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NEW ENGLAND LEAD BURNING CO.(NELCO)
EATON METALS
SALT LAKE CITY, UTAH

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I. SUMMARY

On July 5, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Director of the Department of Safety and Health, United Association of the Plumbing and Pipe Fitting Industry, to conduct a health hazard evaluation (HHE) at the New England Lead Burning Company, Inc. (NELCO) project in Salt Lake City, Utah. The requestor was concerned about lead exposure among members of Lead Burners Local 153 working at the NELCO contract site in Utah.

On July 10, an environmental and medical evaluation was conducted at the Salt Lake City location. Environmental samples were collected for lead, hydrogen chloride, noise, and temperature. An occupational physician 1) distributed a symptom questionnaire, 2) interviewed employees, and 3) collected blood specimens to determine lead and zinc protoporphyrin (ZPP) levels.

All 17 of the employees working the day and evening shifts on July 10, 1991 completed the symptom questionnaire and provided a blood specimen. No employees reported symptoms suggestive with lead poisoning. The mean blood lead level was 34 ug/100 grams whole blood (range 11 to 77 ug/100 grams whole blood). Two employees (12%) had blood lead levels over 50 ug/100 grams whole blood, the level requiring medical removal from areas where lead exceeds 30 ug/M^3 by the OSHA lead standard. The mean ZPP level was 58 ug/dl (range 26-139 ug/dl). Seven employees (41%) had ZPP levels above the upper limit of normal (>50 ug/dl).

Time-weighted average exposures for lead ranged from 141 to 307 micrograms of lead per cubic meters of air (ug/M^3). These concentrations are above the Occupational Safety and Health Administrations (OSHA) Permissible Exposure Limit (PEL) of 50 ug/M^3 as an 8-hour TWA. The short-term lead concentrations for the three major jobs ranged from 215 to 307 ug/M^3 during lead burning, 280 to 390 ug/M^3 during tinning, and from 27 to 42 ug/M^3 for grinding. The employees were wearing respiratory protection; therefore, the actual exposures may have been less than these values, provided that the respirators were properly fitted and maintained. Wipe sampling revealed the presence of lead contamination on table surfaces in the lunchroom, on workers clothes and shoes which they wore home, in the workers' cars, and on the floor of the change room. Detector tube samples showed hydrogen chloride levels from 3 to >10 ppm. The results of area air samples analyzed for trace metals revealed that no other metals were present in significant amounts when compared to their exposure criteria. Average noise levels for all jobs were greater than 90 dB(A). Dry bulb temperatures ranged from 115 to 125°F during tinning operations.

On the basis of the data collected, a health hazard existed at the time of this survey from employee exposure to lead, noise, hydrogen chloride, and potentially heat stress at the NELCO site in Salt Lake City. Recommendations designed to reduce exposures to these chemical and physical hazards are included in this report.

KEY WORDS: SIC 3443 (Fabricated Plate Work), Tank Construction, Inorganic Lead, Lead Lining, Lead Burning, Lead Burners, Blood Lead, Noise, Zinc Protoporphyrin, Hydrogen Chloride, Heat Stress

II. INTRODUCTION

On July 5, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Director of the Department of Safety and Health for the United Association of the Plumbing and Pipe Fitting Industry to conduct a health hazard evaluation (HHE) at the New England Lead Burning Company, Inc. (NELCO) project in Salt Lake City, Utah. The requestor was concerned about lead exposure among members of Lead Burners Local 153 who were working at the NELCO site.

On July 10, an environmental and medical evaluation was conducted at Eaton Metals in Salt Lake City, Utah, where NELCO was working. Environmental monitoring was conducted for lead, hydrogen chloride, noise, and temperature. Employees completed a symptoms questionnaire, were interviewed by an occupational physician, and provided a blood specimen for lead and zinc protoporphyrin (ZPP). The environmental results were provided to the company and union via telephone on July 19, 1991. Blood lead and ZPP levels were reported to participating employees by telephone between July 19-23, 1991 and by mail on July 31, 1991.

III. BACKGROUND

A. General Description of NELCO Operations

The New England Lead Burning Company, Inc. (NELCO) contracts for jobs throughout the United States that involve the use of lead. The NELCO job at Eaton Metals involved the lining of two 85-foot long, 14-1/2 foot diameter steel tanks with lead sheets. The tanks had been constructed by Eaton Metals and the lining of the tanks had been subcontracted to an engineering firm which contracted with NELCO to complete the task. The job was scheduled to be completed in 14 weeks.

B. Workforce

The NELCO employees working at the Salt Lake City location are members of Lead Burners Local 153, headquartered in North Carolina. Members of the local, about 100, travel across the country to various jobs which may last a week to several months. There are two main employers who hire members of the local, although other companies may also employ them.

C. Description of Company Operations

The tanks being lined were to be used for the processing of copper ores where acids are used to extract the metal from the ore. The purpose of the lead lining in the tanks was to provide an acid-resistant coating. Lead sheeting (18 inches by 48 inches by 5/16-inch thick) was bonded to the steel tank, and the 1/2-inch wide seams between the sheets were filled-in with lead to the same depth. All areas around the intakes to the tanks (nozzles) had to have 8-inches of homogeneous lead lining. The nozzles sticking out from the tank also had to have homogeneous lead linings. The job of lining a tank with lead involved three steps: grinding, tinning, and bonding/burning.

1. Grinding

   The first step involved grinding the surface of the tank down to bare metal. The whole inside surfaces of the nozzles, 8-inches around the nozzle openings into the tank, and the outline of the lead sheets (1/2-inch seams) were ground until the areas marked off were completely shiny. These ground areas then had to be soldered quickly in order to avoid reoxidation of the steel.

