U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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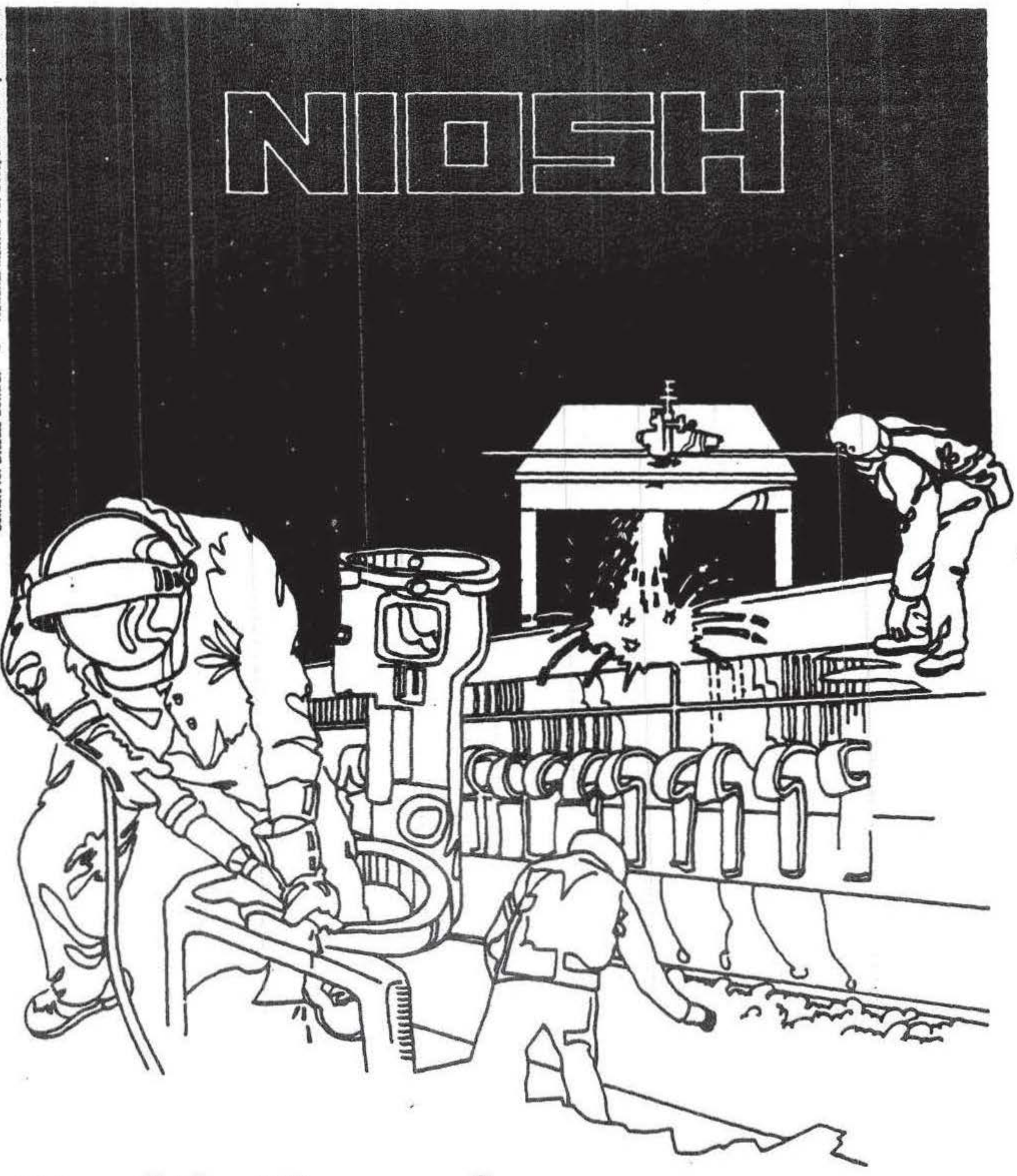

Health Hazard Evaluation Report

HETA 84-060-1645
GENERAL MOTORS CORPORATION
DAYTON, 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 84-060-1645
DECEMBER 1985
GENERAL MOTORS CORPORATION
DELCO MORAINE DIVISION, SOUTH PLANT
DAYTON, OHIO

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I. SUMMARY

In November 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate two cases of arsenic poisoning among workers at General Motors Corporation (GMC), Delco Moraine Division, South Plant, Dayton, Ohio. One millwright from Department 48 had been diagnosed as having arsenic poisoning in September 1973; a second millwright from the same department was diagnosed in July 1983. NIOSH investigators made site visits on January 12-13, January 16-20, and January 30 through February 3, 1984.

During the site visits, NIOSH investigators attempted to determine if arsenic was present in sufficient amounts to have caused the poisonings by taking samples of airborne and settled dust, taking bulk samples of ingredients used in the process, and by interviewing millwrights who currently or previously worked in Department 48. The company had measured trace amounts of arsenic (approximately 0.001%) in bulk samples from the department in late 1983.

Only one of the 68 air samples collected contained a detectable amount of arsenic. This was an area sample with a concentration of 3.3 micrograms per cubic meter of air (ug/m^3). The NIOSH recommended standard is 2 ug/m^3 and the OSHA permissible exposure limit is 10 ug/m^3. The analytic method used also provided data on over 20 other metals. These supplemental results indicated that breathing-zone air concentrations of nickel and barium exceeded current occupational exposure criteria for millwrights at work in the furnaces. Fifteen nickel values (17.6 to 1280) exceeded the NIOSH recommended standard of 15 ug/m^3 and four barium values (502 to 678 ug/m^3) exceeded the OSHA and ACGIH criteria of 500 ug/m^3. Arsenic was below the limit of detection (0.005%) in all 36 bulk samples collected. One copper sample value (5700 ug/m^3) exceeded the OSHA and ACGIH criteria of 1000 ug/m^3. NIOSH investigators also measured the air levels of carbon monoxide and arsine gases. Arsine was not detected; carbon monoxide concentrations ranged up to 15 parts per million (ppm), which is below the NIOSH recommended standard of 35 ppm.

NIOSH investigators also performed a questionnaire survey and monitoring of urine arsenic levels for the workers in Department 48 to determine if anyone exhibited symptoms of arsenic poisoning. None of the workers had symptoms consistent with arsenic poisoning. Urine arsenic levels ranged from nondetectable to 76 ug As/g creatinine. All values were below the suggested limit of 100 ug As/g creatinine.

Based on these findings NIOSH concluded that employees were not exposed to detectable levels of arsenic during the time of the NIOSH investigation.Trace amounts of arsenic measured in bulk samples by the company are unlikely to have caused the two cases of arsenic poisoning. Our bulk sample analysis did not reveal any location where arsenic had accumulated in quantities above our laboratory limit of detection (0.005%). Due to equipment removal, past exposures could not be evaluated completely. Excessive exposure to nickel, barium and copper were discovered. Recommendations are made in Section VII to reduce exposures to these compounds.

KEYWORDS: SIC 3714 (motor vehicle parts and accessories), arsenic, nickel, barium, lead, carbon monoxide, arsine, methane

II. INTRODUCTION

In November 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from an official of the United Auto Workers Union representing workers at the South Plant of General Motors Corporation (GMC), Delco Moraine Division, in Dayton, Ohio, for an evaluation of potential occupational exposures which may have caused two cases of arsenic poisoning in Department 48. NIOSH investigators made site visits on January 12-13, January 16-20, and January 30 through February 3, 1984. All employees who participated in the urine arsenic testing were notified of their own test results in June 1984. The environmental results was distributed in August 1984 to union and management representatives.

III. BACKGROUND

A. Facility Description

The South Plant of GMC's Delco Moraine Division is a large complex consisting of two major buildings built in 1914 and 1955. The complex employs 2650 employees and manufactures the component parts and assemblies for brake, air-conditioning, transmission, and other automotive systems. Department 48 is located in the southern end of the east building and occupies part of two floors.

B. Processing

Department 48 produces a variety of metal parts by a metal-sintering process. This process begins on the second floor where iron or copper-based powders are mixed. One mixture contains primarily iron with graphite and zinc stearate comprising less than 10% each. A second iron mix is similar except that it contains approximately 3% sulfur. A third mix is primarily copper with nickel comprising less than 20%. A special mix for brake linings contains iron, steel wool and barium. After mixing, the mixes are transferred in containers to feed ports located above a corresponding hydraulic press. The mixes are gravity fed into each press and compressed in dies into the desired shape, forming a friable part called a "green" part. The metal powder aggregate is then stacked on trays which are fed by automatic conveyors into a metal-sintering furnace.

