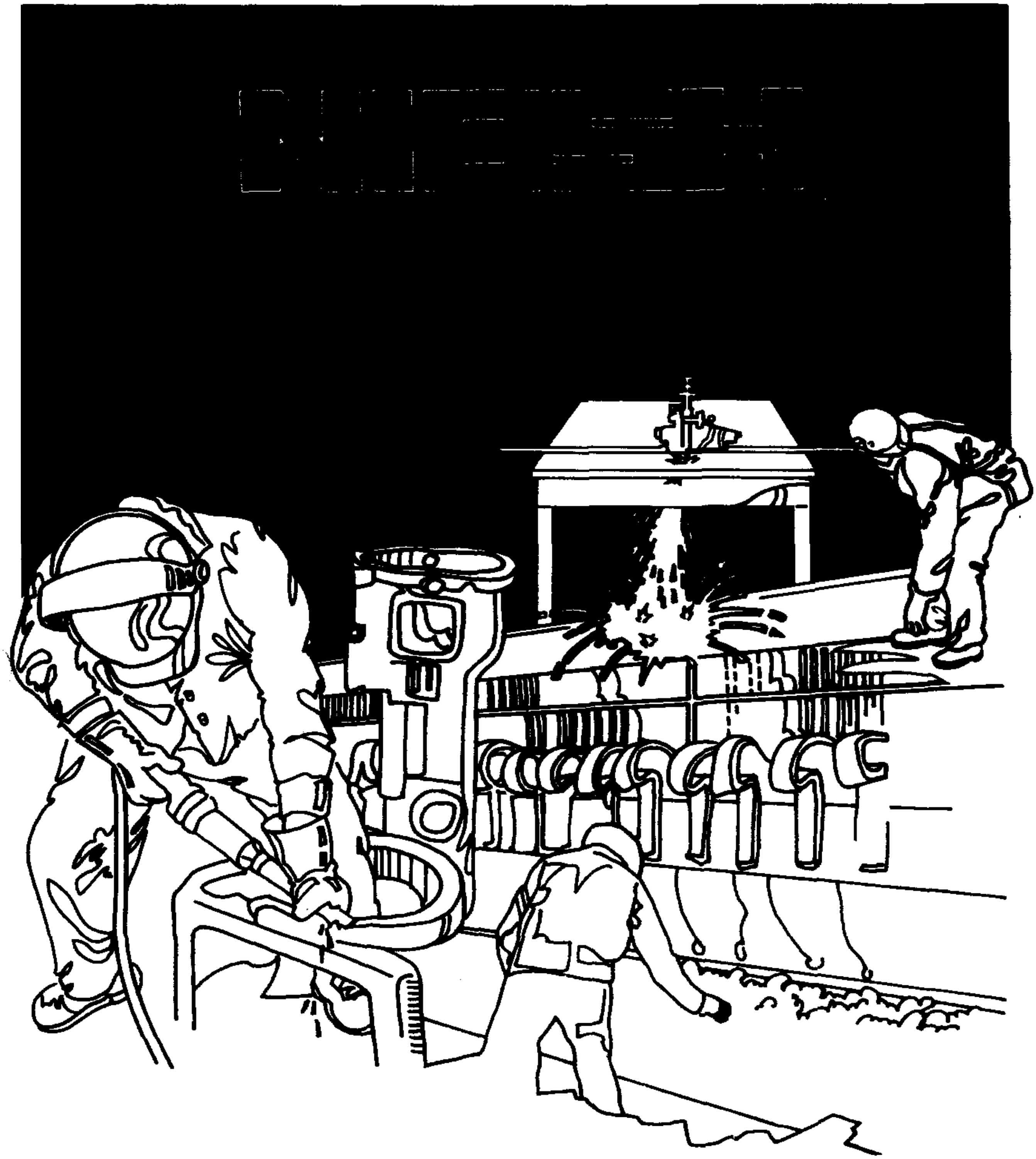


Health Hazard Evaluation Report

HETA 88-244-1951
ORRVILLE BRONZE
AND ALUMINUM COMPANY
ORRVILLE, OHIO

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 88-244-1951
MARCH 1989
ORRVILLE BRONZE AND ALUMINUM COMPANY
ORRVILLE, OHIO

NIOSH INVESTIGATORS:
Michael Montopoli, M.D.
Paul Seligman, M.D.
Dennis O'Brien, Ph.D.
Dennis Zaebst, M.S., C.I.H.

I. SUMMARY

On April 20, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Molders and Allied Workers Union (IMAWU) to evaluate occupational exposure to lead at the Orrville Bronze and Aluminum Company, a non-ferrous foundry in Orrville, Ohio. Approximately seven workers were reported to have elevated blood lead levels (BLL) at the time of the request. A worker at the foundry had filed a workers' compensation claim for lead toxicity in 1987. This employee had been removed from the workplace for medical protection at the time of the survey.

On June 23-24, 1988, NIOSH investigators conducted an environmental and medical evaluation at the foundry. Environmental measurements were made to determine worker exposure to lead, copper, and zinc. The medical evaluation consisted of blood lead and zinc protoporphyrin (ZPP) determinations and completion of confidential questionnaires.

