2	(40)	1	(20)
Hot Metals Crane Operator	7			1	(14)	3	(43)	3	(43)
Bricklayer	6			1	(17)	3	(50)	2	(33)
Laborer - Sweep Inside Foundry	5	1	(20)	1	(20)	1	(20)	2	(40)
Laborer - Sweep Inside/Outside Foundry	3			1	(33)	2	(67)		
Sampling - Fork Truck Operator	2			2	(100)				
Sampling - SMBE	9	5	(56)	2	(22)	2	(22)		
TOTAL	50	6	(12)	10	(20)	16	(32)	18	(36)

Table V

Analysis of Lead in Wipe Samples Obtained in the North and South Foundry Lunch Rooms

Chemetco, Incorporated
Alton, Illinois

February 4 and 5, 1982

Sample Description	Micrograms of Lead per 100 Square Centimeters Surface Area
South Lunch Room: center of lunch table	68
South Lunch Room: center of left third of lunch table	34
North Lunch Room: center of right third of lunch table	17
North Lunch Room: center of left third of lunch table	46

Table VI

Tank House - Personal and Work Area Sulfuric Acid Exposure Concentrations

Chemetco, Incorporated
Alton, Illinois

April 28, 1983

Sample Description	Sampling Period	Sample Vol. Liters	Air Concentration ug/m^3
Tank House Operator	0705-1446	922	77.0
Tank House Operator	0706-1447	922	56.0
Tank House Operator	0712-1500	864	97.2
Tank House Operator	0708-1449	922	56.4
West side of tank house - aisle between block 3 and 4	0716-1455	918	30.7
East side of tank house - aisle between block 5 and 6	0723-1455	904	55.3
Millwright	0700-1448	936	86.5
Millwright	0704-1502	956	64.9
Millwright	0710-1501	942	191.1
Environmental Criteria			1000

Table VII

Symptoms Occurring in Prior Month (January 1982)
Among 30 Workers

Chemetco, Incorporated
Alton, Illinois

February 1982

	Number With Symptoms	Frequency
Running nose, sneeze (excl. cold)	15	0.56
Shortness of breath	10	0.33
Skin rash	10	0.33
Sore throat	9	0.30
Watery, burning eyes	8	0.27
Numbness in hands and feet	7	0.23
Cough with phlegm	7	0.1
Burning nose	7	0.23
Joint pain	6	0.200
Shakiness	5	0.12
Chest pain	5	0.17
Cough	5	0.17
Weakness	4	0.13
Wrist Weakness	4	0.13
Chest tightness	3	0.10
Nausea	2	0.07
Stomach cramps	1	0.03
Wheeze	1	0.03
Difficulty walking	1	0.03
Difficulty with balance	1	0.03

Table VIII

Symptoms: Tankhouse vs. Other Work Areas

Chemetco, Incorporated
Alton, Illinois

February 1982

Sympton	Tankhouse (9 workers)	Non-Tankhouse (7 workers)	p-value*
Watery, burning eyes	4	4	.0596
Burning nose	3	4	N.S.**
Running nose, eyes	7	8.[1] (of 20)	.0081***
Sore throat	5	4	.0138
Metallic taste	3	7	N.S.
Shortness of breath	3	7	N.S.
Skin rash	3	7	N.S.
Numbness	0	7	.1535
Ear ringing	2	5	N.S.
Fatigue	1	10	.2146
Nervousness	2	8	N.S.

1 Excludes three people with colds
*2-tailed Fisher's exact test
**Not significant - p>0.0025
***Significant at 0.05 level

Table IX

Weighted Mean Blood Lead Levels by Season and Job Category

Chemetco, Incorporated
Alton, Illinois

Job	Blood Lead (ug/dl)	
	Cold Weather	Warm Weather
Anode Casting	43.5	40.7
Foundry	45.7	46.2
Labor Pool	44.6	43.0
Maintenance	42.1	41.4
Sampling	33.5	33.7
Tankhouse	36.5	31.3

Results include 93 workers with at least one blood drawn in both cold and warm weather months.

