DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 72-89-154

GOLDEN FOUNDRY
COLUMBUS, INDIANA

NOVEMBER 1974

I. TOXICITY DETERMINATION

It has been determined that the airborne concentrations of silica are potentially toxic as measured at the Slinger (Block) Floor, Moldmaster Shakeout, Shot Blast-Knockout and Stationmaster Shakeout areas. The concentrations of carbon monoxide have been determined to be not toxic in the Moldmaster and Slinger (Block) Floor areas. The concentrations of toluene and xylene in the mold and pattern spray operations located on the Slinger (Block) Floor are not toxic as used or found. Although the measured concentration of ammonia and formaldehyde did not exceed established federal standards, there was evidence suggestive of irritant toxicity to ammonia, formaldehyde, or phenol in the Shell Core and North Core rooms. Also, the concentrations of iron oxide (as a nuisance dust) in the Cleaning Room operations are not toxic as measured. Concentrations of iron oxide dust were found to be potentially toxic at the Stand Grinder located near the end of the Squeezer Floor; however, the hazardous condition is controlled by use of a supplied air respirator on the operator. The determinations are based upon environmental measurements, medical interviews with employees and observation of work practices.

Recommendations have been offered regarding both the environmental and medical aspects of employees' exposure to the potentially toxic substances investigated at the foundry.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, Fifth and Walnut streets, Cincinnati, Ohio 45202. Copies have been sent to:

A. Golden Foundry - Columbus, Indiana
B. Authorized Representative of Employees
C. U.S. Department of Labor - Region V
D. NIOSH Regional Consultant for OSH - Region V

For the purposes of informing the approximately 900 "affected employees," the employer will promptly "post" the Determination Report in a prominent place(s) near where affected employees work for a period of 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding the exposure of some 900 molders, grinders, laborers, millwrights, maintenance men and coremakers to dusts, gases and mists at the Golden Foundry, Columbus, Indiana.

IV. HEALTH HAZARD EVALUATION

A. Plant Process - Conditions of Use

The Golden Foundry is engaged in the manufacture of gray iron castings for engine blocks, pumps, etc. There are approximately 900 employees in the work areas on three overlapping shifts with two shifts principally concerned with molding and casting. The processes used are similar to most foundry operations, i.e., scrap iron is melted in a cupola, sand molds are prepared including cores, gray iron is cast, the castings are allowed to solidify, the molds are shaken out and the castings are cleaned and prepared for shipping.

B. Evaluation Design and Methods

On November 21, 1972, June 21-22 and October 9-10, 1973, NIOSH representatives, including industrial hygienists and medical officers, conducted environmental and medical investigations of the facility. Environmental investigations included sampling for airborne concentrations of respirable and total dust (Quartz), iron oxide, ammonia, formaldehyde, toluene, xylene and carbon monoxide.

Dust sampling was performed on workers at the Slinger (Block) Floor, Moldmaster Shakeout, Shot Blast-Knockout, Stationmaster Shakeout and on a ladle pourer and forklift truck operators in the Moldmaster, Shot Blast-

Knockout and Slinger (Block) Floor areas. In addition, general workroom air concentrations were measured in the Moldmaster and Slinger (Block) floor areas. Samples were collected during both the day and night shifts, for periods of time ranging from 70 to 365 minutes, with a mean sampling time of slightly more than 4 hours.

Respirable dust samples were collected, using personal air sampling equipment with filter cassettes fitted with pre-weighed 5.0u PVC filters located in close proximity of the employees' breathing zone. The air (flowing at 1.7 liters per minute) was drawn through a cyclone separator prior to passing through the filter. General workroom air samples were collected for both total (no cyclone-closed face) and respirable dust at flow rates of 9 liters per minute.

The total respirable dust content was determined by the weight difference between the previously tared PVC filter and the same filter after sample collection. The percent Free Silica was then determined on these filters colorimetrically.

Personal samples for iron oxide were collected as a nuisance dust using personal air samplers and Type AA membrane filters (closed face) located in the workers' breathing zone. A flow rate of 1 liter per minute was maintained. The AA filters were ashed with nitric acid and dissolved in 1:1 HCl and deionized water. The amount of iron was determined by atomic absorption.

