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THE GENERAL CASTINGS CO.-
CURTIS STREET FACILITY
DELAWARE, OHIO

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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-Curtis Street Facility, a gray and ductile iron foundry cleaning facility in Delaware, Ohio.

On March 3-5, 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 (quartz), cristobalite, metals, and organic solvents. Work practices, engineering control measures, and noise exposures were also evaluated.

The PBZ air concentrations of respirable silica ranged from 163 (shotblast operator) to 1870 micrograms per cubic meter [µg/m^3] (grinder), as nearly full-shift time-weighted averages (TWAs). All 24 personal exposures exceeded their respective Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) for respirable silica (as quartz) and the NIOSH Recommended Exposure Limit (REL) of 50 µg/m^3 for respirable crystalline silica (regardless of morphology). Cristobalite was detected in 21 samples. The semi-quantitative cristobalite exposures (24-127 µg/m^3) indicated overexposures at the NIOSH REL of 50 µg/m^3 for cristobalite. Nine of the 16 iron exposures [56%] (range: 1560 to 46560 µg/m^3; geometric mean: 8160 µg/m^3) measured for the chipper/grinders exceeded the OSHA PEL of 10000 µg/m^3 for iron and 12 of the 16 exposures (75%) exceeded the NIOSH REL of 5000 µg/m^3 for iron. Nickel concentrations for one chipper/grinder (1920 µg/m^3) and one welder (1130 µg/m^3) exceeded the OSHA PEL of 1000 µg/m^3 for nickel. Nine of the 22 nickel PBZ exposures (41%) exceeded the NIOSH REL of 15 µg/m^3 for nickel. Since grinders wore air-purifying respirator helmets, the inside-respirator exposures of the employees were probably lower than the exposures measured. All four personal noise exposures measured for grinders exceeded the OSHA PEL of 90 decibels, A-weighted levels, [dB(A)], as an 8-hour TWA. One area sample from the paint dip tank (214 parts per million [ppm]) exceeded the NIOSH, OSHA, and ACGIH criteria for xylene of 100 ppm, indicating a potential hazard to employees. Concentrations of benzene (0.007 to 0.015 ppm), ethyl benzene (0.12 to 10.1 ppm), and toluene (0.6 to 4.1 ppm), and the metals: aluminum, chromium, copper, lead, magnesium, manganese, and zinc (range: 1 to 408 µg/m^3) did not exceed their respective occupational evaluation criteria.

The industrial hygiene sampling data indicate that workers were overexposed to respirable silica, cristobalite, iron, nickel, and noise; and that xylene exposures constituted a potential health hazard to employees in the welding, painting, and cleaning areas at this facility. Recommendations for engineering controls, an improved respiratory protection program, and improved work practices can be found in Section VIII of this report.

KEYWORDS: SIC 3321 (Gray and Ductile Iron Foundries), respirable silica (quartz), cristobalite, noise exposure, organic solvents, welding, painting, engineering controls.

II. INTRODUCTION

On March 3-5, 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-Curtis Street facility, a casting cleaning facility for gray and ductile iron foundries, in Delaware, Ohio. This visit was made in response to a management request to evaluate worker exposures in the grinding, shotblast, and painting areas of the plant. Since the facility was newly acquired by the company, there was a general interest in identifying potential occupational health hazards. The sampling results had been sent to the company in January 1993.

III. BACKGROUND

The General Castings-Curtis Street Facility is housed in a metal/masonry building with several additions. The facility operated two shifts with a total of 52 employees. Castings were brought from two other facilities on flat bed trucks for cleaning, repair, painting, and final shipment.

The cleaning process was split into many areas throughout the building. A shotblast machine was used for removing sand from castings; the machine was exhausted to a bag house dust collection system located outside. The machine was loaded and unloaded using a hand-operated hoist and an overhead crane. After shotblasting, the castings were loaded onto carts and pallets which forklifts take to the grinding area for additional cleaning to remove sand adhering to the castings. There were approximately 25 individual grinding stations separated by plywood partitions. Grinders used Ingersall Rand® chippers, cone grinders, and grinding wheels to complete the cleaning. Compressed air was used to remove excess sand from the internal cavities of the castings in the shotblast and grinding areas. If there were major sand inclusions in the casting, it might be sent to the sandblasting area. This area consisted of a room with a sandblast machine, which was open along the ceiling to the rest of the plant and to the outside via a garage door. The operation was not running during the site visit and there were no engineering controls in place.

