HETA 92-092-2333
JULY 1993

GENERAL CASTINGS - POWER STREET FACILITY CINCINNATI, OHIO

NIOSH INVESTIGATORS:
NANCY C. BURTON, MS
DENNIS O'BRIEN, PhD, CIH

I. SUMMARY

In November 1991, the National Institute for Occupational Safety and Health (NIOSH) received a management request to evaluate worker exposures throughout the General Castings-Power Street Facility, a gray and ductile iron foundry in Cincinnati, Ohio.

On February 20-21, 1992, NIOSH representatives, with field assistance from the Ohio Department of Health, conducted an industrial hygiene survey. Personal breathing zone (PBZ) and area air samples were collected for respirable silica and cristobalite, metals, phenol, formaldehyde, carbon monoxide (CO), and organic solvents. Work practices and engineering control measures were also evaluated.

The PBZ air concentrations of respirable silica ranged from less than [<] 14 (maintenance workers) to 160 micrograms per cubic meter [µg/m^3] (grinder), as time-weighted averages (TWAs). Four of the 15 sample concentrations (27%) exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 100 µg/m^3 for respirable silica (as quartz), and 5 of the 15 sample concentrations (33%) exceeded the NIOSH Recommended Exposure Limit (REL) of 50 µg/m^3 for respirable crystalline silica (regardless of morphology). Cristobalite was not detected in any of the samples. Since grinders wore powered air-purifying helmet respirators, the inside-respirator exposures of the employees were probably lower than the exposures measured. A local exhaust ventilation and bag house system was being installed at the time of the survey in the cleaning area. The PBZ lead exposures measured for the furnace operator (160 µg/m^3) and two pourers (74 and 117 µg/m^3) exceeded the OSHA PEL of 50 µg/m^3. PBZ benzene exposures for two coremakers (0.131 and 0.16 parts per million [ppm]) and a pourer (0.124 ppm) exceeded the NIOSH REL of 0.1 ppm for benzene, as a TWA. PBZ exposures for CO ranged from 6 to 38 ppm; one of the 6 samples collected (pourer) exceeded the NIOSH REL of 35 ppm. Concentrations of phenol (0.01 to 0.08 ppm), toluene (< 0.03 to 0.03 ppm), formaldehyde (0.014 to 0.016 ppm), and the metals: aluminum, chromium, copper, iron, magnesium, nickel, and zinc (range: 0.5 to 4793 µg/m^3) did not exceed their respective occupational evaluation criteria.

The industrial hygiene sampling data indicate that workers without respiratory protection were overexposed to respirable silica, lead, carbon monoxide, and benzene in the coremaking, melting, pouring, and cleaning areas at this facility. Recommendations for engineering controls and improved work practices can be found in Section VIII of this report.

KEYWORDS: SIC 3321 (Gray and Ductile Iron Foundries), foundry industry, respirable silica, engineering controls, lead, benzene, carbon monoxide, formaldehyde, phenol.

II. INTRODUCTION

On February 20-21, 1992, National Institute for Occupational Safety and Health (NIOSH) representatives, with field assistance from the Ohio Department of Health, conducted a site visit at the General Castings-Power Street Facility, a gray and ductile iron foundry, in Cincinnati, Ohio. This visit was made in response to a management request to evaluate worker exposures in the coremaking, molding, pouring, melting, shakeout, cleaning, and sand handling areas of the facility. Since the company was under new management, there was a general interest in identifying potential occupational health hazards.

III. BACKGROUND

The General Castings-Power Street Facility, which was housed in a masonry and steel building, operated one shift with 32 employees. Three coremaking processes were used: hot shell, oil-baked, and no-bake. A core is used to define the internal hollows desired in the casting. Cores were made both by hand and by machine. A hot shell core is produced by dumping a resin-coated sand into a heated pattern, holding the coremaking materials in place long enough to produce curing on the surface, removing excess sand from the core, and then removing the hollow-cured shell from the pattern. Employees made oil-based cores, containing linseed oil and petroleum distillates, which were baked in a gas-fired ovens to make a solid core. No-bake cores were made of a phenolic-formaldehyde binder (PEPSET I®, PEPSET II®, and PEPSET III®, Ashland Chemical Company, Columbus, Ohio) mixed with silica sand in an automatic mixer. A polymeric methylene phenylene diisocyanate (MDI) was used as the binder catalyst. According to the Material Safety Data Sheets (MSDSs), the decomposition products from these no-bake binders may include carbon dioxide, carbon monoxide, hydrocarbons, and phenols.

A mold provides the cavity into which the metal is poured to produce a casting. Seven squeeze jolt molding machines, which use green sand containing coal dust, were used in conjunction with the deck pouring conveyor. These machines use an air-rammer to compact the sand to make a solid mold. Excess sand was removed using compressed air. The finished molds are placed on a conveyor using chain hoists or manual lifting. One large Osburn molding machine was separate from the rest and had its own pouring conveyor. A mold parting compound was used in the molding area.

To produce molten iron, the plant used three electric induction furnaces with a total capacity of 3.5 tons. Each furnace had a tight fitting lid to help control fumes. There were two ceiling propeller exhaust fans over the melting area. At the time of the site visit, the company was producing gray and ductile iron. Metal scrap yards were located both inside and outside the facility.