Grab samples for ammonia and formaldehyde were obtained in the Shell Core and North Core rooms as near as possible to employees' breathing zones by use of length of stain, direct reading, chemical detector tubes. Personal samples for toluene and xylene were collected at the mold and pattern spray operations located on the Slinger (Block) Floor. Samples were obtained by using personal air sampling equipment operating at 0.5 cubic feet per hour, passing workers' breathing zone air through an activated charcoal tube. The charcoal tubes were laboratory analyzed by gas chromatography. General room air concentrations of carbon monoxide were measured in the Moldmaster and Slinger (Block) Floor areas using a direct reading carbon monoxide detector attached to a strip chart recorder.

The Medical investigation included conversations with the day shift first-aid corpsman, the safety officer, and the foundry's medical consultant. A sample of 38 men on the day shift from various areas of the plant were interviewed by questionnaire. It was elected to focus more extensively on those exposed to a potential silica hazard. Hence, the majority (29) of those interviewed were working in areas of known silica exposure (e.g., Cleaning Area, Block-Knockout, North Core Room, Stationmaster, and Slinger). The remainder were interviewed in areas of lesser silica exposure (e.g.,

quality assurance, cupola, shellcore, etc.).

C. Evaluation Criteria

The Occupational Health Standards as promulgated by the U.S. Department of Labor (Title 29, Chapter XVII, Part 1910, Subpart G, Section 1910.93, Tables G-1, G-2 and G-3) applicable to the substances measured for this Determination are:

TABLE G-1

Substance	p.p.m.[a]	mg/M^3 [b]
Ammonia	50	35
Carbon Monoxide	50	55
Phenol-Skin	5	19
Xylene (xylol)	100	435

---

a = Parts of vapor or gas per million parts of contaminated air by volume at 25° C. and 760 mm. Hg pressure.

b = Approximate milligrams of particulate per cubic meter of air.

TABLE G-2

Material	8-hour time weighted average	Acceptable ceiling concentration	Acceptable max. peak above acceptable ceiling concentration for an 8-hour shift.	
			Concentration	Maximum duration
Formaldehyde	3 p.p.m.	5 p.p.m.	10 p.p.m.	30 minutes
Toluene	200 p.p.m.	300 p.p.m.	500 p.p.m.	10 minutes

TABLE G-3 - Mineral Dusts

Substance	mg/M^3
Silica:	
Crystalline:	
Quartz (respirable)	$\frac{10mg/M^3}{\%SiO_2+2}$
Quartz (total dust)	$\frac{30mg/M^3}{\%SiO_2+2}$
Inert or Nuisance Dust <1% quartz	
Respirable fraction	$5mg/M^3$
Total Dust	$15mg/M^3$

Occupational health standards for individual substances are established at levels designed to protect workers occupationally exposed on an 8-hour-per-day, 40-hour-per-week basis over a normal working lifetime. Evaluation of exposures to multiple contaminants requires assessment of "total exposures" with regard to combined, potentiated, or inhibited toxic effects.

The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for Chemical Substances in Workroom Air (from whence the Federal Standards were adopted from the 1969 TLV publication) have reduced in 1973 the allowable concentrations of ammonia to 25 p.p.m. or $18mg/M^3$, of toluene (toluol) to 100 p.p.m. or 375 mg/M^3 and of formaldehyde to a "ceiling limit" of 2 p.p.m. or $3mg/M^3$.

Numerous investigators have noted a number of potential health hazards which exist in the foundry environment.[1,2,3,4,5,6] With specific reference to Golden Foundry, the NIOSH investigators focused upon the various potential respiratory hazards in that facility for these were the chief agents to which the men were exposed. A brief review of the adverse effects of silica, phenol, formaldehyde, ammonia, and iron oxide follows:

1. Silica - The chief concern regarding excessive silica exposure is

the development of silicosis. This form of pneumoconiosis usually occurs only after a number of years of exposure, although silicosis can occur in a short time with severe exposure. Early silicosis (termed "simple silicosis") is usually first diagnosed by chest x-ray examination. At this stage there is usually little, if any, functional impairment, and there are often no associated symptoms and signs. Symptoms occur when silicosis advances and becomes complicated by infection and emphysema. These changes are marked by intolerance to exertion, episodes of coughing, and production of thick purulent sputum. When silicosis has progressed to this point, the chest x-ray is usually read as "conglomerate silicosis." Conglomerate silicosis many times progresses in spite of termination of exposure, becomes incapacitating to the affected workers, and is irreversible.

2. Phenol - Acute effects in many are noted when phenol is ingested. Swallowing it causes intense burning of the mouth and throat followed by marked abdominal pain. Cyanosis is usually marked, and subsequent muscular collapse and unconsciousness ensue. Chronic effects which may occur after inhalation over a number of years include digestive disturbances, such as diarrhea and excessive salivation; nervous disorders, including headache, fainting, vertigo and mental disturbances; and, possibly, skin eruption.