After cleaning, the castings were sent to different departments depending upon customer specifications and the condition of the castings. The painting department consisted of three spray paint booths and two paint dip tanks. Two of the spray paint booths were in use during the site visit and the other was being installed. Spray painters used a compressed air atomizer with a pressure pot for spraying paint. The paint dip tanks were located adjacent to the cleaning area and there were no local ventilation controls in place. Dipped parts were placed in the second spray paint booth and in the surrounding open area and allowed to dry. According to management, the two spray paint booths would be eliminated when the new one was completed.

If the castings needed minor repairs, they were sent to either the machine shop in the front of the facility or the welding department. Synthetic oils were used as coolants in the machining operations. After final cleaning and repair, the castings were sent to the shipping/quality control department which was located next to the welding area. If necessary, this area performed minimal grinding and chipping on the castings before shipping.

Safety shoes, hard hats, and safety glasses were required throughout the facility. NIOSH/Mine Safety And Health Administration (MSHA) approved 3-M® air-purifying respirator helmets which had high efficiency particulate air (HEPA) filters and a built-in face shield are used in the grinding areas. NIOSH/MSHA approved disposable 3-M® 8710 dust, fume, and mist respirators were used by the shotblast operators and by the grinders under their helmets. According to management, NIOSH/MSHA approved HEPA cartridge half-mask respirators were used by the sandblasters. Painters wore latex gloves. Hearing protection devices (disposable plugs) are required throughout the facility's cleaning areas. Brooms and shovels are used to clean up material throughout the facility.

General ventilation is supplied by open doors and windows. Large free-standing propeller "man-cooling" fans are used through out the plant. At the time of the survey, three propeller wall fans were being installed in the cleaning area. Heat is provided during winter months by overhead gas-fired radiant heaters and a make-up air heater located next to the paint dip tanks which supplied heated outside air to the facility..

IV. METHODS

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

A. Respirable Silica and Cristobalite

Twenty-four PBZ 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 millimeter (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. The laboratory-assigned analytical limit of detection (LOD) and limit of quantitation (LOQ); and the corresponding minimum detectable concentration (MDC) and minimum quantifiable concentration (MQC), assuming a sample volume of 666 liters, are as follows:

Analyte	LOD µg/sample	LOQ µg/sample	MDC $\mu g/m^3$	MQC $\mu g/m^3$	Minimum Volume (liters)
Quartz	10	30	15	45	666
Cristobalite	15	30	23	45	666

B. Metals

Twenty-two PBZ and one area air samples were collected on mixed-cellulose ester filters (37 millimeter [mm] diameter, 0.8 micrometer [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 laboratory-assigned MQCs, using a sample volume of 598 liters, for the selected metals are listed in Table 3.

C. Organic Solvents

Four PBZ and five area air samples were collected on charcoal tubes at a flowrate of 0.2 l/min. One additional sample was used for qualitative analysis to identify major constituents by gas chromatography/mass spectroscopy (GC/MS) analysis. The charcoal tubes were desorbed with carbon disulfide and screened by gas chromatography/flame ionization detector (GC-FID), according to NIOSH Methods 1501 and 1550.[3,4] Total hydrocarbons were quantitated against n-octane. The laboratory-assigned LODs and LOQs; and calculated MDCs and MQCs, assuming a sample volume of 88 liters, are as follows:

Analyte	LOD µg/sample	LOQ µg/sample	MDC ppm	MQC ppm	Minimum Volume (liters)
Benzene	1	3.3	0.004	0.012	88
Ethyl Benzene	10	33	0.026	0.086	88
Toluene	10	33	0.029	0.088	88
Xylene	10	33	0.004	0.374	88

The laboratory-assigned LOD and LOQ; and calculated MDCs and MQCs, assuming a sample volume of 88 liters, for total hydrocarbons are as follows:

Analyte	LOD mg/sample	LOQ mg/sample	MDC mg/m^3	MQC mg/m^3	Minimum Volume (liters)
Total Hydrocarbons	0.1	0.33	1.13	3.74	88

D. Noise

Area noise samples were measured with a Quest Electronics Model 2400 Sound Level Meter. Four personal noise dosimeters (Quest Electronics M-27 Noise Logging Dosimeters) were also used during this survey. The dosimeter consists of a small noise recording device which is worn on the worker's collar or shoulder area. The device measures noise in decibels, A-weighted levels (dB[A]), integrates the data according to OSHA noise regulations, and stores it for later analysis.

