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

HEALTH HAZARD EVALUATION DETERMINATION
REPORT HE 79-9-615

ARAPAHOE ALUMINUM AND BRASS FOUNDRY, INC.
ENGLEWOOD, COLORADO

SEPTEMBER 1979

I. TOXICITY DETERMINATION

NIOSH has determined, based on environmental and medical evidence, observation of work practices, comprehensive literature reviews, and professional judgment that a hazard to the health of employees exposed to airborne inorganic lead fumes and crystalline silica particulates existed at the Arapahoe Aluminum Foundry, Englewood, Colorado, during the period of a Health Hazard Evaluation conducted on November 29, 30, and December 1, 1978 and February 12-14, 1979.

Environmental sampling indicated that 18 of 41 (44%) lead exposures and 24 of 31 (77%) crystalline silica exposures were in excess on the occupational exposure criteria. It was also determined that employee exposures to the gases carbon monoxide (CO), carbon dioxide (CO_2), nitric oxide (NO), nitrogen dioxide (NO_2), ozone (O_3), phosgene ($COCl_2$), and sulphur dioxide (SO_2); the vapors of organic alkanes, organic aromatics, ammonia, formaldehyde, phenol, perchloroethylene, pyridine, styrene, toluene, hexamethylene tetramine (HMTA), and methylene bisphenyl isocyanate (MDI); and the particulates of aluminum, copper, chromium, coal tar pitch volatiles, fluorides, iron, cyanide, oil mist, nickel, magnesium, zinc and total nuisance dusts were not in excess of the occupational exposure criteria. Some of these exposures, however, approached recommended exposure criteria and could be potential hazards to the workers' health. A noise survey also revealed potentially excessive exposures.

The medical evaluation revealed that 9 of 48 (19%) production employees complained of symptoms of sore muscles, light-headedness, headache, tiredness, chafed skin, irritated nose and throat, and occasional chills. Many of these symptoms are associated with metal fume fever. Of the forty-seven blood lead and free erythrocyte protoporphyrin (FEP) determinations, thirty-eight (81%) of the blood leads exceeded the new OSHA standard of 40 micrograms (μg) lead (Pb)/100 grams (g) whole blood, but zero (0%) exceeded the ultimate mandatory removal level of 60 μg Pb/100 g. Thirty-four (72%) of the FEP's exceeded the normal range of 356-662 μg FEP/liter of red blood cells.

The results of this evaluation are contained in the body of this report and recommendations are included to assist in ensuring worker health and safety.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address. Copies of this report have been sent to:

a) Employer Representative, Arapahoe Aluminum and Brass Foundry, Inc., Englewood, Colorado 80110
b) U.S. Department of Labor, Region VIII
c) NIOSH Region VIII

For the purpose of informing the approximately 50 "affected employees", the employer shall promptly "post" for a period of thirty calendar days this Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an 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 National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized employer representative regarding worker exposures to substances used throughout the foundry, finishing, heat treating, and core room areas.

NIOSH scientists conducted a walk-through survey at the facility on November 29, 30 and December 1, 1978. Management was supplied copies of NIOSH publications concerning foundries, training programs, publication lists and OSHA recordkeeping and accident/occupational disease logs. Management was sent an interim report with the initial findings in January, 1979. A combined environmental-medical followup evaluation was conducted during the week of February 12, 1979.

IV. HEALTH HAZARD EVALUATION

A. Facility Description

The Arapahoe Aluminum and Brass Foundry consists of three adjacent, connected, cement block buildings. Each building is heated with direct gas-fired heaters suspended from the ceilings. There are a total of seven heaters in the three buildings. None of the buildings have makeup air ventilation systems. The offices, core making area, finishing shop, casting repair and storage area, restrooms, lunchroom, welding area, and zinc and lead furnaces are all located in the first building which occupies about 8500 square feet. The lunchroom area is partitioned off from the finishing shop but has no ceiling to enclose it. There was no exhaust ventilation in the building except for the lead furnace which was locally exhausted.

The main foundry building occupies 5000 square feet and contains 3 aluminum induction furnaces, 5 aluminum/brass induction pit furnaces, 1 core sand muller, 1 mold sand muller, and 9 mold lines. There were two 36-inch diameter wall exhaust fans located 12-15 feet above the floor on the west end of the building. One of these fans was located above the mold sand muller. Two similar type fans were also located above the pit furnaces, although neither was operating. About 3/4 of the ceiling above the furnaces was cut out to provide for convective ventilation to help dissipate furnace heat. The third building contains a patternshop with 2600 square feet and a metal heat-treating department with about 2600 square feet. Bulk chemicals were also stored in the heat-treating area.

The patternshop started operations in 1965 and the foundry in 1973. The foundry is primarily a specialty foundry, casting aluminum and brass to customer specifications. Aluminum castings are the main product (1-2 tons/day) and brass is intermittently cast (300+ lbs./day when poured).

The foundry operates 8-10 hours per day, 5 days per week. The work force has a high turnover rate, but on the average there are about 50-60 full-time employees (see Appendix A for Demography Data), the majority of whom are Mexican-Americans. There is no union representation in the foundry but the patternshop employees are members of the Patternmakers League of North America.

B. Process Description

Blue prints and specifications for each customer's product are received and forwarded to the patternshop where the appropriate wooden or metal patterns are made. (NIOSH previously evaluated the patternshop and a complete description is available in Health Hazard Evaluation Report No. HE 77-104-446). Core shells for each type of mold casting are made utilizing one of 3 methods; "hot box", "cold box cure", or "CO_2-silicate".

1. The "hot box" method of core making utilizes a pre-mixed silica core sand and phenolic-urea-formaldehyde resin mixture. The sand-resin mixture is dumped into a small hopper on the core machine. The hopper feeds the mixture into a metal mold, contained in the core machine, which "bakes" the mixture for about 30 seconds to 1 minute depending upon the size of the core. The heat causes the resin to polymerize or "setup" thus forming a solid, brittle core shell. The core machine has replaceable molds so that various core types can be made. There are three "hot box" core machines but only one was in operation during the survey. One operator operates a core machine and produces about 960 small sized cores per day.

2. The "CO_2-silicate" method for making core shells requires no heat. Wooden molds are hand packed with a silica-sodium silicate sand mixture which is cured by carbon dioxide (CO_2). The operator applies CO_2 through a hollow probe into the packed sand for varying lengths of time (15 seconds-3 minutes) depending on the size of the core. There are 4 stations for making this type of core but only 2 were in operation.

3. The "cold box" core method is a urethane type system. (It is located in the foundry area and is considered as mold line #9). The operators mix core sand (100% quartz), resin, catalyst, and solvent in a core muller. Core molds are sprayed with an aluminum paint to prevent the mixture from "sticking" to the mold. The mold is then hand packed with the mulled sand-resin mixture and allowed to cure. The mixture cures without any addition of heat or CO_2. The resin's primary component is an isocyanate (methylene bisphenyl isocyanate (MDI)). There are two operators of the system.

After core shells are made they are taken to the foundry mold casting lines. Each of the 8 mold lines are basically similar except that each may make a different type of mold. Mold sand is supplied to each line's overhead hopper (sand slinger) via a conveyor system. The conveyor system is fed from the mold sand muller. The muller mixes mold sand (southern and/or western bentonite) with water to achieve the specified moisture content so that the sand will pack appropriately for the solid molds (too much moisture will cause the mold to explode when molten metal is poured into it).

A mold operator releases sand from the overhead hopper into a screening box. The sand is screened and dumped into the top of the flask. The flask is made of two wooden halves; the top half is called a drag and the bottom a coop. A pattern is placed between the drag and a coop. The drag is filled with screened mold sand and the sand is tamped down on the pattern. The process is then repeated without screening the sand. A squeeze box is then placed over the drag and pressure is applied by an air press unit. The flask is then turned over and the coop is filled in the same manner. The pattern is then removed and a core shell is inserted. The two halves of the flask are then pressed together using a pneumatic air press, the wooden flask sides are removed and risers are inserted for metal pouring spouts. The finished mold is then lined up on a roller system (pallet line) to receive molten metal. The mold process is then repeated. During the molding process the operator applies a mold release powder (calcite) and repeatedly blows off the excess sand from the mold, pattern, and work area with an air hose. The mold machine/process is often referred to as jolt-squeeze molding.