3. Formaldehyde - The characteristic effects of inhalation include detection of odor well below 1 p.p.m.; discomfort noted at 2-3 p.p.m. when a mild tingling sensation in the eyes, nose and posterior pharynx is felt; increasing discomfort at 4-5 p.p.m.; and burning of eyes, nose and throat with difficult breathing at 10-20 p.p.m. Serious inflammation of the respiratory tract may occur with only 5-10 minute exposure to 50-100 p.p.m. Dermatitis has also been noted occasionally in individuals at low levels of exposure.

4. Ammonia - Respirable concentrations of ammonia at 400-700 p.p.m. cause considerable irritation to eyes, nose and throat. With sustained high concentrations permanent injury to the cornea, damage to the throat and upper respiratory tract, and deleterious effects upon the heart and lungs may occur. High concentrations (>1000 p.p.m.) can also cause skin irritation, while concentrations of 3000 p.p.m. may produce chemical burns. Detection limits of below 5 p.p.m. and complaint levels about 20-25 p.p.m. have been reported by the Detroit Department of Health.

5. Iron oxide - Prolonged, excessive exposure to this agent gives rise to "iron pigmentation" of the lungs, known as siderosis, which is considered a benign pneumoconiosis. This type of dust or fume is found in a number of jobs (welding, iron ore mining, foundry and fettling opera-

tions, and others). Regarding the systemic absorption of iron from iron oxide inhalation, no evidence of impairment has been noted. With regard to local effects, upper respiratory and sinus irritation and congestion have been known to occur with excessive exposure to the dust or fume.

D. Evaluation Results and Discussion

1. Environmental

Sample results reported for mineral (silica-containing) dust are not 8-hour time-weighted averages, but are approximations of expected 8-hour time-weighted averages.

A total of 46 air samples were collected in the molding, casting and shake-out areas to determine airborne dust concentrations (36 personal samples from 19 employees for respirable dust and 10 general room air samples - 7 for respirable and 3 for total dust). The results of these samples are tabulated in Tables I and II. Eighteen of the 36 personal samples exceeded the allowable concentrations, two-thirds by a factor of 2 or more, with the Moldmaster Shakeout workers and Forklift Truck operators having the highest exposures. Nine of 10 general area samples at the Moldmaster Shakeout and on the Slinger (Block) Floor were in excess of allowable concentrations, again by factors of 2 or more. There were 1 of 6 personal samples at the Shot Blast-Knockout over the allowable concentration, 2 of 5 at the Station-master Shakeout and 1 of 3 on the Slinger (Block) Floor during nighttime shakeout. Additional discussion regarding the excessive silica laden dust exposure to employees is contained in Section E of this report.

The results of 8 iron oxide personal samples collected in the Cleaning Room ranged from 1.78 to 8.87 mg/M^3 with a mean of 3.56 mg/M^3. One sample on an employee near a swing grinder showed a concentration of 21.43 mg/M^3; however, this did not coincide with 2 other samples collected on the same individual. Two samples on the Stand Grinder (Squeezer Floor) indicated air concentrations of 32.7 and 36.9 mg/M^3. This exposure is excessively high and, though the employee is equipped with an air-supplied respirator, efforts should be made to improve the local ventilation at the Stand Grinder to reduce these concentrations below allowable standards.

Six personal samples were collected at the Mold and Pattern Spray operations on the Slinger (Block) Floor and analyzed for toluene and xylene. Toluene concentrations ranged from 1.4 to 2.0 mg/M^3 with a mean concentration of 1.7 mg/M^3. Xylene concentrations ranged from nondetectable to 8.1 mg/M^3, with a mean of 4.0 mg/M^3.

Carbon monoxide concentrations on the Slinger (Block) Floor and in the vicinity of the Moldmaster Shakeout were relatively consistent throughout the sampling period, ranging between 20 and 30 p.p.m.

Ten samples for ammonia in the Shell Core Room ranged from 1 to 25 p.p.m., with a mean of 15 p.p.m. No aldehydes, including formaldehyde, were detected. No ammonia or aldehydes were detectable in the North Core Room. The range of detectability for the sampling tubes were: ammonia - 10-1500 p.p.m. and formaldehyde - 1-100 p.p.m.