The metal pouring operation was performed inside the facility using molds on conveyor systems. Molten metal was poured into a large transport ladle and transferred into small ladles with flip lids for pouring on the conveyor deck. Chain hoists were used to maneuver the ladles. The molds were allowed to cool in the location where they were poured. The molds advance to the end of the platform where they fall on the floor. The two pourers also hand-separate castings from the sand. A Bobcat® front-end loader was used to load the sand reclamation system and shakeout some of the castings. The reclamation system feeds the sand muellers in the molding areas. The system uses an open exhaust duct for dust control.

The cleaning department had three grinders and one cut-off saw operator. The worker in charge of shipping also did repair welding. A local exhaust ventilation and bag-house system for the grinding and cutting operations was being installed during the site. The facility used an abrasive blasting machine and a steel shotblast machine to clean castings.

Safety shoes, hard hats, hearing protection (disposable plugs), and safety glasses were required throughout the facility. The grinders and cut-off saw operator used NIOSH/Mine Safety and Health Administration (MSHA) approved air-purifying respirator helmets which had high efficiency particulate air (HEPA) filters and a built-in face shield. The Bobcat operator used a NIOSH/MSHA approved disposable dust, mist, and fume mask. Flame retardant clothing was worn by the pourers and furnace operator.

Heat was provided to occupied areas by direct-fired gas space heaters. General ventilation was supplied by ceiling fans. Additional general ventilation was supplied by open doors and windows during the warmer months. An industrial vacuum cleaner with HEPA filters was used to remove excess sand once a week.

IV. METHODS

Personal breathing zone (PBZ) and area air samples were collected for the following compounds. The facility's Material Safety Data Sheets, hearing protection policy, and respiratory protection policy were also reviewed.

A. *Respirable Silica and Cristobalite*

Fifteen PBZ and 2 area air samples for respirable dust (aerodynamic diameter less than 10 micrometers [µm]) were collected at a flowrate of 1.7 liters per minute (l/min) using 10 millimeters (mm) nylon cyclones mounted in series with pre-weighed polyvinyl chloride (PVC) filters (37 mm diameter, 5 µm pore size). They were analyzed for quartz and cristobalite content with X-ray diffraction. Samples were analyzed according to NIOSH Method 7500[1] with the following modifications: a) the filters were dissolved in tetrahydrofuran rather than being ashed in a furnace, and, b) standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than the suggested normalization procedure. A bulk sample of the mold parting compound was also analyzed. The analytical limit of detection (LOD), limit of quantitation (LOQ), minimum detectable concentration (MDC), and minimum quantifiable concentration (MQC) for respirable silica (quartz) and cristobalite are presented in the following chart:

Analyte	LOD µg/sample	LOQ µg/sample	MDC $\mu g/m^3$	MQC $\mu g/m^3$	Average Volume (liters)
Quartz	10	30	14	42	718
Cristobalite	15	30	21	42	718

B. *Metals*

Ten PBZ and 1 area air samples were collected on mixed-cellulose ester filters (37 mm diameter, 0.8 µm pore size) using a flowrate of 2.0 l/min. The samples were analyzed for metals according to NIOSH Method 7300.[2] In the laboratory, the samples were wet-ashed with concentrated nitric and perchloric acids and the residues were dissolved in a dilute solution of the same acids. The resulting sample solutions were analyzed by inductively coupled plasma atomic emission spectrometry. The MQCs, using a sample volume of 890 liters, for the selected metals are listed in Table 3.

C. *Phenol*

Four PBZ and 3 area air samples were collected on XAD-7 silica gel tubes using a flowrate of 0.1 l/min. The samples were desorbed in methanol and analyzed by high performance liquid chromatography according to OSHA Method 32 for phenol. The analytical LOD, LOQ, MDC, and MQC for phenol are presented in the following chart:

Analyte	LOD µg/sample	LOQ µg/sample	MDC ppm	MQC ppm	Minimum Volume (liters)
Phenol	1	3.1	0.006	0.018	43.9

D. *Carbon Monoxide*

Carbon monoxide (CO) was measured using Draeger® passive diffusion tubes which utilize a colormetric method (carbon monoxide reacts with palladium salts, resulting in a color change or stain). The diffusion tubes were fastened to the employee's collar in the breathing zone for the duration of the shift. The length of the resulting stain was determined and the time-weighted average calculated. Six PBZ samples were collected. According to the manufacturer, the MDC for an 8-hour sample was 6 ppm.

E. *Formaldehyde*

Five area air samples were collected using impingers filled with 1% sodium bisulfite solution at a flowrate of 1 l/min. For analysis, color was developed by adding chromotopic acid and concentrated sulfuric acid to each sample. Samples were heated in a 95°C water bath for 15 minutes and allowed to cool 2 to 3 hours. The samples were read by visible spectroscopy according to NIOSH Method 3500.[3] The analytical LOD, LOQ, MDC, and MQC for formaldehyde are presented in the following chart:

Analyte	LOD µg/sample	LOQ µg/sample	MDC ppm	MQC ppm	Minimum Volume (liters)
Formaldehyde	0.6	1.7	0.001	0.004	354

F. *Solvents*

Five PBZ and 2 area air samples were collected on charcoal tubes at a flowrate of 0.2 l/min. The charcoal tubes were desorbed with carbon/disulfide and screened by gas chromatography/flame ionization detector (GC-FID), according to NIOSH Method 1501.[4] Total aromatic hydrocarbons were based on the presence of n-hexane. The analytical LODs, the LOQs, the MDCs, and the MDQs for the major constituents are presented in the following chart:

Analyte	LOD µg/sample	LOQ µg/sample	MDC ppm	MQC ppm	Minimum Volume (liters)
Benzene	1	3.3	0.004	0.012	87.2
Toluene	10	33	0.03	0.101	87.2

The analytical LOD for total aromatic hydrocarbons was 100 µg per sample, which equates to a MDC of 1.15 mg/m^3, assuming a sampling volume of 87.2 liters. The LOQ for total aromatic hydrocarbons was 330 µg per filter, which equates to a MQC of 3.78 mg/m^3, assuming a sampling volume of 87.2 liters.