E. Ventilation Measurements

Face velocity measurements were made at the face of the spray paint booth using a hot-wire anemometer, and the flow rate was calculated by multiplying the average velocity by the area of the opening.

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-exiting 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 (OSHA) PELs.[7] In July 1992, the 11th Circuit Court of Appeals vacated the 1989 Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA-approved job safety and health programs will continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 limits, or the RELs, whichever are lower. 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 related 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 and the OSHA PELs included in this report are the 1971 values.

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.[9] The NIOSH RELs for respirable quartz and cristobalite, published in 1974, are 50 µg/m^3, as time-weighted averages (TWAs), for up to 10 hours per day during a 40-hour work week.[10] 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.[11-13] OSHA requires that the 1971 PEL for respirable silica be dependent upon the percent silica in the sample, and that the respirable dust exposure for an 8-hour TWA not exceed the value obtained from the formula:

$$\frac{10\ mg/m^3}{\%SiO_2\ +\ 2}$$

The ACGIH TLV®s for respirable quartz and cristobalite are 100 and 50 µg/m^3, as 8-hour TWAs, respectively.[7,8]

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. 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]

Exposure to low concentrations of ethyl benzene may cause irritation of the skin and mucous membranes. Chronic exposures to high concentrations of ethyl benzene have been associated with fatigue, sleepiness, headache, and irritation of the eyes and respiratory tract.[13,19] The NIOSH REL, ACGIH TLV®, and OSHA PEL for ethyl benzene are 100 ppm as a TWA.

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.[12,18] The NIOSH REL for toluene is 100 ppm as a 10-hour TWA. The ACGIH TLV® for toluene is 50 ppm as an 8-hour TWA. The current OSHA PEL for toluene is 200 ppm as an 8-hour TWA. OSHA had lowered the PEL to 100 ppm in 1989 under the Air Contaminants Standard.

Xylene exposure may cause irritation of the eyes, mucous membranes, skin, and respiratory tract.[11,17] The NIOSH REL, ACGIH TLV®, and OSHA PEL for xylene are 100 ppm as a TWA.

D. Noise/Hearing Loss

Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to excessive noise levels produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[22] While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 hertz (Hz) (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[23]

The OSHA standard for occupational exposure to noise (29 CFR 1910.95)[24] specifies a maximum PEL of 90 dB(A)-slow response for a duration of eight hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship. This means that in order for a person to be exposed to noise levels of 95 dB(A), the amount of time allowed at this exposure level must be cut in half in order to be within OSHA's PEL. Conversely, a person exposed to 85 dB(A) is allowed twice as much time at this level (16 hours) and is within his daily PEL. Both NIOSH, in its Criteria for a Recommended Standard,[25] and ACGIH, in their TLV®s,[6] propose an exposure limit of 85 dB(A) for eight hours, 5 dB less than the OSHA standard. Both of these latter two criteria also use a 5 dB time/intensity trading relationship in calculating exposure limits.

TWA noise limits as a function of exposure duration are shown as follows:

Duration of Exposure (hrs/day)	Sound Level dB(A)	
	NIOSH/ACGIH	**OSHA**
16	80	85
8	85	90
4	90	95
2	95	100
1	100	105

1/2	105	110
1/4	110	115*
1/8	115*	---
		**

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

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

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

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

VI. RESULTS

A. Respirable Silica and Cristobalite

The results of the PBZ air sampling are presented in Table 2. The 24 PBZ sample concentrations ranged from 163 to 1870 µg/m^3, as TWAs. All 24 personal exposures exceeded their respective OSHA PELs for respirable silica (quartz) and exceeded the NIOSH REL of 50 µg/m^3 for respirable silica. The 22 samples collected for the grinders had exposures ranging from 300 to 1870 µg/m^3 (geometric mean: 636 µg/m^3). The shotblast operators' exposures were 163 and 353 µg/m^3. Cristobalite was detected for 20 grinders (range: 25-127 µg/m^3) and one shotblast operator at 24 µg/m^3. Due to the large volume of respirable material collected on the filters, all of the samples were split into portions for quantitative analysis, resulting in semi-quantitative values for cristobalite. Assuming that the cristobalite samples are accurate, 12 of the 21 samples (57%) exceeded the NIOSH REL of 50 µg/m^3 for cristobalite. Grinders wore air-purifying respirator helmets; therefore, the inside-respirator exposures to the grinders were probably lower than the measured exposures.