2. Medical

The day shift first-aid corpsman could recall no unusual occurrance of injury or illness while attending the dispensary; yet he did note a preponderance of minor eye injuries as one might expect in a foundry environment. The safety officer indicated that there were some problems with men not using certain safety equipment. For example, in certain areas which have high noise exposures, hearing protection is not always worn. He attributed this, in some cases, to the fact that there have been ear infections in several men using ear plugs for protection. Another problem is the lack of use of respirators in some areas of high silica exposure.

Phone conversation was held with the company's physician consultant. He stated that in his tenure with the company, two cases of silicosis in long-term employees have come to his attention. One individual was a 17-18 year employee, who was found to have simple silicosis by chest x-ray 2 to 3 years ago. This man subsequently died from a lung malignancy. The second man is a 24-25 year employee at Golden Foundry, whose condition was discovered this year. His chest x-ray revealed conglomerate silicosis and pulmonary function testing has revealed compromised function. The physician pointed out that he has recommended that pre-employment and periodic chest x-rays be done on the employees. He noted that this would be a costly endeavor for the plant because of such a large turnover in newly acquired employees.

A breakdown of the positive responses of the employees to the questions is listed below:

Number of Men Interviewed:	POSITIVE RESPONSES: Shell Core Area (n = 5)	POSITIVE RESPONSES: All Other Areas of The Plant (n = 33)
Are you having or have you had any medical problems which you think may be related to your work?	2	8
Do you: Smoke?	1	25
Have sinus problems?	1	8
Do you have:		
Shortness of breath?	2	11
Whistling in chest?	1	6
Cough?	2	15
Skin problems?	0	8
Arthritis?	1	6
Watering or burning of the eyes?	4	10
Watering or burning of the nose or throat?	2	3
Headache?	1	6
All Other Questions		3 or less

Questionnaire interview of a sample of the employees revealed several findings which deserve mentioning. Findings from all surveyed areas except the Shell Core Area showed a large percentage of men with shortness of breath and cough. It is difficult to evaluate the role which the work environment plays in these symptoms because nearly all men who experienced these symptoms were presently or previously smokers. The complaint of skin problems varied from acne and warts to heat burns and blistering of the skin by chemical solvent. Another area which showed considerable positive response in all areas of the plant was watering or burning of the eyes; nearly one-third of those questioned experienced these symptoms frequently. In regions other than the Shell Core Area this may likely be due to the suspended particulates in the general room atmosphere. Although only a small number of workers were interviewed in the Shell Core Area, irritative symptoms of

the mucous membranes of the nose and throat and especially irritation of the eyes were frequently reported. With the exposure in this area to formaldehyde, ammonia and phenol, these symptoms indicate at least periodic local irritation to one or more of the agents. At the time of the NIOSH environmental sampling, none of the sample measurements for aldehydes or ammonia was above the federal standards; however, these measurements were taken at only one point in time and may not reflect an occasional excrescence. In fact, the high percent of irritative symptoms in the small number of men interviewed certainly suggests that this is the case.

As already stated, silicosis usually occurs only after a number of years of exposure. With this in mind, it is apparent that radiologic diagnosis of silicosis demonstrates that an individual has had excessive exposure to silica in the past; it says nothing of that individual's present exposure and, therefore, is of little value in assessing whether silica exposure in his present environment is sufficient to cause disease; for this reason periodic environmental monitoring is very important for determining worker exposure to silica. However, despite this limitation, a number of important purposes are served by appropriate radiologic examination. Two of the most important are as follows:

1. Pre-employment radiologic examination (and pulmonary function testing - P.F.T.) helps to identify individuals who may be at special risk in a silica-containing atmosphere. This would include individuals with such diseases as undiagnosed simple silicosis or conglomerate silicosis, active pulmonary tuberculosis, arrested or healed tuberculosis, marked restrictive or obstructive pulmonary disease, as well as other cardiopulmonary disease.

2. Periodic radiologic examination (and P.F.T.) helps to identify individuals who may have become a risk during their employment in the foundry with such diseases as noted above.

E. Recommendations

1. In view of the findings which demonstrate a silica exposure for many foundry workers of 2 or more times the present federal standard, it is most strongly recommended that immediate measures to lower silica air levels below the federal standard, as well as implementation of a medical surveillance program be instituted. Improved ventilation should be a primary consideration. Also, a modification in some of the work practices could contribute to a reduction of employee exposure. Housekeeping should be improved to eliminate the accumulation of large quantities of sand on the floor. This is most likely the reason for high exposure of the forklift truck operator to dust, having to continually plow through the sand and cause its re-entry

into the atmosphere. A sample medical surveillance program is outlined below; a program similar to it will likely become in the near future the official program to which all workplaces with a potential silica hazard must conform.

a. Preplacement: A comprehensive medical examination should take place within 30 days following an individual's employment in an occupation where airborne concentrations of free silica may occur. The examination should include, as a minimum:

(1) A chest x-ray (posteroanterior 14 x 17 or 14 x 14 inches) classified according to the 1971 ILO International Classification of Pneumoconioses.