2. Tinning

   The term "tinning" is derived from the solder used on the newly ground surfaces which contained an 85% mixture of lead and tin. The remaining 15% consists of zinc chloride, ammonium chloride and ethylene glycol ether. The solder was diluted in a crucible with muriatic acid (20% hydrochloric acid) before application. The surface to be soldered was first heated with gas fired torches. These torches were placed under the tank around the area to be tinned and allowed to heat the surface for about 30 minutes. The tinning process required 2 to 3 workers: one to operate the torch, one to apply the solder, and one to wipe the newly tinned surface with a rag. The solder would be applied to the surface and the torch operator would heat the solder until it was bonded. Once he removed the torch, the other worker would quickly wipe the newly soldered surface to insure that the surface was well covered. The torch operator would then apply the torch again, followed again by wiping until the job was complete. Two workers could do the job if the one wiping also applied the solder. The process required substantial heat for proper application of the solder. If the areas were not completely soldered, the lead sheets would not be effectively bonded to the tank.

3. Bonding/Burning

   Once the outline for the lead sheets had been tinned, the lead sheets were laid in place and bonded to the seam. This was accomplished by simply melting the edge of the lead sheet to the soldered area. The seam left between the juncture of two sheets was filled to a uniform depth with lead material. Lead rods were melted by torches to fill in these gaps. This was referred to as lead burning. Those areas which required homogeneous linings with lead were completely filled in by lead burning.

D. Personal Protection and Engineering Controls

Personal protective equipment worn by the workers included a half-face piece respirator with a combination cartridge that included a high efficiency particulate filter and organic vapors/acid gases cartridges. Those workers grinding wore full-face piece respirators with the same cartridges. When tinning, either full or half-face piece respirators could be worn; however, the workers who did the grinding, and thus, wore full-face piece respirators, also did the tinning. All workers wore disposable Tyvek coveralls, work boots, safety glasses, and gloves. Hearing protection (ear plugs) was used while grinding and sometimes while tinning.

Several fans were used on each tank to ventilate the area. Four supply fans were used on each tank to provide general dilution ventilation. One tank had four and the other five local exhaust fans which were used at the point where workers were burning lead. Additional supply and local exhaust fans were at the job site waiting for installation. Most of the available inlets to the tanks, minus one or two for worker access, were utilized for ventilation.

At the end of the shift, most of the workers changed from their work boots to street shoes in the trailer; however, this was not mandatory. No separate change rooms, work clothes, or shower facilities were available. Most workers had received qualitative fit testing and training on proper use and care of their respirators at their previous job, which had also been in the Salt Lake City area. A few of the newer employees, however, said that they were picking up information on use and care of respirators by watching the other workers. There was no concerted effort to train the workers for each job or on a routine basis. Likewise, cartridges were changed at the worker's discretions when they became plugged or when they could smell odors through them. Respirators were generally stored on open pegs in the change area of the trailer between shifts, but during the survey were seen on the floor and in open boxes. None were stored in sealed bags or containers. During breaks, respirators were left at various places including in the tanks, on top of lead sheets, and on work benches and posts outside the tanks.

Smoking and eating was limited to the trailer area; however, several workers carried their cigarettes in their pockets while they worked. There was only a single wash sink in an adjacent building for cleanup. Workers were instructed to remove their Tyvek clothing and wash their hands before breaks, lunch, and going home.

E. Environmental and Medical Monitoring Program

Air and blood monitoring of the employees for lead levels was performed through a local occupational health consultant. The job was expected to last 14 weeks, and the workers had been monitored prior to this job for blood lead. Air monitoring had been conducted once since the job started. Since many of the workers had been employed by NELCO for their last job, which was also in Salt Lake City, blood lead results were available for these workers for the last two months (in a few cases, 3 results were available). No lab reports were available, only results that had been recorded by the job superintendent. Blood lead levels from June 21, 1991 ranged from 21 to 58 micrograms per 100 grams of whole blood (ug/100 g), with an average of 35 ug/100 g.

IV. MATERIALS AND METHODS

A. Environmental

On July 10, 1991, an environmental survey was conducted to determine employee exposures to lead, trace metals, noise, and acid gases.

During this survey, personal breathing zone (PBZ) air samples were collected near the workers' breathing zone for lead and trace metals, and general area air samples were collected at locations throughout the work area. Samples were obtained using Gilian model HSF 513A battery-powered sampling pumps operating at 2.0 liters of air per minute. The pumps were attached by Tygon tubing to the collection medium (37-millimeter (mm), 0.8 micron pore size, mixed-cellulose ester membrane filters contained in 2-piece plastic cassettes). The sampling media for the personal samples were replaced between each break during the work shift (except during the tinning operation). Wipe samples for lead contamination were collected using the same 37-mm filter media that had been wetted with isopropyl alcohol.

The air and wipe samples were analyzed for lead by atomic absorption spectroscopy according to NIOSH method 7082.[1] In addition, the samples collected during grinding and tinning operations were analyzed for 30 trace metals using inductively coupled plasma - atomic emission spectroscopy in accordance with NIOSH Method 7300.[1]

Area samples were collected for hydrogen chloride (hydrochloride acid) using Draeger #1/a Hydrogen Chloride (Hcl) indicator tubes as per the manufacturer's instructions. The tubes ranged from 0-10 parts per million (ppm) for Hcl.

Sound level measurements were determined with a Quest Model 215 sound level meter. All measurements were made on the A-scale, with slow response. The calibration of the sound level meter was checked just prior to use. Limited personal monitoring for noise was conducted using DuPont model MK-3 personal noise dosimeters, which were also calibrated just prior to and after use.