V. EVALUATION CRITERIA

To assess the hazards posed by workplace exposures, industrial hygienists use a variety of environmental evaluation criteria. These criteria propose exposure levels to which most employees may be exposed for a normal working lifetime without adverse health effects. These levels do not take into consideration individual susceptibility, such as pre-existing medical conditions, or possible interactions with other agents or environmental conditions. Evaluation criteria change over time with the availability of new toxicologic data.

There are three primary sources of environmental evaluation criteria for the workplace: 1) NIOSH Recommended Exposure Limits (RELs)[5], 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs)[6], and 3) the U.S. Department of Labor Occupational Safety and Health Agency (OSHA) Permissible Exposure Limits (PELs).[7] The OSHA PELs may reflect the feasibility of controlling exposures in various industries where the agents are used; whereas the NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

A. *Respirable Silica and Cristobalite*

Crystalline silica (quartz) and cristobalite have been associated with silicosis, a fibrotic disease of the lung caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and non-specific chest illnesses. Silicosis usually occurs after years of exposure, but may appear in a shorter period of time if exposure concentrations are very high.[8] The NIOSH RELs for respirable quartz and cristobalite, published in 1974, are 50 µg/m^3, as TWAs, for up to 10 hours per day during a 40-hour work week.[9] These RELs are intended to prevent silicosis. However, evidence indicates that crystalline silica is a potential occupational carcinogen and NIOSH is currently reviewing the data on carcinogenicity.[10,11,12] The OSHA PELs and the ACGIH TLV®s for respirable quartz and cristobalite are 100 and 50 µg/m^3, as 8-hour TWAs, respectively.[6,7]

B. *Metals*

A list of selected metals along with a brief summary of their primary health effects are presented in Table 1. The evaluation criteria for occupational exposures to these contaminants are included in Table 3.

C. *Organic Solvents*

Acute benzene overexposure can cause central nervous system depression with symptoms such as headache, nausea, and drowsiness. Chronic exposure to benzene has been associated with the depression of the hematopoietic system and is associated with an increased incidence of leukemia and possibly multiple myeloma.[5,19] The NIOSH REL is 0.1 ppm. NIOSH classifies benzene as a human carcinogen and recommends that exposures be reduced to the lowest feasible level (LFL). The OSHA PEL is 1 ppm. The current ACGIH TLV® is 10 ppm as a suspected human carcinogen. ACGIH has proposed to lower the TLV® to 0.1 ppm and classify it as a proven human carcinogen.[6]

Toluene exposure has been associated with central nervous system depression. Symptoms may include headache, dizziness, fatigue, confusion, and drowsiness. Exposure may also cause irritation of the eyes, respiratory tract, and skin.[13,19] The NIOSH REL and ACGIH TLV® for toluene is 100 ppm as a TWA. ACGIH has proposed a TLV® of 50 ppm in their notice of intended changes. The OSHA PEL is 200 ppm as a TWA.

D. *Phenol*

Phenol is an irritant of the eyes, mucous membranes, and skin. Systemic absorption can cause convulsions as well as liver and kidney disease. The skin is a route of entry for the vapor and liquid phases. Phenol has a marked corrosive effect on any tissue. Symptoms of chronic phenol poisoning may include difficulty in swallowing, diarrhea, vomiting, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly a skin rash.[13] The NIOSH REL, ACGIH TLV®, and OSHA PEL for phenol are 5 ppm as a TWA. NIOSH has set a ceiling limit of 15.6 ppm. All criteria include a skin notation, which indicates that skin absorption may be a significant route of exposure.

E. *Carbon Monoxide*

Carbon monoxide (CO) is a colorless, odorless, tasteless gas which can be a product of the incomplete combustion of organic compounds. CO combines with hemoglobin and interferes with the oxygen carrying capacity of blood. Symptoms include headache, drowsiness, dizziness, nausea, vomiting, collapse, myocardial ischemia, and death.[13] The NIOSH REL for carbon monoxide is 35 ppm as a TWA. NIOSH has established a ceiling level (not to be exceeded at any time during the workday) of 200 ppm. The current OSHA PEL for CO is 50 ppm as a TWA. OSHA had lowered the PEL to 35 ppm in 1989 under the Air Contaminants Standard. In July 1992, the 11th Circuit Court of Appeals vacated this standard. OSHA is currently enforcing the 50 ppm standard; however, some states operating their own OSHA approved job safety and health programs will continue to enforce the lower limits of 35 ppm. OSHA continues to encourage employers to follow the 35 ppm limit. The ACGIH TLV® for carbon monoxide is 25 ppm as an 8-hour TWA.

