SENTINEL EVENT NOTIFICATION SYSTEM FOR OCCUPATIONAL RISKS (SENSOR):

FOLLOW-UP STUDY FOR CONTROL OF SILICA EXPOSURE

at

Woodbridge Sanitary Pottery Corporation
Woodbridge, New Jersey

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PLANT SURVEYED:	Woodbridge Sanitary Pottery Corporation 500 Green Street Woodbridge, New Jersey 07095 (201) 634-3950
SIC CODE:	3261 Vitreous China Plumbing Fixtures
SURVEY DATE:	June 11-13, 1991
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I. SUMMARY

In 1987, the National Institute for Occupational Safety and Health (NIOSH) initiated the Sentinel Event Notification System for Occupational Risks (SENSOR) program, a cooperative state-federal effort designed to develop local capability for the recognition, reporting, follow-up, and prevention of selected occupational disorders. The New Jersey Department of Health is participating in the SENSOR program for occupational asthma and silicosis. The Engineering Control Technology Branch (ECTB) of NIOSH is assisting in the conduct of follow-back surveys in selected plants to recommend improved controls. In June 1988, an in-depth survey of exposures to silica dust was made at the Woodbridge Sanitary Pottery Corporation, Woodbridge, New Jersey, as part of this effort. Environmental, engineering, and ergonometric evaluations were conducted. Recommendations were made on ways to reduce high silica exposures that existed at the time of this survey. In June 1991, a follow-up in-depth survey was conducted at this same facility to determine the progress made in reducing silica exposures since the 1988 survey.

The environmental evaluations for the 1991 survey included the collection of six bulk/material samples, analyzed for crystalline silica content, and 53 personal and 33 area air samples, analyzed quantitatively for respirable crystalline silica and respirable dust. Respirable crystalline silica dust exposures averaged 0.04 mg/m^3, approximately a 78 percent reduction since 1988. Respirable dust exposures averaged 0.34 mg/m^3, approximately a 65 percent reduction. Area respirable dust levels average 0.12 mg/m^3, a 70 percent reduction.

Of the four departments, there was a statistically significant difference at the 95 percent confidence level in the **average respirable dust exposure** in the Casting Department (48 percent decrease), and the Spray Department (85 percent decrease). There was an increase, although not statistically significantly different, in the average dust exposures in the Glaze Preparation Department (37 percent). There was a statistically significant difference in the **average respirable dust levels** in the Slip House (79 percent decrease). There were reductions, although not statistically significant, in the average dust levels in the Spray Department (79 percent), the Casting Department (54 percent), and the Glaze Preparation Department (86 percent).

Areas where improvements have been made were identified. Deficiencies in the design and maintenance of workstations, work practices, and ventilation control systems still existing were identified and recommendations for their modification or improvement are offered.

II. 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 technologies. 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 Sentinel Event Notification System for Occupational Risks (SENSOR) program, 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 are made available to the health care provider; second, medical evaluations of coworkers who may be at risk of developing similar disorders are conducted; and finally, action directed to reduce work site exposures are considered. To assist the states in developing intervention plans for exposure reduction, ECTB has been conducting engineering assistance projects with selected states participating in SENSOR. This assistance has included specific control recommendations for individual plants identified and selected by the state, or for an industry 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) 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 has been 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.

Since the NJDOH has shown the pottery industry to be a high silicosis risk industry plant studies were initiated to: 1) develop effective risk reduction programs for use in this and in similar type plants; 2) demonstrate the feasibility of effective intervention in reducing the silicosis risk; and 3) reduce the incidence of silicosis in this industry. In 1988, an in-depth survey was conducted at the Woodbridge Sanitary Pottery Corporation, Woodbridge, New Jersey, as a part of this federal-state effort. In 1991, a follow-up in-depth survey was conducted at this same facility to determine both the progress being made in reducing the silicosis risk and the effectiveness of the control program at this facility. This report documents the changes made in engineering controls, work practices, and administrative control programs by presenting data on current worker exposures to silica-containing dusts. This report also provides further recommendations to improve the dust control and disease prevention programs at this facility.

A. Plant Description

The Woodbridge Sanitary Pottery Corporation manufactures vitreous china products, such as lavatories and toilet bowls. The work force at this plant consists of approximately 150 employees, including 30 salaried and 120 hourly workers that work in the following departments:

Slip Preparation	3	Kiln	10	Molding	3
Casting	57	Packaging	13	Labor	9
Glaze Preparation	2	Shipping	3	Maintenance	6
Glaze Spraying	9	Refiring	5		

The plant capacity is approximately 9,500 units per (5-day) week. (A unit may be a toilet tank with a lid, a lavatory, or a toilet bowl.)