The furnaces are charged with aluminum ($\sim$ 500-600 lbs./charge) or brass (300 lbs./charge) ingots for melt down. Flux tablets are also added during melt down. When the prescribed temperature is achieved (30 minutes-3 hours), degasser tablets are added to prepare the molten metal for pouring. Aluminum is poured at temperatures ranging from 1500-1600^{o}F using hand-held ladles. The ladles are dipped into the molten metal, carried to the molding lines, and poured through the riser into the mold. Brass is poured at about 2500^{o}F using a hand-operated hoist and molten metal crucible.

When the poured metal has cooled in the mold, the mold is dumped from the roller conveyor system onto the floor to break up the sand mold. The castings are then taken to shakeout. (In fair weather shakeout is performed outside, otherwise it is done inside). Shakeout consists of "beating" the castings with an air hammer to dislodge excess mold and core sand. The sand is shoveled up and dumped into a pile by the mold sand muller to be recycled. The castings are taken to the finishing area where the metal riser portion is sawed off with a band saw. The rough mold edges on the casting are then ground down to specification using stationary and hand-held wheel grinders. None of the grinders had local exhaust ventilation.

In the southeast corner of the finishing shop next to the doorway leading into the foundry there is a welding area. Here equipment is repaired/welded using either electrode or heliarc welding equipment. Holes in the ladles are welded continuously. Opposite the welding area on the west side of the finishing shop there is a lead and zinc "furnace". The lead melting pot was not in use during the survey but the zinc furnace was. Zinc ingots are melted down at 1100^{o}F and hand poured into metal molds for casting automotive leaf spring shims. The zinc furnace is not locally exhausted.

Within the heat-treating area various metal parts, bolts, etc., are heat-treated. Materials used here include draw-temp salts, (sodium nitrite, potassium nitrite, and their respective nitrate salts), cyanide, and carbon black. The treated/hardened metals can be quenched in either oil or water. The heat-treating pots were locally exhausted; however, the duct work was rotted out and improperly designed. Two employees operate the heat-treating department.

1. Environmental Evaluation

On the first site visit information concerning materials used, suppliers, process and facility descriptions, employee demography data (See Appendix A), and health and safety policies were obtained from management.

Photographs, bulk samples of all materials used, relative humidity and temperature measurements were obtained, and numerous workplace and work practice observations were made.

Environmental sampling was conducted to characterize airborne contaminants and non-directive medical questionnaires were completed on each production employee. Releases for medical records from private physicians were obtained from each interviewee. On the followup evaluation environmental samples were obtained for all identified contaminants and informed consent was obtained from each employee wanting a blood lead determination.

Personal and general area samples were obtained to evaluate employee exposures to airborne dusts, metals, gases, vapors, and fumes. Samples were taken utilizing battery-operated personal sampling pumps set at airflows of 1.7, 1.5, 1.0, and 0.2 liters per minute (ℓpm).[1,2] The pumps were hung on belts around the employees' waists and were connected to the sampling media via Tygon® tubing. The sampling media was clipped in the breathing zone of the employee. The medias used to evaluate the various potential airborne contaminants included filters, liquid absorbents, and solid adsorbents. Direct reading instruments were used to evaluate several airborne contaminants and swipe samples were used to evaluate surface contamination.

a) Filters

1) Crystalline Silica

Pre-tared FWSB filters in two-piece plastic cassettes were used to evaluate particulate and silica exposures. Samples for respirable size particulate and silica were obtained utilizing a 10 millimeter (mm) nylon cyclone. Samples were obtained in duplicate sets; one for total particulate and silica and the other for respirable sized particulates and silica. The samples were obtained at airflows of 1.5 and 1.7 ℓpm respectively, and all foundry employee exposures were evaluated.

2) Metals

Pre-tared DM-800 filters in three-piece plastic cassettes were used to evaluate total particulate and metals exposures. The samples were obtained at airflows of 1.5 ℓpm. All finishing room personnel, furnace attendants, and welders were evaluated. A pattern worker and the pattern-shop was also re-evaluated.

3) Fluorides

Pre-treated AA filters in three-piece plastic cassettes were used to evaluate gaseous and particulate fluorides. The samples were obtained at airflows of 1.5 ℓpm and all welders and furnace attendants were evaluated.

4) Oil Mist

AA filters in three-piece plastic cassettes were used to evaluate oil mist exposures in the heat-treating area.

5) Coal Tar Pitch Volatiles (CTPV)

Samples were obtained at airflows of 1.5 ℓpm utilizing three-piece plastic cassettes with glass fiber filters backed up with silver membrane filters. Samples were taken in the heat-treating and foundry areas. All of the above filters were sealed with plastic shrink bands prior to sampling.

b) Liquid Absorbents

1) Ammonia

Personal and general area samples for airborne ammonia were obtained at airflows of 1.0 ℓpm utilizing spill-proof impingers containing 10-15 milliliters (mℓ) of 0.1N sodium hydroxide (NaOH) absorption solution. The "hot box" core operator and the core room area were evaluated.

2) Aldehydes

Spill-proof impingers containing 10-15 mℓ of 1% sodium bisulphite solution were used to evaluate airborne formaldehyde. The samples were obtained at airflows of 1.0 ℓpm and the core room, foundry, and "hot box" operator were evaluated.

3) Ozone

Spill-proof impingers containing 10-15 mℓ of potassium iodide solution operated at airflows of 1.0 ℓpm were used to evaluate ozone in the welding area.

4) Phenol

Spill-proof impingers containing 10-15 mℓ of 0.1N NaOH solution operated at airflows of 1.0 ℓpm were used to evaluate the foundry and core room areas.

5) MDI

Spill-proof impingers with 10-15 mℓ of modified Marcali solution operated at airflows of 1.0 ℓpm were used to evaluate the core muller/mold line #9 area.

All the above described impingers contained an AA prefilter when the sample was taken in an area of high particulate concentrations. This was done to prevent potential interferences from the particulates trapping in the impinger media.

c) Combination Filter-Absorption Media Sampling Trains

1) Cyanide

AA prefilters in three-piece plastic cassettes and spill-proof impingers containing 10-15 mℓ 0.1N NaOH operated at airflows of 1.0 ℓpm were used to evaluate airborne particulate and gaseous cyanide in the heat-treating area.

2) Hexamethylene tetramine

Fibrous glass prefilters in three-piece plastic cassettes and spill-proof impingers containing 10-15 mℓ double distilled water operated at airflows of 1.5 ℓpm were used to evaluate the hot box core operator and core area. The filters were removed and placed in glass scintillation vials and the impinger solution was added, thus combining the media for analysis of hexamethylene tetramine.

All impinger solutions described above were placed in glass scintillation vials with Teflon® lined caps, and sealed prior to shipment to the NIOSH laboratory.

d) Solid Adsorbents

1) Organic Vapors

General area and personal samples for airborne organic vapors were obtained utilizing 150 milligram (mg) activated charcoal media tubes, operated at airflows of 0.2 ℓpm. The core room, casting repairman, and cold box operators were evaluated.

2) Oxides of Nitrogen - Nitric Oxide and Nitrogen Dioxide

Samples were obtained utilizing triethanol amine impregnated molecular sieve media tubes operated at airflows of 0.2 ℓpm. The welders and the welding area were evaluated.

3) Swipe Samples

Whatman* filter swipes were used to evaluate surface contamination from heavy metals. Approximately one square foot of surface was swiped with a filter. Samples were obtained both moistened and dry and the lunch room, office desks, lunch boxes, and other employee contact areas were evaluated. The swipe filters were placed in glass scintillation vials and sealed prior to shipment to the NIOSH laboratory.

e) Direct Reading Indicator Tubes

Drager* detector tubes were used to evaluate airborne concentrations in the employee breathing zone for ammonia, carbon monoxide, carbon dioxide, formaldehyde, ozone, oxides of nitrogen, phenol, phosgene, and sulfur dioxide. Samples were taken throughout the facility.

f) Bulk Samples

Bulk material samples and surface dusts were obtained in glass scintillation vials with Teflon® lined caps. All samples were sealed prior to being sent to the NIOSH laboratory.

2. Environmental Sample Analysis[3-6]

a) Filters

Pre-tared filters were reweighed to an accuracy of 0.01 milligrams per filter for particulate weights. Samples taken for crystalline silica were analyzed by a modified NIOSH P & CAM method #109. The method is an x-ray diffraction technique. Filter samples for metals were analyzed using NIOSH P & CAM method #173 which involves wet oxidation of the filter in an acidic solution followed by atomic absorption spectrophotometry. The swipe samples were also analyzed in this manner.