On July 18, a return visit was made to collect additional wipe samples and personal noise monitoring. The same Dupont noise dosimeters were used. The wipe samples were collected with a baby wipe (Scott Paper Company Wash a-bye Baby) which had been tested by other NIOSH personnel and shown to contain very low levels of background lead contamination. The samples were analyzed according to NIOSH Method 7802.[1]

B. Medical

On July 10, 1991, employees working the day and evening shift completed a symptom questionnaire designed to elicit symptoms of lead poisoning and were interviewed by an occupational physician, who also obtained a blood sample for lead and zinc protoporphyrin (ZPP) determination. Sixteen employees and the one job superintendent participated in the survey, for a total of 17 participants.

The blood leads and ZPPs were analyzed by a laboratory approved for blood lead analysis by the Occupational Safety and Health Administration based on proficiency testing.[2] The blood leads were determined utilizing anodic stripping voltimetry, and ZPPs were determined by photofluormetric techniques.[3] NIOSH's contract laboratory reported the blood lead levels as microgram (ug) per deciliter (dl). These values were converted to ug per 100 grams whole blood (units used in the OSHA lead standard), using 1.052 as the specific gravity of blood.

V. EVALUATION CRITERIA

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 important, however, 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 preexisting 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 often are 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 becomes 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 (TLVs), and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards [Permissible Exposure Limits (PELs)]. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that the company is required by the Occupational Safety and Health Administration to meet those levels specified in 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.

A brief discussion of the toxicity and evaluation criteria for inorganic lead, noise, and hydrogen chloride is presented as follows.

A. Inorganic Lead

1. <u>Toxicity</u>

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in the industrial setting. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the peripheral and central nervous systems, gastrointestinal system, kidneys, reproductive system, hematopoietic system (blood forming organs), and virtually all other systems of the body.[4] The acute effects may manifest as weakness, tiredness, irritability, reduced intelligence, slowed reaction times, abdominal pain, or high blood pressure.[5] Chronic lead exposure can cause infertility, kidney damage, and, in pregnant women, fetal damage manifested as prematurity, reduced birth weight, reduced red blood cell production, and reduced intelligence.[6-10] The blood lead test is one measure of the amount of lead in the body and is the best available measure of recent lead absorption. The mean serum lead level for US men between 1976 and 1980 was 16 ug/dl;[11,12] however, with the implementation of lead-free gasoline and reduced lead in food, the 1991 average serum lead level of U.S. men will probably drop below 9 ug/dl.[4] A summary of the lowest observable effect levels of lead are listed in Table 1.

2. Medical Exposure Criteria

The OSHA lead standard requires annual blood lead testing for employees exposed to lead above the action level (30 ug/M^3).[13] If an employee's blood lead level is at or above 40 ug/100 grams of whole blood, the employee must have his blood lead checked every 2 months. If an employee's blood lead level averages 50 ug/100 grams of whole blood or more, he must be removed from areas containing more than 30 ug/M^3 airborne lead, and have monthly blood lead tests.[13] For employees removed from lead exposure, the OSHA lead standard requires the employer to maintain the earnings, seniority, and other employment rights and benefits of an employee as though the employee had not been removed. For an employee to return to work in the area with excessive lead exposure, their blood lead level must be below 40 ug/100 grams of whole blood on two consecutive tests if the original blood lead was between 50-60, or drop at least 20 ug/100 grams of whole blood on two consecutive tests if the original blood lead was greater than 60.[13] The blood samples must be analyzed by a laboratory that has been approved by OSHA.[2]

Zinc protoporphyrin (ZPP) levels measure the effect of lead on the red blood cell enzyme ferrochelatase, the last enzyme involved in the process of heme synthesis. In men, ZPP levels increase abruptly when blood lead levels rise above 35 ug/dl, and they tend to stay elevated for several months.[14] In women, ZPP level rise at a BBL of 25 ug/dl. ZPP levels vary between laboratories, however most laboratories consider 50 ug/dl the upper limits of normal.[15]

3. Occupational Exposure Criteria

The current OSHA PEL for airborne lead is 50 ug/m^3 calculated as an 8-hour TWA for daily exposure. The standard also specifies that if more than 8 hours is worked in any work day, the PEL should be adjusted accordingly, e.g., the PEL for a 10-hr work day is 40 ug/m^3.[13] In addition, the OSHA lead standard establishes an "action level" of 30 ug/m^3 TWA which initiates several requirements of the standard, including periodic exposure monitoring, medical surveillance, and training and education.[13] If the initial determination shows that any employee's 8-hr TWA PBZ results are above 30 ug/m^3, air monitoring must be performed every six months until the results show two consecutive levels of less than 30 ug/m^3 (measured at least seven days apart).

B. Noise

Exposure to high levels of noise may cause temporary or permanent hearing loss. The extent of damage depends primarily upon the intensity of the noise and the duration of the exposure. There is abundant epidemiological and laboratory evidence that protracted noise exposure above 90 dB(A) causes hearing loss in a portion of the exposed population.

The OSHA standard for noise specifies a PEL of 90 dB(A)-slow response for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship. This means that in order for a person to be exposed to noise levels of 95 dB(A), the amount of time allowed at this exposure level must be cut in half to be within the PEL. Conversely, a person exposed to 85 dB(A) is allowed twice as much time at this level (16 hours) to remain within his daily PEL.[16] Both NIOSH and ACGIH recommend an exposure limit of 85 dB(A) for 8 hours, 5 dB less than the OSHA standard. Both these latter two criteria also use a 5 dB time/intensity trading relationship in calculating exposure limits.