The furnace heats the powdered metal to the point where it fuses into a solid part, but does not melt. The 120-foot-long furnace is divided into a preheat zone, a three-section high temperature zone, a "shock" zone, and a cooling zone. The preheat zone is heated by natural gas and operates at temperatures ranging from 800-1600°F, the high temperature zones are heated electrically and operate at 1950-2050°F. The entire furnace is filled with a nonoxidizing atmosphere of methane, carbon dioxide, hydrogen, nitrogen, and carbon monoxide kept at a concentration above the upper explosive limit of the mixture. After passing through the furnace, the parts are cooled further and inspected. They are then sent to other areas for machining and/or assembly. The process runs 24 hours a day, 5 days per week.

Production capacity has been decreasing as old furnaces are phased out; some of the furnaces have been removed completely. The number of active sintering furnaces has decreased from 23 to 7. Concurrently, daily production has dropped from approximately 200,000 lbs in 1970 to 25,000 lbs in 1984.

One variation of the metal sintering process involves the use of copper as an additive to the metal parts. In this variation, copper powder is pressed into a washer shape that is placed on top of an iron powder "green" part. This is then fed into the furnace, where the copper powder, with its lower melting point, melts and runs into the crevices between the iron particles.

C. Furnace Maintenance

Maintenance of the sintering furnaces usually consists of three specific types of operations. From the outside of the furnace, the burnoff stacks that burn and vent the flammable furnace atmosphere to the hoods above are cleaned once per shift. This involves opening a clean out plug at the bottom of the stack and using a metal rod to remove residue. Single conveyor rollers can be replaced by partially cooling the oven and pulling the roller out of the side. Most of the other maintenance requires furnace entry. This entails a 48-hour cool down and aeration procedure to make it safe to enter. After cool down, the safety department checks the furnace interior for the absence of carbon monoxide and the presence of adequate oxygen. Then millwrights and welders are allowed to enter. Common repairs to the interior of the furnace include replacing deformed rollers and broken heating elements, or repairing the firebricks lining the furnace. Replacing heating elements requires using a torch to remove the nickel-steel elements and then welding in new elements. The interior of the furnace is shaped like a tunnel about four feet high and four feet wide. Workers lie on the rollers while working in the furnace.

D. Muffle Furnaces

Another set of furnaces, called muffle furnaces were also in Department 48. These furnaces produced simpler parts by a more automated metal sintering process. The parts are fed automatically from the press onto a steel mesh belt which carries the parts through the muffle furnace. In the past, the muffle furnaces had been used to manufacture babbitt iron pistons. The metal powder mixture for this part contained lead and necessitated a blood lead screening program for the workers in the area and in the powder mix room upstairs. Use of the lead based powder ceased in 1982.

E. Employee Profile

Department 48 includes approximately 35 workers. The first and second shifts require about 15 workers each, with the remaining employees covering the third (midnight) shift. The mixer is responsible for preparing each specific mix. This employee also operates the regrind equipment in which scrap parts are ground and then recycled by addition to some mixes. Furnace operators monitor furnace door cycle times, zone temperatures, and conveyor speeds. They also load trays of parts onto the furnace belt. Press operators run presses, check part quality, and load pressed parts onto trays for sintering. They operate from one to three presses each, depending on the size of the press. Job setters are responsible for adjusting presses and changing press dies. Truckers are responsible for moving supplies between different areas. The lab man is responsible for monitoring the atmosphere inside each furnace, and selecting the furnace and proper sintering cycle for each lot of powder. Custodians are responsible for general cleanup of the area.

Millwrights are part of the maintenance department and assigned to different areas in the plant, including Department 48. They are responsible for maintenance of the furnaces and other equipment. They work with welders, electricians, etc., depending on the specific task involved.

The primary occupational exposures in Department 48 are to metals (i.e., nickel, copper) and gases (i.e., CO). Sources of metals include the raw materials being used, accumulations from past production, and welding and torching activities. These are also potential sources for arsenic which is often a trace contaminant in metals. It may also be used as a alloying agent for metals such as lead.[1] The primary source of gases are the furnace atmospheres.

The furnace heats the powdered metal to the point where it fuses into a solid part, but does not melt. The 120-foot-long furnace is divided into a preheat zone, a three-section high temperature zone, a "shock" zone, and a cooling zone. The preheat zone is heated by natural gas and operates at temperatures ranging from 800-1600°F, the high temperature zones are heated electrically and operate at 1950-2050°F. The entire furnace is filled with a nonoxidizing atmosphere of methane, carbon dioxide, hydrogen, nitrogen, and carbon monoxide kept at a concentration above the upper explosive limit of the mixture. After passing through the furnace, the parts are cooled further and inspected. They are then sent to other areas for machining and/or assembly. The process runs 24 hours a day, 5 days per week.

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Exposure to both gases and metals would result from emissions from the processing equipment. Emissions from the furnaces could involve both gases and metals, emissions from other processing equipment (i.e., presses) would usually involve only metals. Other sources of metals include clean-up and maintenance activities.

IV. EVALUATION DESIGN AND METHODS

A. Environmental Investigation

The environmental investigation included an assessment of current and potential past exposures to arsenic and other metals. For assessment of current exposures personal air samples were collected from the breathing zone of millwrights and other employees, and area samples were collected in various locations. These samples were analyzed for metals and arsine (a gaseous arsenic compound, AsH_3). Area air samples for arsine were also obtained near the furnaces. Bulk samples of two different sealing materials used on furnace inspection doors were obtained and analyzed for asbestos content. Additionally, bulk samples of metal powder raw materials used during the surveys were collected.

To assess the potential for past exposures, current and past millwrights were interviewed concerning their work activities to determine if any specific job or location was a likely exposure area. This group of employees included both millwrights who had been diagnosed as having arsenic poisoning. Additionally, bulk samples of dust were collected throughout Department 48. Dust samples were collected from rafters, ventilation hoods, and processing equipment including various locations inside the sintering furnaces where millwrights periodically conduct maintenance activities. Samples were collected from furnaces temporarily down for repair as well as furnaces which had not been used for several years.

Airborne metals samples were collected on mixed cellulose ester membrane filters and analyzed using inductively coupled plasma-atomic emission spectroscopy (ICP-AES) for 31 separate metals. The limit of detection for this analysis is 1 ug/sample. Air samples for arsine were collected on charcoal tubes and analyzed using atomic absorption spectroscopy. All bulk samples were analyzed for over 20 separate metals using ICP-AES.

Due to problems of spectral interferences, arsenic could not be quantified with any reasonable certainty and therefore a portion of each bulk sample was analyzed specifically for arsenic using a graphite furnace technique with a laboratory limit of detection of 0.005% (50 ppm).

Direct-reading air samples for arsine and carbon monoxide were collected using gas detector tubes. Additional information on sampling and analytic techniques is presented in Appendix I.

B. Medical Investigation

Questionnaires were administered to workers in Department 48 to elicit any symptoms of arsenic toxicity and any other health effects associated with working in the department. Urine samples were also collected and analyzed for total arsenic by anodic stripping voltammetry.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards.