(2) A medical and occupational history to elicit work exposure to free silica and signs and symptoms of respiratory disease.

(3) Pulmonary function tests including forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1).

(4) Tuberculin skin test.

(5) A baseline body weight.

(6) Height.

(7) Age.

b. Periodic examinations: At least once each three years, a comprehensive medical examination should be made available to employees engaged in occupations where exposure to airborne concentrations of free silica may occur. Such an examination should include as a minimum items a. (1), (2) and (3) above.

c. Termination of employment: Within 30 days before or after termination of employment of an employee engaged in an occupation exposed to airborne concentrations of free silica, a comprehensive medical examination should be made available, including as a minimum items a. (1), (2) and (3) above.

d. Recent examinations: If adequate records show that the employee has been examined within the past one-year period in accordance with paragraphs a. and b. above, no further medical examination is required of the employee.

e. Medical management

(1) An employee with roentgenographic evidence of simple silicosis should be permitted to work in an environment with effective dust control (dust level below the recommended standard).

(2) An employee with conglomerate silicosis should be excluded from an industrial environment that contains known amounts of free silica.

(3) An employee with or without roentgenographic evidence of silicosis who also has respiratory symptomatology and/or pulmonary functional impairment should be fully evaluated by a physician who is qualified to advise the employee with reference to continuing work in a dusty environment.

(4) An employee found to have active tuberculosis (pulmonary) should be placed under treatment and should not be permitted to resume employment at a dusty occupation while under treatment for this disease. Workers with arrested or healed reinfection tuberculosis should be allowed to continue to work, but should observe the same precautions as the man with roentgenographic evidence of simple silicosis. Healed primary tuberculosis is not a contraindication for employment in a dusty trade.

2. A program of periodic sessions in safety education should be implemented. One approach which has been of aid in other industries with a similar problem has been serial programs in safety education, conducted by a combined labor/management committee (e.g., union safety committee plus safety officer). In this approach brief informative and meaningful session are arranged for small groups of employees in those areas of special concern. Such a program enables workers to be more aware of the necessity for appropriate safety equipment and safety practices and can alert management to the reasons why there is not complete compliance to the use of certain equipment.

3. Need for improved ventilation in the Shell Core Area is stressed because of the local irritative symptoms which the workers experience there. Also, with the ammonia standard being reduced to 25 p.p.m. by the ACGIH and the fact that many of the grab samples collected in the Shell Core Room were 25 p.p.m. ± 25%, it is possible that airborne concentrations could exceed the recommended allowable 8-hour time-weighted average under conditions that did not exist during this evaluation.

4. The one high concentration of iron oxide on the sample from the worker near the swing grinder should not be completely disregarded. Efforts should

be made to maintain employee exposure in the Cleaning Room to an absolute minimum. Also, it should be pointed out that the possible exposure of employees in the Cleaning Room to silica dust generated during the chipping and grinding operations was not investigated and could produce a significant exposure.

5. Finally, there is a definite need to improve the atmosphere at the Stand Grinder. Local exhaust ventilation should be provided to eliminate the potential of exposure to the employee without the need for air-supplied respirators.

V. REFERENCES

1. Jones, W.W., Annals of Occupational Hygiene, Vol. 10, pp. 241-248, July, 1967.

2. Hamlin, L.E., Industrial Medicine & Surgery, Vol. 30, p. 435, October, 1972.

3. Clarke, N.E., Industrial Medicine, Vol. 41, No. 6, June, 1972.

4. "Foundry," Encyclopedia of Occupational Health & Safety, Vol. 1, pp. 576-581, 1971.

5. "Fettling," Encyclopeida of Occupational Health & Safety, Vol. 1, K1971.

6. Leach, J.R., Hospitals, JAHA, Vol. 46, pp. 74-75, September 16, 1972.

Other Sources of Information:

McCarl, G.W., Journal of Occupational Medicine, Vol. 13, No. 12, pp. 570-572, 1971.