Time-weighted average (TWA) noise limits as a function of exposure duration are shown as follows:

Duration of Exposure (hrs/day)	Sound Level (dB(A)) NIOSH/ACGIH[17,18]	OSHA[16]
16	80	85
8	85	90
4	90	95
2	95	100
1	100	105
1/2	105	110
1/4	110	115*
1/8	115*	- **

* No exposure to continuous or intermittent noise in excess of 115 dB(A).

** Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

The OSHA regulation, which has an additional action level (AL) of 85 dB(A), stipulates that an employer shall administer a continuing, effective hearing conservation program when the TWA value exceeds the AL. The program must include monitoring, employee notification, observation, an audiometric testing program, hearing protectors, training programs, and recordkeeping requirements. All of these stipulations are included in 29 CFR 1910.95, paragraphs (c) through (o).[6]

The OSHA noise regulation also states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels. Also, a continuing, effective hearing conservation program shall be implemented.

C. Hydrogen Chloride (Hydrochloric Acid)

Hydrogen chloride is a strong skin, eye, and mucous membrane irritant. Short-term inhalation may result in respiratory irritation, with burning, choking, and coughing. Ulceration of the nose and throat can occur. Eye damage can cause severe eye irritation and even permanent eye damage with loss of sight. Skin exposure may result in inflammation or burns. Long-term exposures may result in erosion of the teeth and skin rash.[16]

The OSHA standard and the NIOSH REL for HCl is 5 ppm as a ceiling value (not to be exceeded). Full eye, skin, and respiratory protection is recommended for exposures over the ceiling value.

VI. RESULTS

A. Air Samples

The results of the air samples for lead are contained in Table 2. Short term exposures as high as 530 ug/M^3 were found in the PBZ samples collected for the lead burners. In three workers monitored for 5.5 to 6.2 hr, exposures averaged 215, 240 and 310 ug/M^3. The first 2.5 hours of the shift were not sampled but were reportedly comparable to the remainder of the day as far as type of work. The values represent a good estimate of at least an 8-hour TWA. The full shift was 10 hours long. These levels are well above the OSHA PEL of 50 ug/M^3 as an 8-hour TWA. It should be noted that the employees were wearing half-face respirators during the burning/bonding of lead. Provided the respirators were properly fitted and maintained, the actual exposures would be expected to be substantially lower than the measured values.

Exposures of workers tinning, which lasted 140 minutes on this day, averaged 390, 280, and 390 ug/M^3 for the three workers monitored (Table 2). Respirators worn during this job were full-face piece type. Grinding operations had exposures which were less than the OSHA PEL, 0-46 ug/M^3. These exposures may vary considerably depending on what other operations are occurring in the tank at the same time. Most of these grinding samples were collected while lead burning was occurring at the other end of the tank. The sample # NL-P-04 was collected when only grinding was being done. The only area sample was collected in the lunch/breakroom area of the trailer; the level concentration was 2.1 ug/M^3 (Table 2).
The wipe sample results are summarized in Table 3. The first set of samples, #W1-W6, were collected on the first site visit with different wipe media than that used during the July 18 site visit. The first 5 samples showed that in the operations trailer the largest amount of surface contamination was on the table where respirators were cleaned and around the base of the water cooler. Wipe samples #W10-W25, collected July 18, 1991, documented large amounts of lead contamination on the floor of the change room (adjacent to the lunch room), on the workers' shoes (especially work boots, but including street shoes), on the workers' clothes (which were taken home to be laundered), and in the workers' cars.

Air samples were collected for trace metal analyses during grinding and tinning operations. The results of the analyses revealed the primary metallic component on the filters to be lead. In addition, trace quantities of iron, tin, and zinc were found. However, the concentrations of the tin and zinc contaminants were 1/5 (tin) to 1/10 (zinc) their respective evaluation criteria (2 mg/M^3 for tin and 5 mg/M^3 for zinc oxide fume). The iron levels were substantially less than its evaluation criterion.

Only two air samples were taken for hydrogen chloride during tinning operations. One, collected in the exhaust air from the #420 tank, adjacent to where workers were tinning, had a concentration in excess of 10 ppm. (The detector tube upper range was 10 ppm, and the sample tube was completely discolored.) The second sample, collected inside the tank about 6 feet from the workers while they were tinning, had 3 ppm.

A summary of the noise measurements is presented in Table 4. The first set of information was collected with a general sound level meter to determine approximate noise levels. Sound levels ranged from 104-110 dB(A) during tinning operations, 91-92 dB(A) during burning and bonding lead, and 96-100 dB(A) during grinding. The limited personal dosimetry measurements revealed average sound levels during tinning of 95-100 dB(A), with maximum of 106-112.6 dB(A). At these levels, the maximum allowable dose, according to the OSHA criteria, would occur in 120-187 minutes, at which time hearing protection would be required. Noise levels during burning and bonding averaged 92.2-93.7 dB(A), with maximum levels of 102.6-109.5 dB(A). The time to 100% dose at these levels was 133-160 minutes. The average sound levels found during grinding were 90-90.5 dB(A), with maximum levels of 100-119.5 dB(A). The time to 100% dose was 99-106 minutes.

High temperatures were measured during tinning operations (Table 4). No attempt was made to measure the heat index, e.g., the Wet Bulb Globe Temperature. The temperatures measured (110-125°F dry bulb) are high enough to cause heat-related illness if work is prolonged under these conditions.

B. Medical

All 17 of the employees working the day and evening shifts on July 10, 1991 completed the symptom questionnaire and provided a blood specimen.

No employees had symptoms suggestive of lead poisoning. The mean blood lead level (BLL) was 34 ug/100 grams of whole blood (range 11 to 77). Four employees (23%) had BLLs over 40 ug/100 g of whole blood, and two employees (12%) had BLLs over 50. The mean ZPP level was 58 ug/dl (range 26-139 ug/dl). Seven employees (41%) had ZPP levels above the upper limit of normal (>50 ug/dl); four of whom had BLLs over 40.