The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

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

B. Specific Substances

1. Arsenic

Arsenic, usually encountered as arsenic trioxide, is a notorious poison. Ingestion leads to vomiting, jaundice, kidney damage, and a delayed (7-14 days) nerve damage.[2] The trivalent form of arsenic is toxic, the pentavalent form is found in seafood and is not known to be toxic. Chronic exposure to arsenic has been associated with skin cancers, and in copper smelters with coexistent sulfur dioxide exposure, a lung cancer excess has been found. Due to the naturally occurring arsenic in the diet, normal urine arsenic levels run up to 100 micrograms per gram of creatinine.[3]

Industrial arsenic poisoning is rarely reported, but can occur when concentrated arsenic compounds are in use. This has happened with arsenical pesticides and in the glass industry where arsenic is an additive. The NIOSH recommended standard for arsenic is 15 ug/m^3 based on a 15 minute sample[4]. The current OSHA permissible exposure limit (PEL) is 10 ug/m^3 based on an 8-hour TWA.[5]

2. Carbon Monoxide

Carbon monoxide is an odorless, colorless gas. It is absorbed through the lungs and binds reversibly to myoglobin, cytochrome oxidase, and hemoglobin. Its net effect is to prevent the normal usage of oxygen in the body. Symptoms of carbon monoxide poisoning occur with increasing frequency as carbon monoxide levels increase: at low levels, headache, nausea, and vomitting occur. At higher levels, dizziness, loss of consciousness, and death may occur. Chronic exposures to lower (less than 100 ppm) levels of carbon monoxide have been associated with heart muscle necrosis and central nervous system damage in animal studies. The risk in humans is primarily in persons with atherosclerotic coronary vascular disease (ASCVD). This is a common condition, affecting up to 77% of males over 20 years old. For this reason, the NIOSH recommended standard is designed to provide protection to persons with ASCVD, by limiting exposure to 35 ppm.[6] The OSHA PEL is 50 ppm.[5]

3. Nickel

OSHA estimates that nearly 75,000 employees are potentially exposed to nickel and its compounds. Human health hazards from exposure to nickel compounds include allergy, dermatitis, rhinitis and sinusitis, and cancer of the nasal cavities, lungs and other organs.[7]

Nickel metal has long been known to cause dermatitis. Exposure to nickel metal fume may cause respiratory irritation and pneumonitis.[8] Nickel refinery workers have been found to have excessive rates of both lung and nasal cancer. The specific nickel compound responsible has not been identified.[7,9] There is disagreement at present over the cancer risk to employees exposed to nickel compounds in non-refinery occupations. The International Labor Office states: "At present there is insufficient information to judge whether or not cancer risks are increased in workers who have been exposed to nickel compounds in non-refinery occupations..."[7] The National Toxicology Program, however in their annual report (1983) stated: "There is sufficient evidence of carcinogenicity of nickel and certain nickel compounds".[10] ACGIH distinguishes between nickel metal and insoluble nickel compounds; soluble nickel compounds; and nickel sulfide roasting dust and fume, with the latter being considered as a material associated with an increased risk of respiratory cancer.[11] NIOSH, on the basis of cancer excess in nickel refinery workers exposed to various nickel compounds and laboratory animal studies, considers inorganic nickel to be carcinogenic and defines nickel to include elemental nickel and all other nickel compounds except organonickel compounds (e.g., nickel carbonyl).[9] The NIOSH recommended occupational exposure criterion is 15 ug/m^3 of air, for up to a 10-hour exposure.[9] The OSHA PEL for nickel metal and soluble compounds is 1000 ug/m^3.[5]

4. Barium

Barium is a metal found in trace amounts in nature. Respiratory exposure to barium causes X-ray changes in the lungs. Long-term follow-up of these workers, however, shows clearing of the barium without evidence of permanent damage. The OSHA PEL for barium is 0.5 milligrams per cubic meter of air, as is the ACGIH TLV.[5,12]

5. Methane

Methane, most commonly encountered as natural gas, has few toxic properties. Its primary hazard is fire and explosion. In confined spaces, it can also exclude oxygen, causing unconsciousness. ACGIH classifies methane as a simple asphyxiant with no specific TLV. The two critical aspects of exposure are maintaining available oxygen above 18% by volume and keeping the air level of methane below the explosive concentration.[11,12]

VI. RESULTS AND DISCUSSION

A. Environmental

1. Sampling

Results of personal and area sampling for metals are presented in Tables 1 and 2. For the 69 personal air samples collected, six metals are of primary concern based on their potential for adversely affecting employee health (arsenic, nickel, lead, chromium, copper, and barium). Results are also presented for iron, because of its abundance in both air and bulk material samples. Of these metals, nickel and barium were found in the highest relative concentrations when compared to current environmental criteria. Fifteen nickel and four barium sample results were at or above the current criteria of 15 ug/m^3 for nickel (NIOSH) and 500 ug/m^3 for barium (OSHA and ACGIH). Of the 15 nickel sample results (ranging from 17.6 to 1280 ug/m^3) exceeding the NIOSH recommended standard, eight were from millwrights and three from welders working inside sintering furnaces. The other four samples were collected from the mixer. Of the four barium sample results (502 to 678 ug/m^3) at or exceeding the OSHA and ACGIH criteria, two were collected from job setters and two from the cold mold press operator.

Arsenic was found on only one air sample, an area sample collected in the break area for Department 48. The arsenic concentration was 3.3 ug/m^3 (2.9 ug on the filter). Arsenic was not detected on any of the personal air samples. Additionally, arsine was not detected on any of the personal or area samples collected.

Air concentrations of copper ranged from below the laboratory limit of detection (1 ug/filter) to 5700 ug/m^3. One sample result exceeded the OSHA PEL of 1000 ug/m^3. The mixer had two of the three highest copper concentrations (360 and 5700 ug/m^3). Air concentrations of chromium, lead, and iron ranged from nondetectable to 82.3 ug/m^3 for total chromium, from nondetectable to 10.3 ug/m^3 for lead, and from 4.2 to 5620 ug/m^3 for iron.

Analysis of bulk dust samples (Table 3) revealed that arsenic was below the laboratory limits of detection (0.005%) in all samples. Raw materials contained high percentages (up to 68%) of copper or iron, with nickel, chromium and lead concentrations all being less than or equal to 0.01%. High percentages of nickel, chromium, and lead were found in some bulk dust samples. Samples collected in or near sintering and muffle furnaces had the highest percentages of these three metals, with nickel comprising up to 27%, chromium up to 16%, and lead up to 65%. Areas where dust contained the highest percentages of these metals were: for nickel and chromium, the heat zones of sintering furnaces; and for lead, the inside of the exhaust hoods at the entrance and exit end of sintering and muffle furnaces.

An interesting aspect of this investigation is the variety of colors of the bulk samples collected. Excluding raw materials the colors included white; light, medium, and dark gray; red/orange; copper; and black. An excellent example of the variety was exhibited in bulk samples (B-23 to B-26) collected at and in front of the shock chamber (inside the furnace) of sintering furnace number 68. Within a distance of 10 feet the colors of bulk samples were white, dark gray, and black. The color differences were probably due to the temperature change as material entered the shock chamber and continued through the cooling chamber. As the temperature cools, different metal compounds probably deposit at different locations as they reach their melting temperatures.

Arsine was not detected on any of the 15 personal and area samples collected (Table 4). These include both short-term (15-minute) and full-shift samples. Area samples were collected at various locations near the sintering and muffle furnaces.

Table 5 presents the results of short-term sampling for arsine and carbon monoxide using direct-reading gas detector tubes. Arsine was not detected on six samples. Carbon monoxide ranged from 8 to 15 ppm on eight samples. The CO values are well below the NIOSH recommendation for full-shift (35 ppm) and ceiling exposures (200 ppm).

One of the two bulk samples of sealing material contained approximately 90% chrysotile asbestos. This sample was of an old type material collected as a furnace inspection door was being removed. The second sample, of a newer sealing material being used to reseal a furnace inspection door, contained no asbestos.

In September - October 1983 management had collected and analyzed bulk dust samples from various furnaces, exhaust hoods, etc., in Department 48. Many of the samples contained trace amounts of arsenic (approximately 0.001%). As a comparison arsenic is present in the earth's surface at approximately 0.0005%.[1]

2. General Observations

Informal interviews with current and previous millwrights revealed considerable concern about arsenic exposure. The employees, in general, were knowledgeable about arsenic and its toxicity. The millwrights and welders are groups with the most potential for acute high exposure to metals since they work in and around sintering furnaces and other processing equipment. In addition to inhalation of metals for workers who enter furnaces other potential hazards include ingestion and deposition of particulates on the eyes.

Protective equipment available to employees included half mask and full face respirators, head coverings, disposable coveralls, safety shoes, sleeves, and gloves. The employees, however, did not use most of the equipment during furnace repair activities.

Company monitoring during the initial survey indicated CO levels of 35-40 ppm near one of the sintering furnaces. The company conducts CO monitoring prior to an employee entering a furnace to ensure that carbon monoxide levels are safe. These values equal the NIOSH recommended limit (35 ppm) for full-shift exposures.

There are various emission sources for metals in Department 48. The presses accumulate metal powder during press operation. Compressed air was used to clean parts after pressing and to clean the presses before changing to a different part. This practice is known to significantly increase airborne concentration of particulates. The mixing area also had two emission points: the mixing machine which emitted particulates as it revolved, and the regrind operation. There was local exhaust ventilation at the mixing area and on the regrind, but it appeared to be ineffective. Other sources of metals include metal powder overflowing when one bin with metal powder is set on top of another bin, and at feed ports above the hydraulic presses.