Vitreous china is a specialized type of ceramics. Raw materials are combined to form a clay slip, the slip is cast, then the casting is shaped, dried, glazed, and fired. The principal raw materials are clay (hydrated aluminum silicates), feldspar (alkaline aluminum silicates), and flint (crystalline silica). One or more glaze coats (containing crystalline silica) are sprayed onto the molded greenware prior to firing in a tunnel kiln. The operations, processes, and materials used to produce these products are shown in Figure 1. The floor plan of the building is shown in Figure 2.

All production work is carried out in one building. After the pieces have been fired, they are inspected and packaged. Pieces having a blemish are sent to the Refire Department to be repaired and refired. All production areas operate during one 8-hour shift per day, 5 days per week. The kiln is fired continuously, 24 hours per day, 7 days per week. Production areas having a potential for silica exposure include the Slip House, Cast Shop, Mold Shop, Spray Area, and the Kiln, Glaze, and Refire Departments.

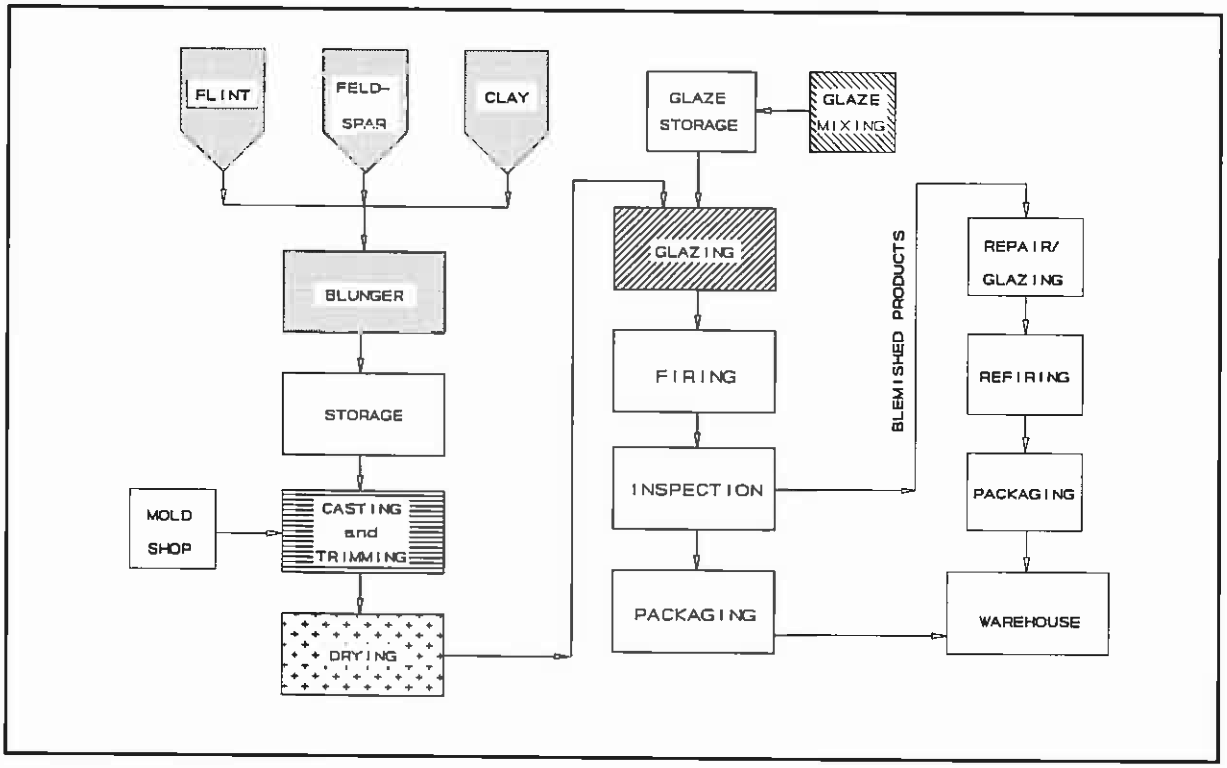

Figure 1: Woodbridge Sanitary Pottery Flow Chart. (The shading of each block corresponds to the shading of the areas in Figure 2.)