C. Personal Protection, Hygiene, and General Housekeeping

Based on observations and information obtained during the course of the survey, several shortcoming were identified related to respirator use, housekeeping, and personal hygiene. For respirators, problems included the lack of routine fit testing, the lack of training on proper use and care of respirators, and poor storage procedures. Some of the new employees had very little training and were learning how to use and care for a respirator by watching the more experienced workers. Respirators were stored on pegs in the change room, in open boxes, and on the floor. During breaks, respirators were observed laying on lead sheets inside the tanks and on tables adjacent to the tanks. Workers wore disposable Tyvek coveralls but did not change clothes or shower prior to leaving the workplace. Occasionally, workers were observed working in their street clothes without the Tyvek suits presumably because of the heat. Most workers changed from their street shoes to work boots at the site, but this was not a company requirement. Separate change rooms and showers were not provided at the time of the survey. The only wash area was a single sink located adjacent to the work area; it was not protected from dust contamination.

VII. DISCUSSION

A. Environmental

The work performed by NELCO was classified as construction, which in the past would have exempted it from most elements of the OSHA general industry lead standard. The State of Utah, however, passed a law which became effective July 15, 1991 eliminating the construction exemption from their state lead standard. Therefore, the company should comply fully with all elements of the OSHA general industry lead standard. The environmental samples for lead were 5 to 10 times the OSHA PEL on a TWA basis. Likewise, the hydrogen chloride levels were high enough to warrant the use of air-purifying respirators. While half-face piece and full-face piece, air-purifying respirators were worn by the employees, many elements of a complete respiratory protection program were missing.

The noise measurements were consistently above 90 dB(A) for all jobs. Therefore, the company should have a complete hearing conservation program. At the time of the survey there was no comprehensive hearing conservation program, although ear plugs were provided. The temperatures measured indicate the potential for heat stress. The company should have a heat stress program (none existed at the time of the survey). Similarly, the company should have a confined space entry program, since the tanks would qualify as confined spaces.

While there are no standards for surface contamination of lead, the levels of contamination found are significantly above background levels and indicate, if nothing else, that lead is being taken home and is potentially available to expose the workers and their families.

B. Medical

Sixteen days after the NIOSH blood samples were collected, NELCO repeated the blood lead levels (BBL) on all employees still working at the site. Five employees had left the workforce, leaving a total of twelve employees. Six of the 12 (50%) NELCO samples had values higher than the NIOSH samples (mean increase 3.7 ug/100 grams whole blood); one sample was the exactly the same value; and five of the 12 (42%) NELCO samples had values lower than the NIOSH values (mean 6.8 ug/100 grams whole blood).

The BLL analyzed during the NIOSH survey and repeated by NELCO were both performed by an OSHA certified laboratory approved for blood lead analysis. The approval list is updated quarterly, and laboratories with 89% or more acceptable sample reports are approved. Individual sample result acceptance is dependent on the sample's mean lead level. For samples less than 40 ug/dl, results can vary up to 6 ug/dl; for samples more than 40 ug/dl, samples can vary up to 15%. This individual sample result variation could explain blood lead discrepancies between laboratories. For example, two laboratories analyzing a split sample containing 50 ug/dl lead, could report "acceptable" results ranging from 43 to 57 ug/dl. This situation could explain the differences in BLLs performed by the NIOSH and NELCO despite both being performed by OSHA certified laboratories.

VIII. CONCLUSIONS

The environmental survey revealed lead exposures above the OSHA PEL for workers tinning and bonding/burning lead. The medical study revealed four workers with BLLs above 40 ug/100 grams of whole blood, and two workers with blood lead levels above 50 ug/100 grams of whole blood. Many of the areas of the break/lunch room, the change room, and workers' cars were contaminated with lead. The opportunity for lead exposure was likely increased by the lack of shower facilities, and the practice of wearing work clothes at home. Overexposures to noise and hydrogen chloride were also documented. The company was using a large number of fans to push and pull air out of the tanks. Local exhaust hoses could be positioned closer to the areas where burning, bonding, and tinning were being performed. The potential for heat stress also existed.

IX. RECOMMENDATIONS

A. LEAD

To ensure that workers are adequately protected from the adverse effects of lead, a comprehensive program of prevention and surveillance is needed. The requirements for such a program are presented in the OSHA lead standard.[13] In addition to specifying PELs for airborne exposure, the OSHA lead standard also contains specific provisions dealing with mechanical ventilation, respirator usage, protective clothing, housekeeping, hygiene facilities, employee training, and medical monitoring.[13] The implementation of the provisions of this standard will help to ensure that the employees are protected against any potential adverse health effects of lead exposure.

A copy of the OSHA lead standard was provided to the employer and will not be repeated in detail in this report. However, to assist the employer in implementing the standard's key provisions, a brief overview related to the findings of this survey follow.

1. Mechanical Ventilation

The supply ventilation on the tanks consisted of four 7000 cfm supply fans. The supply fans provided enough air to have an air change in each tank every 2-3 minutes. Measurement of percent oxygen and combustible gases indicated the ventilation was effective for confined space purposes. For local exhaust ventilation, there was four 1200 cfm fans on tank #420 and five on tank #410. Additional supply and exhaust fans were waiting to be installed at the time of the survey. Lead concentrations are still quite high during burning, bonding, and tinning, indicating improvement is needed in the local exhaust ventilation. There is also the concern that when the tank is rotated so that the large nozzles are pointed up, proper ventilation of the tank will become more difficult. The local exhaust ventilation should be measured to insure that it meets current recommended guidelines. The ACGIH recommends that capture velocities for substances released at low velocity into moderately still air be at least 100 to 200 feet per minute (fpm), and that the upper end of this range be used for contaminants of high toxicity (e.g., lead).[19] The workers need to be reminded to use the flexible ducts and to ensure the ducts are moved as close as practical to the work area. Some of the local exhausts ducts had flanged openings while others had only the open end of the duct hose. All local exhaust ducts should be equipped with flanged openings to increase the collection efficiency.