Observation of the millwrights activities revealed that the employees were provided a wide selection of protective equipment. Improvements are needed however, in the use of the equipment. For example, some employees observed wearing respirators had beards. Beards or any facial hair extending into the sealing surface compromises the effectiveness of the respirator.[13-15] Additionally, many employees who were assigned respirators reported that they had not been fit tested.

B. Medical Results

One millwright had been diagnosed as having arsenic poisoning in September 1973, and a second in September 1983. Both were hospitalized for several months and were paralyzed for part of the time. One worked as a millwright at the plant about one year before becoming ill. The other whose illness began during a vacation worked in production initially, then seven years as a millwright. Interviews with the two millwrights did not establish a common link between their activities during the months preceding their illness. Although both had been assigned to Department 48 during the year prior to becoming sick, they engaged in no unique activities which might explain where the arsenic was encountered.

None of the other employees interviewed had symptoms suggestive of arsenic toxicity. Urinary arsenic levels (measured in 26 specimens from 18 workers) ranged from nondetectable to 76 ug As/g Creat., with a median of 6.5 ug As/g Creat. All these results are within the suggested limit of 100 ug As/g Creat.[3]

Discussion and Conclusions

Results of this investigation indicate that employees were not exposed to detectable levels of arsenic during the time of the NIOSH visits. Employees were exposed to air concentrations of nickel, barium, and copper at or above at least one of the current occupational exposure limits. Additionally, the older furnace-door sealing material contained a high percentage of chrysotile asbestos. Improvements are needed in employee training and education concerning respiratory protection.

Arsenic had been measured by the company in trace amounts in samples of dust from Department 48. However, at the amounts measured it is unlikely that occupational exposures would cause overt poisonings. For example, at 0.001% arsenic, an exposure of 100 mg/m^3 would result in an arsenic air concentration of 1 ug/m^3. The highest exposure to metals measured on a millwright was around 1 mg/m^3. Some maintenance activities may expose millwrights to much higher particulate concentrations than were measured during the NIOSH surveys. Even then however, personal arsenic exposures would probably not exceed 1 ug/m^3.

Ingestion, as indicated earlier, is also a potential route of exposure. At the trace amounts measured however, it is unlikely that much arsenic would be ingested.

If the poisonings were a result of plant exposures, other explanations are more feasible. First, arsenic may have been present in higher concentrations in the past but reduced through process changes, such as discontinuing the use of lead based powders in 1982. We did not, however, learn of significant changes after the second individual became ill. Second, arsenic may have accumulated in higher amounts in a location in Department 48 which was not evaluated. This seems unlikely, given the thorough sampling of workers and active and inactive equipment in the department. Lastly, the exposures could have occurred in a different department. However, interviews with the two millwrights did not suggest a likely location.

NIOSH conducted a previous health hazard evaluation at this facility in 1973.[16] During that evaluation environmental samples were collected for asbestos and metals including lead, nickel, copper, and chromium. Arsenic levels were not measured. Most air samples were below the applicable exposure limits, except for one sample for lead and one for copper. NIOSH has conducted approximately 20 health hazard evaluations (HHE) in plants producing automotive parts. However, only three of the plants were using powdered metal as a raw material.[16-18] Barium has been evaluated in two previous HHEs with concentrations being higher in one study and lower in the other.[18-19]

VII. RECOMMENDATIONS

Based on the results of this investigation the following recommendations are made:

1. The respiratory protection program should be improved to ensure that employees who wear respirators do not have facial hair interfering with the sealing surface. Additionally, all employees assigned respirators should be fit tested.

2. Management should continue monitoring millwrights for metals and other exposures during non-routine maintenance activites. Of particular importance are activities that are anticipated to involve high exposure to metals or other chemicals (e.g., repair of duct work, air cleaners, muffle furnaces).

3. During non-routine type repairs, millwrights and other employees (i.e., welders) should continue wearing protective equipment particularly respirators and goggles.

4. Management should proceed with efforts to reduce employee exposures to nickel and barium. Engineering controls, and improvements in work practices such as eliminating the use of compressed air are preferred techniques. Respiratory protection may be necessary on an interim basis.

5. Carbon monoxide monitoring of the furnace area in Department 48 should be conducted at least once a shift. Carbon monoxide leaks on the furnaces should be repaired promptly.

6. The old type sealing material, which contains asbestos, should no longer be used. Additionally, until such time that all old type sealing material has been replaced, employees removing furnace inspection doors should wear respiratory protection that is certified for use in atmospheres containing asbestos.

VIII. REFERENCES

1. Windholz M, Budavari S, Stroumtsos LY, Fertig MN, eds. The merck index: an encyclopedia of chemicals and drugs. 9th ed. Rahway: Merck & Co., 1976.

2. Hamilton and Hardy's Industrial Toxicology, Fourth Edition, AJ Finkel, ed. John Wright, PSG Inc. 1983.

3. Lauwerys, RR. Industrial Chemical Exposure: Guidelines for Biological Monitoring, page 29, Biomedical Publications, Davis, California 1983.

Discussion and Conclusions

Results of this investigation indicate that employees were not exposed to detectable levels of arsenic during the time of the NIOSH visits. Employees were exposed to air concentrations of nickel, barium, and copper at or above at least one of the current occupational exposure limits. Additionally, the older furnace-door sealing material contained a high percentage of chrysotile asbestos. Improvements are needed in employee training and education concerning respiratory protection.

Arsenic had been measured by the company in trace amounts in samples of dust from Department 48. However, at the amounts measured it is unlikely that occupational exposures would cause overt poisonings. For example, at 0.001% arsenic, an exposure of 100 mg/m^3 would result in an arsenic air concentration of 1 ug/m^3. The highest exposure to metals measured on a millwright was around 1 mg/m^3. Some maintenance activities may expose millwrights to much higher particulate concentrations than were measured during the NIOSH surveys. Even then however, personal arsenic exposures would probably not exceed 1 ug/m^3.

Ingestion, as indicated earlier, is also a potential route of exposure. At the trace amounts measured however, it is unlikely that much arsenic would be ingested.

If the poisonings were a result of plant exposures, other explanations are more feasible. First, arsenic may have been present in higher concentrations in the past but reduced through process changes, such as discontinuing the use of lead based powders in 1982. We did not, however, learn of significant changes after the second individual became ill. Second, arsenic may have accumulated in higher amounts in a location in Department 48 which was not evaluated. This seems unlikely, given the thorough sampling of workers and active and inactive equipment in the department. Lastly, the exposures could have occurred in a different department. However, interviews with the two millwrights did not suggest a likely location.

NIOSH conducted a previous health hazard evaluation at this facility in 1973.[16] During that evaluation environmental samples were collected for asbestos and metals including lead, nickel, copper, and chromium. Arsenic levels were not measured. Most air samples were below the applicable exposure limits, except for one sample for lead and one for copper. NIOSH has conducted approximately 20 health hazard evaluations (HHE) in plants producing automotive parts. However, only three of the plants were using powdered metal as a raw material.[16-18] Barium has been evaluated in two previous HHEs with concentrations being higher in one study and lower in the other.[18-19]

VII. RECOMMENDATIONS

Based on the results of this investigation the following recommendations are made:

1. The respiratory protection program should be improved to ensure that employees who wear respirators do not have facial hair interfering with the sealing surface. Additionally, all employees assigned respirators should be fit tested.

2. Management should continue monitoring millwrights for metals and other exposures during non-routine maintenance activites. Of particular importance are activities that are anticipated to involve high exposure to metals or other chemicals (e.g., repair of duct work, air cleaners, muffle furnaces).

3. During non-routine type repairs, millwrights and other employees (i.e., welders) should continue wearing protective equipment particularly respirators and goggles.

4. Management should proceed with efforts to reduce employee exposures to nickel and barium. Engineering controls, and improvements in work practices such as eliminating the use of compressed air are preferred techniques. Respiratory protection may be necessary on an interim basis.

5. Carbon monoxide monitoring of the furnace area in Department 48 should be conducted at least once a shift. Carbon monoxide leaks on the furnaces should be repaired promptly.

