WALK-THROUGH SURVEY REPORT:

CONTROL TECHNOLOGY SUPPORT FOR SENSOR

AT

General Foundry Company
Flagtown, New Jersey

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SIC CODE:	3321
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INTRODUCTION

Under the Occupational Safety and Health Act of 1970, the National Institute for Occupational Safety and Health (NIOSH) has been given a number of responsibilities including the identification of occupational safety and health hazards, evaluation of these hazards, and recommendation of standards to regulatory agencies to control the hazards. Located in the Department of Health and Human Services (formerly DHEW), NIOSH conducts research separate from the standard setting and enforcement functions conducted by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects relevant to the control of these hazards in the workplace.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. The objective of each of these studies has been to document and evaluate effective techniques for the control of potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

In 1987, NIOSH initiated the SENSOR program (Sentinel Event Notification System for Occupational Risks), a cooperative state-federal effort designed to develop local capability for the recognition, reporting, and prevention of selected occupational disorders. Under this program, the state health department (or other agency) launches three types of actions upon notification of a case of occupational disease: first, disease management guidelines will be made available to the health care provider; second, medical evaluations of co-workers who may be at risk of developing similar disorders will be conducted; and finally, action directed to reduce work site exposures will be considered. To assist the states in developing intervention plans for exposure reduction, ECTB will conduct a pilot engineering assistance project with selected states participating in SENSOR. This assistance may include specific control recommendations for an individual plant identified and selected by the state, or for an industry that would be selected based on the state disease records, with the intent of developing guidelines for the elimination of occupational disease in the entire industry.

Since 1984, the New Jersey Department of Health (NJDOH) has been involved in the surveillance of the occupational disease silicosis, under the NIOSH Capacity Building Program. This surveillance system utilizes morbidity (hospital discharge) data and mortality (death certificate) data to identify cases of silicosis. NJDOH is currently participating in the SENSOR program for occupational asthma and silicosis, which utilizes physicians' reports of silicosis. Health department surveillance data indicate the largest number of silicosis cases in the state exists in the sand mining and processing, foundry, and pottery (sanitary ware) industries. This disease is caused by exposure to crystalline silica in these industries.

At least one study is being conducted by ECTB in a facility of each of these industries to develop specific control recommendations to eliminate future cases of disease; to train state personnel in the application of engineering control; and to develop a model protocol for the identification and control of exposure sources.

This report describes a walk-through survey conducted as a part of this federal-state effort at the General Foundry Company, located in Flagtown, New Jersey. Since the NJDOH has shown the foundry industry to be a high silicosis risk industry, this plant was one of three foundries visited to select a site to demonstrate the feasibility of effective intervention in reducing the silicosis risk; to develop effective risk reduction programs for use in this and in similar type plants; and, thereby, to reduce the incidence of silicosis in this industry.

The specific purposes of this survey were to identify a plant for in-depth study; to evaluate potential worker exposures to silica-containing dusts; to qualitatively evaluate the effectiveness of current engineering controls, work practices, and administrative control programs in reducing dust exposures; and to recommend basic improvements in the dust control and disease prevention programs.

PLANT AND PROCESS DESCRIPTION

PLANT DESCRIPTION

The General Foundry Company is a family-owned-and-operated business founded in 1947. In 1975, the foundry was destroyed by fire and was rebuilt. The New Jersey Department of Health identified a case of silicosis in a retired worker at this facility. Among other duties, this worker performed sand blasting, an operation that is no longer performed.

The plant employs 20 to 22 hourly and 8 salaried workers, and operates on 1 shift (6:30 a.m. to 3:00 p.m.) 6 days per week. The plant occupies 24,000 square feet on a 6.9 acre site in a rural area. The main foundry building is constructed of concrete block (lower half), with steel siding (upper half) and steel roof. The floor is concrete covered with molding sand in the no-bake department. No makeup air is provided to the building. Space heating is accomplished by natural gas-fired infrared heaters. A schematic layout of the plant is included as Figure 1.

PROCESS DESCRIPTION

Melting

The plant is a job shop which produces ferrous castings (gray and ductile iron). Purchased scrap (crushed and washed motor blocks, sorrel, and steel bushing) and graphite are both stored inside the foundry adjacent to the furnace area. Two induction furnaces are used to melt the scrap. Only one furnace is in operation at any time. One furnace has a capacity of 750 pounds; the other has a capacity of 1,200 pounds. Each furnace is powered by a 500 kilowatt transformer. No local exhaust is utilized on either of the furnaces, but a roof fan is located directly above the furnace. Furnace refractories (silica) are replaced every 30 to 60 days.