F. *Formaldehyde*

Formaldehyde is a colorless gas with a strong odor. Exposure can occur through inhalation and skin absorption. The acute effects associated with formaldehyde are irritation of the eyes and respiratory tract and sensitization of the skin. The first symptoms associated with formaldehyde exposure, at concentrations of 0.1 to 5 parts per million (ppm), are burning of the eyes, tearing, and general irritation of the upper respiratory tract. There is variation among individuals, in terms of their tolerance and susceptibility to acute exposures of the compound.[22] In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents. Formaldehyde exposure has been identified as a possible causative factor in cancer of the upper respiratory tract in a proportionate mortality study of workers in the garment industry.[23] NIOSH has identified formaldehyde as a suspected human carcinogen and recommends that exposures be reduced to the lowest feasible concentration (0.016 ppm based on LOD). The OSHA PEL is 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL.[24] ACGIH has designated formaldehyde to be a suspected human carcinogen and therefore, recommends that worker exposure by all routes should be carefully controlled to levels "as low as reasonably achievable" below the TLV.[7] ACGIH has set a ceiling limit of 0.3 ppm.

VI. RESULTS

A. *Respirable Silica and Cristobalite*

The results of the PBZ air samples are presented in Table 2. The 15 PBZ approximately full-shift sample concentrations ranged from < 14 to 160 µg/m^3, as TWAs. Four of the 15 sample concentrations (27%) exceeded the OSHA PEL of 100 µg/m^3 for respirable silica and 5 of the 15 sample concentrations (33%) exceeded the NIOSH REL of 50 µg/m^3 for respirable silica. The samples collected for the chipper/grinders had the highest exposures (124 to 160 µg/m^3; geometric mean: 143 µg/m^3), followed by the shakeout operators (62 and 125 µg/m^3), front-end loader operator (40 µg/m^3), molders (<14 to 12.4 µg/m^3, geometric mean: 2.9 µg/m^3), and maintenance workers (<14 µg/m^3).

Grinders wore air-purifying helmet respirators, therefore, the inside-respirator exposures of the employees were probably lower than the exposures measured. Cristobalite was not detected in any of the samples (<21 µg/m^3). The 2 area samples in the shakeout area showed traces of quartz but the concentrations were below the analytical LOD. The mold parting compound contained 1.6% crystalline silica.

B. *Metals*

The 10 PBZ and 1 area air sample concentrations are presented in Table 3. Concentrations of aluminum, chromium, copper, iron, magnesium, nickel, and zinc (range: 0.5 to 4793 µg/m^3) did not exceed the respective occupational evaluation criteria. However, since the valence state of chromium was not determined, worker exposures to the more toxic Chromium VI are unknown. The PBZ lead exposures measured for the furnace operator (160 µg/m^3) and two pourers (74 and 117 µg/m^3) on the first day of sampling exceeded the OSHA PEL of 50 µg/m^3.

C. *Phenol*

The results of the 4 PBZ and 3 area air samples collected in the coremaking area are presented in Table 4. The PBZ concentrations ranged from 0.01 to 0.08 ppm (geometric mean: 0.026 ppm) which were below the current occupational evaluation criteria of 5 ppm. The area phenol concentrations ranged from <0.006 to 0.06 ppm.

D. *Carbon Monoxide*

The results for the 6 PBZ and 2 area air samples are listed in Table 5. The CO PBZ concentrations ranged from 6 to 38 ppm. One of the 6 samples collected (pourer) exceeded the NIOSH REL of 35 ppm. These results indicate that workers are potentially overexposed to carbon monoxide at this facility. The most likely source of the carbon monoxide was the decomposition of the organic compounds used in the molds and cores.

E. *Formaldehyde*

The results for the five area air samples in the coremaking, molding, and pouring areas are given in Table 6. Sample concentrations ranged from 0.014 to 0.016 ppm, in the range that is generally considered to be background concentrations.

F. *Organic Solvents*

The 5 PBZ and 2 area sample results for benzene and toluene are given in Table 7. PBZ benzene concentrations ranged from 0.017 ppm to 0.16 ppm (geometric mean: 0.069 ppm). The highest concentrations were collected for two coremakers (0.131 and 0.16 ppm) and a pourer (0.124) which exceeded the NIOSH REL of 0.1 ppm for benzene, as a TWA. Area benzene concentrations for the sand mixer and pouring area were 0.005 and 0.03 ppm, respectively. PBZ toluene concentrations ranged from <0.03 to 0.03 ppm which were below the current evaluation criteria of 100 ppm. Toluene was not detected in the area samples (<0.03 ppm).

G. *Observations of Work Practices*

It was observed that some individuals were not wearing hearing protection or safety glasses in the building where required. The written respiratory and hearing protection policies were appropriate. Employees were observed smoking and eating lunch in the general work area. Workers were observed lifting and moving molds weighing up to approximately 75 pounds. This could result in back and other injuries. There is an opening in the railing leading into the scrap yard pit from the furnace platform which would constitute a fall hazard. During the walkthrough, it was noted that employees were exposed to high noise levels as metal casting scraps were being dropped into metal bins in the cleaning area.