6. The old type sealing material, which contains asbestos, should no longer be used. Additionally, until such time that all old type sealing material has been replaced, employees removing furnace inspection doors should wear respiratory protection that is certified for use in atmospheres containing asbestos.

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1. Windholz M, Budavari S, Stroumtsos LY, Fertig MN, eds. The merck index: an encyclopedia of chemicals and drugs. 9th ed. Rahway: Merck & Co., 1976.

2. Hamilton and Hardy's Industrial Toxicology, Fourth Edition, AJ Finkel, ed. John Wright, PSG Inc. 1983.

3. Lauwerys, RR. Industrial Chemical Exposure: Guidelines for Biological Monitoring, page 29, Biomedical Publications, Davis, California 1983.

4. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to inorganic arsenic (revised). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1975. (DHEW publication no. (NIOSH) 75-149).

5. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1983.

6. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to carbon monoxide. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. (NIOSH) 73-11000).

7. International Labour Office. Encyclopedia of occupational health and safety. Vol II/L-Z. Geneva: International Labour Office, 1983.

8. National Institute for Occupational Safety and Health. NIOSH/OSHA occupational health guidelines for chemical hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 81-123).

9. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to inorganic nickel. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-164).

10. National Toxicology Program. Third annual report on carcinogens. 1983 National Toxicology Program (DHHS) publication no. (NTP) 83-010.

11. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values. 4th ed. Cincinnati, Ohio: ACGIH, 1980.

12. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment and biological exposure indices with intended changes for 1984-85. Cincinnati, Ohio: ACGIH, 1984.

13. Held, BJ. Facial hair and breathing protection. Int. Fire Chief 46(12)25-28. December 1980.

14. Hyatt EC, et al. The effect of facial hair on respirator performance. Los Alamos Scientific Laboratories, publication number LA-DC-13307.

15. National Institute for Occupational Safety and Health. A guide to industrial respiratory protection. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-189).

16. National Institute for Occupational Safety and Health. Health hazard evaluation report no. HETA 73-40-116. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984.

17. National Institute for Occupational Safety and Health. Health hazard evaluation report no. HETA 71-21-22. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1972.

18. National Institute for Occupational Safety and Health. Health hazard evaluation report no. HETA 81-100-1140. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1982.

19. National Institute for Occupational Safety and Health. Health hazard evaluation report no. HETA 78-093-536. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978.

20. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 3, 2nd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW (NIOSH) publication no. 77-157-C).

21. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 7, 2nd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 82-100).

22. Drager. Detector tube handbook. 5th edition. Lubect, Federal Republic of Germany: Drager February 1983.

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Delco Moraine Division, General Motors Corporation, Dayton, Ohio
2. United Auto Workers Union, Local 696
3. NIOSH, Region V
4. OSHA, Region V

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

TABLE 1

Airborne Concentration for Metals
First Follow-Up Survey

Delco Moraine Division, GMC
Dayton, Ohio
HETA 84-060
January 17-20, 1984

Sample Number	Location/Job	Volume (liters)	Sample Time	Date	Type Of Sample	Comment	Airborne Concentration (ug/m^3) As	Ni	Cr	Pb	Cu	Ba	Fe
A-2	Millwright	660	700-1420	1-17	P	Replacing elements, furnace no. 68, inside furnace 1 hr. wore resp. while in furnace - had beard	<1.5	72.7	53	6.1	39.4	3	177
A-12	Millwright	689	705-1444	1-18	P	Replacing elements, furnace no. 68, inside furnace 3.5 hrs. wore resp. while in furnace	<1.5	21.8	26.1	4.4	37.8	10	121
A-26	Millwright	708	648-1440	1-19	P	Replacing elements, furnace no. 68, inside furnace 2 hrs. did not wear resp. today	<1.4	80.5	52.3	5.6	21.2	7.1	184
A-35	Millwright	596	657-1334	1-19	P	Replacing elements, furnace no. 68, inside furnace 1.5 hrs. Left early, wore resp. while in furnace	<1.7	168	82.3	10.1	45.3	16.8	227
A-30	Millwright	683	650-1425	1-20	P	No welding done today	<1.5	27.8	22	8.8	83.5	22	233
A-28	Millwright	683	652-1430	1-20	P	No welding done today	<1.5	14.7	11.7	7.3	42.5	10.2	101
A-31	Millwright	678	653-1425	1-20	P	No welding done today	<1.5	14.7	8.8	10.3	72.7	16.2	152
A-10	Millwright	650	717-1430	1-17	P	During shift worked in model shop, removed hoist at muffle furnace, replaced brake on punch press, worked outside on generator	<1.5	1.5	<1.5	3.1	12.3	7.7	41.6
A-11	Millwright	641	718-1425	1-17	P	During shift worked in model shop, removed hoist at muffle furnace, replaced brake on punch press, worked outside on generator	<1.6	3.1	<1.6	4.7	7.8	6.2	29.6
A-36	Millwright	704	645-1434	1-19	P		<1.4	21.3	2.8	4.3	14.2	11.4	39.8
A-5	Welder	501	736-1310	1-17	P	Welded in furnace, no. 68 for 1-hr, left for meeting at 1310	<2	81.8	25.9	4	55.9	5.6	174
A-22	Welder	675	652-1422	1-19	P	Welded in furnace, no. 68 for 2-hrs, also welded in aisle next to furnace for 5-hrs.	<1.5	22.2	23.7	8.9	13.3	29.6	157

TABLE 1 (continued)

A-21	Welder	668	703-1428	1-18	P	Only welded for 5 min. most of day in weld shop	<1.5	<1.5	<1.5	1.5	6	58.4	31.5
A-7	Mixer	428	910-1355	1-17	P	Dumped 9600 pounds copper, 5000 pounds reclaim 104 1400 pounds matris nickel 200 pounds inco nickel	<2.3	1280	<2.3	4.7	360	114	133
A-27	Mixer	627	703-1400	1-19	P	Dumped 21000 lbs. ancor 1000, 5000 lbs. MH100 430 lbs zinc sterate 15000 lbs. sulfur 1024.5	<1.6	17.6	<1.6	3.2	23.9	70.2	311
A-32	Mixer	636	656-1400	1-20	P	Dumped 35000 lbs. ancor, 12,500 lbs MH, 2500 lbs mix reclaim (93) 500 lbs graphite, 450 lbs. zinc sterate	<1.6	31.4	<1.6	1.6	50.3	45.6	162
A-19	Electrician	705	645-1435	1-18	P	Most of shift in dept. 48, 0.5 hrs. on CO-MO's	<1.4	<1.4	<1.4	2.8	7.1	38.4	38.4
A-40	Electrician	690	645-1425	1-20	P		<1.4	<1.4	<1.4	4.3	14.5	4.3	36.2
A-18	Plumber	701	647-1434	1-18	P	Worked all over dept. 48	<1.4	<1.4	<1.4	2.9	24.3	14.3	45.6
A-41	Plumber	693	643-1425	1-20	P		<1.4	<1.4	<1.4	4.3	14.4	4.3	36.1
A-4	Attached to Furnace 67	465	826-1336	1-17	A	Across from port where air was exhausted from furnace 68	<2.2	58.1	36.6	8.6	68.8	4.3	237
A-17	Attached to Furnace 67	707	708-1459	1-18	A	Across from port where air was exhausted from furnace 68	<1.4	5.7	5.7	2.8	36.8	7.1	67.9
A-23	Attached to Furnace 67	620	729-1422	1-19	A	Across from port where air was exhausted from furnace 68	<1.6	14.5	19.4	3.2	12.9	9.7	163
A-16	Weld Shop	732	653-1501	1-18	A		<1.4	<1.4	<1.4	1.4	6.8	46.4	28.7
A-24	Dept. 48, Lunch Area	609	719-1433	1-19	A		<1.6	<1.6	<1.6	3.3	3.3	6.6	49.3
A-25	Millwright Break Area	683	655-1430	1-20	A		<1.5	<1.5	<1.5	4.4	24.9	5.9	51.2
A-29	Locker/Shower	653	700-1415	1-20	A		<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	1.5
Environmental Exposure Criteria (ug/m^3)		NIOSH					2^D	15	NA^E	50	NA	NA	NA
		OSHA					10	1000	1000	50	1000	500	15000^F
		ACGIH					200	1000	500	150	1000	500	10000^F
Laboratory Limit of Detection (ug/filter)							1	1	1	1	1	1	1