B. Metals

The 22 PBZ and one area air sample concentrations for metals are presented in Table 3. Concentrations of aluminum, chromium, copper, lead, magnesium, manganese, and zinc (range: 1 to 408 µg/m^3) did not exceed the respective occupational evaluation criteria. Nine of the 16 (56%) iron concentrations measured for the chipper/grinders exceeded the OSHA PEL of 10000 µg/m^3 for iron and 12 of the 16 sample concentrations (75%) exceeded the NIOSH REL of 5000 µg/m^3 for iron. The 16 samples collected for the grinders had exposures ranging from 1560 to 46560 µg/m^3 (geometric mean: 8160 µg/m^3). Iron concentrations measured for four welders ranged from 663 to 3630 µg/m^3 (geometric mean: 1280 µg/m^3). The two foreman/leadman concentrations for iron were 1750 and 1230 µg/m^3. Nickel concentrations for one chipper/grinder (1920 µg/m^3) and one welder (1130 µg/m^3) exceeded the OSHA PEL of 1000 µg/m^3 for nickel. Nine of the 22 samples (41%) exceeded the NIOSH REL of 15 µg/m^3 for nickel. Grinders wore air-purifying respirator helmets; therefore, the inside-respirator exposures to the grinders were probably lower than the measured exposures.

C. Organic Solvents

The four PBZ and five area sample results for benzene, ethyl benzene, toluene, and xylenes are given in Table 4. None of the PBZ or area concentrations for benzene (PBZ: 0.007 to 0.010 ppm; area: 0.007 to 0.015 ppm), ethyl benzene (PBZ: 0.22 to 0.42 ppm; area: 0.12 to 10.1 ppm), and toluene (PBZ: 2.4 to 4.1 ppm; area: 0.6 to 1.6 ppm) exceeded the current occupational evaluation criteria. The PBZ xylene concentrations (1.9 to 12.8 ppm) were below current occupational criteria but one area sample from the paint dip tank (214 ppm) exceeded the NIOSH, OSHA, and ACGIH criteria for xylene of 100 ppm indicating a potential hazard.

D. Noise

To determine some of the potentially high noise activities in specific areas, a sound level meter, in the maximum hold position, was used to take readings in the slow dB[A] mode during a walk-through survey (Table 5). The noisiest activities in the grinding department were use of the chipper and the small grinding wheel. The small sander in the paint department also generated high noise levels. The written hearing protection policy was reviewed and contained the appropriate components.

Dosimeter measurements show how short-term noise levels affect an employee's noise exposure for an entire shift. A summary of the personal noise dosimeter measurements is given in Table 6. All four full-shift samples (103-107.1 dB[A]) exceeded the OSHA PEL of 90 dB(A) for noise and the 85 dB(A) criteria used by NIOSH and ACGIH for noise. All four personal exposures measured were over 115 dB(A) which current evaluation criteria state should not occur.

The personal noise dosimeter printouts are presented in Figures 1-4. The changes in the personal exposure patterns seem to correlate with break periods when the workers left the area and clean-up at the end of the day. The noise levels were quite consistent throughout the day for all four grinders.

E. Ventilation Measurements

The average face velocity of the paint booth used for spray painting was 30 feet per minute. This is less than the recommended ACGIH flow of 100 feet per minute for large spray paint booths.[26]

F. Observations

Three conditions were observed which could result in recirculation of dust into the plant: dust was visibly leaking from the shot/sand mechanical separator of the shotblast machine, the waste abrasive bin was full, and material was stuck in the discharge chute. Visible clouds of dust escaped when the shotblast doors were opened immediately after the cleaning cycle finished. The operator did not wait for the turntable inside the machine to stop.

The written respiratory and hearing protection policies were appropriate, but NIOSH investigators observed that some individuals were not wearing hearing protection or safety glasses in the building where required. Employees were observed with the visors of their respirator helmets up, presumably because the visors have deteriorated to the point that vision is obscured. One grinder was not wearing his respirator, stating that it was not working correctly. Employees were observed smoking and eating lunch in the general work area.