Samples taken for oil mist were analyzed using the method described in NIOSH P & CAM #S272. Particulate and gaseous fluoride samples were analyzed by P & CAM #212 and benzene soluble coal tar pitch volatile samples were analyzed by P & CAM #217.

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*Mention of manufacturer's name does not constitute a NIOSH endorsement.

b) Liquid Absorbents

Impinger samples for ammonia were analyzed by an ion chromatography technique. Dionex columns were used with 0.005 $NHNO_3$ as the element.

The samples taken for cyanide were analyzed by NIOSH method P & CAM #S250 and the isocyanate samples by P & CAM #141 and 142. Ozone samples were analyzed by P & CAM #154 and formaldehyde by P & CAM #125. Other aldehydes were screened for by a gas chromatography technique utilizing a FID detector and a 6-foot 4% Carbowax 1% PPI column. Hexamethylenetetramine samples were analyzed by NIOSH method P & CAM 263 which is a colorimetric procedure.

c) Solid Adsorbents

Activated charcoal tube media samples taken for pyridine were analyzed by a modified NIOSH method P & CAM #S161. The method is a gas chromatography technique. Oxides of nitrogen samples were analyzed by P & CAM S321.

d) Bulk samples were analyzed by emission spectroscopy and gas chromatography/mass spectrometry for identification of all major components.

3. Medical Evaluation

All employees were offered the opportunity for an interview with a NIOSH medical technician. The interviews were conducted to assure confidentiality and non-directive medical questionnaires were completed during the interview. The questionnaires elicited responses concerning personal health status, work history, work-related health complaints, and smoking and medication histories. Authorization forms for release of personal medical records from family physicians were also obtained during the interviews.

On the followup survey each employee was asked to participate in a blood lead analysis. Informed consent was obtained prior to the collection of two blood samples via vena puncture.

All but two production employees participated in the blood lead evaluation. The blood samples were analyzed for inorganic lead via atomic absorption spectrophotometry. Free erythrocyte protoporphyrin was also determined.[7]

D. Evaluation Criteria

1. Environmental

The following occupational exposure criteria were used in evaluating the environmental contaminants found at the time of the survey: (1) National Institute for Occupational Safety and Health (NIOSH), Recommended Criteria for Occupational Exposures, (2) American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values for Substances and Physical Agents in the Workroom Environment and supporting documentation, and (3) U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Standards (29 CFR 1910.1000, Tables 21, 22, and 23).

The criteria are listed in the Tables of Results under each of the respective substances identified. These criteria are designed to protect most workers for an eight to ten-hour day, forty-hour week, during a normal working lifetime. However, there are numerous factors that may influence an individual's response to a particular substance, such as age, sex, health status, smoking and alcohol habits, etc. Also, these criteria are based on single substance exposures; thus, effects from exposures to combinations of substances may be additive or synergistic when the substances elicit similar physiological responses.

2. Medical Criteria

The health effects of all substances found to exceed the occupational exposure criteria are discussed below. For those substances identified in the environment, but which did not exceed exposure criteria, the health effects are not presented in this report. However, in the reference section of this report are included several sources which can be consulted for the health effects of the substances not presented here.

1. Toxicity Data

a) Inorganic Lead[8]

Inorganic lead is a heavy metal which can be absorbed into the body by injestion or inhalation. Upon absorption, the lead becomes bound primarily with the red blood cells and is distributed throughout the body into the soft tissues, particularly kidneys and liver. Over a period of time the lead is redistributed and deposited into hard tissues such as bone, teeth, and hair. Lead absorption is accumulative and the elimination from the body is slow. The absorbed lead affects each body system it comes in contact with, including the red blood cells.

The symptoms most often associated with lead intoxication (plumbism) are loss of appetite, constipation, abdominal pains (intestinal colic), anorexia, headaches, tremor, anemia, fatigue, and peripheral motor paralysis of certain extensor muscles (wrist and/or ankle drop). Generally, pallor, anemia, and emaciation are present in plumbism. Rarely, an indication of significant lead absorption may also be a blue line along the gums, often referred to as "lead line".

Inorganic lead has been shown to be mutagenic and teratogenic. It can cross the placental barrier and can affect embryological and fetal development. Lead is eliminated from the body via urine and feces.

NIOSH has recommended that a blood lead value of 60 micrograms per 100 grams whole blood (60 µg/100 g blood) be the maximum tolerated occupational blood lead level. The new OSHA standard has dictated that by the end of four years this will become the level at which a worker must be removed from further lead exposure until his blood lead level has dropped to normal values. OSHA has further set an average blood lead level of 50 µg/100 g whole blood as requiring removal until blood lead levels are normal (by the fifth year of the standard). OSHA's aim is to keep as many workers' blood lead levels as possible below 40 µg/100 g, the upper limit of blood leads in unexposed individuals.

b. Crystalline Silica

Crystalline silica (SiO_2) is a toxic mineral which can be deposited in the lungs from inhalation of dust containing the various crystalline forms of silica. The lungs react to the deposited mineral dust by producing fibrotic changes in the lung's wall lining. Silica also inhibits macrophages from cleaning out the dusts in the lower airways. This action creates hardened tissue and nodules which results in impaired lung functions. The disease state is called silicosis. It can develop into a chronic disabling respiratory disease which may result in a shortened life expectancy.

E. Results and Discussion

1. Environmental

The results of the environmental evaluation are contained in Tables I-XIV and Appendix B. These results should be considered as the minimum concentrations present because the actual exposures of the employees are of a longer daily duration than were the environmental samples obtained.

Bulk sample analysis (Appendix A) revealed that the mold sand (Southern and Western Bentonite) contained approximately 7.4% quartz and the core sand 100% quartz. However, from recycling the core and mold sand mixture after shakeout, the quartz content of the mold sand increases steadily and was found to average 30% quartz in the samples obtained on the followup survey two months later. This could be avoided in part because the Olivine sand being used does not contain free crystalline silica, thus, if the facility is cleaned up and maintained, the overall quartz content will not build up as rapidly if at all.

Tables V and VII contain the results of the samples obtained for total particulates and crystalline silica. The results indicate that there are excessive exposures to silica throughout the foundry. The muller operator appears to be overexposed regularly to toxic concentrations of silica and particulates, whereas, the mold operators are variably overexposed. This variation is due to the type of mold being made and work practices such as blowing off the work areas with compressed air.

Analysis of the risers and mold release powder revealed that they were free of detectable asbestos. The mold release powder was a calcite material. The cold box (air set) resin system components were analyzed and numerous organic compounds were present. MDI is the most toxic of the compounds identified in the system and it is a potential sensitizer; thus, exposures including direct contact should be kept at a minimum.

Tables I and II contain the results of the direct reading indicator tube screening samples. In general, most exposures were found to be below the environmental criteria, although some instantaneous exposures to oxides of nitrogen appeared to be above the NIOSH criteria for the welders. These results, however, are not as accurate as the personal samples results contained in Table IX which revelaed that the welders were not excessively exposed to the substances over a longer period of the normal working day. The phosgene results (Table I) revealed that during the degassing of the molten metal, prior to pouring, it is variably released in significant concentrations for a minute or two. However, the employees added the degasser tablets and then backed away from the area for two to three minutes to allow the phosgene to be released and dissipated. Degassing is an intermittent operation; thus, exposures are infrequent and of short duration. Formaldehyde was found to be variably released from the molds during pouring. At certain times for short intervals there may be some excessive exposures to this irritant, although no personal samples were obtained to accurately document the exposures. (The personal samples were not obtained on mold pourers because of the delicacy of the sampling train and the rough, vigorous type work the employee performed.) General area measurements (Table X) did reveal, however, that the concentrations throughout the foundry were below the exposure criteria.

Samples taken to evaluate total particulate and metal exposures (Tables III and VI) reveal that many employees were exposed to excessive concentrations of inorganic lead. These exposures can be expected to be higher on the days when more brass is poured than was poured on the survey dates. This would also explain why the metal fume fever symptoms appear intermittently. They may well correlate with increased brass and/or zinc pouring. Also, due to accumulated dusts containing the lead fume condensate there are lead exposures even when brass is not being poured, however. This was confirmed by the swipe samples (Table XII) which showed that the lunchroom and office are contaminated with lead. It should be noted that the samples taken on moistened swipes are more accurate of skin contact exposure and those taken dry may well be much higher than indicated.