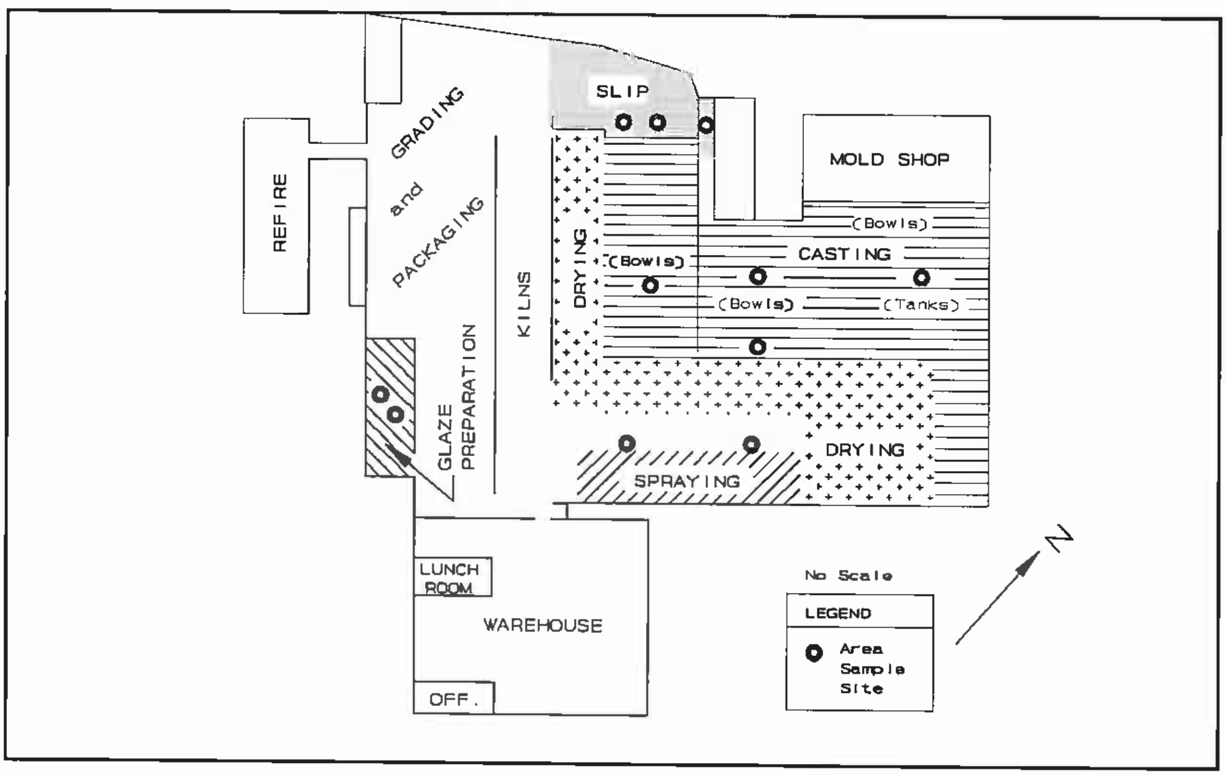

Figure 2: Floor Plan.

B. Process Description

The four departments evaluated in 1988 were again evaluated in 1991. A description of the process in these departments follows:

1. Slip House Department

In 1988, powders were transferred manually from the silos to the blungers (slurry mixing tanks) by means of a front end skip loader. In 1991, an automated batching system was used to transfer the powders to the blungers. Scrap was recycled by passing it through a crusher and stockpiling it in a partially enclosed area of the Slip House. (During the study, dust could be seen escaping from the Recycle Scrap Area into the Slip House. At the conclusion of the study, the company had completed installation of a garage-type door to enclose this scrap area.)

2. Casting Department

The cast shop consists of approximately 50 workstations with one worker per station. Casters start the shift by pouring slip from a hose into several rows of plaster molds, which had been set up the previous day. Each worker's production quota may vary, depending on his negotiated work schedule and the type of fixture being cast, e.g., tanks - 80 per day, lavatories - 52 per day, and bowls - 24 to 32 per day. After casting, the slip is allowed to set (typically an hour or more) before the molds are removed. After the molds are removed, they are dusted with a parting compound in preparation for the next day's work. The pieces are dried at least several hours, smoothed and trimmed using an assortment of hand tools (minor repairs are made and large mold marks are removed), and then dried further for one to two days. Because of limited storage space, the castings are stored on carts in and around the casting area while they are drying. At night, waste heat from the kilns is directed to this area to enhance drying. The entire casting area, therefore, may be considered to be a large drying area. In addition to drying greenware, dust and pieces of scrap clay on the floor become thoroughly dried, presenting an opportunity for reentrainment into the air and adding appreciably to the likelihood of a high background dust level.

3. Glaze Spray Department

The dried pieces are carted from the Casting Department to the Spray Department, where nine to twelve employees are involved in piece inspection and glaze spraying. One or more coats of glaze (depending on the type of fixture) are applied in ventilated spray booths by means of a compressed-air spray system.