Molding and Coremaking

The foundry produces molds in both green sand (using olivine) and furan no-bake (using silica sand) molding systems. Sand from each system is segregated. There is some silica contamination of the olivine sand from clay binders and some furan no-bake cores. No sea coal is added to either sand mix.

Green sand molds are produced automatically on a Hunter molding machine and manually by squeeze-type molding machines. Molds from the Hunter machine are poured on an automatic carousel from a fixed pouring station. No local exhaust is used at this station, but could be incorporated easily if warranted by the contaminant concentrations. Manually-produced molds are placed on pallets and are poured in the open (adjacent to the Hunter molds). An unvented mechanical shakeout (unvented) removes sand from the castings. Both hot and cold castings

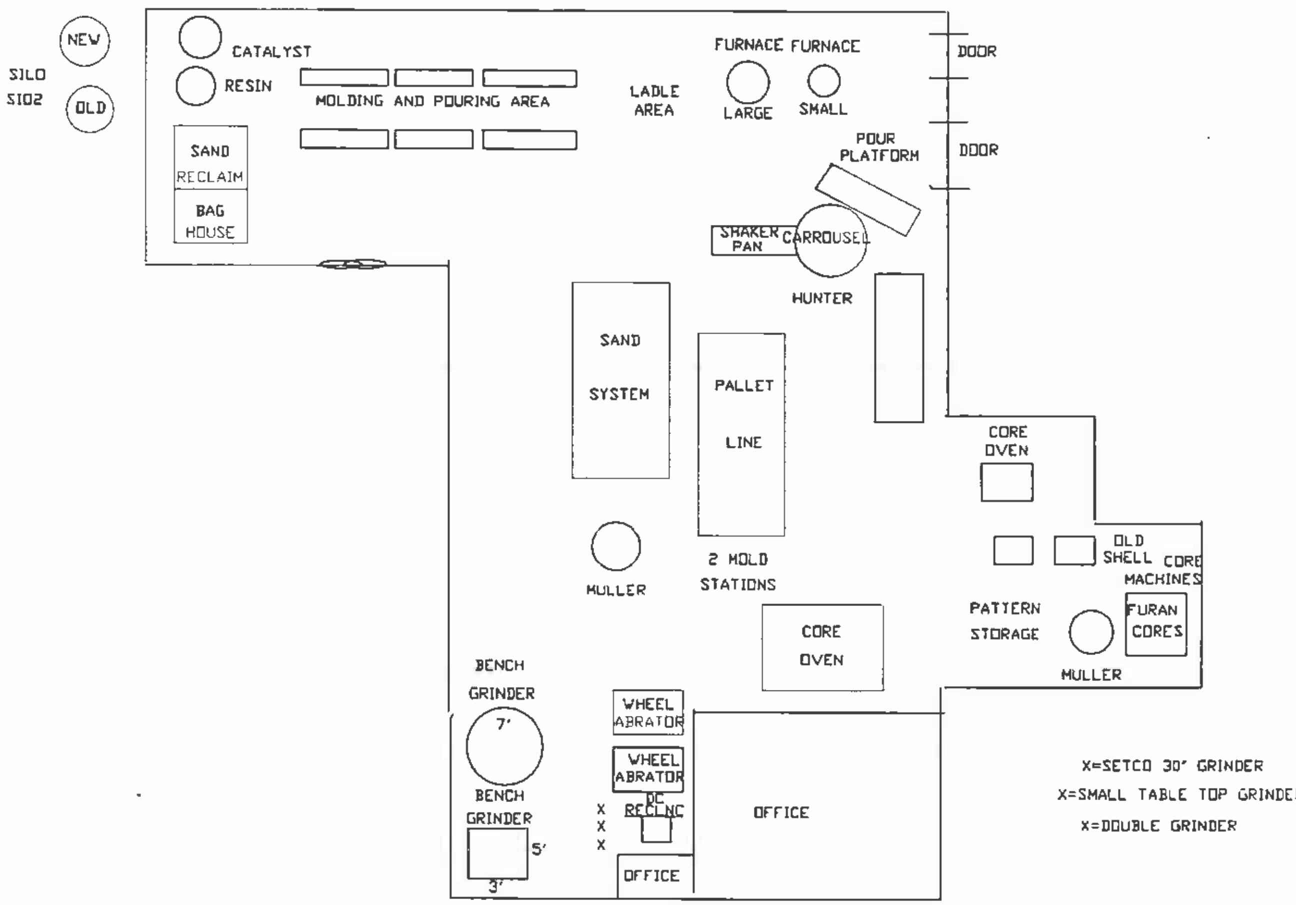

Figure 1. Schematic layout - General Foundry Company.

are shaken out. The sand is screened and conveyed to the sand muller for recycling.