Airborne lead concentrations in six personal breathing-zone samples ranged from 38 to 520 micrograms per cubic meter of air (ug/m^3). Five samples exceeded the OSHA permissible exposure limit (PEL) for lead of 50 ug/m^3 averaged over an 8-hour period. Airborne copper concentrations ranged from 26 to 2601 ug/m^3. Three samples exceeded the OSHA PEL for copper of 100 ug/m^3. Airborne zinc concentrations ranged from 219 to 3165 ug/m^3. All were below the OSHA PEL of 5000 ug/m^3.

Blood lead and zinc protoporphyrin levels were measured in 18 of 20 workers present in the plant on June 24, 1988. Three workers had BLLs in excess of 60 ug/dl, the level at which the Occupational Safety and Health Administration (OSHA) requires immediate medical removal protection. ZPP levels ranged from 16 to 279 ug/dl. In adults, the upper limit of the laboratory's reference range for the ZPP level is 79 ug/dl. This level was exceeded in 9 of 18 (50%) of workers tested.

On the basis of environmental and medical data, NIOSH investigators have determined that overexposures to airborne lead and copper represent a serious health hazard to employees of the Orrville Bronze and Aluminum Company, Orrville, Ohio. Measured airborne lead concentrations were up to 10 times greater than the level permitted by OSHA. High prevalences of elevated blood lead and zinc protoporphyrin levels also indicate excessive lead exposure among workers. Recommendations on engineering controls, work practices, and housekeeping to control these hazards are presented in Section VIII of this report.

Keywords: SIC 3362 - Nonferrous foundries (brass, bronze, copper), lead exposure, elevated blood lead levels, elevated zinc protoporphyrin (ZPP) levels

II. INTRODUCTION

On April 20, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the International Molders and Allied Workers Union (IMAWU). A recent medical screening had found at least seven union members with blood lead levels (BLLs) in excess of 40 ug/dl. One worker had a BLL in excess of 100 ug/dl and was placed on medical removal protection. The union requested assistance in establishing a medical surveillance program and in reducing the risk of exposure to lead dust and fumes at the plant.

NIOSH conducted an environmental and medical evaluation of the facility on June 23-24, 1988, to assess worker exposure to lead, copper, and zinc. Preliminary results of the June survey and specific recommendations to control exposure to lead at the foundry were contained in a letter sent to the company and union on July 5, 1988. A recommended medical surveillance program for workers exposed to inorganic lead and crystalline silica was provided in an attachment to the letter.

On July 8, 1988, a letter was mailed to each worker tested for BLL and ZPP. The letter provided the individual's own test results, summarized the results of all workers tested, explained the health effects of lead, summarized the OSHA requirements for medical surveillance of lead-exposed workers, and recommended testing of household members for lead absorption.

The testing of household members was subsequently provided by the Wooster Health Department in cooperation with the Ohio Department of Health. Also, the Ohio Department of Health requested that the Ohio Environmental Protection Agency assess the possibility of foundry emissions causing contamination of the surrounding community.

III. BACKGROUND

A. Plant History

Orrville Bronze and Aluminum Co. is a small (approximately 30 employees), privately owned, non-ferrous foundry specializing in small- to medium-sized bronze, brass, and copper castings. The foundry consists of a single-story building of approximately 27,000 square feet on a site of about 4.75 acres. The foundry was built in the 1890's and was bought by the current owners in 1934. Various additions and modifications were made to the foundry over the years.

B. Process Description

Manufacturing activities at the Orrville site consist of green-sand mulling and mold making; oil- and shell-core making; melting, pouring, and shakeout; centrifugal casting; abrasive blasting, cutting, grinding, and polishing; and maintenance. All of these activities are carried out in separate but interconnected rooms within the main building.

The company manufactures a variety of small-size bronze, brass, and copper castings. The casting process incorporates typical foundry operations. The company prepares sand molds using either an automated green-sand molding process (Hunter^{tm} Molding Machine), or a manual, no-bake (Airset^{tm}) process in which silica sand is mixed with a phenol-formaldehyde resin and 0.3% phosphoric acid as a catalyst. The automated green-sand molding process is used for most high-production small parts, and the manual, airset process for larger castings and/or special-order castings. Both processes were used during this survey.

In the green sand mulling process, sand, clay, seacoal, woodflour, and water are mixed in the muller located on a platform (mezzanine) about 15 feet above the main foundry floor. The mulled sand is then transferred to the Hunter molding machine. This machine fills mold plates (preformed steel boxes) with the mold sand and automatically dispenses, packs, and compresses the mold sand into the mold plates. In this process, the bottom half of each mold is first rammed (compressed) by the machine. The operator then inserts cores into the bottom half, rams the top half of the mold, and assembles the two halves of the mold. He then places weights and jackets on the molds. The molds are then moved manually on a roller conveyor into the pouring area (adjacent to the Hunter Machine).

Airset mold sand is made by mulling silica sand with a phenol-formaldehyde resin and 0.3% phosphoric acid as a catalyst. The mulled sand is then manually packed into large mold-boxes (along with cores) located adjacent to the main pouring area. These are made on a batch basis as necessary.