"Silicosis," Encyclopedia of Occupational Health & Safety, Vol. 2, pp. 1309-1313, 1971.

Cole, C., Annals of Occupational Hygiene, Vol. 10, pp. 277-284, 1967.

International Classification of Radiographs, of Pneumoconiosis (U-C Revision), revised 1971, International Labor Office, Beneva, Bulletin 22 (revised), 1971.

Documentation Of The Threshold Limit Values for Substances in Workroom Air, American Conference of Governmental Industrial Hygienists, Third Edition, p. 11, 1971.

VI. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared by:

Richard S. Kramkowski
Regional Consultant for Occupational Safety and Health
Region V - Chicago, Illinois

John Cromer, M.D.
Medical Officer
Medical Services Branch
Division of Technical Services
Cincinnati, Ohio

Originating Office:

Jerome P. Flesch
Chief
Hazard Evaluation Services Branch
Division of Technical Services
Cincinnati, Ohio

Acknowledgments:

Henry Ramos
Industrial Hygienist
Hazard Evaluation Services Branch
Division of Technical Services
Cincinnati, Ohio

Melvin T. Eddleston
Industrial Hygienist
Hazard Evaluation Services Branch
Division of Technical Services
Cincinnati, Ohio

Steven K. Shama
Medical Officer
Medical Services Branch
Division of Technical Services
Cincinnati, Ohio

(Continued)

Acknowledgments (continued):

Staff
Physical and Chemical Analytical Branch
Division of Laboratory and Criteria Development
Cincinnati, Ohio:

Robert Larkin
Chemist

Ceola H. Moore
Physical Science Aide

Limtiaco Leonardo
Chemist

William B. Gilbert
Physical Science Trainee

John L. Holtz
Chemist

Anthony W. Smallwood
Chemist

Robert W. Kurimo
Chemist

Ardith A. Grote
Chemist

Also:

Martha J. Seymour

Charles Nenadic

TABLE I

Results of Personal Air Samples
for
respirable-Mineral Dust

Location	% Free Silica	Calculated Standard (mg/M^3)	mg/M^3 (Sample)	Ratio Sample/Standard
Moldmaster Shakeout	unavailable	---	3.3	---
	0	5.0	2.1	0.4
	5.4	1.3	2.7	2.1
	23.6	0.4	1.9	4.8
	0	5.0	1.1	0.2
	0	5.0	2.3	0.4
	7.2	1.1	2.9	2.6
	1.7	2.7	2.7	1.0
	0	5.0	2.6	0.6
	3.5	1.8	3.9	2.2
	unavailable	---	<0.1	---
	17.7	0.5	1.0	2.0
	14.7	0.6	1.2	2.0
	8.1	1.0	1.7	1.7
	8.0	1.0	5.7	5.7
Shot Blast-Knockout	0	5.0	1.1	0.2
	0	5.0	1.4	0.2
	4.2	1.6	0.4	0.2
	18.5	0.5	0.6	1.2
	0	5.0	0.7	0.2
	12.2	0.7	0.4	0.6
Slinger (Block) Floor	0	5.0	0.6	0.2
	1.9	2.6	3.1	1.2
	0	5.0	1.0	0.2
Ladle Operator	0	5.0	1.0	0.2
Forklift Operator	0	5.0	1.6	0.4
	12.8	0.7	1.7	2.4
	18.5	0.5	1.4	2.8
	13.9	0.6	1.6	2.7
	39.2	0.2	1.0	5.0
	0.7	3.6	1.7	0.5
Stationmaster Shakeout	3.4	1.9	1.2	0.6
	0.3	2.3	0.4	0.2
	15.9	0.6	0.9	1.5
	8.2	1.0	0.4	0.4
	20.0	0.4	0.5	1.2

TABLE II

Results of General Room Air Samples for Mineral Dust

Location	Total Dust (T) or Respirable Dust (R)	% Free SiO_2	Calculated Standard (mg/M^3)	mg/M^3 Sample	Ratio Sample/Standard
Moldmaster Shakeout	R	14.0	0.6	3.5	5.8
	R	9.4	0.9	5.1	5.7
	R	35.6	0.3	0.8	2.7
Slinger (Block) Floor	R	4.5	1.5	5.1	3.4
	R	10.4	0.8	5.9	7.4
	T	4.0	5.0	0.7	0.4
	R	9.6	0.9	5.1	5.7
	T	8.6	2.8	4.8	5.3
	R	10.0	0.8	4.5	5.6
	T	9.0	2.7	6.8	7.6