Table IV contains the results obtained for organic vapor characterization. The results show that no exposures to the identified substances were above the criteria. On the followup survey samples taken for airborne organics were analyzed only for pyridine and none was detected, although the laboratory did report finding significant amounts of some unidentified organic compound.

Table VIII contains the results of the fluoride samples. The results reveal that the welders and furnace attendants are not exposed to excessive concentrations of gaseous or particulate fluorides. The source of the fluorides are the flux tablets, used in metal melting, and as a minor component in some welding rods.

Table XI contains the results of the benzene soluble particulate analysis. These results, however, may be somewhat misleading in that no specific polynuclear aromatics (PNA's) were detected; thus, the soluble portion is probably due to oil mists and the NIOSH coal tar pitch volatile recommended standard of 0.1 mg/m^3 would not apply.

Table XIII results reveal that the core resin emissions are well below the exposure criteria, although HMTA has no exposure criteria and only recently has it been measured in foundries. Personal exposures to these substances were not readily obtainable due to the delicacy of the sampling trains and the type of vigorous work the workers performed; thus, personal exposures may be higher than indicated, although probably well within the exposure criteria.

Table XIV contains the noise survey results. As is revealed, there is considerable noise exposures throughout the foundry as could be expected in any heavy industry. The results do show that hearing protection should be mandatory.

In general, this facility was found to be crowded, lacked supply air ventilation and local exhaust ventilation, had inadequate housekeeping, and there existed a language barrier between management and employees, thus health and safety educational training couldn't be passed along readily. Also, the lunchroom/shower facilities were inadequate and, in fact, contributed to the employees overall exposures through general contamination which was evident by the moistened swipe samples obtained. Because of the size and layout of the facility, most employees in any type of job will be exposed to all contaminants.

2. Medical

The results of the non-directive medical questionnaires (Table XV) revealed that only 9 (19%) of the employees had any health complaints other than that the air was "dirty" and their nasal passages felt "clogged" up. None, however, had had a pulmonary function test; thus it is unknown if they are experiencing any decrease in vital capacity. It should be noted that most employees have only worked at the foundry for about 3 years; thus, one wouldn't expect them to be experiencing any adverse pulmonary effects from the particulate and silica exposures yet. The exposures are excessive, however, and in time, they would be expected to produce adverse effects if the exposures are not reduced. The health complaints were basically non-specific, intermittent and of short duration. The complaints of headaches and chills may be associated with zinc and/or brass pouring on days that the facility is closed up due to inclement weather or increased production, thus producing higher exposures to metal fumes and gases resulting in metal fume fever symptoms. The complaints of sore muscles would not be unusual for the type of heavy work performed although proper lifting techniques may help to reduce the potential muscle strains.

The results of the blood lead and FEP analysis revealed that thirty-eight (81%) of the employees had a blood lead value in excess of the new OSHA standard of 40 µg Pb/100 g whole blood, one of which was 59.9. The FEP's revealed that 34 (72%) were above the normal range of 356-662 µg FEP/liter RBC. Overall there was little difference between job categories. These results could be expected to be even higher when more brass is poured or more overtime work is performed than was during the survey. It does show that the excessive airborne lead exposures and general contaminations are producing an increased body burden to inorganic lead and that further biological testing should be performed to establish a data base in order to determine whether or not there are any major fluctuations in the blood lead values. This is particularly important since 81% are already above the upper normal limit of 40 µg. The effects on women of childbearing age warrants a strict surveillance program because 2 of the 3 office females tested did have elevated blood leads and one of these is required to work in the shop areas for variable lengths of time. Also, with Equal Opportunity Employment there may be females working in the shop areas in the near future and the reproductive effects from lead are an important consideration.

F. Conclusions/Recommendations

1. Conclusions

Based on the information obtained during this evaluation it has been determined that an airborne hazard to inhalation of crystalline silica and inorganic lead exists at this non-ferrous foundry. There is lead contamination throughout the facility for even the office girls had blood leads above 40 µg/100 g and moistened swipe samples did show lead to be present in the offices. All other airborne contaminants in the facility were found to be below the single substance exposure criteria and thus are not considered a health hazard. The exposures, however, could be potentially toxic if production conditions change without a corresponding improvement in the ventilation. This is particularly true if more furnaces are put into operation, as was being prepared during the survey, or if more brass is poured than on the dates evaluated. The first effects which will probably be seen if production is increased as stated above will be more cases of metal fume fever which will increase in frequency and duration. A corresponding increase in blood leads will also appear. The effects from silica, however, may not appear for several years yet and then it will be too late since silicosis is irreversible.

Several deficiencies in the facility were identified during the evaluation and possible corrective actions are outlined below to help management ensure worker health and safety. It should be pointed out that this is a small facility with no room to expand, a large turnover rate in employees, and a limited operating budget all of which will make it difficult to correct the deficiencies and remain a viable business.

2. Recommendations

The following recommendations are made to help management correct the deficiencies in an order that will produce the greatest effect.

a. As an interim measure to protect the employees from excessive exposures to toxic airborne particulates, all employees in the foundry and grinding area should be issued disposable NIOSH approved dust respirators until local exhaust ventilation controls can be installed. New respirators should be issued on a daily basis and the proper usage should be explained as well as the reasons why they should be worn.

b. As an interim measure all employees should be issued hearing protection and its proper usage and maintenance must be explained. The usage should be mandatory except in areas documented as being below the standard for an eight-hour daily exposure. This will require a noise evaluation to document personal exposures.

c. No cooking, heating of foods or eating should be allowed in the work area. A hot plate or microwave oven could be provided in a clean area for the employees' use.

d. A ceiling should be built over the lunchroom area and the area should be cleaned at least daily.

e. The facility should be thoroughly cleaned, including all overhead beams to eliminate contaminant buildup. An industrial vacuum system could be used to clean up. This would help prevent redistribution of the contaminants into the air. The housekeeping should be done on a regular basis.

f. A bilingual person should be designated to facilitate communities of health and safety practices, policies, and education to the work force. This person will need some education in health and safety matters. Proper work practices and good personal hygiene must be stressed to the employees to help reduce personal and familial contamination.

g. The foundry area requires additional exhaust and makeup air. As a general guide, there should be a minimum of 25-35 cubic feet of air per minute (CFM) per square foot of foundry area. The best approach and overall most effective control is to have local exhaust ventilation with the corresponding supply air system to keep the systems balanced. Also the work practices in this area may be modified to reduce silica exposures by reducing the amount of compressed air blow off of the work area and molds. Possibly some type of vacuum system could be used.

h. The stationary grinders should be locally exhausted. The proper airflow, duct and hood design should be obtained from an industrial ventilation manual as listed in the reference section or an industrial ventilation expert should be consulted. It is essential that all ventilation controls be properly maintained on a regular basis to assure adquate performance.

i. The exhaust duct work in the heat treating area should be repaired and redesigned for proper performance.

j. Management should consider providing work coveralls to the employees to help improve personal hygiene and prevent contaminating their cars and homes. The coveralls could be supplied and laundered by an industrial laundry service.

k. The furnace attendants need new safety equipment such as face shields and heat protective gloves and clothing. The "cold box" air cure molders and core muller operators need impervious gloves to prevent skin contact with the resin system components. They should be light-weight and amendable to cleaning by solvents to remove the sticky resin. A neoprene-type of glove may be adequate.

l. The medical recommendations in the NIOSH criteria documents for silica and lead should be considered. The OSHA medical requirements must be met as outlined in the new OSHA lead standard. Although there may be a high turnover rate in the work force, some medical surveillance is needed until exposures are well below the standards. Management should consider the possibility of forming a plan with other small foundries in the area for a clinic to provide group medical services for routine tests such as blood leads, pulmonary functions and hearing tests.