Table X

Comparison of the Weighted Mean Difference Between Cold Weather and Warm Weather Blood Lead Levels

Chemetco, Incorporated
Alton, Illinois

February 1982

	Anode Casting	Foundry	Labor Pool	Maintenance	Sampling	Tank House	All
Group 1	9.0 (2)		-3.0 (2)	-1.5 (5)	0.2 (5)	8.3 (13)	4.9 (24)
Group 2	4.3 (2)	-3.2 (8)	6.7 (3)	0.7 (12)	-.2 (3)	2.3 (3)	0.4 (31)
Group 3	-1.00 (4)	2.5 (7)	0.7 (6)	1.0 (14)	1.3 (3)	-2.7 (4)	0.7 (38)
n =	3.00 (8)	-0.5 (15)	1.6 (11)	0.7 (28)	-0.2 (11)	5.2 (20)	1.7 (93)

p = <.05

AC[1] = Anode casting
F[2] = Foundry
LP[3] = Labor Pool
M[4] = Maintenance
S[5] = Sampling
T[6] = Tankhouse

Groups I, II, III are delineated by the frequency of blood lead determining (I = 2 times per year, II = 3-4, III = >5)

The numbers in parenthesis represent workers whose bloods were tested and matched.

Cold weather months are October - March
Warm weather months are April - September

The actual number in the table represent the difference between weighted means with a (+) sign meaning the blood lead level was higher in cold weather and a (-) sign meaning it was higher in warm weather.

Table XI

Symptoms and Skin Examination Findings Among Tankhouse Workers

Chemetco, Incorporated
Alton, Illinois

Case No.	Symptoms** Eyes	Skin	SOB*	Nasal Irritation	Nosebleeds	Skin Exam
1		+++	+		+	Irritant rash
2						Hand fissures
3			+			Folliculitis
4		++	++	++	+	Irritant rash
5		+		+		Hand fissures
6			+	+		Negative
7			+	+	+	Negative
8	+	+	+	+		Hand fissure
9	+	+	+	+		Irritant rash

*SOB = shortness of breath
**Symptoms were rated as +,++, or +++ with higher ratings based on greater frequency.

Table XII

Symptom Profile on 16 Workers Participating in the Beryllium Protocol

Chemetco, Incorporated
Alton, Illinois

Case	Symptom*												
	A	B	C	D	E	F	G	H	I	J	K	L	M
1						+							+
2			+		+	+	+					+	+
3			+			+			+	+	+	+	+
4	+							+					+
5	+	+		+		+		+					+
6						+							
7	+		+		+	+	+	+	+	+		+	+
8						+							
9				+		+							+
10	+					+			+	+			+
11	+												
12				+									
13	+	+		+									
14								+					
15													+
16	+	+				+		+	+	+			+

A - Symptomatic Cough
B - Shortness of Breath
C - Wheeze
D - Chest Tightness
E - Fevers
F - Body Aches
G - Chill
H - Chronic Cough
I - Pneumonia
J - Bronchitis
K - Asthma
L - Hayfever
M - Smoking: + former smoker; ++ current smoker

APPENDIX I

Environmental Evaluation Criteria

Chemetco, Incorporated
Alton, Illinois

Substance	Criteria - ug/m3		
	NIOSH*	OSHA**	ACGIH**
Inorganic Arsenic	2	10	200
Beryllium	0.5	2	2
Cadmium	40	200	50
Inorganic Lead	50	50	150
Inorganic Nickel	15	1000	100

* The NIOSH criteria refer to the Time Weighted Average (TWA) concentrations for up to a 10-hour workday, 40-hour workweek, except that for arsenic which is a ceiling concentration.

** The OSHA standards and ACGIH Threshold Limit Values refer to a TWA-concentration for an 8-hour workday, 40-hour workweek.

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