WALK-THROUGH SURVEY REPORT:

CONTROL TECHNOLOGY SUPPORT FOR SENSOR

at

Alloy-Tech, Inc.
Delran, New Jersey

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SIC CODE:	3321
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I. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary federal agency engaged in occupational safety and health research. Located in the Department of Health and Human Services (formerly the Department of Health, Education, and Welfare), it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs 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 (DPSE) has been given the lead within NIOSH to study the engineering aspects of hazard control.

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 exist 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 Alloy-Tech, Inc., located in Delran, 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.

II. PLANT AND PROCESS DESCRIPTION

Plant Description:

The present plant was formerly operated under the name "Abrasive Alloy Casting Company, Inc." The former owners declared bankruptcy and the plant and equipment is being leased by them to the current owners of Alloy-Tech, Inc., since June 1988.

The plant employs 15 to 23 hourly and 6 salaried workers and operates on one shift (7:00 a.m. - 3:30 p.m.). It occupies five acres adjacent to an automobile salvage yard in a rural community. The basic plant dates from 1943, with additional structures added during the ensuing years. The buildings consist of concrete block construction (lower half) with steel siding (upper half) and steel roof. The roof is badly deteriorated. The floor is concrete covered with molding sand. No make-up air is provided to the building. Space heating is accomplished by portable natural gas burners contained within a barrel of perforated steel. A schematic layout of the plant is included as Figure 1.

Process Description:

Melting--
The plant is a job shop which produces ferrous castings to order in alloys ranging from iron to stainless steel. These alloys may contain aluminum, chromium, nickel, magnesium, and manganese. Purchased scrap (punchings, rail, and spikes) is stored both inside a building adjacent to the furnace area, and outdoors. The plant uses four induction furnaces to melt the scrap. Only one furnace is in operation at any time. Each furnace has a melt rate of about 0.5 tons per hour. No local exhaust is utilized on any of the furnaces.