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Table I

Indicator Tube Measurements for Airborne Contaminants

Arapahoe Aluminum Foundry
Englewood, Colorado

November 30 & December 1, 1978

HE 79-9

	Results (ppm)*							
Location	CO[1]	CO_2[2]	NH_3[3]	NO_x[4]	Formaldehyde	Phosgene	Phenol	Sulfur Dioxide
Core Room	<10	.3%	5-10 20-45	-	<.5	-	+**	-
Furnaces	<10	-	-	-	-	0.3-1.2+	-***	-
Molding/Pouring	<10	-	-	-	4-10+	0	+	-
Heat Treating	<10	-	0	0	-	-	-	-
Welding	5-10	-	-	0.5-1.0 3.0-4.0	-	-	-	-
Environmental Criteria:								
NIOSH	35	1.0%	50	1	1	0.1	5.2	0.5
OSHA	50	0.5%	50	5	1	0.1	5	5
TLV	50	0.5%	25	5	2	0.1	5	2

*parts of contaminant per million parts of air
**detected
***not detected
1. Carbon Monoxide
2. Carbon Dioxide
3. Ammonia
4. Oxides of Nitrogen

Table

Indicator Tube Measurements for Airborne Contaminants

Arapahoe Aluminum Foundry
Englewood, Colorado
HE 79-9
February 1979

Environmental Conditions: Indoors, Temperature 67-88^{o}F Relative Humidity ~10-20% B.P. 625 mm Hg

Location	Description	Results (ppm)*[1]								
		CO[2]	CO_2[3]	NH_3[4]	NO_x[5]	Form[6]	O_3[7]	Phos[8]	Phenol	SO_2[9]
Core Room	Operator making shell cores CO_2-silicate method	< 5	0.3-1.5%	-	-	-	-	-	-	-
Core Room	Operator making shell cores-hot box method	< 5	-	5-10	-	N.D.[10]	-	-	-	-
Furnaces	Operator adding flux to molten aluminum	10	-	-	-	-		+[11]	-	-
Molding/ Pouring	Operator fill molds with molten aluminum	10	-	+	-	+	-	-	+	-
Welding	Operator welding-electrode and heliarc types	30-50	-	-	0.5-2.0	-	0.2	-	-	-
Environmental Criteria										
NIOSH		35	1.0%	50	1	1	-	0.1	5.2	0.5
OSHA		50	0.5%	50	5	1	0.2	0.1	5	5
TLV		50	0.5%	25	5	2	0.2	0.1	5	2

* ppm - parts per million
1 - measurements made in breathing zone of employees. Concentations indicate momentary exposures and not eight-hour time weighted average (TWA) exposures.
2 - carbon monoxide
3 - carbon dioxide
4 - ammonia
5 - oxides of nitrogen
6 - formaldehyde
7 - Ozone
8 - Phosgene
9 - sulfur dioxide
10 - not detected
11 - detected

T[illegible] III

Results of Air Sampling for Airb[illegible] Total Particulates and Metals

Arapahoe Aluminum Foundry
Englewood, Colorado

November 30 and December 1, 1978

HE 79-9

Environmental Conditions: Indoors, Doors Open, Temperature 63°F, R.H. ≈ 10%, B.P. 616 mm Hg, 0625 HR

Sample Number	Time	Description	Al[1]	Cu[2]	Fe[3]	Ni[4]	Pb[5]	Mg[6]	Zn[7]	Total Particulate
			Results (mg/M³)*							
D1883	0555-1520	Personal Sample (P.S.) Foundry Foreman	0.18	0.07	0.06	N.D**	0.03	0.11	0.11	2.4
D1898	0552-1522	P.S. Furnace Operator	0.23	0.05	0.10	N.D.	0.05	0.20	0.08	4.0
D1882	0549-1415	P.S. Foundry Area Helper	0.14	0.03	0.07	N.D.	0.03	0.13	0.04	4.4
D1891	0602-1429***	P.S. Saw Operator Al castings	1.8	0.59	0.09	0.01	0.20	0.15	0.42	6.4
D1888	0605-1525	P.S. Mechanic/Welder	0.57	0.54	0.51	0.01	0.29	0.14	0.44	6.3
D1895	0608-1430	P.S. Stationary Grinder #1	2.1	0.60	0.09	0.01	0.15	0.13	0.61	6.7
D1893	0612-1425	P.S. Zn Furnace Operator	0.36	0.11	0.06	N.D.	0.06	0.05	0.30	3.0
D1886	0617-1422	P.S. Hand Grinder #2	0.61	5.1	0.12	0.02	3.2	0.25	0.56	17
D1890	0622-1423	P.S. Hand Grinder #3	0.44	0.97	0.05	N.D.	0.55	0.07	0.37	5.7
D1894	0630-1429	P.S. Stationary Grinder #3	46	0.65	0.21	0.01	0.12	3.3	4.2	51
D1878	0622-4426	P.S. Zn/Brass Cutter	0.93	0.21	0.10	N.D.	0.10	0.08	0.37	5.3
D1885	0645-1425	P.S. Stationary Grinder #1	1.3	0.36	0.09	N.D.	0.16	0.07	0.55	5.2
D1877	0730-1602	P.S. Furnace Attendent	0.47	0.05	0.13	N.D.	0.04	0.22	0.11	4.9

Environmental Exposure Criteria

	Al[1]	Cu[2]	Fe[3]	Ni[4]	Pb[5]	Mg[6]	Zn[7]	Total Particulate
NIOSH	-	-	-	-	0.1	-	5	-
OSHA	-	1	10	1	0.05	15	5	15
TLV	10	1	5	1	0.15	10	5	10

*Milligrams of substance per cubic meter air

** Not detected - The limit of detections for these metals was:

	Al	Cu	Fe	Ni	Pb	Mg	Zn	Total Particulate
Limit of detection	0.030	0.004	0.005	0.004	0.01	0.003	0.004	0.01

*** Pump off ½ hour for lunch

	Al	Cu	Fe	Ni	Pb	Mg	Zn	Total Particulate
Number of Samples exceeding criteria (n=13)	1	1	0	0	10	0	0	2

1. Aluminum
2. Copper
3. Iron
4. Nickel
5. Lead
6. Magnesium
7. Zinc

Table IV

Results of Air Sampling of Airborne Organic Vapors

Arapahoe Aluminum Foundry
Englewood, Colorado

November 31 & December 1, 1978

Environmental Conditions: Indoors, Door Open, Temperature 63°F, R.H. ∿ 10%, B.P. 616 mm Hg, 0625 HR

Sample #	Time	Description	Results (mg/M³)* Alkanes	Aromatics	Perchloroethylene	Phenol	Styrene	Toluene
CT-1	0636-1422	Personal Sample (P.S.) Casting Repair	1.2	1.4	0.54	-	1.1	N.D.**
CT-2	0640-1445	General Area (G.A.) Casting Line #4	3.3	4.4	0.31	-	N.D.	0.02
CT-5	0602-1418	P.S. Hot Box Cores Operator #2	1.5	0.91	0.34	0	0.45	N.D.
CT-6	0632-1130***	P.S. Core Painter - Cold Box Cores	2.5	4.2	N.D.	-	N.D.	N.D.
CT-7	0650-1430	G.A. Core Sand Muller	2.6	4.2	0.21	-	N.D.	0.21
CT-8	1230-1425	P.S. Casting Repair - Finishing	N.D.	N.D.	0.57	-	2.6	N.D.
SG-2	0645-1421	P.S. Hot Box Cores Operator #2	-	-	-	2.5	-	-
Environmental Criteria								
NIOSH			350	1800	339	20	-	375
OSHA			1000	2950	670	20	420	750
TLV			1000	1600	670	19	420	375
**Not detected - the limit of detection for these samples was:			0.05	0.02	0.02	0.10	0.02	0.05

*Approximate milligrams of substance per cubic meter air

**Not detected - the limit of detection for these samples was: (see values above)

***Sample removed early because employee went home sick

Table

Results of Air Sampling for Airborne Total Dust and Crystalline Silica

Arapahoe Aluminum Foundry
Englewood, Colorado

November 30 & December 1, 1978

HE 79-9

Environmental Conditions: Indoors, Door Open, Temperature 63°F, R.H. ∿ 10%, B.P. 616 mm Hg, 0625 HR

Sample Number	Time	Description	Results (mg/M^3)* Quartz	Total Particulate
D1899	0708-1515	Personal Sample (P.S.) Pattern Wood Shop (Mahogany)	-	7.1 (wood dust)
FW3398	0555-1400	P.S. Mold Sand Muller Operator	0.98	17.0
FW3376	0600-1400	P.S. Sand Mold Helper	0.13	5.5
FW3390	0605-1603	P.S. Mold Helper - all over Plant	0.27	3.3
FW3384	0610-1427	P.S. Core Shakeout	0.37	3.7
FW3392	0615-1526	P.S. Furnace Attender	0.16	4.0
FW3391	0627-1604	P.S. Core Sand Muller Operator	0.16	3.3
FW3386	0630-1503	P.S. Molder #1	0.21	5.9
FW3397	0635-1600	P.S. Bobcat Driver	0.20	3.1
FW3385	0636-1512	P.S. Molder #2	0.21	5.6
Limit of Detection			0.03	0.01

*Approximate milligrams per cubic meter air

Environmental Criteria

The OSHA exposure criteria based on non-respirable total mass samples is calculated by: $\frac{30\ mg/M^3}{\%SiO_2+3} \approx 0.29\ mg/M^3$

The ACGIH exposure criteria based on non-respirable total mass samples is calculated by: $\frac{30\ mg/M^3}{\%SiO_2+2} \approx 0.29\ mg/M^3$

NIOSH does not currently have an exposure criteria for non-respirable type samples. The respirable fraction exposure criteria is 0.05 mg free silica/m^3.