The company makes oil sand cores and shell cores in a separate room isolated from the main foundry floor. Two employees are engaged in core making. This room contains two core-baking ovens and one shell-core making machine. Sand for oil cores is mixed in a small muller in the core room. The oil cores are manually compressed on a bench and are then stacked in the core room for subsequent use. Shell-core sand is bought pre-mixed, and consists of a phenolic resin-coated thermal-setting silica sand. This sand is blown into the shell-core machine and cured, after which the cores are removed, dipped in a graphite-isopropyl alcohol mixture, and dried by firing or further baking. Carbon dioxide (CO_2) core sand (silica sand and sodium silicate) is mixed in the muller and placed manually into a core box. CO_2 is then blown from a tank into the core box to harden the sand.

Melting, pouring, and shakeout operations are done in the main foundry room (containing two tilting, electric induction melting furnaces), or in an adjacent room containing four additional similar furnaces, as well as a centrifugal casting operation. The company is equipped to manufacture a variety of non-ferrous alloys, including manganese and aluminum bronzes, and copper alloys, including leaded red brass - the alloy being melted at the time of the survey. This alloy contains approximately 7% lead.

Ingots of brass and scrap are brought to temperature in the furnaces during the first several hours of each shift. Molten metal is tapped into preheated ladles by tilting the furnaces. The ladles are then manually pushed away from the furnace, and are then pulled into the pouring area, located in the same room. Two workers, the furnace tender and pouring operator (ladleman), perform the tapping, ladle transport, and pouring operations. After pouring, the molds are allowed to cool in place in the pouring area. Once cooled, the molds are manually moved on the roller conveyor to the shakeout station, where the shakeout operator (also the furnace tender on the day of the survey) removes the mold jackets and manually breaks apart the mold. The sand from the molds falls through a vibrating grate to a belt conveyor below. The conveyor moves the sand back to the mulling area, where it is recycled as needed. The castings are placed in steel transport boxes and are moved by lift truck to the cleaning room.

The cleaning room houses an enclosed sandblasting machine (Wheelabrator[tm]), cutoff saws (bench mounted and swing-frame), chipping and grinding benches, an abrasive-belt grinding station, and a welding (repair) area. In this area, castings are blasted, cleaned (saws are used to remove casting appendages), and polished using grinding and polishing wheels of various grits. In the adjacent machine shop, cast parts are, if necessary, further polished, cut, and/or machined to specifications using lathes, drill presses, and other machine tools as required.

C. General Ventilation

No fresh make-up air is introduced into the foundry. Air enters the building through open doors and windows, potentially causing cross contamination of all process areas.

In about 1976 a comprehensive fume control system (similar to that described in Case History #14, NIOSH Publication No. 79-114)[1] was installed. This system included furnace exhaust hoods, along with a ladle-mounted hood and mobile duct system which permitted capture of metal fumes. All exhaust air from this system was cleaned before discharge by means of fabric filtration. Some time later, maintenance problems with the furnace hoods and a baghouse fire led to an abandonment of the system. Non-functioning remnants of the system can still be found in and around the plant. It is doubtful that any of the components could be salvaged for use in a new system.

D. Personal Protective Equipment and Hygiene

Employees are given a choice as to which type of respirator to wear, and operators were seen wearing several different types of respirators during the survey. The furnace tender (main pouring area) and the ladleman were wearing powered air purifying respirators fitted with HEPA filters. Other employees in the pouring area were wearing half-facepiece, air-purifying, dual-cartridge respirators (Norton 7500 or 7700).

The furnace tender (centrifugal casting area) and a utility man working in the pouring area were noted to be using the wrong cartridge type on the day of the survey. The cartridges worn by these employees were approved for organic vapors (not lead fume), and consisted of a bed of activated carbon and a particulate pre-filter. These filters are not tested for protection against metal fumes.

There was no regular inspection, cleaning, or maintenance of respirators by trained personnel. Each employee was responsible for the care of his or her own respirator. No clean storage area for respirators was provided.

E. Housekeeping

Workers are provided with a locker room and shower facilities. Clean workclothes are made available once weekly. Workers are required to change in the locker room at the beginning and the end of each shift. Personal clothing and workclothes are stored in the same locker; no double change room is available. Respirators are also stored in the same locker.

Shower facilities are not cleaned on a regular basis. Dust and grime have accumulated on the walls and floors of the showers and locker room. Few, if any, workers shower before leaving work, reportedly because of the dirty conditions.

There is no lunchroom or cafeteria on the premises. In good weather, most workers eat their lunches on the grounds immediately outside the plant. At other times, workers eat inside the plant in various active work areas, particularly the core room.

Smoking is not permitted inside the plant. Smoking is permitted on the grounds immediately outside the plant. Workers are permitted to carry cigarettes and other tobacco products in their workclothes.

Handwashing prior to smoking or eating is not required.