Furan no-bake molds using silica sand are produced in a separate area. Sand, furan binder, and a toluene sulfonic acid catalyst are combined in screw mixers. Nonsilica parting compounds are used. Molds are poured in an open room, and dumped manually. Sand is removed after the shift by front-end loader to a sand reclaimer connected to a bag house. The sand reclamation is also done off-shift. The bag house exhausts to the plant interior, near a roof fan.

Cores are made with olivine sand using a drying oil binder. The oil polymerizes on heating in an oven. Some no-bake cores are produced using silica sand. The plant contains two small shell core machines, which were not in operation during this survey. Shell cores represent less than 2 percent of the production.

Zircon, rather than silica-based washes, are used on molds and cores. Isopropyl alcohol is the solvent used in the mold/core wash.

Casting Cleaning

After shakeout and cooling, castings are cleaned by steel shot in either a 66-inch swing-table or 48-inch tumble-blast abrasive cleaning cabinet. Appendages are removed from castings using a table-top grinder, a dual 18-inch diameter pedestal grinder (a modern 30-inch diameter pedestal grinder is in place but not connected), or numerous hand-held chipping hammers or grinders. The hand cleaning operations are performed on either a 7-foot diameter or 3- by 5-foot downdraft benches. These benches (manufactured by Wolverine), recirculated filtered air back into the foundry. The open metal grating of the rectangular bench has been overlaid/replaced with a wooden lattice to minimize noise.

Personal Protection and Hygiene

Safety shoes and safety glasses are required in all areas of the plant. NIOSH-approved disposable dust respirators are required in no-bake areas and during sand loading in the coremaking area. The respirator policy is incorporated into the work rules. A locker room and shower is provided. Showering is optional. Leather gloves are available. Latex surgeons' gloves are used for chemical changes.

Medical

The company provides employment physical examinations (including a chest X-ray) to all employees after completing a 90-day probationary period. Annual physicals are provided and chest X-rays are repeated at 3-year intervals. The physical examinations are performed by a local physician under contract to the foundry.

POTENTIAL HAZARDS

The main purpose of the SENSOR program is to follow-up silicosis cases to prevent the development of new cases of this disease. Other major airborne hazards occurring in foundries are metal fumes and dusts, combustion and decomposition products of mold and core materials, and carbon monoxide. Information is also presented on these hazards, as attempts to control them may also cause a concomitant reduction in exposure to silica.

Crystalline Silica

Crystalline silica is contained in molding and coremaking sands, in clays used as bonding agents, in parting compounds, in some refractory materials, and as surface contamination on castings. Exposure can occur almost anywhere within the foundry. In most operations, workers may have exposure to other contaminants as well.

The crystalline forms of silica can cause severe tissue damage when inhaled. Silicosis is a form of pulmonary fibrosis 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 nonspecific chest illnesses. Silicosis usually occurs after years of exposure, but may appear in a shorter time if exposure concentrations are very high. This latter form is referred to as rapidly-developing silicosis, and its etiology and pathology are not as well understood. Silicosis is usually diagnosed through chest X-rays, occupational exposure histories, and pulmonary function tests. The manner in which silica affects pulmonary tissue is not fully understood, and theories have been proposed based on the physical shape of the crystals, their solubility, toxicity to macrophages in the lungs, or their crystalline structure. There is evidence that cristobalite and tridymite, which have a different crystalline form from that of quartz, have a greater capacity to produce silicosis.[1]

Metals

The hazard of exposure to metals is dependent upon the type of metal cast. The most hazardous metal likely to be present in this foundry would be lead, potentially occurring as a contaminant in the motor blocks used as scrap.

Lead--

Inhalation (breathing) of lead dust and fume is the major route of lead exposure. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood-forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.[2,3]

Decomposition Products

Epidemiological studies suggest that workers in ferrous foundries are at a greater risk of dying from lung cancer than persons in the general population. The risk is a function of the job performed, with molders, metal pourers, and cleaning room personnel having the greatest rate of mortality from lung cancer.[4] There are strong suspicions that the agents responsible may be formed during the thermal decomposition of a wide variety of organic additives and binders used in foundry mold and coremaking processes.[5] These materials undergo thermal decomposition from the intense heat produced when the molten metal is poured. These decomposition products may be released during pouring, mold cooling, and shakeout. They may also remain in the sand or adhere to the surface of the casting.