As= arsenic, Ni = nickel, Cr = chromium, Pb = lead, Cu = cooper, Ba = barium, Fe = iron
P = Personal sample
A = Area sample

D = Based on a 15-minute sampling period
E = These values represent total chromium including all of its valence states, NIOSH has criteria for chromium VI materials
F = As total nuisance particulates

TABLE 2 (continued)

A-131	Press Operator B	858	651-1400	2-1	P		<1.2	<1.2	<1.2		82.9	5.6	68.2
A-166	Press Operator B	876	655-1413	2-2	P		<1.1	1.5	1.5	3.1	36.2	13.1	128
A-111	Press Operator C	658	656-1245	1-31	P	Left early	<1.5	4.9	<1.5	3.5	550	65.8	297
A-113	Acme Operator	938	650-1439	1-31	P		<1.1	<1.1	<1.1	1.2	1.5	61.8	19.9
A-171	Acme Operator	914	654-1431	2-2	P		<1.1	<1.1	<1.1	<1.1	<1.1	6.6	4.2
A-112	Piston Press Operator	920	655-1435	1-31	P		<1.1	<1.1	<1.1	1.4	4.2	75.7	105
A-132	Piston Press Operator	950	650-1455	2-1	P	Nut impregnator part of day	<1.1	<1.1	<1.1	2.9	50.9	71.3	62.9
A-165	Piston Press Operator	974	652-1459	2-2	P		<1	<1	1.3	1.6	11.2	36.2	82
A-107	Cold Mold Press Operator	912	658-2434	1-31	P		<1.1	<1.1	<1.1	1.2	1.8	432	25.2
A-144	Cold Mold Press Operator	894	657-1424	2-1	P		<1.1	<1.1	<1.1	1.7	3.1	502	21.9
A-172	Cold Mold Press Operator	876	657-1415	2-2	P		<1.1	<1.1	<1.1	1.6	10.5	678	33
A-102	Plater Press Operator	904	659-1431	1-31	P		<1.1	<1.1	<1.1	<1.1	1.3	123	20.1
A-167	Plater Press Operator	900	658-1428	2-2	P		<1.1	<1.1	<1.1	<1.2	9.9	112	23.7
A-105	Furnance Operator (sintering furnaces)	844	657-1359	1-31	P	Only 2 furnaces operating, nut impregnator also	<1.2	2	2.5	2.5	167	63.4	116
A-136	Furnace Operator	846	656-1359	2-1	P	Part of day at muffle furnace, nut impregnator also	<1.2	1.3	<1.2	2.6	50.2	68.4	561
A-176	Furnance Operator (sintering furnace)	846	715-1418	2-2	P		<1.2	<1.2	<1.2	1.4	33.5	6.7	50.5
A-123	Job Setter	872	700-1416	1-31	P		<1.1	<1.1	<1.1	<1.1	<1.1	38.5	167
A-110	Jet Setter	866	702-1435	1-31	P		<1.2	<1.2	<1.2	1.7	34.1	586	81.9
A-143	Job Setter	870	700-1415	2-1	P		]g1.1	<1.1	<1.1	1.3	1.4	58.4	58
A-142	Job Setter	918	706-1444	2-1	P		<1.1	4.4	<1.1	2.6	155	502	138
A-173	Job Setter	882	659-1420	2-2	P		<1.1	<1.1	<1.1	1.4	3.6	19.7	79.6
A-170	Job Setter	804	705-1347	2-2	P		<1.2	<1.2	<1.2	2.5	11.3	395	47
A-119	Trucker	874	659-1416	1-31	P		<1.1	4.1	1.5	2.9	76.7	161	5620
A-138	Trucker	872	655-1411	2-1	P		<1.1	<1.1	<1.1	1.4	5.2	114	32.7
A-124	Mixer	824	708-1400	1-31	P		<1.2	10.3	<1.2	2.3	52.4	32.8	632
A-141	Mixer	822	704-1355	2-1	P		<1.2	5.6	<1.2	1.6	22	50.2	316

TABLE 2

Airborne Concentration for Metals
Second Follow-Up Survey

Delco Moraine Division
Dayton, Ohio

January 17-20, 1984

Sample Number	Location/Job	Volume (liters)	Sample Time	Date	Type Of Sample	Comment	Airborne Concentration (ug/m^3)						
							As	Ni	Cr	Pb	Cu	Ba	Fe
A-115	Millwright	922	647-1428	1-31	P	Replacing belt on muffle furnace all day, blew furnace stacks at start of shift	<1.1	1.4	2.3	5.5	4.4	89	51.7
A-106	Millwright	942	645-1436	1-31	P	Replacing belt on muffle furnace all day, blew furnace stacks at start of shift	<1.1	1.2	3	5.5	4.1	61	36.1
A-134	Millwright	896	646-1414	2-1	P	Removed portal covers on furnace 67, cut slack from muffle furnace bell (63), got supplies from second floor	<1.1	3.1	<1.1	3.3	13.6	16.5	43.3
A-147	Millwright	696	828-1416	2-1	P	Removed portal covers on furnace 67, cut slack from muffle furnace bell (63), got supplies from second floor	<1.4	2.6	<1.4	2.9	5.9	18.1	35.1
A-162	Millwright	912	649-1425	2-2	P	Replacing heating elements for furnace 67, inside furnace 1 hr.	<1.1	143	67.5	6.8	22.7	5.2	68.5
A-163	Millwright	910	650-1425	2-2	P	Replacing heating elements for furnace 67, inside furnace 1 hr.	<1.1	77.4	27.6	3.4	14.6	2.2	56.6
A-160	Welder	938	640-1429	2-2	P	Replacing heating elements furnace 67, welding inside furnace 1 hr.	<1.1	63.3	17.1	3.8	38.5	12.8	100
A-114	Press Operator A	890	653-1418	1-31	P		<1.1	<1.1	<1.1	3	115	16.7	63.7
A-129	Press Operator A	910	648-1423	2-1	P		<1.1	1.2	<1.1	3.2	99.7	9.1	67.5
A-164	Press Operator A	900	651-1421	2-2	P		<1.1	<1.1	<1.1	3.2	11.3	6.1	32.4
A-116	Press Operator B	750	745-1400	1-31	P	Come in late	<1.3	4	2	3.5	191	35.3	204

TABLE 2 (continued)

A-174	Mixer	842	704-1404	2-2	P	<5.7	150	<1.2	8	5700	27.7	2420
A-121	Lab Support	860	717-1427	1-31	P	<1.2	<1.2	<1.2	<1.2	33.3	17.8	27.4
A-149	Lab Support	906	716-1449	2-1	P	<1.1	<1.1	<1.1	1.4	20.3	25.4	24.1
A-175	Lab Support	902	711-1442	2-2	P	<1.1	<1.1	<1.1	2.1	29	5.3	25.4
A-140	Plumber	756	817-1435	2-1	P	<1.3	<1.3	<1.3	2.1	3.6	8.1	26.4
A-161	Plumber	946	645-1438	2-2	P	<1.1	2.9	<1.1	1.6	4.3	5.3	22
A-146	Electrician	852	729-1435	2-1	P	<1.1	<1.1	<1.1	1.5	1.3	9	8.3
A-169	Electrician	880	706-1426	2-2	P	<1.1	<1.1	<1.1	2.4	6.7	14.4	32.3
A-168	Inspector Dept. 48	910	700-1435	2-2	P	<1.1	<1.1	<1.1	1.2	12.9	49.6	23.4
A-117	Supervisor Dept. 48	888	701-1425	1-31	P	<1.1	<1.1	<1.1	1.8	14.1	30.6	28.7
A-127	Supervisor Dept. 48	940	639-1429	2-1	P	<1.1	<1.1	<1.1	1.7	5	17.1	12.2
A-156	Supervisor Dept. 48	854	636-1343	2-2	P	<1.2	<1.2	<1.2	2.3	6.4	14.3	22.4
A-103	Maintenance Break Area	888	659-1423	1-31	A	<1.1	<1.1	<1.1	3.7	4.5	12.4	12.2
A-133	Maintenance Break Area	928	636-1420	2-1	A	<1.1	<1.1	<1.1	1.9	2.9	1.1	10.7
A-158	Maintenance Break Area	968	631-1435	2-2	A	<1	<1	<1	1.9	2.4	1.7	12.9
A-109	Department 48 Cafeteria	878	703-1422	1-31	A	3.3	<1.1	<1.1	6.8	4.7	5.2	14.1
A-126	Department 48 Cafeteria	938	636-1425	2-1	A	<1.1	<1.1	<1.1	2.4	5.4	1.3	17.9
A-157	Department 48 Cafeteria	9166	632-1435	2-2	A	<1	<1	<1	3	4.1	1.8	18.5
A-128	Press Operators Break Area	928	638-1422	2-1	A	<1.1	<1.1	<1.1	1.4	2.4	117	10.7
A-159	Press Operators Break Area	960	631-1431	2-2	A	<1	<1	<1	1.3	17.8	40.8	26.7
A-120	Shower/Locker Area	850	711-1416	1-31	A	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	21.1
A-145	Furnace Repair Area	692	851-1437	2-1	A	<1.4	<1.4	<1.4	3.9	25.7	16.9	37.4
A-155	Furnace Repair Area	960	637-1437	2-2	A	<1	8.2	2.6	5.4	85.4	6.7	72.3
Environmental Exposure Criteria (ug/m^3)		NIOSH				2^{A}	15	NA^{B}	50	NA	NA	NA
		OSHA				10	1000	1000	50	1000	500	
		ACGIH				200	1000	500	150	1000	500	
Laboratory Limit of Detection (ug/filter)						1	1	1	1	1	1	1