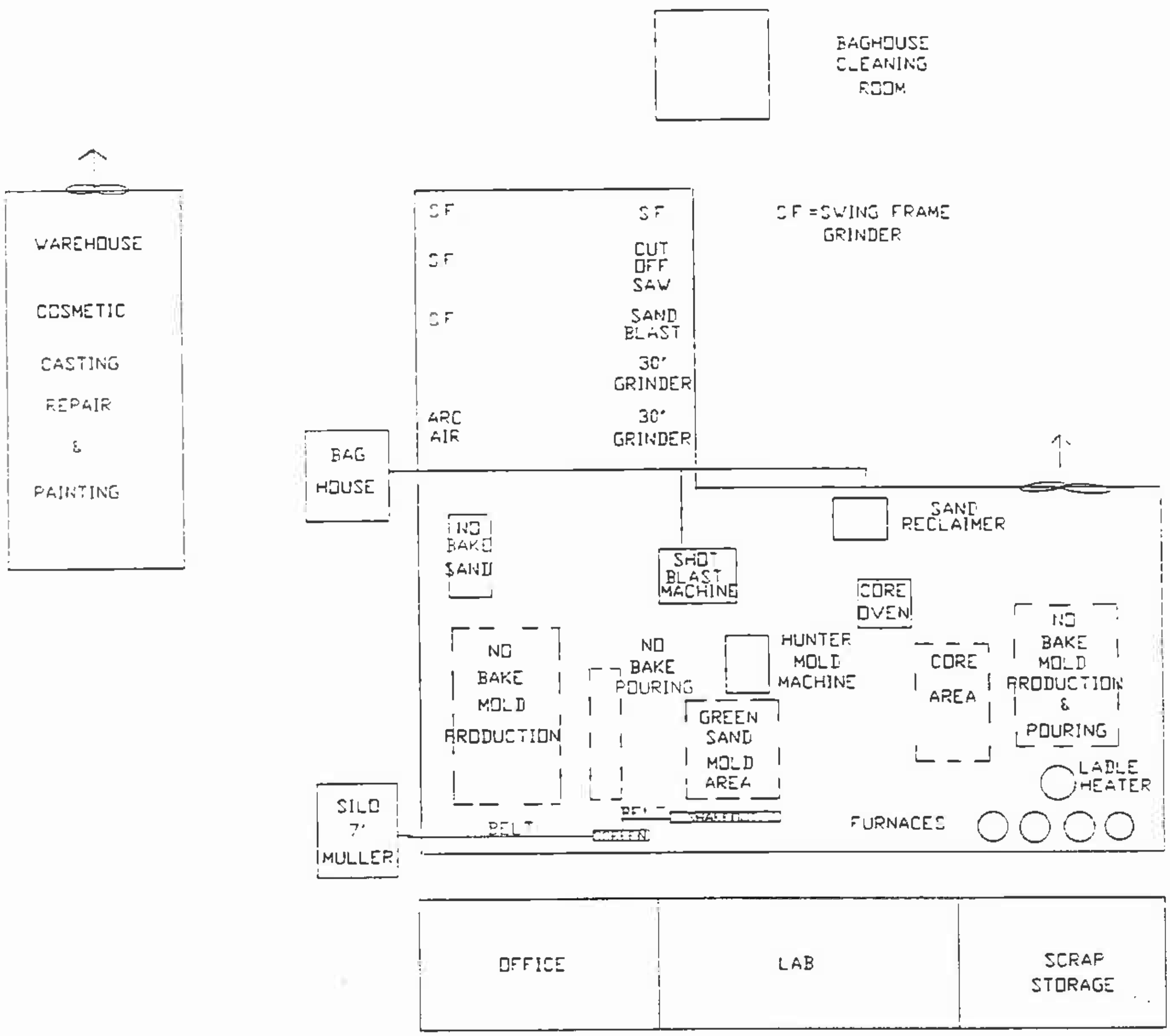

Figure 1. Schematic Layout - Alloy-Tech, Inc.

Furnace refractories (alumina/sodium silicate) are replaced at the rate of about one furnace every three weeks. A quality control laboratory (operated by the plant engineer) has the capability of performing spectroscopy of metal samples and various tests on molding sand.

Molding and Coremaking--
The foundry produces molds using both green sand and furan no-bake molding systems. Sand from each system is segregated.

Green sand molds are produced on a Hunter automatic molding machine. Bentonite is used as a binder and seacoal is added to benefit the casting finish. Molds are poured in an open room (a roof fan of unknown capacity provides dilution ventilation). Green sand molds are poured about twice a day. Each pouring session takes about 15 to 20 minutes. A mechanical shakeout (unvented) removes sand from the castings. Both hot and cold castings are shaken out. The sand is screened and conveyed to the sand muller (located in a separate building) for recycling.

No-bake molds are produced in two areas. Sand, furan binder, and a benzene sulfonic acid catalyst are combined in one of two screw mixers. The furan binder is based on furfuryl alcohol (85 to 95%) and bisphenol-A (4 to 6%). Molds are poured in an open room, and dumped manually. No-bake molds are poured two or three times daily. Each pouring session takes about 15 to 20 minutes. Sand is removed by shovel and front end loader to a sand reclaimer (exhausted to a baghouse).

Cores are made with a blend of 25% zircon and 75% silica sand using a drying oil binder. The oil polymerizes on heating in an oven (which was vented inside the plant, causing a blue haze). Some no-bake cores are produced.

Zircon, rather than silica-based washes, are used on molds and cores.

Casting Cleaning--
After shakeout and cooling, castings are cleaned by steel shot in an abrasive blasting cabinet. Appendages are removed from castings using two 30-inch pedestal grinders, four swing frame style grinders/cutoff saws, or numerous hand-held chipping hammers or grinders. The two pedestal grinders and all of the swing frame grinders are connected to a ventilation system connected to a second baghouse. Three of the swing frame grinders had small hoods attached to the grinder frame; the fourth was surrounded by a partial enclosure. A small, self-contained sand blasting unit was also used. An arc-air torch was also used for gate and riser removal and blemish removal. A cosmetic casting repair (polyester/styrene auto body putty) and painting operation was conducted in a different building.

Personal Protection and Hygiene--
Safety shoes, safety glasses, hard hats, and ear plugs are required in all areas of the plant. NIOSH-approved disposable dust respirators are required in all departments except melting. The melter wears a NIOSH-approved half facepiece respirator with high efficiency filter cartridge. Work clothing is provided by the company to the pouring crew (seven uniforms/week each).

Medical--
The company provides pre-employment physicals to all employees. Annual physicals are provided to the grinders. Physicals include a chest X-ray.

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. Some of the more hazardous metals used at this facility are manganese, chromium, and nickel. Metal fumes can be encountered at melting, pouring, and various types of welding and brazing operations. Metal dusts produced during grinding operations are usually not as significant as the fume, because the dusts are of a larger particle size.[2]

Manganese

Chronic manganese poisoning primarily involves the central nervous system. Early symptoms include sluggishness, sleepiness, and weakness in the legs; later symptoms may include a mask-like appearance of the face, emotional disturbances, and a spastic gait.[3]

Nickel

Inorganic nickel compounds are suspected of causing lung and nasal cancer, based on the mortality experience of nickel refinery workers. Nickel metal and its compounds can also produce a contact dermatitis known as "nickel itch."[4]

Chromium

Chromium alloys can be oxidized to chromium trioxide fume, a soluble chromium (VI) compound. These compounds can produce health effects such as contact dermatitis, irritation and ulceration of the nasal mucosa, and perforation of the nasal septum. Certain insoluble chromium (VI) compounds are suspect carcinogens.[5]

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.[6] 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.[2] 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.[7]

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.[8]

Other Hazards--

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

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.[9] 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.[10] These results have prompted NIOSH to recommend that formaldehyde be handled as a potential occupational carcinogen.