F. Warning Signs

There were no signs warning of the lead or silica hazards at the plant, nor signs indicating in which part of the plant respirator use was mandatory.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

1. Real time measurements

Aerosol measurements were made in the plant using a GCA Real-time Aerosol Monitor (RAM) to identify and prioritize potential sources of exposure to dusts. This instrument samples the workroom air and instantaneously measures the concentration of airborne dusts and mists by measuring the amount of light scattered by these materials. Although the results of these measurements are reported in mg/m^3, these numbers should be considered as estimates of the true concentration, as the amount of light scattered also depends on the optical characteristics of the specific aerosol. This unit can be operated with a cyclone preseparator to measure respirable aerosol (dusts and mists well below about 10 micrometers in diameter) or can be operated with a plain inlet to nominally measure all sizes of dust and mists. The unit was operated with the cyclone preseparator in this evaluation.

2. Personal Sampling

Full-shift personal samples were obtained on six different employees in various areas of the foundry for evaluation of airborne exposures to lead, copper, and zinc fume and dusts. The six workers included two furnace tenders (one in the main pouring area and one in centrifugal casting), a Hunter machine operator, an abrasive belt machine operator, a cutoff saw operator, and a ladleman.

Exposures of the furnace tenders, Hunter operator, and pouring operator (ladleman) were predominantly to lead (and other metal) fumes. Exposures to the cutoff saw operator and abrasive belt machine (grinder) operator were predominantly to metal dust generated by the physical removal of metal from the casting.

Company records of previous industrial hygiene evaluations were reviewed. Studies performed by the Division of Safety and Hygiene (DSH) of The Industrial Commission of Ohio in 1981 and 1984 indicated overexposure to silica in the following operations: sand molding, processing, shakeout, coremaking, and cleaning. No measurements for ambient silica were performed during this survey. However, no improvements in ventilation or control of silica dust had been made since the DSH reports.

B. Medical

The medical evaluation consisted of two parts, a questionnaire and blood tests. After obtaining written consent from each worker to participate in the survey, NIOSH medical personnel administered a questionnaire to each participant. The questionnaire elicited the following information: demographics (name, address, telephone number, age, sex and race); length of employment; current and previous job titles; history of lead intoxication; use of personal protective equipment; smoking and eating habits in the workplace; and symptoms associated with lead toxicity. Each participant was assigned a unique identification number to protect confidentiality.

Venous blood was collected from consenting workers for analysis of lead and zinc protoporphyrin (ZPP). The specimens were preserved on ice at the workplace and during the return trip to NIOSH. The specimens were then refrigerated at NIOSH while awaiting transport to the contract laboratory.

At NIOSH request, the company management provided photocopies of the reports of recent blood lead level (BLL) and ZPP determinations of the workers. The reports were dated July 29, 1987; February 25, 1988; and April 20, 1988.

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 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 not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes or by ingestion during eating or smoking. Finally, evaluation criteria may change over the years as new information of 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 (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. 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. 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 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 supplant the TWA where there are recognized toxic effects from high short-term exposures.

B. <u>Toxicological</u>

<u>Lead</u>

Lead is a heavy metal widely used in industry. Lead has no known function in the human body. Absorption of inorganic lead generally occurs through inhalation of lead dust or fumes or by ingestion of lead while eating or smoking. Lead then enters the bloodstream and is carried to various organs, including the nervous system, the bone marrow, and the kidneys. Lead may damage these organs as well as the reproductive system of both men and women.[2]

The BLL is the single most important means of monitoring persons currently exposed to lead. This test provides an accurate estimate of the degree of recent lead absorption. The ZPP is a measure of the adverse effect of lead on the production of the precursors of hemoglobin. Hemoglobin is a protein in the red blood cells and is primarily responsible for the transport of oxygen from the lungs to other tissues.[2]

Lead is particularly hazardous to children.[3] Employees exposed to lead may carry lead dust from the workplace to their homes and automobiles. This dust may then be inhaled or ingested by other household members, including pregnant women and children. Lead can cross the placenta and affect the developing fetus. Lead may cause learning and behavioral difficulties in young children. The Centers for Disease Control recommends that the BLL in children and fetuses (and, therefore, pregnant women) never exceed 25 ug/dl. Recent studies indicate that developmental effects on children may occur at levels considerably below 25 ug/dl.[4]

OSHA requires employers to provide medical monitoring for employees exposed to lead in excess of the action level of 30 ug/m^3. Medical monitoring includes, but is not limited to, periodic blood testing for lead. An average BLL of 50 ug/dl or greater based on three blood samples over a six month period or one sample exceeding 60 ug/dl requires employee medical removal from lead exposure without loss of wages, benefits, or seniority. The OSHA Lead Standard should be referred to for details regarding medical surveillance and removal requirements.[5]

The OSHA permissible exposure limit for lead, as an eight-hour time-weighted average, is 50 ug/m^3.[5] The Environmental Protection Agency ambient air lead standard sets a limit of air exposure at 1.5 ug/m^3.[6]

Copper

Copper is a malleable metal frequently incorporated into alloys such as brass and bronze. Copper is an essential element in human metabolism. Occupational exposure to copper in metal polishing operations has produced copper-fume fever (metal fume fever is described below) when the metal is heated to very high temperatures. Other potential health problems include nasal ulceration and stuffiness, contact dermatitis. and conjunctivitis.[2]

The OSHA Permissible Exposure Limit (PEL) for copper dust and fume is 100 ug/m^3. The ACGIH Threshold Limit Value for copper is 200 ug/m^3 for fume and 1000 ug/m^3 for dust.