Table VI

Results of Sampling for Airborne Total Particulate and Metals

Arapahoe Aluminum Foundry
Englewood, Colorado

February 1979

HE 79-9

Environmental Conditions: Indoors, Temperature 62-88°F, Relative Humidity ~10-30%, B.P. 625 mm Hg

Sample No.	Time	Description	Results (mg/M³) Al[1]	Cu[2]	Cr[3]	Mg[4]	Mn[5]	Pb[6]	Zn[7]	Total Particulate
D1661	0801-1447	Personal Sample (P.S.) welder/mechanic	0.33	0.06	N.D.**	0.05	0.01	0.03	0.25	2.8
D81581	0610-1525	P.S. aluminum furnace attendant #1	0.26	0.1	N.D.	0.24	N.D.	0.2	1.3	5.9
D8300	0612-1446	P.S. zinc furnace operator	0.18	0.12	0.01	0.02	N.D.	0.01	0.14	1.0
D81211	0615-1446	P.S. finishing room helper	2.2	0.27	N.D.	0.01	0.04	0.03	3.4	4.2
D1853	0620-1452	P.S. glove box sander operator	0.13	0.11	0.01	0.01	N.D.	N.D.	0.14	1.2
D1855[8]	0621-1430	P.S. handgrinder #1	0.3	0.12	N.D.	0.03	N.D.	0.02	0.14	1.9
D1870	0622-1450	P.S. handgrinder #2	0.49	0.17	N.D.	0.04	0.004	0.02	0.22	2.7
D1864[8]	0625-1430	P.S. handgrinder #3	0.47	0.15	N.D.	0.03	0.004	0.01	0.19	3.2
D1872	0634-1452	P.S. stationary grinder #2	0.9	0.16	N.D.	0.02	0.01	0.02	0.21	8.3
D1865	0627-1445	P.S. stationary grinder #1	2.3	0.37	N.D.	0.05	0.01	0.03	0.4	7.5
D1598	0635-1450	P.S. stationary grinder #3	0.46	0.22	N.D.	0.02	N.D.	0.02	0.22	2.2
D1590	0640-1452	P.S. finishing room helper	0.77	0.27	N.D.	0.04	0.004	0.07	0.3	3.1
D1867	0645-1512	P.S. mold helper	0.24	0.05	0.01	0.3	N.D.	0.07	0.54	5.7
D1857	0650-1445	P.S. brass saw operator	0.69	0.87	N.D.	0.05	0.01	0.03	0.81	4.7
D1852[8]	0651-1445	P.S. shipper/helper	0.28	0.37	N.D.	0.02	N.D.	0.01	0.25	2.1
D1868	0655-1500	P.S. welder #1	0.34	0.14	N.D.	0.13	0.01	0.03	0.4	3.7
D1873	0645-1515	P.S. heat treating operator	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.5	0.99
D1874	0735-1510	P.S. aluminum furnace attendant #2	0.32	0.07	N.D.	0.29	N.D.	0.28	1.6	7.2
D1866[8]	0731-1500	P.S. mold helper	0.19	0.04	N.D.	0.22	N.D.	0.05	0.3	3.7
D1856[8]	0735-1528	P.S. aluminum furnace attendant #3	0.21	0.05	0.01	0.18	N.D.	0.07	2.1	5.3
D1859	0750-1500	P.S. welder #2	0.53	0.13	0.02	0.09	0.03	0.02	0.39	4.1
D1858	0848-1503	P.S. core muller operator	0.34	0.04	N.D.	0.10	N.D.	0.09	0.52	7.4
D1677	0904-1503	P.S. core muller helper	0.82	0.05	N.D.	0.43	N.D.	0.09	0.71	11
D1711	0710-1445	General area (G.A.) furnace area	0.41	0.04	0.01	0.34	N.D.	0.03	0.62	6.7
D1871	0730-1530	G.A. mounted on bobcat at breathing zone height-all ore foundry	0.24	0.03	N.D.	0.46	N.D.	0.03	0.43	5.1
D1685	0733-1525	G.A. zinc furnace area	0.11	0.10	N.D.	0.02	N.D.	0.02	0.55	2.0
D1681	0745-1515	P.S. pattern maker(worked with sugarpine)	0.03	0.03	N.D.	0.01	N.D.	N.D.	0.01	0.68
D1680	0745-1515	G.A. patternshop	0.03	N.D.	N.D.	.0.02	N.D.	N.D.	0.01	0.33
D1854	0815-1516	G.A. welding area	0.19	0.08	N.D.	0.01	N.D.	N.D.	0.15	1.3
Environmental Criteria										
NIOSH			-	-	0.025	-	-	0.1	5	-
OSHA			-	1.0	1.0	15	5	0.05	5	15
TLV			10	1.0	0.05	10	5	0.15	5	10
*approximate milligrams of substance per cubic meter air **not detected: the limit of detections for these metals was:			0.015	0.004	0.005	0.002	0.003	0.008	0.005	0.01
Number of samples exceeding criteria (n=29)			0	0	0	0	0	8	0	1

1. Aluminum
2. Copper
3. Chromium
4. Magnesium
5. Manganese
6. Lead
7. Zinc
8. Pump failed - exposure values should be considered as minimum concentration present.

Table VII

Results of Sampling for Airborne Crystalline Silica and Particulates

Arapahoe Aluminum Foundry
Engelwood, Colorado
February 1979
HE 79-9

Environmental Conditions: Indoors, Temperature 62-80°F, R.H.∿10-30%, B.P. 625 mm Hg