The major hazardous degradation products which are expected to be present in most pouring and cooling operations are: carbon monoxide, carbon dioxide, aliphatic and aromatic hydrocarbons (most likely benzene, toluene, and xylenes), and smoke. The smoke may contain various polynuclear aromatic hydrocarbons with suspected carcinogenic properties. Depending on the specific core and mold materials used, numerous other substances may be present.[6]

Carbon Monoxide

In the foundry, carbon monoxide is produced by melting processes based on combustion from internal combustion engines, from other combustion sources, and from the decomposition of organic molding materials during pouring and cooling. Carbon monoxide has typically been used as an index of the hazard in mold pouring and cooling areas in gray iron foundries. Carbon monoxide combines with hemoglobin in the blood, reducing the oxygen-carrying capacity of the blood. Symptoms of CO poisoning are headache, dizziness, drowsiness, nausea, vomiting, collapse, coma, and death. Long-term, low-level exposure to CO can increase the risk of heart attack for some people.[7]

Other Hazards

Exposures to the following materials may occur in some foundry operations, depending on the specific process used.

Alcohols--

Isopropyl and methyl alcohol are used in core and mold washes. Vapors of isopropyl alcohol are mildly irritating to the conjunctiva and mucous membranes of the upper respiratory tract. Isopropyl alcohol is potentially narcotic at high concentrations. However, no cases of poisoning from industrial exposure have been recorded for either normal or isopropyl alcohol. Methyl alcohol may cause optic nerve damage and blindness, although these effects are usually associated with ingestion rather than inhalation.[7]

Formaldehyde--

Exposure to formaldehyde can occur in mold and coremaking processes using formaldehyde-based resins, and from the decomposition of other organic materials during pouring and cooling of castings. The primary health effects of exposure to formaldehyde are irritation of the respiratory tract, eyes, and skin. Eye and respiratory tract irritation has been reported in workers exposed to concentrations of less than 1 ppm.[8] Recent studies have found that formaldehyde induced nasal cancer in rats exposed to high levels (15 ppm) of formaldehyde over a long period of time.[9] These results have prompted NIOSH to recommend that formaldehyde be handled as a potential occupational carcinogen.

Hydrogen Cyanide--
Exposure to hydrogen cyanide can occur in pouring and cooling of castings when nitrogen-containing binders are used. Hydrogen cyanide is a chemical asphyxiant. It inactivates certain enzymes, the most important being cytochrome oxidase, which are used by the cells of the body for cellular respiration. Although the cells receive an adequate supply of oxygen through the blood stream, they are unable to use this oxygen because the metabolic process has been blocked by the presence of the -CN group. Inhalation, ingestion, or skin absorption of hydrogen cyanide may be rapidly fatal. Large doses may cause loss of consciousness, respiratory arrest, and death. Lower levels of exposure may cause weakness, headache, confusion, nausea, and vomiting.[7]

Phenol--
Phenol is rapidly absorbed through the skin and is damaging to the eyes, so that care should be taken when handling resins containing phenol. Chronic inhalation exposure may result in various effects in the central nervous system, the liver, and the kidneys.[10]

Sulfur Compounds--
Sulfur dioxide gas is used as a curing agent in certain coremaking processes. Sulfur dioxide is also produced from the combustion of fuels high in sulfur content and from the decomposition of sulfur-containing molding materials. Depending on operating conditions, hydrogen sulfide may also be formed. Sulfur dioxide is irritating to the respiratory tract. The pulmonary effects are increased in the presence of respirable particles. Chronic exposure can cause runny nose, dryness of the throat, and cough. Long-term, low-level exposure can cause chronic bronchitis and reduced pulmonary function.[7] Hydrogen sulfide can also produce irritation to the respiratory tract. Hydrogen sulfide interferes with cellular respiration; high exposures can rapidly cause death from respiratory failure.[7]

ENVIRONMENTAL CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 preexisting 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. For example, in the foundry, gases such as the oxides of nitrogen and sulfur dioxide may adsorb on dust particles and produce health effects at levels normally considered safe. 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 becomes available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH recommended exposure limits (RELs), (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs®), and (3) the U.S. Department of Labor (OSHA) permissible exposure limits (PELs).[11,12,13] Often, the NIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA PELs. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA PELs. The OSHA PELs also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, 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 PEL.