Zinc

Zinc is a metal which is used in alloys such as brass, bronze, aluminum and nickel. Zinc oxide is highly volatile at relatively low temperatures. Zinc oxide fumes appear as a dense, white "smoke". Exposure to such fumes can cause a flu-like syndrome called "metal-fume fever" or "zinc shakes". The effects develop 4 to 12 hours after exposure and consist of a metallic taste, sore throat, cough shortness of breath, weakness, fatigue, and muscle and joint pains. Fever (102-104°F) then develops, with sweats and shaking chills. The illness generally lasts 24-48 hours.[2]

The NIOSH recommended exposure limit for zinc oxide is 5 mg/m^3 as a 10-hour TWA and 15 mg/m^3 as a 15-minute ceiling; the OSHA PEL is 5 mg/m^3 as an 8-hour TWA; the ACGIH TLV is also 5 mg/m^3, with a short-term exposure limit (STEL) of 10 mg/m^3.

VI. RESULTS AND DISCUSSION

A. Environmental

Tables 1-3 contain the results of six, full-shift breathing-zone personal samples, obtained on six different employees in various areas of the foundry, for evaluation of exposures to lead, copper, and zinc fume and dusts, respectively. Breathing zone concentrations of airborne lead (Table 1) ranged from 38 ug/m^3 (Hunter machine operator) to 520 ug/m^3 (abrasive belt machine operator). Concentrations of airborne copper fume or dust (Table 2) ranged from 26 ug/m^3 (Hunter operator) to 2601 ug/m^3 (abrasive belt operator). Concentrations of airborne zinc (Table 3) ranged from 219 ug/m^3 (Hunter operator) to 3165 ug/m^3 (furnace tender, main melting area).

Exposures of the furnace tenders, Hunter operator, and pouring operator (ladleman) were predominantly to lead (and other metal) fumes. Exposures to the cutoff saw operator and abrasive belt machine (grinder) operator were predominantly to metal dust generated by the physical removal of metal from the casting. The highest exposures to lead fume (exclusive of respiratory protective equipment worn) were incurred by the furnace tender (main melting area, 335 ug/m^3), followed by the pouring operator (ladleman, main melting area, 233 ug/m^3) and the furnace tender (centrifugal casting area, 135 ug/m^3). Exposures (exclusive of respiratory equipment worn by the operators) to lead dust in the grinding/cutting operations were 520 ug/m^3 and 501 ug/m^3 in the breathing zones of the grinding (abrasive belt) machine operator and the cutoff saw operator, respectively.

With the exception of the Hunter machine operator, all measured air concentrations of lead greatly exceeded the OSHA PEL of 50 ug/m^3. The furnace tender's (centrifugal casting area) actual exposure may also have exceeded the OSHA PEL since he was wearing a non-approved respirator cartridge. It is also possible that the utility man's exposure was also excessive for the same reason, although his exposure was not measured during the survey.

Measurements of airborne copper during the survey indicated concentrations of copper dust in the breathing zones of cleaning room employees in excess of the OSHA PEL (Table 2). The furnace tender's (main pouring area) exposure was also in excess of these limits for copper fume. None of the measured concentrations of zinc dust or zinc oxide fume exceeded NIOSH, OSHA, or ACGIH limits.

Real-time measurements of lead-containing dusts and fumes measured in the plant are presented in Table 4. These results indicate that the pouring operation represents the greatest exposure potential in this plant. Measurements in the melting and casting cleaning areas presented in this table were recorded before the onset of pouring. Measurements in the general molding area taken during pouring indicate that substantial contamination of all plant areas could occur from pouring.

Inspection of the roof revealed that the exhaust fan was in an inaccessible position. Exhaust volumes could not directly be determined but were estimated by measuring duct velocity in an accessible duct, then calculating flow in other ducts by multiplying by the duct area (this assumes that duct velocity is the same in all ducts). These estimated exhaust volumes are presented in Table 5, along with exhaust rates suggested in the ACGIH publication, Industrial Ventilation.[7] The estimated exhaust rates are far below those recommended by the ACGIH.

B. Medical

Of the 20 workers present on the day of the survey, 19 completed the questionnaire and 18 of these had blood tests. Three persons had BLLs greater than 60 ug/dl, the level at which immediate medical removal protection is required by the OSHA lead standard. There were nine workers with ZPP levels in excess of 79 ug/dl, the upper limit of the laboratory's reference range. Table 6 summarizes BLL and ZPP by job title and length of employment.

Employees with one or more years of employment had higher mean blood lead (41 vs. 26 ug/dl) and ZPP levels (143 vs. 44 ug/dl) than those with less than one year. Of the eight workers with less than one year of seniority, six had been hired within two months of the survey date. This fact probably explains the significant difference in ZPP observed between the two groups, as the ZPP level reflects lead absorption over the preceding 3-4 months.

The lack of a statistically significant difference in BLLs is consistent both with the overexposures to lead noted in the air monitoring and with BLLs being a reliable measure of current or recent lead absorption.