VII. DISCUSSION AND CONCLUSIONS

The foundry industry has been identified as a complex process with numerous associated health hazards.[27] 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 reference population.[28] However, smoking history was not available for these studies. Additional investigations are needed to determine if chronic health effects do result from exposures to current foundry emissions. The industrial hygiene sampling data indicate that workers were overexposed to respirable silica, cristobalite, iron, nickel, and noise in the cleaning and welding areas at this facility. There was a potential for overexposure to xylene in the paint dip tank area. During the walk-through survey, some potential safety and health hazards were identified, such as the use of compressed air to clean loose sand from castings, and unenforced hearing and eye protection policies.

VIII. RECOMMENDATIONS

The following recommendations are offered to reduce workers' exposures to respirable silica, cristobalite, iron, nickel, noise, and xylene, and to correct safety and health issues 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. Until appropriate engineering controls are implemented to reduce exposures to within OSHA and NIOSH recommended criteria, employees in the welding and cleaning departments should be provided respiratory protection for respirable silica, iron, and nickel exposure. NIOSH considers inorganic nickel to be an occupational carcinogen, and as such, recommends that exposures be reduced to the lowest feasible level. Based on this recommendation, workers in the cleaning and welding areas should use supplied air respirators.[29,30] A routine respirator maintenance program should be established which should include the replacement of visors and motors when needed.

2. The current written hearing and eye protection policies should be strictly enforced. Based on the noise dosimeter survey, mandatory hearing protection should continue in the cleaning area. An in-depth noise evaluation should be conducted to determine if hearing protection is needed in other areas of the plant.

3. To reduce respirable silica exposures, all hand grinding operations for small castings should be conducted on downdraft benches and a hood for the snag grinding operation should be installed, as described in the ACGIH publication, Industrial Ventilation.[26] Also, high velocity, low volume (HVLV) tool hoods with noise mufflers should be used for the hand grinders. Chipping and grinding in the interior of large castings could be controlled by the use of a flexible exhaust duct which could be inserted into the interior of the casting.

4. To control dust from the shotblast machine at the end of the abrasive cycle, the machine exhaust should be allowed to run for 2-3 minutes before opening the door of the blast chamber as instructed by the manufacturer. The possibility of installing an automatic compressed air blower within the blast chamber should be explored. As an alternative, the doors could be opened a small amount (~2 feet) and the operator could blow off the castings while the table rotates.

5. Due to the health hazard from the use of silica sand, the company was advised at the time of the site visit that the current sandblasting operation should be replaced. Adequate controls, including a separate

sandblast room with a less hazardous abrasive material such as industrial ventilation, use of local exhaust ventilation or sandblasting machines, and positive-pressure abrasive blasting respirator programs should be immediately implemented.[26,31]

6. To reduce the noise emitted when castings are dumped into the portable metal bins, the bins should be lined with damping compound.[32]

7. To improve general ventilation, a make-up air system should be installed to supply fresh air and to replace existing space heaters. The air exhausted from the building should be replaced with tempered air from an uncontaminated source. This air could be directed to operator work areas to provide a cleaner environment. The use of man-cooling fans is not recommended since they would interfere with local exhaust hoods.

8. To reduce exposures to respirable silica and noise during casting cleaning, 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) and equipped with regulators.[33] An industrial vacuum should be used on a regular basis to collect loose sand/dust on the floor instead of dry sweeping and shoveling.

9. To avoid 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.

10. To reduce solvent exposures in the dip tank area, side draft exhaust hoods should be installed behind the tanks. Objects removed from the tanks should be moved into a ventilated drying area. Detailed recommendations are contained in the ACGIH publication, Industrial Ventilation.[26]

11. To reduce solvents exposures in the spray painting area, a more efficient painting system such as airless painting could be used. The airflow in the current paint booth could be brought up to recommended levels by increasing the amount of exhaust and by installing a series of baffles or slots at the rear of the booth to provide uniform velocity.[26] The painter should paint objects in the rear of the booth near the exhaust progressing forward. If paints containing isocyanates are used, supplied air respirators should be used by the employees based on the potential allergic (asthmatic) reactions and potential risk of cancer associated with these compounds.[34-36] If possible, paints not containing isocyanate compounds should be used.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report have been sent to:

1. The General Castings Company - Curtis 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 - Curtis Street Facility
Delaware, Ohio
HETA 92-0089