Sample No.	Time	Description	Results (mg/M³)* Total Particulate	Total Cryst. Sil[1]	Total Quartz	Respirable Particulate	Respirable Cryst. Sil[1]	Respirable Quartz
FW3624/3596	0637-1453	Personal sample (P.S.) molder #2	155	4.5	0.54	2.5	0.75	0.05
FW3675/3625	0701-1425	P.S. Core muller operator	9.3	2.8	1.5	1.7	1.7	0.17
FW3663/3627	0700-1443	P.S. molder #7	7.1	2.1	0.43	1.6	0.48	N.D.**
FW3587/3626	0655-1428	P.S. molder #8	3.6	1.1	0.24	0.68	0.2	N.D.
FW3628/3601	0705-1448	P.S. molder #5	3.7	1.1	0.22	0.98	0.29	0.05
FW3680/3623	0710-1426	P.S. mold helper	2.5	0.75	0.20	0.93	0.28	N.D.
FW3632/3594	0610-1437	P.S. core muller helper/bobcat driver	9.0	2.7	1.1	0.14	0.04	N.D.
FW3616/3668	0605-1405	P.S. muller operator	12.0	3.5	0.49	0.55	0.17	N.D.
FW3624/3590[2]	0630-1450	P.S. molder #3	19.0	5.7	0.40	1.0	0.31	N.D.
FW3631/3666	0628-1435	P.S. molder #1	8.3	2.5	0.44	1.4	0.41	N.D.
FW3671/3630[2]	0645-1445	P.S. molder #4	7.0	2.1	0.31	0.94	0.28	0.04
FW3622/3670	0712-1432	P.S. bobcat driver	2.5	0.74	0.30	0.67	0.20	N.D.
FW3597/3617[2]	0723-0758	P.S. molder #7	3.3	0.99	N.D.	1.2	0.3	N.D.
FW3588/3618	0725-1440	P.S. mold helper	3.6	1.1	0.31	7.5	2.3	0.38
FW3620/3667	0727-1430	P.S. mold helper	4.1	1.2	0.36	1.1	0.32	N.D.
FW3673/3619	0730-1423	P.S. mold helper	5.1	1.5	0.34	2.2	0.67	0.28
FW3658/2621	0732-1439	P.S. mold helper	3.0	0.89	0.31	0.76	0.23	N.D.
FW3591/3669	0720-1400	P.S. muller operator	9.1	2.7	0.82	0.71	0.21	N.D.
FW3665/3661	0726-1521	P.S. shakeout operator	2.5	0.75	0.93	0.37	0.11	0.1
FW3615/3595	0625-1400	P.S. muller operator	12	3.7	0.59	1.0	0.31	0.04
FW3592	0639-1430	G.A. bobcat	16	4.8	0.68	-	-	-
FW3612	0630-1445	P.S. core muller operator	-	-	-	2.0	2.0	0.33
FW3674	0631-1530	P.S. core muller helper	14	14	0.66	-	-	-
FW3611/3589	0635-1430	P.S. shakeout operator	6.9	2.1	1.8	0.71	0.21	0.38
FW3593	0825-1450	G.A. catwalk west end	9.2	2.8	0.61	-	-	-
FW3614	0825-1450	G.A. catwalk east end	9.8	2.9	0.68	-	-	-
Environmental Criteria								
NIOSH			-	-	-[1]	-	0.05	-[3]
OSHA			15	-	0.94[1]	5	-	0.31
TLV			10	-	0.91[1]	5	-	0.31
**not detected - the limit of detections for these sample was:			0.01	-	0.03	0.01	-	0.03
Number of samples exceeding criteria (n=22 of each type personal sample)			4	-	4	0	22	8

*approximate milligrams of substance per cubic meter air

**not detected - the limit of detections for these sample was: see values above

1. Free crystalline silica (SiO_2) based on % quartz composition of dust in the sample: core mullers = 100%, other samples = 30%
2. Pump failed - exposure values should be considered as minimum concentrations.
3. The NIOSH Recommended Standard is based on all forms of free crystalline silica of which quartz is one form, thus the concentration of quartz alone exceeded the NIOSH Criteria.

TABLE

Results of Sampling for Particulate and Gaseous Fluorides
Arapahoe Aluminum Foundry
Englewood, Colorado
February, 1979
HE 79-9

Environmental Conditions: Indoors, Temperature 62-80° F, R.H.~10-30%, B.P. 625 mmHg

Sample No.	Time	Description	Results (mg/M³)* Particulate Fluorides	Gaseous Fluorides
HF-3	0821-1422	Personal Sample (P.S.) Zinc Furnace Operator	0.09	0.01
HF-14	0733-1525	General Area (G.A.) Zinc Furnace	0.02	N.D.**
HF-8	0655-1500	P.S. Welder #1	0.04	N.D.
HF-15	0750-1500	P.S. Welder #2	N.D.	N.D.
HF-11		G.A. Welding Area	N.D.	N.D.
HF-7	0757-1457	P.S. Aluminum Furance Attendant	0.02	N.D.
HF-4	0710-1445	G.A. Aluminum Furnace Area	N.D.	N.D.
HF-9	0730-1530	G.A. Bobcat - all over foundry	N.D.	N.D.
HF-5	0825-1445	G.A. Catwalk east end	0.03	0.01
HF-6	0825-1445	G.A. Catwalk west end	0.03	0.01
Environmental Criteria				
NIOSH			2.5	2.5
OSHA			2.5	5.0
TLV			2.5	2.0

* Approximate milligrams of substance per cubic meter air
** Not detected: The limit of detection for these samples was: 0.005 (Particulate Fluorides) 0.004 (Gaseous Fluorides)

TABLE

Results of Sampling for Airborne Oxides of Nitrogen and Ozone
Arapahoe Aluminum Foundry
Englewood, Colorado
February, 1979
HE 79-9

Environmental Conditions: Indoors, Temp. 62-80° F, R.H.~10-30%, B.P. 625 mmHg

Sample No.	Time	Description	Results (mg/M^3)* Nitrogen Dioxide	Nitric Oxide	Ozone
OZ-1	0810-1310	General Area (G.A.) Welding Area	—	—	0.03
OZ-2	1310-1455	General Area (G.A.) Welding Area	—	—	0.02
NO1	0715-1120	Personal Sample (P.S.) Welder #1	1.1	0.17	—
NO1A	1120-1230	Personal Sample (P.S.) Welder #1	0.28	0.06	
NO1B	1230-1447	Personal Sample (P.S.) Welder #1	0.18	0.98	
NO2A	1040-1235	P.S. Welder #2	0.03	0.59	
NO2B	1235-1447	P.S. Welder #2	0.28	0.07	
NO3	0800-1019	G.A. Welding Area	0.09	0.07	
NO3A	1919-1455	G.A. Welding Area	0.08	0.05	
Environmental Criteria					
NIOSH			1.8**	30	—
OSHA			9**	30	0.2
TLV			9**	30	0.2

* Approximate milligrams of substance per cubic meter air
** Based on a 15 minute ceiling not an eight hour time weighted average.

Table X

Results of Sampling for Airborne Contaminants
Arapahoe Aluminum Foundry
Englewood, Colorado
February, 1979
HE 79-9

Environmental Conditions: Indoors, Temperature 62-80°F, R.H. ~ 10-30%, B.P. 625 mm Hg

Sample No.	Time	Description	Results (mg/M^3)* Ammonia	Cyanide	Formaldehyde[1]	Oilmist	Ozone
NH_3-1	0815-1430	Personal Sample (P.S.) Hot Box Core Operator	2.9	--	--	--	--
NH_3-2	0630-1430	General Area (G.A.) Core Room	3.1	--	--	--	--
Cya-1	0740-1456	G.A. Heat Treating Room	--	N.D.**	--	--	--
Cya-2	0740-1456	P.S. Heat Treating Operator	--	0.02	--	--	--
Oz-1	0810-1310	G.A. Welding Area	--	--	--	--	0.03
Oz-2	1310-1455	G.A. Welding Area	--	--	--	--	0.02
AA-1	0645-1515	P.S. Heat Treating Operator	--	--	--	0.29	--
AA-53	0750-1434	G.A. Heat Treating Area	--	--	--	0.35	--
AA-83	0740-1600	P.S. Heat Treating Operator	--	--	--	0.15	--
AA-87	0747-1434	P.S. Heat Treating Operator	--	--	--	0.64	--
Ald-3	0611-1430	P.S. Hot Box Core Operator	--	--	0.01	--	--
Ald-4	0755-1430	G.A. Core Muller Area	--	--	0.07	--	--
Ald-5	0810-1450	G.A. Mounted on Bobcat (all over foundry)	--	--	0.03	--	--
Ald-6	0825-1445	G.A. East End of Overhead Catwalk	--	--	0.07	--	--
Environmental Criteria							
NIOSH			35	5	1.2	--	--
OSHA			35	5	3	5	0.2
ACGIH			25	5	3	5	0.2
** Not Detected - The limit of detection for these samples were:			0.002	0.003	0.004	0.05	0.001

* Approximate milligrams of substance per cubic air
** Not Detected - The limit of detection for these samples were: see last row above
[1] Other aldehydes screened for were not detected and included acetaldehyde, propionaldehyde, n-butyraldehyde, and n-valeraldehyde.

Ti XI

Results of Sampling for Airborne Benzene Soluble Particulates

Arapahoe Aluminum Foundry
Englewood, Colorado
December, 1978 and February, 1979
HE 79-9

Environmental Conditions: Indoors, Temperature 62-88° F, R.H. - 10-30%, B.P. 616, 625 mm Hg

Sample No.	Time	Description	Results (mg/M³)* Benzene Soluble Fraction[1]
FGAG-1	0600-1430	General Area (G.A.) between Mold Line #4-5	0.02
FGAG-2	0550-1430	G.A. Core Muller	0.19
FGAG-1	0750-1434	G.A. Heat Treating Room	0.20
FGAG-2	0747-1434	Personal Sample Heat Treating Operator	0.33
FGAG-4	0710-1445	G.A. Furnace Area	0.12
FGAG-5	0730-1530	G.A. Mounted on Bobcat (All over Foundry Area)	0.06

*Approximate milligrams of substance per cubic meter air

1. It is possible that the benzene soluble fraction was due to oil mist and not coal tar pitch volatiles (CTPV) thus the occupational exposure criteria of 0.1 may not apply for these samples. No specific polynucleararomatics (PNA's) were detected.