Oxides of Nitrogen

Nitric oxide (NO) and nitrogen dioxide (NO2) are usually found together. High temperatures used in welding and cutting operations, and in arc furnaces, oxidize nitrogen in the air to form nitric oxide, which subsequently reacts with oxygen at room temperature to form nitrogen dioxide. Nitrogen dioxide is an irritant to the respiratory system. Repeated acute exposures may result in the development of chronic obstructive lung disease. Exposures to high concentrations of nitric oxide can produce methemoglobinemia and cyanosis.[11]

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.[12]

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.[8] 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.[8]

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 become 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).[13,14,15] 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 samples for up to a 10-hour work day, 40-hour work week.

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.

III. 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.

IV. RESULTS

Review of Previous Monitoring Data:

OSHA has conducted inspections involving silica exposure determinations in 1978, 1983, and 1986. The 1978 data were not available. However, the 1983 inspection report noted that the plant had installed a new abrasive blasting machine, new pneumatic sand handling system, and hoods on the swing frame grinders in response to the 1978 inspection. The 1983 sampling indicated exposure to the shake out operator at 2.5 times the OSHA PEL for silica, and exposures to three swing frame grinders at 2.0, 2.2, and 5.2 times the PEL. This report indicated that these individuals had been grinding castings that had not been precleaned in the abrasive blasting unit. The 1986 inspection reported silica exposures to two swing frame grinders at 22% and 57% of the PEL. This reduction was attributed to the lack of work due to bad economic conditions at the plant.

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).[17] No estimates were made in melting and pouring operations, or areas where the potential for silica contamination were considered to be low. These results indicate that the sand shovelling operation represents the greatest exposure potential in this plant. Potentially excessive exposures exist near the abrasive blasting machine; this indicates that the unit may be in need of maintenance or that the exhaust rate may not be adequate to contain the dust within the machine. Also, potentially excessive exposures exist during grinding using hand-held tools, this suggests that a substitute for silica sand be tried or that exhaust ventilation be installed for this operation.

Detector Tube Measurements:

These data 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 detector tube data indicate potential exposure to phenol (or other aromatic hydrocarbons with hydroxy groups) in the mold pouring area. The origin of the phenol is unclear. It may be a decomposition product of the seacoal contained in the green sand or a decomposition product of bisphenol-A (from the furan binders) if no-bake cores were present. Potential exposure to sulfur dioxide in the mold pouring area was also noted.

Table 1. Real-Time Aerosol Measurements.

Location	Respirable Dust Concentration (mg/m^3)*	Estimated Quartz Concentration ($mg\ SiO2/m^3$)**
Outside of plant	0-0.02	NA
Scrap preparation area	0.05	NA
Melting area, near ladle	0.1	NA
Melting area, near ladle heater	0.05-0.06	NA
Mold line, general area, during pouring of stainless steel	0.2-0.3	NA
No-bake mold area, near breathing zone, during sand shovelling	2-7	0.3-1.2
No-bake mold area, near sand reclamation machine (not running)	0.2	NA
Coremaking area, near breathing zone	0.02-0.04	NA
Casting cleaning, near breathing zone of stand grinder operator	0.8-1.2	0.1-0.2
Casting cleaning, near breathing zone of hand-held grinder operator	1.5-3.5	0.3-0.6
Casting cleaning, near breathing zone of swing frame operator	0.6-0.8	0.1
Casting cleaning, general area, sand blasting machine area	0.4-0.6	0.1
Casting cleaning, general area, abrasive blasting machine area	0.4-1.2	0.1-0.2
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	C6H6	SO2	C6H5OH
Scrap preparation area, by ladle heater	<10				
Melting area, near gas heater	<10				
Mold line, breathing zone, during pouring of stainless steel	5	<0.15	<2	1	>5
Mold line, top of mold, during pouring of stainless steel	150		<3	3-4	>5
Core oven, near door	<10	<0.2			
Core oven, in exhaust	200	>5			