VII. DISCUSSION AND CONCLUSIONS

The foundry industry has been identified as a complex process with numerous associated health hazards.[25] Little information is available about the long-term health effects of emissions from molds composed of synthetic chemical molding materials. Mortality studies have indicated that a two- to three-fold excess risk of lung cancer has been identified for molders, pourers, and cleaning room operators when compared to a standard population.[26] Smoking history was not available for these studies. Additional investigations are needed to determine if chronic health effects do result from exposures to current mold emissions. The industrial hygiene sampling data indicate that respirable silica, carbon monoxide, lead, and benzene exposures in the coremaking, pouring, melting, and cleaning areas at this facility constitute a potential health hazard to workers. During the walkthrough survey, some potential safety and health hazards were identified, such as unenforced hearing and eye protection policies. The new local exhaust ventilation and bag house system in the cleaning area should reduce employee exposures in that area.

VIII. RECOMMENDATIONS

The following recommendations are offered to reduce workers' exposures to respirable silica, benzene and other solvents, lead, carbon monoxide, and to correct safety and health hazards that were identified at this facility. NIOSH and OSHA recommend that engineering controls should be used to control hazards to the extent feasible, followed by work practices, and, if necessary, personal protective equipment.

1) In accordance with the OSHA lead standard (29 CFR 1910.1025), the environmental lead monitoring should be repeated quarterly to see if the workers' exposures exceed the PEL.[27] Until the lead exposures are reduced, a half-mask air-purifying respirator with a high-efficiency particulate filter should be used, after determining if the employee is physically able to wear it. A biological monitoring program should be developed in accordance with the OSHA standard to determine blood lead levels and appropriate medical follow-up.

2) To reduce CO and decomposition product exposures and improve general ventilation, a make-up air system should be installed in the facility to supply fresh air and heat. This would also replace the existing indirect-fired gas space heaters. Air exhausted from the building should be replaced with tempered air from an uncontaminated source. This air could be directed to operator work areas such as pouring and molding in the form of a low velocity shower to provide a cleaner environment. The American Foundrymen's Society "Foundry Ventilation Manual" recommends that general ventilation rates of 20-50 cubic feet per minute (cfm) per square foot (ft^2) of floor area be used to control emissions in pouring areas.[28]

3) To provide better dust control, the open exhaust duct in the sand handling area should be connected to a side-draft shakeout hood. The hood should be movable to provide access to the shakeout pit for maintenance.

4) To reduce respirable silica exposures during shake-out activities, the castings could fall into a metal bin at the end of the conveyor and be carried by forklift to the shakeout area.

5) To reduce exposures to respirable silica during the cleaning of the core and mold surfaces, the compressed air hoses should be eliminated and replaced with a central vacuum system. As an interim measure, the existing air lines should be regulated to reduce air to less than 30 pounds per square inch (psi) to lessen dust levels currently being generated.[29] A collection bin should be used to store excess sand until the end of the shift to aid in clean-up. The industrial vacuum cleaner with HEPA filters should be used to clean-up spilled sand.

6) To reduce exposures to respirable silica, all chutes transporting dry sand in the coremaking/molding departments should be enclosed and ventilated. At a minimum, the hinged lids on the chutes should be gasketed to help reduce dust emissions. Transfer points, particularly where valves activate, should also be enclosed with sheet metal and ventilated to reduce dust emissions. The sand free fall distance from the machine to the core box should be reduced or enclosed.

7) A railing should be installed between the pouring platform into the inside scrap yard to prevent falls.

8) To prevent ingestion or inhalation of contaminants such as heavy metals and hydrocarbons, employees should not be allowed to eat, drink, or smoke in the production area.

9) The current written hearing and eye protection policies should be strictly enforced. During the site visit, it was observed that some workers did not wear their hearing protection or safety glasses.

10) Employees should use the available crane hoists instead of manually lifting and moving cores and small molds.

11) To reduce the noise emitted when metal parts are dumped into the portable metal bins at the abrasive blasting and shot blast machine areas, the bins should be lined with damping compound.[30]

12) Local exhaust hood air flows in the cleaning department should be checked and compared to current guidelines. The local exhaust ventilation requirements for cleaning operations can be found in the ACGIH publication Industrial Ventilation.[31] All hand grinding operations should be conducted on downdraft benches and a hood for the cut-off saw operation should be installed, as described in the ACGIH publication Industrial Ventilation.[31]

IX. REFERENCES

1. NIOSH [1989]. Silica, crystalline, respirable: method no. 7500 (supplement issued 5/15/89). In: Eller PM, ed. NIOSH manual of analytical methods. 3rd rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) publication No. 84-100.

2. NIOSH [1984]. Elements (ICP): method no. 7300. In: Eller PM, ed. NIOSH manual of analytical methods. 3rd rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-100.

3. NIOSH [1989]. Formaldehyde: method no. 3500. In: Eller PM, ed. NIOSH manual of analytical methods. 3rd rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-100.

4. NIOSH [1984]. Hydrocarbons, aromatic: method no. 1501. In: Eller PM, ed. NIOSH manual of analytical methods. 3rd rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-100.

5. NIOSH [1992]. Recommendations for Occupational Safety and Health: Compendium of Policy Documents and Statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

6. ACGIH [1992]. Threshold limit values and biological exposure indices for 1992-93. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

7. Code of Federal Regulations [1992]. OSHA Table Z-1. 29 CFR 1910.1000. Washington, DC: U.S. Governmental Printing Office, Federal Register.

8. NIOSH [1986]. Occupational respiratory diseases. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-102.

9. NIOSH [1974]. Abrasive blasting respiratory protective practices. Washington, DC: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 74-104, p. 106.