Substance	Primary Health Effects
Aluminum	Metallic aluminum dust is considered a relatively benign "inert dust".[13]
Chromium	Chromium (Cr) exists in a variety of chemical forms and toxicity varies among the different forms. For example, elemental chromium is relatively non-toxic.[13] Other chromium compounds may cause skin irritation, sensitization, and allergic dermatitis. In the hexavalent form (Cr(VI)), Cr compounds are corrosive, and possibly carcinogenic. Until recently, the less water-soluble Cr(VI) forms were considered carcinogenic while the water-soluble forms were not considered carcinogenic. Recent epidemiological evidence indicates carcinogenicity among workers exposed to soluble Cr(VI) compounds.[14-18] Based on this new evidence, NIOSH recommends that all Cr(VI) compounds be considered as potential carcinogens.
Copper	Inhalation of copper fume has resulted in irritation of the upper respiratory tract, metallic taste in the mouth, and nausea.[13] Exposure has been associated with the development of metal fume fever.[5]
Iron	Inhalation of iron oxide dust may cause a benign pneumoconiosis called siderosis.[19]
Lead	Chronic lead exposure has resulted in nephropathy (kidney damage), gastrointestinal disturbances, anemia, and neurologic effects.[13] These effects may be felt as weakness, fatigue, irritability, high blood pressure, mental deficiency, or slowed reaction times. Exposure also has been associated with infertility in both sexes and fetal damage.[20]
Magnesium	Magnesium can cause eye and nasal irritation.[21] Exposure has been associated with the development of metal fume fever.[5]
Manganese	Manganese fume exposure has been associated with chemical pneumonitis and central nervous system effects.[13,19]
Nickel	Metallic nickel compounds cause sensitization dermatitis.[13] NIOSH considers nickel a potential carcinogen, as nickel refining has been associated with an increased risk of nasal and lung cancer.[21]
Zinc	Zinc has been associated with shortness of breath, minor lung function changes, and metal fume fever.[5,21]

Table 6

Personal Noise Dosimeter Survey

General Castings Company
Curtis Street Facility
Delaware, Ohio
HETA 92-0089
March 3-5, 1992

Job Category	Sample Period [minutes]	Time-Weighted Avg. [dB(A)]	Minutes Over Ceiling Limit [115 dB(A)]
Grinder	456	104.4	9
Grinder	455	103.0	1
Grinder	448	107.1	30
Grinder	453	107.0	16
NIOSH Recommended Exposure Limit (REL):		85	
OSHA Permissible Exposure Limit (PEL):		90	
ACGIH Threshold Limit Value (TLV®):		85	

Table 3

Results of Personal Breathing Zone Air Samples for Metals

General Castings Company
Curtis Street Facility
Delaware, Ohio
HETA 92-0089
March 3-5, 1992

Job Title	Sampling Time	Sampling Volume (liters)	Metal Concentrations (TWA-µg/m³)*								
			Al	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
Chipper/Grinder	6:16-2:10	882	408	14	40	13600	66	170	1920	ND	24
Chipper/Grinder	6:22-2:08	940	1	5	28	5750	29	90	10	ND	14
Welder	6:43-2:05	882	272	6	63	3630	82	113	1130	2	9
Welder	6:14-2:04	954	31	1	9	1150	18	19	101	ND	4
Chipper/Grinder	6:18-2:08	942	74	10	36	7020	46	106	13	ND	50
Chipper/Grinder	6:17-2:10	950	105	12	28	10100	43	137	17	ND	20
Chipper/Grinder	6:21-2:09	928	108	17	37	16160	48	205	22	ND	19
Leadman	6:30-2:06	898	22	2	8	1230	20	20	7	ND	4
Chipper/Grinder	6:23-2:12	944	95	10	46	10280	56	127	17	ND	24
Grinder (Rework)	6:26-2:04	896	22	1	13	1560	30	20	8	ND	3
Chipper/Grinder	6:19-2:08	856	199	22	37	16360	54	304	22	ND	60
Chipper/Grinder	3:59-11:37	930	140	9	41	3550	30	151	5	ND	6
Minimum Quantifiable Concentrations (Sampling Volume - 598 liters)			12	1	1	1	2	1	1	2	1

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

Metals	OSHA PELs (µg/m³)	NIOSH RELS (µg/m³)	ACGIH TLVs® (µg/m³)
Al - Aluminum	15000	10000	10000
Cr - Chromium	1000	500	500
Cu - Copper	1000	1000	1000
Fe - Iron	10000	5000	5000
Mg - Magnesium	15000	None	10000
Mn - Manganese	5000	1000	5000 (200 proposed)
Ni - Nickel	1000	15 (Carcinogen)	1000 (50 proposed)

Pb - Lead	50	<100	150
Zn - Zinc	15000	5000	10000

Table 3 (Continued)