Periodic testing of all local exhaust ventilation systems is necessary to ensure their continued efficiency. Such systems should be tested every three months, and following any major modification.[13] A complete discussion of specific details regarding ventilation system testing, as well as information regarding the design, construction, and operation of local exhaust ventilation systems, is contained in the ACGIH Industrial Ventilation, A Manual of Recommended Practice.[19]

2. Air Monitoring

Despite the presence of engineering controls, periodic monitoring for airborne lead is needed to ensure that these controls operate effectively. Air monitoring can also be used to pinpoint the need for further employee protection (i.e., respirators) in certain areas or during certain procedures. When airborne exposures are found to be above the OSHA action level of 30 ug/M^3, as was the case in this survey, the standard calls for repeat monitoring every six months. This monitoring should be continued until such time as concentrations are found to be below this level in two consecutive measurements conducted at least one week apart.[13] Employees should be informed of the monitoring results.

3. Respiratory Protection

Due to their inherent limitations, respirators should not be considered a primary means of employee protection. A more appropriate means of exposure control would be properly designed engineering controls; i.e., local exhaust ventilation. However, the use of respiratory protection is a suitable means of exposure control in the event that engineering controls can not feasibly reduce the exposure levels. They may also be used as a backup to existing engineering controls when substances of high toxicity are present. In order to ensure the effective use and function of the respirators, a comprehensive respiratory protection plan should be put in place. Such a program is outlined in the OSHA Respiratory Protection Standard, 29 CFR 1910.134.[20] The program should include a written standard operating procedure which addresses respirator selection, training, fitting, testing, inspection, cleaning, maintenance, storage, and medical examinations. A detailed discussion of these key program elements is provided in the NIOSH Guide to Industrial Respiratory Protection, a copy of which has been provided to the employer.[21]

Assuming proper maintenance and fitting, the respirators worn by the employees during the survey should have significantly reduced their actual exposures. However, the blood lead levels indicate that workers are being overexposed to lead either due to inadequate respiratory protection or lack of proper hygiene facilities and clothes change procedures.

4. Personal Protective Clothing and Hygiene Facilities

Wherever lead dust is present, there is a possibility that the employee's skin and clothing may become contaminated. This can result in subsequent inhalation or ingestion of the lead, which can substantially increase the employee's overall absorption of lead. In addition, lead contamination on skin or clothing may be transported to other areas of the facility, and possibly to the worker's homes, where secondary exposure of co-workers or family members can occur.

In one recent study, blood lead levels were found to be markedly higher in household members residing in homes of workers with occupational lead exposure compared to members of homes of people not occupationally exposed to lead.[22]

To prevent this secondary source of lead exposure, separate change rooms, free from lead contamination, should be provided to the employees to store their "street" clothing. Street clothing should be stored separately from clothing worn during work. Showers should be taken at the completion of the work shift to remove any lead that may have reached the employee's skin. Work clothing should be laundered by the employer and not taken home. After showering, no clothing or equipment worn during the shift may be worn home, and this includes shoes and underwear. Any clothing worn during the shift should be carried home in plastic bags and cleaned carefully so that it does not contaminate the home.[13]

5. Hygiene Practices

Food, beverages, or tobacco products should not be used or stored in lead contaminated areas. These items can become contaminated with lead and cause subsequent absorption of lead through inhalation or ingestion during eating, drinking, or smoking. Employees should also continue to eat their lunch in the trailer lunchroom separate from the worksite. However, efforts need to be made to regularly clean the lunchroom. Workers should remove all contaminated outer garments prior to entering the lunchroom, and wash their hands and face.

6. Housekeeping

Housekeeping plays an important role in controlling lead exposures. Dust which has accumulated on surfaces can be reintroduced into the air thereby increasing airborne lead exposures. Also, dust accumulated on chairs or work surfaces can cause unnecessary contamination of the employees protective clothing. Therefore, all surfaces in the trailer should be kept as free as practicable of the accumulation of lead dust. Vacuuming, using a high efficiency particulate aerosol (HEPA) filter, is the preferred means of removing lead dust. Wet sweeping should be used in areas where vacuuming is not feasible; dry sweeping should not be used. A regular housekeeping program should be established to ensure that all areas are periodically cleaned. Pertinent specifications to consider when selecting vacuum cleaners are included in Appendix I.

7. Medical Monitoring

While the previously discussed recommendations have been aimed at preventing or minimizing lead exposure, medical monitoring plays a supplemental role in that it ensures that the other provisions of the program have effectively protected the individual. The OSHA standard for inorganic lead places significant emphasis on the medical surveillance of all workers exposed to levels of inorganic lead above the action level of 30 ug/M^3 TWA. Even with adequate worker education on the adverse health effects of lead and appropriate training in work practices, personal hygiene, and other control measures, the physician has a primary responsibility for evaluating potential lead toxicity in the worker. It is only through a careful and detailed medical and work history, physical examinations to rule out other potential causes of symptoms, and appropriate laboratory testing that an accurate assessment can be made. Some of the adverse health effects of lead toxicity are either irreversible or only partially reversible; therefore, early detection of disease is very important.[13]

The OSHA lead standard provides detailed guidelines on the frequency of medical monitoring, the important elements in medical histories and physical examinations as they relate to lead, and the appropriate laboratory testing for evaluating lead exposure and toxicity. This standard should be consulted by company management and the local physician for guidance in carrying out an ongoing medical monitoring program.[13] NELCO, in conjunction with the union, should select a company physician to oversee the medical management of the employees regardless of the job location. In summary, a comprehensive program is necessary for controlling lead exposures at the work site. While the company has put into place some elements of an exposure prevention program, ongoing attention is needed in all of the areas previously discussed in order to effectively reduce the risk of adverse health effects.