TABLE XII

Results of Swipe Samples for Heavy Metals Contamination
Arapahoe Aluminum Foundry
Englewood, Colorado
February, 1979
HE 79-9

Sample No.	Description	Results ($\mu g/ft^2$)* Al[1]	Cr[2]	Cu[3]	Pb[4]	Zn[5]
SS-1[6]	Lunch room table	130	N.D.**	93	8	39
SS-1A[7]	Lunch room table	10000	15	8100	540	2400
SS-2[6]	Office - receptionist's desk	32	N.D.	15	N.D.	9
SS-2A[7]	Office - receptionist's desk	170	N.D.	90	10	49
SS-3[6]	Lunch room table	73	N.D.	68	5	37
SS-4[6]	Office - desk	32	N.D.	13	N.D.	9
SS-6[6]	Surface where employees heat up food	200	N.D.	N.D.	N.D.	20
SS-7[6]	Lunch box - Zinc furnace operator	31	N.D.	13	N.D.	24
SS-8[6]	Locker	580	N.D.	900	53	470

* Approximate micrograms of substance per square foot of surface area

** Not Detected: The limit of detection for these metals was:	10	5	2	5	2

1. Aluminum
2. Chromium
3. Copper
4. Lead
5. Zinc
6. Swipe sample taken dry - These samples would not be as representative of real contact exposure as would the moistened swipe samples.
7. Swipe sample moistened with double distilled water before swiping surface - This would be the most representative of the contamination of skin contact because the surface skin would be moist from perspiration.

TABLE XIII

Results of Sampling for Core Resin Emmissions
Arapahoe Aluminum Foundry
Englewood, Colorado
HE 79-9

February 1979

Environmental Conditions: Temperature 62-80° F, R.H.~10-30%, B.P. 625 mm Hg

Sample Number	Time	Description	Results (mg/M3)* HMTA[1]	MDI[2]	Phenol
HMTA-1	0725-1509	General Area (G.A.) Hot box core area	0.01	-	—
HMTA-2	0630-1430	G.A. Hot box xore area	0.02	-	—
Phen-1	0845-1509	G.A. Hot box core area	—	-	0.52
Phen-2	0848-1510	G.A. Cold box core muller area	—	-	<0.1***
Phen-3	0611-1430	Personal Sample (P.S.) Hot box core operator	—	-	0.60
Phen-4	0755-1430	G.A. Cold box core muller area	—	-	0.25
Phen-5	0810-1450	G.A. Mounted on Bobcat (all over foundry)	—	-	0.23
Phen-6	0825-1445	G.A. Catwalk east end	—	-	0.79
Phen-7	0825-1445	G.A. Catwalk west end	—	-	0.53
MDI-1	0835-1510	G.A. Cold box core muller area	—	N.D.**	—
MDI-2	0755-1430	G.A. Cold box core muller area	—	N.D.	—

* Approximate milligrams of substance per cubic meter air
** Not Detected
*** "<" Denotes less than
1. Hexamethylenetetramine
2. Methylene bisphenyl isocyanate

Environmental Criteria	HMTA	MDI	Phenol
NIOSH	—	0.05	20
OSHA	—	0.2	19
ACGIH	—	0.2	19

TABLE XIV

Results of Noise Survey
Arapahoe Aluminum Foundry
Engelwood, Colorado
February, 1979
HE 79-9

Location	Description	Noise level dBA (slow response)
Core Room	Background	70-75
Core Room	Hot box core machine vibrator 5 seconds/minute	102
Finishing	Background at lunch	74-78
Finishing	Background during production	90-92
Finishing	Hand Grinder - large disc	105-108
Finishing	Hand Grinder - small disc	95-105
Finishing	Stationary Grinder #1	95-105
Finishing	Stationary Grinder #2	90-100
Finishing	Stationary Grinder #3	100-103
Finishing	Aluminum cast saw	99-105
Finishing	Zinc Furnace	80-90
Finishing	Heliarc welding	85-92
Foundry	Furnace	95-100
Foundry	Mold lines	90-100
Foundry	Mold packing - air hammer	100-110
Foundry	Muller	87-94
	Shakeout	100-110-112 peak
Heat Treating	Background	80-85
Patternshop	Background	70-75
Patternshop	Disc sander	90-95

Environmental Criteria

NIOSH 85 dBA for an eight hour time weighted average (TWA) daily exposure
OSHA 90 dBA for an eight hour time weighted average (TWA) daily exposure
TLV 85 dBA for an eight hour time weighted average (TWA) daily exposure

TABLE XV

Employee Demography and Medical Data

Arapahoe Aluminum Foundry
Englewood, Colorado

November 30 & December 1, 1978

HE 79-9

A. Number of Employees at Time of Request:

	Administrative		Production[1]	
	Male	Female	Male	Female
	4	3	64	0
Total:	7		64	

Total 71

B. Number of Employees at Time of First Evaluation

	Male	Female	Male	Female
	4	3	48	0
Total:	7		48	

Total 55

C. Number of Employees Interviewed: 48 (100% of Production)

33 (69%) Smokers
7 (15%) Ex-Smokers
8 (16%) Non-Smokers

1. Number of Employees indicating health problems - 9 (19%)
2. Number of Employees indicating no health problems - 39 (81%)
3. Average age of employees interviewed - 32
4. Average length of employment at Arapahoe Foundry - 2.6 years

D. Number of Participants in the Blood Lead Evaluation during the Following Survey: 47 - 3 (females)
44 (males)

1. Number of blood lead values exceeding the new OSHA standard of 40 ug $^{Pb}/100_g$ blood - 38 (81%)
2. Number of Free Erythrocyte Protoporphyrin (FEP) values exceeding the normal range of 356-662 ug FEP/liter RBC - 34 (72%)
3. Of those with a blood lead over 40 ug $^{Pb}/100$ g whole blood:

28 (74%) Smokers
10 (26%) Non-Smokers

Appendix A

Results of Bulk Sample Analysis

Arapahoe Aluminum Foundry
Englewood, Colorado

November 30 & December 1, 1978

HE 79-9

Sample Number	Description	Results - Substances Identified								
		Al[1]	Cr[2]	Cu[3]	Fe[4]	Mg[5]	Mn[6]	Ni[7]	Pb[8]	Zn[9]
B-15	Foundry Dust	-*	+**	+	+	+	+	+	+	-
B-17a	Grinding Area Dust	+	+	+	+	+	+	+	+	+
B-17b	Saw Area Dust	+	+	+	+	+	+	+	+	+
B-14	Al Flux	-	-	-	-	-	-	-	+	-
B-20	Al-Zn Fluz	+	-	-	-	-	-	-	-	-
B-4	Degasser	+	-	-	-	-	-	-	-	-

Sample Number	Description	Results
B-8 B-9	Fibrous insulation " "	no asbestos; the material is fibrous mineral wool primarily composed of Al-Si
B-21	Mold release powder	not asbestos; the material is primarily calcite
B-22	Mold release paint	C_7H_{16} alkanes including, C_7H_{14} cycloalkanes including methyl cyclohexane, trace toluene
B-6a	Resin component for cold box molds	C_9H_{12} aromatics including propyl benzene and trimethyl benzene isomers, $C_{10}H_{14}$ aromatics diethyl benzene and tetramethyl benzene isomers, phenol, butyl cellosolve acetate, o-hydroxybenzyl alcohol, formaldehyde
B-6b	Resin component for cold box molds	methylene bisphenyl isocyanate, aromatics as in 6h
B-6c	Resin component for cold box molds	4-(3-phenylpropyl) pyridine, aromatics as in 6a
B-12	Core Sand	100 % quartz <0.8% Cristobalite
B-5	Mold Sand	7.4% quartz <1.0% Cristobalite

1. Aluminum
2. Chromium
3. Copper
4. Iron
5. Magnesium
6. Manganese
7. Nickel
8. Lead
9. Zinc

*not detected
**detected