The NIOSH Recommended Exposure Limit (REL): NIOSH recommends that occupational exposure be controlled so that no worker is exposed to a time-weighted average (TWA) exposure concentration of crystalline free silica greater than 50 micrograms per cubic meter of air (0.05 mg/m^3) as determined by full-shift respirable dust sample for up to a 10-hour workday, 40-hour workweek.

The ACGIH Threshold Limit Value (TLV®): The ACGIH TLV® for respirable silica (quartz) is 0.1 mg/m^3 as a TWA for an 8-hour day.

The OSHA Permissible Exposure Limit (PEL): The OSHA PEL is now in a transitional period. The new PEL is 0.1 mg/m^3 as a TWA for an 8-hour day. This new standard is effective on March 1, 1989, and enforceable on September 1, 1989.

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.

METHODS

An initial meeting was conducted to familiarize the plant personnel with the purpose of the study, and to obtain a description of the processes and exposure controls employed in the operation. A walk-through of the plant was then conducted to further acquaint the survey team with the facility. After the walk-through, previous sampling data (if any) were reviewed, and spot measurements of airborne contaminants were made. At the conclusion of the survey, results of the direct-reading measurements were presented and preliminary recommendations for control were discussed.

Aerosol measurements were made in the plant using a Hand-held Aerosol Monitor (HAM) (PPM, Inc., Knoxville, Tennessee) to identify and prioritize potential sources of exposure to dust in the foundry. These measurements were used to identify areas or operations causing potential exposure to silica; they may not reflect actual exposures measured by long-term sampling techniques.

This instrument samples the workroom air and instantaneously measures the concentration of airborne dusts and mists by measuring the amount of light scattered by these materials. Although the results of these measurements are reported in mg/m^3, these numbers should be considered as estimates of the true concentration, as the amount of light scattered depends on the characteristics of the specific aerosol in addition to its concentration. The optical characteristics of the HAM are such that it is most sensitive to respirable aerosols (dusts and mists well below about 10 micrometers in diameter). As a first approximation, the instrument responds roughly to particle volume, so the instrument readings can be corrected for particle density by multiplying by the ratio of the actual particle density to the density of the factory calibration aerosol (1.5 mg/m^3).

Analyses for selected chemical hazards were determined through the use of detector tubes (National Draeger, Inc., Pittsburgh, Pennsylvania). These devices consist of a glass tube containing an inert carrier impregnated with a reagent. The ends of the tube are broken and the tube connected to a hand-operated air pump. Workplace air is pulled through the tube and the contaminant reacts with the reagent. The concentration is typically determined by the length of stain produced or by the number of pump strokes needed to produce a color change. Detector tubes are manufactured by several manufacturers and are available for a wide variety of airborne hazards. Detector tubes were used in this survey to identify the presence of potential chemical hazards. These measurements were used to identify areas or operations causing potential exposure; they may not reflect actual exposures measured by long-term sampling techniques.

RESULTS

REAL-TIME DUST MEASUREMENTS

Concentrations of dusts measured in the plant are presented in Table 1. Crude estimates of silica exposure are included in this table based on a density estimated to be about 2.6 mg/m^3 [16] and an assumed average silica content of 10 percent (based on information developed by Wisconsin OSHA to estimate silica compliance using respirable mass).[15] These estimates were made only for the casting cleaning and no-bake molding operations where there is likely to be exposure to silica sand. In casting cleaning, there is mixed exposure to silica/olivine sand; therefore, these exposure estimates may be high. The real-time results indicate that the casting cleaning operations represents the greatest exposure potential in this plant. Potentially excessive exposures also exist in the hand molding of the no-bake sand.

High respirable dust concentrations exist near the green sand system shakeout. Dust levels at this location increase dramatically when the overhead (building access) door is opened: the lack of any makeup air in the plant produces a high velocity draft which stirs up dust from this and other operations. This provided graphic evidence of the need for makeup air. High respirable dust concentrations also exist during the dusting of green sand molds. This underscores the necessity of using parting compounds that are free of silica.

DETECTOR TUBE MEASUREMENTS

Detector tube measurements are presented in Table 2 for various operations. Unfortunately, the pouring time was too short to allow testing for all of the potential decomposition products. The absence of air contaminants was attributable to the lack of organic materials present in the green sand molds. More and higher concentrations of air contaminants would be expected during the pouring and cooling of the no-bake molds. (Due to the limited time available, no detector tube measurements were taken during the pouring of no-bake molds during this survey.) Potential exposure to sulfur dioxide in that mold pouring area would be anticipated.