Results of Personal Breathing Zone Air Samples for Metals

General Castings Company
Curtis Street Facility
Delaware, Ohio
HETA 92-0089
March 3-5, 1992

Job Title	Sampling Time	Sampling Volume (liters)	Metal Concentrations (TWA-µg/m³)*								
			Al	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
Chipper/Grinder	4:14-11:44	902	89	29	155	46560	60	366	59	2	45
Chipper/Grinder	4:00-11:39	932	21	2	10	1930	15	28	10	ND	4
Chipper/Grinder	3:45-11:46	886	23	3	21	4510	19	53	7	ND	8
Foreman	3:49-11:50	974	52	8	13	1750	18	45	3	ND	4
Chipper/Grinder	6:46-2:22	916	131	15	78	14190	69	240	14	ND	106
Welder/Machine Shop	6:21-2:15	884	11	1	16	962	26	17	7	3	28
Chipper/Grinder	6:49-2:20	912	66	8	38	6470	38	110	18	ND	57
Chipper/Grinder	6:42-2:24	930	108	10	43	10540	43	151	12	ND	56
Welder/Machine Shop	6:22-2:14	950	21	2	9	663	20	29	2	ND	9
Chipper/Grinder	6:43-2:20	822	122	11	44	11680	54	195	13	ND	96
Area: Grinding	6:33-2:15	926	43	4	19	4640	33	67	10	ND	14
Minimum Quantifiable Concentrations (Sampling Volume - 598 liters)			12	1	1	1	2	1	1	2	1

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

Metals	OSHA PELs (µg/m³)	NIOSH RELS (µg/m³)	ACGIH TLVs® (µg/m³)
Al - Aluminum	15000	10000	10000
Cr - Chromium	1000	500	500
Cu - Copper	1000	1000	1000
Fe - Iron	10000	5000	5000
Mg - Magnesium	15000	None	10000
Mn - Manganese	5000	1000	5000 (200 proposed)

Ni - Nickel	1000	15 (Carcinogen)	1000 (50 proposed)
Pb - Lead	50	<100	150
Zn - Zinc	15000	5000	10000

Table 5

Area Sound Level Measurements

General Castings Company
Curtis Street Facility
Delaware, Ohio
HETA 92-0089
March 3-5, 1992

Location/Activity	Sound Level [dB(A)]
Chipping/Grinding	
- Small Grinding Wheel	101-104
- Large Grinding Wheel	96-101
- Chipper	109
Central Walkway Between Grinders	92-93
Large Shotblast Machine While Operating	90
Shipping Department	85-90
Small Sander in Paint Shop	93
Machine Shop	78

Table 4

Results of Personal Breathing Zone and Area Air Samples for Volatile Organic Compounds General Castings Company-Curtis Street Facility Delaware, Ohio HETA 92-0089 March 3-5, 1992

Job Title	Sampling Time	Sampling Volume (liters)	Ethyl Benzene Conc. (TWA-ppm)*	Benzene Conc. (TWA-ppm)	Toluene Conc. (TWA-ppm)	Xylenes Conc. (TWA-ppm)	Hydrocarbons Conc. (TWA-mg/m^3)**
Personal:							
Painter	6:35-2:01	89	0.238	0.007#	2.8	1.9	39.3
Leadman	6:35-2:0	89	0.219	0.011#	2.44	7.49	41.39
Painter	6:25-2:16	94	0.416	0.010#	4.14	9.23	63.63
Painter	6:26-2:16	94	0.345	0.010#	2.56	12.83	37.43
Area:							
Paint Booth	6:37-2:00	88	0.12	0.011#	1	3.3	14.7
Lunchroom	6:40-2:02	89	0.2	0.007#	1.59	3.84	18.1
Dip Tank	6:38-2:08	90	0.67	0.01#	0.87#	14.5	6.58
Dip Tank	6:32-2:20	94	10.1	0.015	0.58	213.9	160.4
Paint Booth	6:27-2:16	94	0.29	0.01#	1.6	6.38	27.63
NIOSH REL:			100	0.1	100	100	
OSHA PEL:			100	1.0	200	100	
ACGIH TLV®:			100	10 (proposed 0.1)	50	100	
Minimum Detectable Conc.		88	0.026	0.004	0.029	0.133	1.13
Minimum Quantifiable Conc.		88	0.086	0.012	0.088	0.374	3.74