B. NOISE

A comprehensive hearing conservation program must be implemented by the company. The program should, at minimum, be tailored to meet the requirements set forth in the OSHA noise regulation.[16] Included in the regulation are sections addressing the need for audiometric testing, noise surveys, worker training, hearing protection devices, and recordkeeping. These requirements, as well as suggestions for engineering controls and program evaluation, are included in a recent NIOSH publication[23] which should be used for setting up the hearing conservation program.

The use of hearing protection devices should be made mandatory in all jobs in the tanks: grinding, tinning, burning, and bonding. The survey results show that noise levels inside the tanks are well above 85 dB(A). Workers should be given the opportunity to choose from among several types of hearing protection devices (HPD). The areas where HPDs are required should be identified with warning signs posted at all entrances.

Audiometric testing must be done on an annual basis. The recorded noise levels are of sufficient intensity to regulate this practice, according to OSHA.[16] The tests will identify individual employees who have changes in their hearing over their work history.

C. HEAT STRESS

The company should develop a heat stress program which includes a program of worker training, medical surveillance, periodic medical exams, posting of heat stress conditions, and periodic measurements of heat stress conditions. The recommendations for a thorough heat stress program are outlined in the NIOSH document, Occupation Exposure to Hot Environments, Revised Criteria 1986.[24]

D. CONFINED SPACE ENTRY

The tanks under construction qualify as a confined space; therefore, the company should develop a confined space entry procedure. With the air-moving fans present at the time of the survey, there was sufficient ventilation in the tanks so that oxygen deficient- or combustible atmospheres were unlikely. However, the possibility exists and should be monitored, particularly prior to reentry into the work space after fans have been turned off. Likewise, at different times, individuals were noted working in the tanks by themselves. A buddy system should be used. Torches and other potential gas sources should be removed from the tanks during breaks, and at the end of shifts, or whenever the tank is left unattended. The confined space aspect of working in the tanks will become more acute as the tanks are turned and access becomes more limited. An overview of confined space entry procedures can be found in the NIOSH document, Criteria for a Recommended Standard, WORKING IN CONFINED SPACES.[25]

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D. NELCO, Santa Fe Springs, California
E. Occupational Safety and Health Administration - Region VIII
F. Utah Department of Health
G. Utah Occupational Safety and Health
H. NIOSH Regional Offices/Divisions

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

TABLE 1

Summary of Lowest Observed Effect Levels for
Key Lead-Induced Health Effects in Adults and Children[@]

BLL[*] (ug/dl)		HEALTH EFFECT	
>100	Adults:	Encephopathic signs and symptoms	
>80	Adults:	Anemia	
	Children:	Encephopathic signs and symptoms	
		Chronic nephropathy (aminoaciduria, etc)	
>70	Adults:	Clinically evident peripheral neuropathy	
	Children:	Colic and other Gastro-Intestinal (GI) symptoms	
>60	Adults:	Female reproductive effects	
		CNS symptoms:	sleep disturbances, mood changes, memory and concentration problems, headache.
>50	Adults:	Decrease hemoglobin production	
		Decreased performance on neurobehavioral tests	
		Altered testicular function	
		GI symptoms:	abdominal pain, constipation, diarrhea, nausea, anorexia
	Children:	Peripheral neuropathy	
>40	Adults:	Decrease peripheral nerve conduction	
		Elevated blood pressure (white males, 40-59 years old)	
		Chronic nephropathy	
	Children:	Reduced hemoglobin synthesis	
>25	Adults	Elevated erythrocyte protoporphyrin levels in males	
15-25	Adults	Elevated erythrocyte protoporphyrin levels in females	
	Children:	Decreased IQ and Growth	
>10[**]	Fetus:	Pre-term Delivery	
		Impaired Learning	
		Reduced Birth Weight	
		Impaired Mental Ability	

[@] Adopted from ATSDR[6], and Goldman et al.[27].
[*] Blood lead level (BLL) in micrograms per deciliter (ug/dl).
[**] "Safe" blood lead level have not been determined for fetuses.

TABLE 2
SUMMARY OF WORKER EXPOSURES TO LEAD
NELCO
SALT LAKE CITY, UTAH
JULY 10, 1991

Worker #	Sample #	Duration (min)	ON	OFF	Total Vol (L)	Tank #	Conc. (ug/M3)	Job Task/Comments
Area	NL-P-02	472	8:48	16:34	944	-	2.1	Collected in lunchroom
1	NL-P-03	185	7:46	10:45	370	420	141	Burning lead in seams
2	NL-P-05	135	8:35	10:45	260	410	462	Burning lead
3	NL-P-06	129	8:41	10:45	258	410	50	Burning lead
3	NL-P-12	113	11:43	13:34	226	410	292	
3	NL-P-23	81	13:48	15:07	162	410	327	
3	NL-P-24	51	15:20	16:10	284	410	284	
TWA		374 (6.2 HR)					215	
4	NL-P-07	135	8:38	10:50	270	410	126	Burning lead
4	NL-P-17	113	11:40	13:32	226	410	531	
4	NL-P-21	79	13:49	15:06	158	410	26	
TWA		327 (5.5 HR)					242	
5	NL-P-08	129	8:37	10:45	258	410	465	Burning lead
5	NL-P-15	117	11:36	13:32	234	410	150	
5	NL-P-22	80	13:48	15:07	160	410	281	
TWA		326 (5.5 HR)					307	
6	NL-P-04	38	8:43	10:45	76	420	0	Grinding carbon steel tank.
6	NL-P-14	54	11:46	12:46	108	420	46	Grinding
6	NL-P-18	141	12:50	15:31	282	420	390	Applying tin/lead solder
TWA		233					247	(Tinning)
7	NL-P-13	62	11:45	12:45	124	420	40.3	Grinding
7	NL-P-20	140	12:50	15:31	280	420	282	Tinning
TWA		202					208	