Table 1. Real-time aerosol measurements.

Location	Respirable Dust Concentration (mg/m^3)*	Estimated Quartz Concentration ($mg\ SiO2/m^3$)**
Outside of plant	0-0.16	NA
Scrap preparation area,		
shoveling	0.25-.5	NA
dumping scrap into charge bucket	0.4-2.0	NA
Melting area, near furnace	0.4	NA
GS mold line		
platform, during pouring	0.2-0.4	NA
carousel, during pouring	0.2-0.4	NA
green sand muller area	0.5-1.2	NA
by Hunter machine	0.9-1.5	NA
GS mold line, hand molder		
hand molding	0.25-1.4	NA
using compressed air	0.3-0.8	NA
dusting molds	16.0	NA
GS shakeout		
near breathing zone	0.5-4.0	NA
sand discharge end	1.5-3.0	NA
sand discharge end, outside door open	10+	NA
No-bake mold line, hand molding	0.4-0.8	0.07-0.14
Casting cleaning		
stand grinder operator	0.35	0.06
hand-held grinder, small bench	0.5-2.0	0.1-0.3
hand-held grinder, large bench	0.8-3.0	0.14-0.5
general area, abrasive blasting machine	0.2-1.2	0.03-0.2
OSHA PEL (8-hour time-weighted average)		0.1
NIOSH REL (10-hour time-weighted average)		0.05
ACGIH TLV (8-hour time-weighted average)		0.1

* Based on factory calibration with an aerosol of density = 1.5 g/cm^3.
** 0.17 times instrument reading; assuming quartz content of 10% and a particle density of 2.6 g/cm^3.
NA: not applicable
Note: these are short (about 1 minute) measurements used to identify areas or operations causing potential exposure; they may not reflect actual exposures measured by long-term sampling techniques.

Table 2. Detector tube measurements.

Location	Concentration (ppm) CO	HCHO	C6H5OH	ROH
Melting area, near furnace	<10			
Mold line, breathing zone, during pouring of green sand molds	<10		<5	
Shakeout, near breathing zone		<0.2		
No-bake molds, during application of mold wash				<100
No-bake molds, during light-off of mold wash				>100

	CO	HCHO	C6H5OH	ROH
OSHA PEL (8-hour TWA)	50	1	5	400
NIOSH REL (10-hour TWA)	35	LF	5.2	400
ACGIH TLV (8-hour TWA)	50	1	10	400

LF: lowest feasible

Note: these are grab samples used to identify areas or operations causing potential exposure; they may not reflect actual exposures measured by long-term sampling techniques.

Key to Table 2

formula	detector tube*	chemical hazard
CO	Carbon monoxide 10/a	carbon monoxide
HCHO	Formaldehyde 0.2/a	formaldehyde
C6H5OH	Phenol 5/a	phenol
ROH	Alcohol 100/a	isopropyl alcohol

* National Draeger, Inc. (Pittsburgh, Pennsylvania)

RECOMMENDED EXPOSURE CONTROLS

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, ventilation, work practices, personal protection, and monitoring. By reducing workplace exposures, new cases of silicosis (and other occupational diseases) can be prevented.

ENGINEERING MEASURES

The real-time measurements suggest that the highest silica exposures are likely to occur in the cleaning of the castings and in the handling of the no-bake molding sands. Because the majority of the no-bake sand handling is manual, ventilation control is virtually impossible. Substitution of front-end loader sand handling with a large, foundry-grade vacuum system (exhausting through appropriate filters to the outdoors) should result in lower exposures.

Olivine is used as a substitute for silica sand in the green sand system used in this foundry. Substitution of olivine sand has been shown to reduce the incidence of silicosis.[16] Silica sand is used in this foundry for their no-bake operation. Olivine could be substituted here as well, but would involve increased cost of molding aggregate and binders (a nonacid catalyzed binder would be required).

LOCAL EXHAUST VENTILATION

Shakeout, sand screening, and sand mulling operations are conducted for only brief periods, therefore no local exhaust is suggested at this time; hopefully, the use of olivine sand minimizes silica exposure from these sources.