As= arsenic, Ni = nickel, Cr = chromium, Pb = lead, Cu = cooper, Ba = barium, Fe = iron
P = Personal sample
A = Area sample

TABLE 3

Percentage of Metals in Settled Dust or Material Bulk Samples

Delco Moraine Division
Dayton, Ohio

January 17-20, 1984

Sample Number	Location Collected From	Collected During	Comment	Percentage By Weight							
				As	Ni	Cr	Pb	Cu	Ba	Fe	Zn
B-1	Furnace parts storage area-second floor	initial survey	collected from various locations	<0.005	0.86	0.04	1.23	1.6	0.48	>40	1.19
B-41	From ledge on platform at midpoint of steps leading from first floor to mixing area	1st follow-up	dark gray color	<0.005	0.34	0.01	0.90	2.92	0.03	>40	0.49
B-16	Settled dust on top of gas genarators	1st follow-up	dark gray to black color	<0.005	0.80	0.10	0.25	1.32	0.27	14.6	1.68
B-6	From rafters above furnace no. 66	initial survey	medium gray color	<0.005	0.19	0.05	0.49	1.05	0.39	3.93	0.88
B-7	From rafters above furnace no. 51	initial survey	lighter gray color	<0.005	0.05	<0.01	0.12	0.09	<0.06	2.99	0.12
B-17	Dust accumulating on press no. R/4 12000 from part pressing	1st follow-up	reddish/orange colored powder	<0.005	0.17	<0.01	0.08	>40	<0.01	1.28	0.14
B-18	Dust accumulating on press no. 6000 (part no. 7323)	1st follow-up	dark colored powder with reddish tint	<0.005	0.14	<0.01	0.02	>30	<0.01	1.49	2.43
B-20	Dust that had settled on small ledge on side of muffle furnace	1st follow-up	dark gray to black color	<0.005	0.60	0.28	13.2	0.95	0.22	>20	1.55
B-101	Muffle furnace no. 61 collected off belt as it revolved (belt being replaced)	2nd follow-up	white-colored material	<0.005	<0.01	<0.01	0.73	<0.01	ND	0.03	>33
B-102	Muffle furnace no. 61 collected from belt as it revolved (belt being replaced)	2nd follow-up	black flaky material	<0.005	1.06	7.08	<0.01	0.01	ND	0.45	0.02
B-103	Muffle furnace no. 61 material collected from inside hood at exit end of furnace	2nd follow-up	rust (red/orange) colored, small pieces of material	<0.005	0.28	0.20	>65	0.03	ND	1.69	3.59
B-104	Muffle furnace no. 61 collected from floor directly below end of belt - exit end	2nd follow-up	white/gray colored pieces of material	<0.005	0.01	0.05	0.90	<0.01	ND	0.13	>30
B-2	Settled dust between furnaces no. 64 and 65	initial survey	area basically undisturbed dust collected from several spots	<0.005	0.67	0.19	2.31	2.33	0.35	20.6	3.83

TABLE 3 (continued)

B-3	Sintering furance no. 64 collected from material accumulating in fire brick in inspection port-heat zone 2	initial survey	dark colored material	<0.005	0.11	0.03	<0.01	0.03	<0.01	1.0	21.9
B-4	Sintering furnaces stack clean out boxes	initial survey	light gray colored material	<0.005	<0.01	<0.01	1.94	0.03	<0.01	0.07	>33
B-5	Sintering furnace no. 66 material from hood at entrance	initial survey	white colored material	<0.005	0.02	<0.01	12.3	0.18	0.04	0.46	>28
B-10	Sintering furnace no. 66 material from hood at exit	initial survey	medium gray colored material	<0.005	0.33	0.34	20.3	5.0	0.03	4.43	16.8
B-110	Sintering furnace no. 67 heat zone no. 1	2nd follow-up	very dark (black) colored powder	<0.005	4.68	>15	<0.01	9.8	ND	11.2	0.03
B-111	Sintering furnace no. 67 heat zone no. 2	2nd follow-up	dark gray colored powder	<0.005	15.5	10.8	<0.01	4.84	ND	7.05	<0.01
B-112	Sintering furnace no. 67 heat zone no. 3	2nd follow-up	black colored powder	<0.005	3.41	4.81	<0.01	1.15	ND	8.01	0.01
B-15	Sintering furnace no. 68 material collected from fire brick in heat zone inspection port	1st follow-up	dark gray material	<0.005	0.16	0.07	2.18	0.10	<0.01	0.70	12.4
B-19	Sintering furnace no. 68 from bottom of heat zone no. 2	1st follow-up	black colored material	<0.005	8.78	7.08	<0.01	>20	<0.01	>13	0.03
B-21	Sintering furnace no. 68 material from upper heating elements, heat zone no. 3	1st follow-up	dark colored material	<0.005	<27	>15	<0.01	0.53	<0.01	4.77	0.03
B-22	Sintering furnace no. 68 material from bottom of heat zone no. 3	1st follow-up	dark colored material	<0.005	8.21	>16	<0.01	0.69	<0.01	9.66	0.05
B-23	Sintering furnace no. 68 in arch at shock chamber	1st follow-up	white colored material	<0.05	0.02	<0.01	<0.02	0.02	0.03	0.17	<0.01
B-24	Sintering furnace no. 68 in arch at shock chamber	1st follow-up	black colored material	<0.005	1.64	0.10	<0.01	0.23	<0.01	4.63	<0.01
B-25	Sintering furnace no. 68 front end of cooling chamber	1st follow-up	flaky dark gray colored material	<0.005	0.03	<0.01	3.71	0.11	<0.01	0.36	35.1
B-26	Sintering furnace no. 68 front end of cooling chamber	1st follow-up	dark colored powder	<0.005	0.04	<0.01	4.35	0.11	<0.01	2.81	35.8
B-8	Sintering furnace no. 64 middle of heat zone no. 2	initial survey	light gray colored material	<0.005	<0.01	<0.01	7.55	<0.01	<0.01	0.03	>33
B-9	Sintering furnace no. 64 front end heat zone no. 2	initial survey	dark material with reddish tint	<0.005	3.16	8.61	<0.01	0.22	<0.01	11.0	0.02
B-40	Homo furnaces - material collected from exhaust slot at top of furnaces	1st follow-up	dark colored material	<0.005	0.31	0.03	0.39	0.72		10.5	1.50

TABLE 3 (continued)

B-105	Copper raw material (old type)	2nd follow-up	bright copper color	<0.005	<0.01	<0.01	0.01	>50	0.22	0.08
B-109	Copper raw material (new type)	2nd follow-up	dull copper color	<0.005	0.06	<0.01	<0.01	>45	2.04	0.25
B-106	Ancor raw material (iron based)	2nd follow-up	gray colored powder	<0.05	0.03	<0.01	0.01	0.05	>68	0.01
B-108	Ancor 1000 raw material	2nd follow-up	dark gray colored powder	<0.005	0.03	0.06	0.01	>67	0.02	0.14
B-107	Reclaim	2nd follow-up	dark gray colored powder	<0.005	0.04	0.04	0.01	0.10	>66	0.10

TABLE 4 (Continued)

L-22, Worn by millwright as he cleaned furnace stacks	15	658-713	1-19	P	ND
L-102, Entrance end of muffle furnace no. 61, next to hood	242	924-1326	1-31	A	ND
L-100, Exit end of muffle furnace no. 65	102	1143-1325	1-31	A	ND

C for sample number indicated regular (small) charcoal tube.
L for sample number indicated large charcoal tube.
Laboratory Limit of Detection (ug) = 0.02 (A-section), 0.01 (B-section) for large tubes and 0.04 (A-section), 0.03 (B-section) for small tubes.