Molders tended to have the lowest BLLs, consistent with the observation that only molders were exposed below the PEL throughout the plant. That the molders' ZPPs were similar to the grinders was due to fact that three grinders had been employed for less than one month thus lowering the mean ZPP for this group. The three workers with BLLs in excess of 60 ug/dl worked in various areas, indicating that lead exposure occurs throughout the plant. No worker interviewed reported symptoms consistent with lead poisoning.

Workers who smoked were twice as likely to have had an elevated BLL than workers who did not smoke. Among the seven smokers, five had a BLL in excess of 40 ug/dl. Among the 11 non-smokers, only four had a BLL in excess of 40 ug/dl.

VII. CONCLUSIONS AND RECOMMENDATIONS

Environmental data collected by NIOSH personnel during the investigation revealed that the employees of Orrville Bronze and Aluminum Company are exposed to airborne lead levels in excess of those permitted by OSHA. Medical data revealed that many workers have evidence of current and/or past absorption of lead. In the interest of preventing future overexposure of employees to lead, copper, and zinc, the following recommendations are presented. Many of these recommendations were made in a letter to company and union dated July 5, 1988.

1. Control of airborne hazards requires design, installation and maintenance of a comprehensive control system. Ideally, a system identical to the original could be installed. This system provides nearly total enclosure of the furnace and exhaust of the hot metal ladle. Alternatively, the furnaces could be provided with a hood such as that depicted in VS-106 of the ACGIH publication, Industrial Ventilation, the ladles provided with covers during transport, and a fixed station pouring process adopted. Such a system would be necessary to provide economy of exhaust air. It would require a mechanical means of transporting the molds past a fixed pouring station into a cooling tunnel or hood. A suggested layout is presented in Figure 1. Details of the pouring hoods can be found on VS-109.[7] One pouring station and cooling tunnel would be required per line. The number of lines required depends on the production needs of the foundry.

2. All air exhausted from the building should be replaced by tempered air from an uncontaminated location. By providing a slight excess of make-up air in relatively clean areas, and a slight deficit of make-up air in dirty areas, cross contamination can be reduced. In addition, this air can be provided directly to operator work areas, providing the cleanest possible work environment. Ideally, this fresh air could be supplied in the form of a low-velocity air shower ($\leq$100 fpm to prevent interference with the exhaust hoods), located directly above the worker.

Local exhaust rates should be improved for all operations to meet the recommended rates detailed in Table 5.

3. Elimination of silica sand from the process should be considered. The simplest approach would be to substitute olivine sand which has been demonstrated to be an effective control measure in foundry operations.[8]

4. The accumulation of dust on the roof indicates the need for air cleaning equipment for the cleaning room exhaust. Similar fallout may also result in environmental contamination of the adjoining residential properties. The accumulation of this material may also represent a safety hazard to workers who must remove the material. If the weight of the material becomes excessive, there is the potential for collapse of the foundry roof.

5. One employee should be responsible for proper inspection and maintenance of <u>all</u> respirators. Care should be taken to ensure that the proper cartridges are inserted in each respirator. We also recommend that signs be posted indicating areas in which respirators must be worn and the type of respirator required. Also, signs with the following format should be posted:

   WARNING
   LEAD WORK AREA
   POISON
   NO SMOKING OR EATING

   Such prohibitions should be strictly enforced.

6. Regular and thorough cleaning of the locker room and shower should be performed to encourage better personal hygiene. The present facility should be replaced with an appropriately designed trailer or other area.

7. A clean and isolated lunchroom facility should be provided for the workers. Eating can then be confined to this area. Workers should be prohibited from carrying cigarettes in their workclothes. Cigarettes should be stored in a clean place. Thorough handwashing should be performed prior to eating, drinking, or smoking.

8. A medical surveillance program for lead and silica should be instituted. The OSHA Lead Standard and the NIOSH Criteria Document for Silica[9] should be consulted for the content of such a program. An outline of such a program was provided to the company and union.

VIII. <u>REFERENCES</u> (see endnotes)

1. National Institute for Occupational Safety and Health. Occupational diseases: a guide to their recognition. An Evaluation of Occupational Control Technology for the Foundry Industry. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. [DHEW (NIOSH) publication no. 79-114].

2. U.S. Department of Health, Education, and Welfare. Occupational Diseases, A Guide to Their Recognition. Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-181, September 1978.

3. Bellinger D, Leviton A, Waternaux C, Needleman H, Rabinowitz M. Longitudinal analyses of prenatal and postnatal lead exposure and early cognitive development. N Engl J Med 1987;316:1037-43.

4. U.S. Department of Health and Human Services. Preventing Lead Poisoning in Young Children. A Statement by the Centers for Disease Control. January 1985.

5. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Exposure to Lead: Final Standard. CFR 1910.1025.

6. Agency for Toxic Substances and Disease Registry. <u>The Nature and Extent of Lead Poisoning in Children in the United States: A Report to Congress</u>. Public Health Service, U.S. Department of Health and Human Services, July 1988.

7. American Conference of Governmental Industrial Hygienists. ACGIH industrial ventilation: a manual of recommended practice, 19th edition. ACGIH Committee on Industrial Ventilation: Lansing, Michigan, 1986.