Recommendations for improvements in local exhaust ventilation are summarized in Table 3 and discussed below:

1. The hand grinding operators are potentially exposed to excessive levels of silica. The castings should be as clean as possible before grinding. The exhaust from the compressed-air tool should be ducted away from the tool via a hose to avoid blowing dust from the casting. Mufflers should be installed at the end of this hose. The plant uses downdraft tables that recirculate filtered air back into the foundry. The filters should be inspected for physical integrity and dust loading, and airflow measured. Detailed recommendations for air recirculation and downdraft bench airflow requirements are contained in the ACGIH publication Industrial Ventilation.[17]

2. Ventilation rates on the pedestal grinders should be measured and be upgraded to those recommended in Industrial Ventilation.

Table 3. Ventilation recommendations.

Equipment	Existing	Recommended	Reference[27]
Hand grinders - downdraft grinding bench	Yes	Inspect and upgrade	VS-412
Pedestal grinders (old)	Yes	Inspect and upgrade	VS-411
Pedestal grinder (new)	Yes	Inspect and upgrade	VS-411.1
Melting furnace-tilting	No	Yes	VS-106

3. Ventilation rates on the abrasive blasting machines should be measured and upgraded as necessary.

4. Consideration should be given to equipping both furnaces with hoods similar to that shown in VS-106 in Industrial Ventilation. While the hoods may not be necessary from the standpoint of contaminant control, they will exhaust less air from the plant than the current roof fan.

5. Several small dust collectors (on grinders, sand reclamation units, etc.) recirculate exhaust back into the plant. While these units provide air that is suitable for discharge out of doors (no visible dust), they may not provide air of breathing quality. The local environmental authorities should be contacted and permits obtained for discharging this air outdoors. It may prove to be more economical for the smaller dust collectors to be eliminated and the exhaust from each hood combined into one duct system discharging through a single, larger dust collection unit.

6. A standard pitot tube and inclined tube manometer should be obtained for measuring volumetric flow rates. An inexpensive swinging vane anemometer is also suggested for purchase to measure air velocities into hoods. A log of these measurements should be maintained.

GENERAL VENTILATION

For the open floor pouring of ferrous castings, the AFS Foundry Ventilation Manual[18] recommends general ventilation rates of 20 to 50 cfm per square foot of floor area. During mold cooling, this can be reduced to 10 to 20 cfm per square foot of floor area. An audit should be performed to determine if the present rate meets these suggested minimums.

No fresh makeup air is introduced into the foundry. Heat is provided by the process and by gas-fired infrared heaters. Air enters the building through open doors and windows, potentially causing cross contamination of all process areas (as the real-time measurements suggest). Ideally, all air exhausted from the building should be replaced by tempered air from an uncontaminated location. By providing a slight excess of makeup air in relatively clean areas and a slight deficit of makeup air in dirty areas, cross contamination can be reduced. In addition, this tempered air can be ducted directly to operator work areas, providing the cleanest possible work environment. For those individuals working at relatively fixed workstations (grinders, hand molders, Hunter operator, coremakers, etc.), this fresh air could be supplied in the form of a low velocity air shower (<100 fpm to prevent interference with the exhaust hoods) located directly above the worker. This is especially important for the case of the no-bake molder, as he always works downwind of mold pouring and cooling.

WORK PRACTICES

When general ventilation is used to minimize the exposure to metal fumes and mold gases, the AFS Foundry Ventilation Manual[18] recommends that the progression of mold pouring should progress towards the makeup air source so that the air contaminants are moving in the opposite direction. In the no-bake pouring area, the flow of air appeared to be from the furnace area towards sand reclamation. In the green sand area, no predominant flow pattern was observed; however, contaminant generation in this area was minimal.

Use of the front-end loader to process large volumes of sand into the reclamation unit should continue to be performed after the work shift, to limit exposure to only the loader operator.

RECOMMENDED PUBLICATIONS

It is important that responsibility for health and safety be assigned to one individual within the plant management. In order to develop the in-house expertise needed to implement a strong health and safety program, it is strongly recommended that <u>all</u> of the following publications be purchased and read:

American Conference of Governmental Industrial Hygienists - (513) 661-7881

Industrial Ventilation, A Manual of Recommended Practice, 20th edition (1988)

Industrial Ventilation Workbook (1989)

Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1988-1989

American Foundrymen's Society - (800) 537-4237

Health and Safety Guides, 1985
Foundry Ventilation Manual, 1985

National Institute for Occupational Safety and Health - (513) 533-8287

NIOSH Publications Catalog

An Evaluation of Occupational Health Hazard Control Technology for the Foundry Industry, 1978. DHEW Publication No. (NIOSH) 79-114

Recommendations for Control of Occupational Safety and Health Hazards . . . Foundries. DHHS (NIOSH) Publication No. 85-116

NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards. DHHS (NIOSH) Publication No. 81-123

FOLLOW-UP STUDY

A follow-up study of this plant is strongly recommended. The plant appears to be economically viable, with management that is committed to worker protection. The plant has made an important step at eliminating silicosis through their use of olivine in their green sand system. A plan could be developed for this foundry that might well serve as a guide to other small foundries.