	CO	HCHO	C6H6	SO2	C6H5OH
OSHA PEL (8-hour TWA)	50	1	1	2	5
NIOSH REL (10-hour TWA)	35	LF	0.1	0.5	5.2
ACGIH TLV (8-hour TWA)	50	1	10	2	5

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
C6H6	Benzene 0.5a	benzene
SO2	Sulphur Dioxide 0.5/a	sulfur dioxide
C6H5OH	Phenol 5/a	phenol

* National Draeger, Inc. (Pittsburgh, Pennsylvania)

V. 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

Both the real-time measurements and the OSHA monitoring suggest that the highest silica exposures occur in the handling of the molding sands and in the cleaning of the castings. Because the majority of the sand handling is manual, ventilation control is virtually impossible. Substitution of broom and shovel sand handling with a large, foundry-grade vacuum system (exhausting through appropriate filters to the outdoors) should result in increased productivity as well as lower exposures.

Olivine is a nonsiliceous mineral that can be used as a substitute for silica sand as a foundry molding aggregate. Substitution of olivine sand has been shown to reduce the incidence of silicosis.[18] Use of olivine would involve increased cost of molding aggregate and binders (a nonacid catalyzed binder would be required to be used), but capital improvements in casting cleaning could be postponed. Substitution of olivine may be the single most important control measure that could be adopted. Numerous nonsilica substitutes are available which could be used in place of silica sand in the blasting cabinet.

If silica sand continues to be used, the supplier of the furan no-bake resin system (or their competitors) should be contacted to determine the feasibility of the substitution of phosphoric acid for benzene sulfonic acid (BSA) as a catalyst. BSA may contain free benzene and/or release benzene and sulfur dioxide/hydrogen sulfide during mold pouring. Substitution would reduce exposure to both hazards.

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 will be adopted minimizing silica exposure from these sources. Recommendations for improvements in local exhaust ventilation are summarized in Table 3 and discussed below for continuous operations:

1. While not observed, the temperatures produced at the torch in the arc-air operation may exceed the boiling point of all the metals. Nickel and chromium levels, if measured, would most likely exceed those encountered in any other operation in the plant.[19] This operation should be isolated in a booth, with the operator wearing a supplied-air respirator because of the number and level of the contaminants present.

2. Frame-mounted hoods for the swing frame grinders are not recommended. Booths similar to those shown in Industrial Ventilation[20] are

Table 3. Ventilation Recommendations.

Equipment	Existing	Recommended	Reference[27]
Hand grinders - HVLV hoods or downdraft grinding bench	No	Yes	VS-412
Pedestal grinders	Yes	Inspect and upgrade	VS-411
Swing frame grinder, frame mounted hood	Yes (3 of 4)	No	
Swing frame grinder, booth	No	Yes	VS-414
Abrasive blasting cabinet	Yes	Inspect and upgrade	VS-101.1
Arc-air operation	No	Enclose in booth	VS-415, VS-416.1
Melting furnace-tilting	No	Furnace melting stainless	VS-106

suggested. If the booth opening can be made small enough, it may only be necessary to build an unventilated booth around the existing grinders, relying on the existing tool-mounted hoods for exhaust.

3. 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 should consider installing a downdraft table or high-velocity, low-volume (HVLV) exhaust hoods. Detailed recommendations are contained in the ACGIH publication Industrial Ventilation.[20]

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

5. Ventilation rates should be measured on the abrasive blasting cabinet and the unit upgraded as necessary.

6. One or two furnaces should be selected for use as the "high-hazard" units and equipped with hoods similar to that shown in VS-106 in Industrial Ventilation. These furnaces should be used for melting alloys containing other than trace amounts of chromium, manganese, or nickel.

The detector tube data indicate that the core oven is needlessly contaminating the plant with carbon monoxide and formaldehyde. In addition, condensed oils contribute a "blue haze" to the process area. A simple gravity exhaust stack connected to the oven outlet would alleviate the problem.

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[21] 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, by gas burners, and by unvented space heaters. Air enters the building through open doors and windows, potentially causing cross contamination of all process areas. 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. Ideally, 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.

Work Practices:

When general ventilation is used to minimize the exposure to metal fumes and mold gases, the AFS Foundry Ventilation Manual[21] 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.

Use of the front end loader to process large volumes of sand into the reclamation unit should 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 all 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

VI. FOLLOW-UP STUDY

A major follow-up study of this plant is not recommended at this time. The plant management has been in contact with various sand suppliers for cost studies on switching over to olivine sand, is building a booth for the arc-air process, and is investigating ventilation improvements in the casting cleaning area. If the plant can weather its present economic difficulties and have these improvements made, the NJDOH may wish to conduct a further investigation of this facility.

VII. REFERENCES

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