A = Area sample
A-Bz = Area sample held in employee's breathing zone
P = Personal sample
ND = Not detected on this sample.
N = None

Environmental Exposure Criteria (ppm):		Short-Term	Full-Shift
	NIOSH	0.0005	N
	OSHA	N	0.05
	ACGIH	N	0.05

N = None

TABLE 4

Airborne Concentration for Arsine
Personal and Area Samples

Delco Moraine Division, GMC
Dayton, Ohio
HETA 84-060

January, 1984

Sample No./Location	Volume (liters)	Sample Time	Date	Type of Sample	Air Concentration
C-1, Entrance end of sintering furnace no. 67	19.2	726-1439	1-17	A	ND
C-2, NIOSH investigator	20.6	745-1437	1-17	P	ND
L-1, Held in breathing zone of millwright as he cleaned furnace stacks	15	708-713	1-17	A-BZ	ND
L-2, Entrance end of sintering furnace no. 67	432	726-1438	1-17	A	ND
L-10, Worn by millwright as he cleaned furnace stacks	15	659-714	1-18	P	ND
L-11, Worn by millwright as he cleaned furnace stacks	15	659-714	1-18	P	ND
C-10, Exit end of sintering furnace no. 66	31.3	735-1455	1-18	A	ND
C-11, Exit end of sintering furnace no. 69	22.2	741-1457	1-18	A	ND
C-21, NIOSH investigator	30.1	715-1430	1-19	P	ND
C-22, Exit end of sintering furnace no. 69 next to hood	12.3	1011-1426	1-19	A	ND
L-23, Exit end of sintering furnace no. 69 next to hood	265	1011-1426	1-19	A	ND
L-21, Worn by millwright as he cleaned furnace stacks	15	658-713	1-19	P	ND

TABLE 5

Arsine and Carbon Monoxide Grab Samples
Collected with Direct Reading Gas Detector Tubes

Delco Moraine Division, GMC
Dayton, Ohio
HETA 84-060

January - February, 1984

Location	Sample	Date	Type of	Air Concentration (ppm)
Exit end of sintering furnace no. 67	922	1-17	Arsine	ND
4' from furnace opening where millwrights is working	934	1-17	Arsine	ND
At entrance to sintering furnace no. 66, right side as you face entrance	1007	1-17	Arsine	ND
At entrance to sintering furnace no. 67, left side as you face entrance	1029	1-17	Arsine	ND
Held tube in millwrights breathing zone as they cleaned furnace stacks	702	1-18	Arsine	ND
Sample taken next to sintering furnace no. 69, near area metals sample	1241	1-19	Arsine	ND
Sample taken 4' from furnace no. 68, opening where millwrights are working	950	1-17	CO	10
At end of conveyor, exit end sintering furnace no. 67	1245	1-17	CO	8
Sample taken 2' from furnace opening to heat zone, sintering furnace no. 68	844	1-19	CO	15
Sample taken inside sintering furnace no. 68, NIOSH investigator was outside furnace held tube through opening	852	1-19	CO	10

TABLE 5 (Continued)

Sample taken in air stream from fan, used to draw air through furnace no. 68; no one inside furnace	900	1-19	CO	10
Sample taken in air stream from fan, used to draw air through furnace no. 68; no one inside furnace	916	1-19	CO	10
Sample collected at sintering furnace no. 67, by furnace port millwrights had just opened; fan used to move air through furnace not operating	740	2-1	CO	10
Sample collected at sintering furnace no. 67, by furnace port millwrights had just opened; fan used to move air through furnace now operating	750	2-1	CO	10

CO = Carbon monoxide
ND = Not detected

Short-term Exposure Criteria (ppm):		Arsine	CO
	NIOSH	0.0005	200
	OSHA	N	N
	ACGIH	N	400

N = No short-term criteria.

Appendix I

Analytical Methods

Delco Morraine
Dayton, Ohio

HETA 84-060

Arsine air samples were collected on charcoal tubes attached via flexible tubing to battery-powdered pumps calibrated at either 0.05 or 1 liter per minute depending on size of the tubes. The samples were analyzed using graphite furnace atomic absorption spectroscopy according to NIOSH method no. S229.[20] The A section was desorbed in 2 ml of 0.01 molar nitric acid. The B section was desorbed in 1 ml of 0.01 molar nitric acid. Laboratory limits of detection for these samples ranged from 0.01 to 0.04 ug/tube section depending on the specific sample set.

Metal samples were collected on a mixed cellulose ester membrane filter attached via flexible tubing to a battery-powered pump calibrated at 1.5 liters of air per minute. The samples were ashed using nitric and perchloric acids. The residues were dissolved in dilute acid and the resulting sample solutions analyzed for trace metal content using inductively coupled plasma-atomic emission spectroscopy (ICP-AES). The laboratory limit of quantitation for these samples was 1 ug of each metal per filter.

Bulk dust and material samples were collected in glass vials. Replicate aliquots of each sample were weighed and then digested with nitric and perchloric acids. The residues were backed with a dilute solution of the same acids, and the resulting sample solutions were analyzed for trace metal content by ICP-AES. The limit of quantitation for these elements was 0.01%. Due to spectral interferences from the large amounts of coexisting elements, arsenic could not be quantified with any reasonable certainty. Therefore a portion of each sample was analyzed separately for arsenic using a modification of NIOSH method no. 346.[21]

The samples were treated with 5 ml of a mixture of nitric and hydrochloric acids (4 ml and 1 ml, respectively) and heated as described in method 346. Because of the nature of the samples, it was judged that hydrogen peroxide would not be helpful in getting the samples into solution so it was not used. Some metals (e.g., iron and nickel) are known to prevent the volatilization of arsenic during the charring step. Concern existed that large amounts of these metals would prevent the quantitative release of arsenic during the atomization

TABLE 6

Range of Air Concentrations For Metals and Arsine
Personal and Area Samples

Delco Moraine Division, GMC
Dayton, Ohio
HETA 84-060

January - February, 1984

Material	No. of Samples	Concentration (ug/m^3)	No. of samples Exceeding an Occupational Exposure Limit
As	87	ND to 3.3	1
Ni	87	ND to 1280	15
Cr	87	ND to 82.3	0
Pb	87	ND to 10.3	0
Cu	87	ND to 5700	1
Ba	87	ND to 678	4
Fe	87	4.2 to 5620	0
Arsine	15	All ND	0

ND = Not detected

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HETA 84-060

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Cu	87	ND to 5700	1
Ba	87	ND to 678	4
Fe	87	4.2 to 5620	0
Arsine	15	All ND	0

ND = Not detected

step. Based on the ICP-AES analysis representative samples were selected for recovery checks. Known amounts of arsenic were added and carried through the graphite furnace portion of the procedure. Recovery of the arsenic ranged from 81% to 117% for all but one sample which was only 51% (this sample contained more than 68% iron). The problem was minor due to the magnitude of the readings but it illustrates the problems encountered when analyzing bulk samples having widely divergent compositions. These uncertainties are reflected in a higher limit of detection than might otherwise be used. The laboratory limit of detection for arsenic was 0.005%.

Bulk insulation samples were collected in glass vials. Representative portions of each sample were observed at 100X magnification on a stereo microscope to ascertain the various components. Portions of each sample were also mounted in cargille liquid having a refractive index equal to 1.550 and observed on the polarized light microscope at 400X magnification. Portions were also prepared for electron microscopy analysis by ultrasonification in ethyl alcohol and evaporating aliquots of the resulting suspensions onto carbon-coated copper grids. Analysis was performed at 10,000X magnification.

Direct-reading samples were obtained for arsine and carbon monoxide using gas detector tubes with the corresponding detector tube pump.[22]

DEPARTMENT OF HEALTH AND HUMAN SERVICES
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