The follow-up study would involve the following elements:

1. The success of olivine in this plant would be evaluated through the determination of the silica exposure of almost all of the production workers.

2. A qualitative assessment of the hazard of decomposition products in the no-bake mold area would be conducted through a comprehensive detector tube work-up.

3. A quantitative evaluation of the hazard of lead exposure to melters and pourers would be performed using conventional sampling techniques.

4. Work practices used in cleaning castings on the downdraft benches would be examined, using a combination of video recording and real-time dust measurement. This examination would attempt to identify activities associated with high dust exposures with the hope of elimination of those activities, where possible.

5. An evaluation of the suggested AFS work practices in the pouring of no-bake molds would be performed using real-time measurement of smoke and carbon monoxide.

6. Dust exposure during sand loading and reclamation would be determined using conventional and real-time instrumentation. Since this is performed off-shift, a safe "re-entry" time would be determined.

7. Since the success of the use of olivine depends on the degree of silica contamination of the molding aggregate, bulk analyses of parting compounds, mold and core washes, cleaning room dusts, and green sand molding aggregate would be done.

8. The advisability of the current use of recirculation would be studied. A portable particle counter would be used to determine the dust removal efficiency of the grinding benches.

9. A ventilation audit would be conducted and recommendations for upgrades that will be made. A conceptual design of a makeup air system would be created and a cost comparison made with the current infrared system.

10. Other evaluations would be performed as the situation permitted.

Ideally, the foundry could adopt the recommendations generated in this study, and a second study could be conducted to determine the exposure reductions achieved.

REFERENCES

1. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Exposure to Crystalline Silica. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1975. (DHEW publication No. (NIOSH) 75-120).

2. Occupational Safety and Health Administration. Occupational exposure to lead--final standard. Federal Register 1978 Nov 14:53007.

3. Wedeen R.P., Maesaica J.K., Weiner B, et al. Occupational lead nephropathy. Am. J. Med. 1975; 59:630.

4. Palmer, W.G. and W.G. Scott: Lung Cancer in Ferrous Foundry Workers: a Review. Am. Ind. Hyg. Assoc. J. 42:329-340. (1981).

5. Tubich G.E.: "The foundry - Its Real Potential Health Hazards", published in the "Proceedings of the Symposium on Occupational Health Hazard Control Technology in the Foundry and Secondary Nonferrous Smelting Industries." December 10-12, 1979. Chicago, Illinois. National Institute for Occupational Safety and Health, 1981. (DHEW publication no. (NIOSH) 81-114).

6. Health and Safety Guides, American Foundrymen's Society, Inc., Des Plaines, Illinois. 1985.

7. Occupational Diseases, A Guide to Their Recognition, Revised Edition, DHEW (NIOSH) Publication No. 77-181, June 1977.

8. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Exposure to Formaldehyde. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 77-126).

9. Chemical Industrial Institute of Toxicology, Progress Report on CIIT Formaldehyde Studies (January 16, 1980). Leon Goldberg, President, Research Triangle Park, North Carolina.

10. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Exposure to Phenol. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-196).

11. "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1988-1989," American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, Ohio.

12. Occupational Safety and Health Administration. OSHA Safety and Health Standards. Table Z-1-A. Federal Register 54(12) January 19, 1989.

13. NIOSH Recommendations for Occupational Health Standards, 1988. Morbidity and Mortality Weekly Report Supplement S-7 37:1-29, 1988.

14. O'Brien, D.M., P.A. Baron, and K. Willeke: Size and Concentration Measurement of an Industrial Aerosol. Am. Ind. Hyg. Assoc. J. 47:386-392. (1986).

15. Zimmerman, R.E. and J.M. Barry: Determining Crystalline Silica Compliance Using Respirable Mass. Trans. Am. Foundrymen's Soc. 84:15-20 1976.

16. Tubich, G.E.: Health Aspects of Olivine: Nonferrous Foundry Applications. Presented at the American Industrial Hygiene Association Conference. May 1-5, 1967, Chicago, Illinois.

17. Industrial Ventilation, A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, 19th edition (1986).

18. Foundry Ventilation Manual, American Foundrymen's Society, Inc., Des Plaines, Illinois, 1985.