8. Tubich GE. Health aspects of Olivine: Non-ferrous foundry applications. Presented at the American Industrial Hygiene Association Conference, May 1-5, 1967, Chicago, IL.

9. National Institute for Occupational Safety and Health. Crystalline Silica. Criteria Document 75-120.

IX. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared by:

Michael Montopoli, M.D.
Medical Section
Surveillance Branch

Paul Seligman, M.D.
Chief
Medical Section
Surveillance Branch

Dennis Zaebst, M.S., C.I.H.
Supervisory Industrial Hygienist
Industrial Hygiene Section
Industrywide Studies Branch

Dennis O'Brien, Ph.D.
Chief
Mining and Minerals Section
Engineering Control Technology Branch

TABLE 1
Concentrations of Lead Oxide Fume and Lead Dust

ORRVILLE BRONZE AND ALUMINUM
ORRVILLE, OHIO

HETA 88-244
JUNE 24, 1988

Shift	Sample Number	Job/Area	Time Start	Time Stop	Concentration (Pb, ug/m^3)
1	OB4/8	Furnace Tender (Centrifugal casting)	7 36	15 26	136
1	OB10/11	Hunter Operator	7 42	15 24	38
1	OB1/12	Cutoff Saw Operator	7 15	15 18	501
1	OB2/13	Abrasive Belt Machine Operator	7 20	15 18	520
1	OB3/5	Furnace Tender (Main pouring area)	7 29	15 23	335
1	OB9/6	Ladleman	7 34	12 39	234

OSHA Permissible Exposure Limit: 50 ug/m^3 (8-hour TWA)

TABLE 2
Concentrations of Copper Oxide Fume and Dust (Cu)

ORRVILLE BRONZE AND ALUMINUM
ORRVILLE, OHIO

HETA 88-244
JUNE 24, 1988

Shift	Sample Number	Job/Area	Time Start	Time Stop	Concentration (Cu, ug/m^3)
1	OB4/8	Furnace Tender (Centrifugal Casting)	7 36	15 26	63
1	OB10/11	Hunter Operator	7 42	15 24	26
1	OB1/12	Cutoff Saw Operator	7 15	15 18	1656
1	OB2/13	Abrasive Belt Machine Operator	7 20	15 18	2601
1	OB3/5	Furnace Tender (Main casting area)	7 29	15 23	313
1	OB9/6	Ladleman	7 34	12 39	58

OSHA Permissible Exposure Limit: 100 ug/m^3 (8-hour TWA, dust, fume)
ACGIH Threshold Limit Value; fume: 200 ug/m^3 (8-hour TWA)
dust: 1000 ug/m^3 (8-hour TWA)

TABLE 3
Concentrations of Zinc Oxide Fume and Dust
ORRVILLE BRONZE AND ALUMINUM
ORRVILLE, OHIO

HETA 88-244
JUNE 24, 1988

Shift	Sample Number	Job/Area	Time Start	Time Stop	Concentration (Zn, ug/m^3)
1	OB4/8	Furnace Tender (Centrifugal casting)	7 36	15 26	739
1	OB10/11	Hunter Operator	7 42	15 24	219
1	OB1/12	Cutoff Saw Operator	7 15	15 18	349
1	OB2/13	Abrasive Belt Machine operator	7 20	15 18	396
1	OB3/5	Furnace Tender (main casting area)	7 29	15 23	3165
1	OB9/6	Ladleman	7 34	12 39	1058

OSHA Permissible Exposure Limit: 5000 ug/m^3 (8-hour TWA)

TABLE 4
Real-time Respirable (<10 microns) Aerosol Measurements

ORRVILLE BRONZE AND ALUMINUM
ORRVILLE, OHIO

HETA 88-244
JUNE 24, 1988

Location	Concentration (mg/m^3)
Outside of plant, near office	0.05
Melting area, near centrifugal caster, one furnace operation	0.1*
Mold line, near breathing zone, during pouring	1.0 - 6.5
Mold line, general area, during pouring	3.0
Shakeout, near breathing zone	1.0 - 1.5
Shakeout, sand discharge end	0.8
Casting cleaning	0.3 - 0.5*

* - these measurements were recorded before the onset of pouring.

Note: these are single, instantaneous measurements used to identify areas or operations causing potential exposure; they may not reflect exposures measured by long-term sampling techniques.

Table 5
Ventilation Recommendations

ORRVILLE BRONZE AND ALUMINUM
ORRVILLE, OHIO

HETA 88-244
JUNE 24, 1988

Equipment	Exhaust rate (cfm)		Reference#
	Existing*	Recommended#	
Downdraft grinding bench (each)	0 - 220	3600 - 6000	VS-412
Pedestal grinders (each wheel)	150	300	VS-411
Abrasive belt machine	0	500	VS-402
Swing frame grinder	220	2400 - 3600	VS-414
Swing frame saw	400	2400 - 3600	VS-414
Radial arm cut-off saw	220	3000	VS-401
Welding area	0	335 - 1000	VS-416.1
Shell core making machine	0	#	VS-115
Shakeout machine	0	4800	VS-110
Pouring station	0	#	VS-109
Melting furnace	0	#	VS-106
Conveyor belt transfer points	0	#	VS-306
Sand muller	0	#	VS-108

* Estimated (see text)

American Conference of Governmental Industrial Hygienists. ACGIH industrial ventilation: a manual of recommended practice, 19th edition. ACGIH Committee on Industrial Ventilation: Lansing, Michigan, 1986.