8	NL-P-16	60	11:48	12:45	120	420	42	Grinding
8	NL-P-19	141	12:50	15:51	282	420	390	Tinning
	TWA		201					299

Evaluation Criterion - Inorganic Lead - OSHA - 50 ug/M^3, 8-hour TWA.
TWA - Time-weighted average: ug/M^3 - micrograms per cubic meter of air

TABLE 3
SUMMARY OF WIPE SAMPLES FOR LEAD
NELCO
SALT LAKE CITY, UTAH
JULY 10 & 18, 1991

Sample # (7-11-91)	Location/Description	Amount (ug Pb)	Area Wiped (cm^2)	Concentration (ug Pb/cm^2)
W1	Trailer lunchroom, left lunch table	8.5	100	0.1
W2	Trailer, center table used to clean respirators	53	100	0.5
W3	Trailer, right lunch table	4.8	100	0.05
W4	Around base of water cooler	34	100	0.3
W5	Trailer door handle	8.9	100	0.09
W6	Field blank	ND	0	0

ug Pb - micrograms of Lead
cm^2 - square centimeters

TABLE 3 (Cont)
SUMMARY OF WIPE SAMPLES FOR LEAD
NELCO
SALT LAKE CITY, UTAH
JULY 10 & 18, 1991

Sample # (7-18-91)	Location/Description	Amount (ug Pb)	Area Wiped (cm^2)	Concentration (ug Pb/cm^2)
W10	Right work boot, toe	860	200	4
W11	Inside work glove, from worker	240	100	2
W12	Inside work glove in change room	210	100	2
W13	Floor of change room	19000	300	60
W14	Street shoe from change room	220	200	1
W15	Shirt collar from worker	150	100	2
W16	Shirt collar wipe	76	100	0.8
W17	Shirt collar wipe	31	100	0.3
W18	Right work boot of worker	4700	200	20
W19	Street shoe from change room	750	200	4
W20	Inside respirator hanging in change room	340	200	2
W21	Street shoe in change room	200	200	1
W22	Floor of car #1 under gas pedal (day shift)	610	300	2
W23	Floor of car #2 under gas pedal (day shift)	100	300	0.3
W24	Floor of car #3 under gas pedal (day shift)	190	300	0.6

W25	Floor of car #4 under gas pedal (day shift)	1300	300	4
Blanks (3)			4,4,7	

ug Pb - micrograms of Lead
cm^2 - square centimeters

TABLE 4
SUMMARY OF NOISE AND ENVIRONMENTAL MEASUREMENTS
NELCO
SALT LAKE CITY, UTAH
JULY 10 & 18, 1991

Sound Level Measurements

Job	Location	Sound Level (dB(A))	Temp. (○F)	RH (%)
Tinning	Tank 420, 2nd nozzle S	110	115	26
Tinning	Tank 420, 2nd nozzle N	105	110	26
Tinning	Tank 420, 2nd nozzle S	106	125	26
Tinning	Tank 420, 5 ft. from worker	104	118	26
Lead burning	Tank 410, nozzle entrance, 10 ft from worker	91-92	-	-
Grinding	Tank 420, 6 ft from	96-100	-	-

Personal Dosimetry

Job	Tank #	Duration (min)	L_{max}* (dB(A))	L_{avg} (dB(A))	Dose % (%)	Dose % Time (min)
Tinning-torch operator	420	38 (27)**	106 (10 s)	95	11	187
Tinning -wiper	420	38 (27)**	112.6	100.4	15.4	120
Burning/bonding	410	76	109.5	93.7	27	160
Burning/bonding	410	72	102.6	92.2	20.6	133

Grinding	420	80	100.3	90.5	19.3	106
Grinding	420	74	119.5	90.0	15.5	99

Note: All sound level measurements are decibels measured on the A-scale, slow response (dB(A)).

*L_{max} = Maximum noise level measured, averaged over a one second time period.
L_{av} = Average decibel level measured over the sampling period
Dose % = Percentage of allowable OSHA dose exposure during sampling period
Dose % Time = Using the OSHA criteria, the maximum time allowed on a daily basis for exposure at this average level.

**Only 27 minutes of this time was actually spent tinning. The (10 s) refers to the amount of time this maximum exposure was recorded, i.e., 10 seconds.

APPENDIX I

VACUUM CLEANING SPECIFICATIONS*

The following specifications may be used as a guide in selecting industrial vacuum cleaning equipment:

1. Hose and tools may be 1-1/2 inch or 2 inch. 1-1/2 inch requires 75 CFM and 2 inch requires 150 CFM per nozzle. The smaller hose is easier to use and less expensive but does not clean as fast.

2. The exhaust blower should be capable of developing about 1 inch of mercury (13.6 inches of water) static pressure at the cleaning nozzle.

3. The dust container should have adequate holding capacity so that it does not have to be emptied frequently.

4. The filter should be made of standard industrial filter cloth. The ratio of air to cloth should not exceed four to one.

5. An after filter similar to HEPA filters should be used where toxic dusts are being handled.

*Adopted from NIOSH [1989].[26]