10. IARC [1987]. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans: silica and some silicates. Vol. 42. Lyons, France: World Health Organization, International Agency for Research on Cancer, pp. 49, 51, 73-111.

11. NIOSH [1988]. NIOSH testimony to the U.S. Department of Labor: statement of the National Institute for Occupational Safety and Health. Presented at the public hearing on OSHA PELS/Crystalline Silica, July 1988. NIOSH policy statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health.

12. DHHS [1991]. Sixth annual report on carcinogens: summary 1991. Research Triangle Park, NC: U.S. Department of Health and Human

Services, Public Health Service, National Institute of Environmental Health Sciences, pp. 357-364.

13. Proctor NH, Hughes JP, and Fischman ML [1988]. Chemical Hazards of the Workplace, 2nd Edition. Philadelphia, PA: Lippincott.

14. Blair A and Mason TJ [1980]. Cancer mortality in the United States counties with metal electroplating industries. Arch Environ Health 35(2):92-94.

15. Franchini I, Magnani F, and Mutti A [1983]. Mortality experience among chromeplating workers: Initial findings. Scand J Work Environ Health 9:247-252.

16. Royle H [1975]. Toxicity of chromic acid in the chromium plating industry. Environ Res 10:39-53.

17. Silverstein M, Mirer F, Kotelchuck D, Silverstein B, and Bennett M [1981]. Mortality among workers in a die-casting and electroplating plant. Scand J Work Environ Health. 7 (suppl. 4):156-165.

18. Sorahan T, Burges DCL, and Waterhouse JAH [1987]. A mortality study of nickel/chromium platers. Br J Ind Med. 44:250-258.

19. NIOSH [1977]. Occupational diseases--a guide to their recognition. Revised Ed. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-181.

20. Hernberg S, Dodson WN, and Zenz C [1988]. Lead and its compounds. In Zenz C., Occupational Medicine: 2nd Ed., Chicago, IL: Year Book Medical Publishers, pp. 547-582.

21. NIOSH [1990]. NIOSH Pocket Guide to Chemical Hazards, 2nd Printing, Cincinnati, Ohio: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 90-117.

22. NIOSH [1977]. Criteria for a recommended standard - occupational exposure to formaldehyde. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-126.

23. Stayner L, Smith AB, Reeve G, Blade L, Keenlyside R, and Halperin W [1985]. Proportionate mortality study of workers exposed to formaldehyde. Am J Ind Med 7:229-40.

24. OSHA [1992]. Occupational exposures to formaldehyde; final rule. The Occupational Safety and Health Administration, Washington, DC in Federal Register **57**(102):2289-22328. U.S. Governmental Printing Office, Washington, D.C.

25. NIOSH [1985]. Recommendations for control of occupational safety and health hazards--foundries. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 85-116.

26. Palmer WG, and Scott WD [1981]. Lung cancer in ferrous foundry workers: a review. American Industrial Hygiene Association Journal. 42(5):329-340.

27. Code of Federal Regulations [1992]. OSHA lead standard. 29 CFR 1910.1025. Washington, DC: U.S. Governmental Printing Office, Federal Register.

28. American Foundrymen's Society [1985]. Foundry ventilation manual. Des Plaines, IL: American Foundrymen's Society, Inc.

29. Code of Federal Regulations [1992]. Hand and portable powered tools and equipment, general. 29 CFR 1910.242. Washington, DC: U.S. Governmental Printing Office, Federal Register.

30. Holmer CI, and Lagace H [1972]. Effect of structural damping on the sound radiated from impacted structures. American Industrial Hygiene Association Journal 33(1):12-18.

31. ACGIH [1988]. Industrial ventilation; a manual of recommended practice. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Nancy Clark Burton, M.P.H., M.S.
Industrial Hygienist
Industrial Hygiene Section
Hazard Evaluation and Technical Assistance Branch

Dennis O'Brien, Ph.D., C.I.H
Chief
Engineering Control Technology Branch
Division of Physical Sciences and Engineering

Field Support by:

John E. Kelly, M.S.
Industrial Hygienist
Industrial Hygiene Section
Hazard Evaluation and Technical Assistance Branch

R. Leroy Michelson, M.S.

Industrial Engineer
Control Section 2
Engineering Control Technology Branch
Division of Physical Sciences and Engineering

Lesliann E. Helmus
Ohio Department of Health
Bureau of Epidemiology and Toxicology

Analytical Support: Data Chem, Inc.
960 West Leroy Drive
Salt Lake City, Utah

Report Formatted By: Donna M. Pfirman
Office Automation Assistant
Industrial Hygiene Section

Originating Office: Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies

XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, VA 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. The General Castings Company - Power Street Facility
2. Employee Representative
3. 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