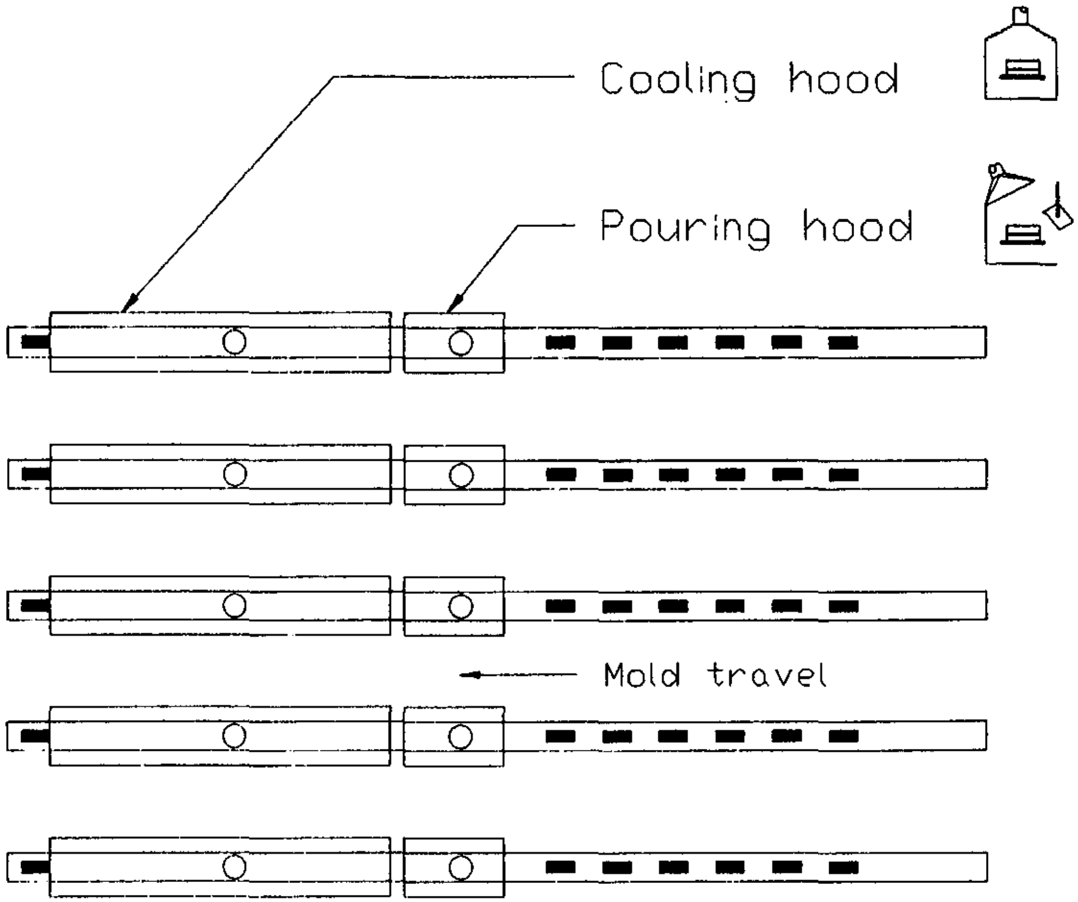
Table 6
Blood Lead and Zinc Protoporphyrin Levels by
Job Title and Length of Employment

ORRVILLE BRONZE AND ALUMINUM CO.
ORRVILLE, OHIO

HETA 88-244
JUNE 24, 1988

Length of employment (years)	Blood Lead Level (ug/dl)*	Zinc Protoporphyrin (ug/dl)*
One or more (10 workers)	41 ± 20 (Range 10-67)	143 ± 71 (Range 36-279)
Less than one (8 workers)	26 ± 15 (Range 4-46)	44 ± 35 (Range 16-119)
	p = 0.09#	p = 0.002#
Job title		
Furnace tender/pourer (3 workers)	54 ± 11 (Range 46-67)	120 ± 75 (Range 35-178)
Grinder (7 workers)	31 ± 19 (Range 10-61)	63 ± 35 (Range 26-107)
Molder (3 workers)	18 ± 13 (Range 4-27)	62 ± 64 (Range 16-135)
Others (foreman, supervisor, machinist, core machine operator) (5 workers)	35 ± 19 (Range 16-66)	159 ± 98 (Range 23-279)
	p=0.1@	p=0.2@

* Mean blood lead or zinc protoporphyrin levels ± one standard deviation
# Student's t-test
@ Kruskal-Wallis one-way analysis of variance



Pouring and Cooling Area Ventilation
Plan view

FIGURE 1
Pouring & Cooling Area Ventilation
Orrville Bronze & Aluminum
HETA 88-244