* = Time-weighted average-parts per million (TWA-ppm)
** = Time-weighted average-milligrams per cubic meter (TWA-mg/m^3)
\# = Between MDC and MQC

Table 2

Results of Personal Breathing Zone Samples for Respirable Silica and Cristobalite General Castings Company Curtis Street Facility Delaware, Ohio HETA 92-0089 March 3-5, 1992

Job Title/ Location	Sampling Time	Sample Volume (liters)	Total Respirable Dust Concentration (TWA-mg/m³)*	OSHA Quartz PEL (TWA-mg/m³)	Respirable Silica Concentration (TWA-µg/m³)**	Cristobalite Concentration (TWA-µg/m³)
Chipper/Grinder	6:16-2:11	818	4.17	0.58	637	61#
Chipper/Grinder	6:23-2:12	804	5.55	0.75	634	37#
Chipper/Grinder	6:21-2:11	814	6.97	0.64	946	98#
Chipper/Grinder	6:19-2:07	801	4.63	0.80	487	50#
Chipper/Grinder	6:15-2:15	821	3.91	0.69	487	49#
Chipper/Grinder	6:18-2:07	801	4.07	0.77	450	50#
Chipper/Grinder	6:20-2:12	806	3.95	0.73	459	ND**
Chipper/Grinder	6:17-2:10	809	8.69	0.62	1240	99#
Chipper/Grinder	6:19-2:12	808	7.43	0.97	619#	37#
Chipper/Grinder	6:25-2:09	796	4.69	0.82	78	ND&
Chipper/Grinder	6:24-2:11	804	4.64	0.84	460	62#
Chipper/Grinder	6:16-2:10	813	3.63	0.70	443	25#
Chipper/Grinder	4:10-11:44	780	1.49	0.44	308	26#
NIOSH Recommended Exposure Limit (REL):					50	50
ACGIH Threshold Limit Value (TLV®):					100	50
Minimum Detectable Concentration (MDC) (Sample Volume: 666 liters)					15	23
Minimum Quantifiable Concentration (MQC) (Sample Volume: 666 liters)					45	45

* = Time-weighted average milligrams per cubic meter (TWA-mg/m³)
** = Time-weighted average micrograms per cubic meter (TWA µg/m³)
& = None Detected, below the MDC (ND)
# = Due to the high concentrations of collected materials, the samples were analyzed in portions and these values are semiquantative estimates.

Table 2 (continued)

**Results of Personal Breathing Zone Samples
for Respirable Silica and Cristobalite
General Castings Company
Curtis Street Facility
Delaware, Ohio
HETA 92-0089
March 3-5, 1992**

Job Title/ Location	Sampling Time	Sample Volume (liters)	Total Respirable Dust Concentration (TWA-mg/m³)*	OSHA Quartz PEL (TWA-mg/m³)	Respirable Silica Concentration (TWA-µg/m³)**	Cristobalite Concentration (TWA-µg/m³)
Chipper/Grinder	4:07-11:53	801	3.68	0.52	624	75#
Chipper/Grinder	3:54-11:41	801	8.79	0.43	873	125#
Chipper/Grinder	3:46-11:42	814	5.23	0.29	1719	98#
Chipper/Grinder	4:04-11:40	666	1.52	0.40	300	30#
Chipper/Grinder	6:36-2:25	799	2.24	0.65	663	88
Chipper/Grinder	6:40-2:25	707	5.36	0.70	1697	127#
Chipper/Grinder	6:34-2:28	804	9.51	0.50	547	25#
Chipper/Grinder	6:35-2:28	811	5.16	0.79	4560	25#
Chipper/Grinder	6:40-2:28	809	0.53	0.30	643#	62
Shotblast Operator	6:30-2:20	799	4.00	0.75	163	ND**
Shotblast Operator	3:41-11:40	822	5.14	0.69	353	24#
NIOSH Recommended Exposure Limit (REL):					50	50
ACGIH Threshold Limit Value (TLV®):					100	50
Minimum Detectable Concentration (MDC) (Sample Volume: 666 liters)					15	23
Minimum Quantifiable Concentration (MQC) (Sample Volume: 666 liters)					45	45

* = Time-weighted average milligrams per cubic meter (TWA-mg/m³)
** = Time-weighted average micrograms per cubic meter (TWA µg/m³)
& = None Detected, below the MDC (ND)
# = Due to the high concentrations of collected materials, the samples were analyzed in portions and these values are semiquantative estimates.