Health Effects Summary for Metals

General Castings Company - Power Street Facility
Cincinnati, Ohio
HETA 92-092

Substance	Primary Health Effects
Aluminum	Metallic aluminum dust is considered a relatively benign dust".[13]
Chromium	Chromium (Cr) exists in a variety of chemical forms and t varies among the different forms. For example, elemental is relatively non-toxic.[13] Other chromium compounds may c irritation, sensitization, and allergic dermatitis. In t hexavalent form (Cr(VI)), Cr compounds are corrosive, and carcinogenic. Until recently, the less water-soluble Cr(V were considered carcinogenic while the water-soluble form considered carcinogenic. Recent epidemiological evidence carcinogenicity among workers exposed to soluble Cr(VI) compounds.[14-18] Based on this new evidence, NIOSH recommen all Cr(VI) compounds be considered as potential carcinoge
Copper	Inhalation of copper fume has resulted in irritation of t respiratory tract, metallic taste in the mouth, and nause Exposure has been associated with the development of meta fever.[5]
Iron	Inhalation of iron oxide dust may cause a benign pneumoco called siderosis.[19]
Lead	Chronic lead exposure has resulted in nephropathy (kidney gastrointestinal disturbances, anemia, and neurologic eff These effects may be felt as weakness, fatigue, irritabil blood pressure, mental deficiency, or slowed reaction tim Exposure also has been associated with infertility in bot fetal damage.[20]
Magnesium	Magnesium can cause eye and nasal irritation.[21] Exposure associated with the development of metal fume fever.[5]
Nickel	Metallic nickel compounds cause sensitization dermatitis. considers nickel a potential carcinogen, as nickel refini associated with an increased risk of nasal and lung cance
Zinc	Zinc has been associated with shortness of breath, minor function changes, and metal fume fever.[5,21]

Table 2

Results of Personal Breathing Zone and Area Samples
for Respirable Silica and Cristobalite

General Castings Company
Power Street Facility
Cincinnati, Ohio
HETA 92-092

February 20-21, 1992

Job Title/ Location	Sampling Time	Sample Volume (liters)	Respirable Silica Concentration (TWA-µg/m³)*	Cr Co
<u>Personal:</u>				
Shakeout Operator	6:24-2:13	799	125	ND**
Shakeout Operator	6:20-2:15	813	61.5	ND
Bobcat® Operator	6:11-1:30	753	40	ND
Bumper Molder	6:16-2:12	811	12	ND
Molder-Large Press	6:08-2:10	819	12.2	ND
Molder-Separate Area	6:09-11:30	546	ND	ND
Molder-Separate Area	6:26-2:04	780	ND	ND
Bumper Molder	6:15-2:11	808	12.4#	ND
Bumper Molder	6:12-2:15	821	ND	ND
Bumper Molder	6:10-2:03	804	ND	ND
NIOSH Recommended Exposure Limit (REL):			50	50
OSHA Permissible Exposure Limit (PEL):				100/500
ACGIH Threshold Limit Value (TLV®):			100	50
Minimum Detectable Concentration (MDC):		718	14	21
Minimum Quantifiable Concentration (MQC):		718	42	42

* - TWA-µg/m³ - Time-weighted average-micrograms per cubic meter

** - ND - None Detected, below the MDC

- Between MDC and MQC

Table 2 (continued)

Results of Personal Breathing Zone and Area Samples
for Respirable Silica and Cristobalite

General Castings Company
Power Street Facility
Cincinnati, Ohio
HETA 92-092

February 20-21, 1992

Job Title/ Location	Sampling Time	Sample Volume (liters)	Respirable Silica Concentration (TWA-µg/m³)*	Crist Conce
Personal:				
Maintenance Worker	6:30-2:09	782	ND**	ND
Maintenance Worker	6:33-2:02	763	ND	ND
Chipper/Grinder	6:19-2:16	811	160	ND
Chipper/Grinder	6:21-2:17	809	148	ND
Chipper/Grinder	6:16-2:11	808	124	ND
Area:				
Shakeout	6:24-9:50	350	ND	ND
Shakeout	9:50-2:09	440	ND	ND
NIOSH Recommended Exposure Limit (REL):			50	50
OSHA Permissible Exposure Limit (PEL):				100 / 50
ACGIH Threshold Limit Value (TLV®):			100	50
Minimum Detectable Concentration (MDC):		718	14	21
Minimum Quantifiable Concentration (MQC):		718	42	42

* - TWA-µg/m³ - Time-weighted average micrograms per cubic meter

** - ND - None Detected, below the MDC

- Between MDC and MQC

Table 6

Results of Area Samples for Formaldehyde

General Castings Company
Power Street Facility
Cincinnati, Ohio
HETA 92-092

February 20-21, 1992

Location	Sampling Time	Sample Volume (liters)	Concentration (TWA-ppm)*
Pouring Floor	8:02-1:58	354	0.016
Coremaking Area-Pepset® Mixer	8:02-1:58	354	0.016
Coremaking Area-Top of Baking Ovens	7:54-1:52	360	0.015
Gas Molding Area	6:59-1:59	421	0.014
Coremaking Area-Pepset® Mixer	6:58-1:58	421	0.014
NIOSH Recommended Exposure Limit (REL):			0.016 [LFC#]
OSHA Permissible Exposure Limit (PEL):			0.75
ACGIH Threshold Limit Value (TLV®):			1
Minimum Detectable Concentration (MDC):		354	0.001 ppm
Minimum Quantifiable Concentration (MQC):		354	0.004 ppm

* - ppm - parts per million

- Lowest Feasible Concentration

Table 5

Results of Passive Dosimeter Monitors for Carbon Monoxide

General Castings Company
Liberty Road Facility
Delaware, Ohio
HETA 92-044

January 14-16, 1992

Location	Sampling Time	Concentration (TWA-ppm)*
Personal:		
Pourer	6:39-2:08	27
Furnace Operator	6:19-2:09	6
Pourer	6:35-2:07	33
Furnace Operator	6:35-2:22	6
Pourer-Platform	6:30-2:22	38
Pourer-Runner	6:27-2:22	14
NIOSH Recommended Exposure Limit (REL):		35
OSHA Permissible Exposure Limit (PEL):		50
ACGIH Threshold Limit Value (TLV®):		50(25-proposec

* - TWA-ppm - time-weighted average - parts per million.

Minimum Detectable Concentration (MDC) for 8-hr shift: 6 ppm

Table 4

Results of Personal Breathing Zone and Area Air Samples
for Phenol

General Castings Company
Power Street Facility
Cincinnati, Ohio
HETA 92-092

February 20-21, 1992

Location/ Job Category	Sampling Time	Sample Volume (liters)	Concentr (TWA-p
Personal:			
Coremaker-Pepset®	6:31-2:20	46.9	0.048
Coremaker-Oil Baked	6:37-2:22	46.5	0.011#
Coremaker-Pepset®	6:37-1:58	44.2	0.077
Coremaker-Oil Baked	6:40-1:59	43.9	0.012#
Area:			
Pepset® Machine	6:33-2:24	47.1	0.027
Pouring Platform	6:44-2:25	46.1	ND**
Pepset® Machine	6:38-1:57	43.9	0.059
NIOSH Recommended Exposure Limit (REL):			5
OSHA Permissible Exposure Limit (PEL):			5
ACGIH Threshold Limit Value (TLV®):			5
Minimum Detectable Concentration (MDC):		43.9	0.006 ppm
Minimum Quantifiable Concentration (MQC):		43.9	0.02 ppm

* - ppm - parts per million

** - None detected, below MDC

- Between MDC and MQC

Table 7

Results of Personal Breathing Zone and Area Air Samples
for Volatile Organic Compounds

General Castings Company
Power Street Facility
Cincinnati, Ohio
HETA 92-092

February 20-21, 1992

Location	Sampling Time	Sample Volume (liters)	Benzene Concentration (TWA-ppm)*	Total Toluene Concentration (TWA-ppm)	Hydroca Concent (TWA-mg
Personal:					
Coremaker-Oil Baked	6:37-2:21	93	0.017	ND**	5.59
Pourer	6:50-2:22	90.4	0.124	ND	2.21
Coremaker-Pepset®	6:31-2:20	93.6	0.131	ND	20.3
Coremaker-Pepset®	6:37-1:58	88.4	0.160	0.03#	28.3
Coremaker-Oil Baked	6:40-1:59	87.8	0.035	ND	5.35
Area:					
Pouring Platform	6:44-2:25	92.2	0.03	ND	ND
Pepset® Mixer	6:42-1:57	87.2	0.005	ND	17.2
NIOSH Recommended Exposure Limit (REL):			0.1	100	
OSHA Permissible Exposure Limit (PEL):			1.0	200	
ACGIH Threshold Limit Value (TLV®):			10 (proposed-0.1)	100 (proposed-50)	
Minimum Detectable Concentration (Sample Volume: 87.2 liters)			0.004	0.03	1.15
Minimum Quantifiable Concentration (Sample Volume: 87.2 liters)			0.012	0.101	3.78

* - TWA-ppm - Time-weighted average - parts per million

** - TWA-mg/m^3 - Time-weighted average - milligrams per cubic meter

\# - Between MDC and MQC

Table 3

Results of Personal Breathing Zone and Area Air Samples for Metals
Using Inductively Coupled Plasma Emission Spectroscopy (ICP)

General Castings Company
Power Street Facility
Cincinnati, Ohio
HETA 92-092

February 20-21, 1992

Job Title	Sampling Time	Sample Volume	Metal Concentrations (TWA-µg/m							
			Al	Cr	Cu	Fe	Mg	Ni	P	
Personal:										
Furnace Operator	6:33-2:22	936	7	3	3	182	7	ND**	160	32
Pourer	6:30-2:22	942	16	1	3	159	6	ND	117	23
Pourer	6:28-2:10	924	24	1	3	152	8	ND	74	14
Grinder	6:20-2:16	952	7	2	9	1050	3	1	11	4
Grinder	6:23-2:14	942	7	1	4	435	3	0.5	11	4
Grinder	6:16-1:56	918	26	8	31	4793	36	4	3	3
Furnace Operator	6:19-2:09	940	20	1	4	436	170	0.5	14	5
Pourer	6:36-2:01	890	20	ND	2	180	85	ND	4	2
Grinder	6:13-2:12	958	11	3	13	1253	25	1	ND	1
Grinder	6:13-2:12	958	15	10	34	4384	25	6	ND	2
Area:										
Pouring Platform	6:23-2:07	926	13	ND	2	151	43	ND	4	2
Minimum Quantifiable Concentration (MQC) (Volume: 890 liters)			0.56	5.6	1.12	1.12	1.12	0.56	2.25	0.56

* - TWA-µg/m³ - Time-weighted average - micrograms per cubic meter
** - ND - None Detected, below the MQC

Metals	OSHA PELs (µg/m³)	NIOSH RELs (µg/m³)	ACGIH TLVs (
Al - Aluminum	15000	10000	10000
Cr - Chromium	1000	500	500
Cu - Copper	1000	1000 (fume-100)	1000
Fe - Iron	10000	5000	5000
Mg - Magnesium	15000	None	10000
Ni - Nickel	1000	15 (carcinogen)	1000 (proposed-15)
Pb - Lead	50	<100	150
Zn - Zinc	15000	5000	10000