4. Glaze Preparation Department

The liquid glaze is prepared in the Glaze Department by two workers mixing Supersil powder (crystalline silica), feldspar, whiting, Pyrax, China clay, talc, and other color producing compounds. Bags of material are dumped manually into one of several pebble mill blenders. In dumping the bags of material, the operator climbs up a portable ladder. The bags of material are placed on a pallet and elevated behind the operator by a fork lift. The operator turns around, takes one bag at a time, and holds each bag near the manway to the pebble mill (which is at shoulder height and even with the ladder). He cuts the bag with a knife, manually dumps it into the pebble mill and manually compresses the bag. (Visible dust is forced from the bag.) The mix is milled overnight and the glaze is then pumped to holding tanks for final adjustment and storage prior to use in the Spray Department.

III. POTENTIAL HEALTH AND SAFETY HAZARDS AND EVALUATION CRITERIA

A. Crystalline Silica

1. Effects of Exposure

The principle material investigated in this study was crystalline silicon dioxide often referred to as silica or free silica. Silica may be present in at least three crystalline forms (alpha quartz, cristobalite, and tridymite), as well as noncrystalline forms (amorphous). Amorphous silica, usually considered to be of low toxicity, may produce changes in the lung, visible by X-ray, without disability.[1,2]

Crystalline silica (quartz) and cristobalite have been associated with silicosis, a pulmonary fibrosis of the lung caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and nonspecific chest illness. Silicosis usually occurs after years of exposure but can appear in a shorter time if exposures are very high.[3] The NIOSH RELs for respirable quartz and cristobalite are 50 $\mu g/m^3$, as time-weighted averages. There is evidence that cristobalite has a greater capability to produce silicosis than quartz.[4,5,6,7,8] NIOSH considers quartz and cristobalite to be potential human carcinogens.[9]

Other chemical or biological factors can influence the rate of reaction of the free silica with the tissue and can create problems in diagnosis. One of the most frequent complications in the past was the occurrence of tuberculosis with silicosis, in which case the disease was called silicotuberculosis or tuberculosilicosis.[10]

2. Exposure Limits

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 work day, 40-hour work week.[10]

The OSHA Permissible Exposure Limit (PEL):
The OSHA PEL is 0.1 mg/m^3 as a TWA for respirable quartz in an 8-hour day. For respirable cristobalite, the TWA is 0.05 mg/m^3 in an 8-hour day.[11]

IV. STUDY PLAN/METHODOLOGY

A. Quantitative Evaluations

Air exposures to dust were evaluated in several ways:

1. Bulk samples of material that had accumulated on the floor in each of the four departments studied, plus a bulk sample of the raw material used as a parting compound, were collected and analyzed for crystalline silica content.

2. Area samples, obtained in general work areas for the estimation of respirable dust levels, were collected on preweighed, 37-mm-diameter, 5-mm-pore size, PVC membrane filters, (Mine Safety Appliances, Inc., Pittsburgh, Pennsylvania) mounted in series with 10 mm nylon cyclones (Mine Safety Appliances, Inc., Pittsburgh, Pennsylvania). Air was drawn through the filter at an approximate flow rate of 1.7 liters per minute (lpm) using a battery-powered sampling pump (SKC Air Check Sampler, Model 224-PC X R7, Eighty-Four, Pennsylvania).

3. Personal samples, for the estimation of respirable dust exposures, were collected using the same type of preweighed PVC filters and portable, battery-operated pumps. Time-integrated samples were collected in the breathing zone of workers for a full day shift, generally for about six hours (ranging from about four to seven hours, depending on individual work schedules).

   All air samples were analyzed for respirable dust and crystalline silica dust content. Determinations of respirable dust content were made gravimetrically according to NIOSH Method 0500,[12] with a Limit of Detection (LOD)[a] considered to be 0.01 mg of respirable particulate per portion.

   Crystalline silica (alpha quartz and cristobalite) was analyzed by NIOSH Method 7500, using X-ray diffraction.[12] Most of the samples contained varying amounts of minerals, such as feldspars, clays, and other aluminosilicates, which interfere with the primary quartz region

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[a] The Limit of Detection (LOD) is the mass of analyte which gives a signal $3\sigma_b$ above the mean field blank signal, where σ_b is the standard deviation of the field blank signal.[13]

used in X-ray diffraction analysis for quartz. The following modifications to NIOSH Method 7500 were made: 1) Filters were dissolved in tetrahydrofuran rather than being ashed in a furnace; 2) standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than using the suggested normalization procedure. The analytical laboratory reported that because of the extremely low levels of cristobalite, interferences can probably be attributed to feldspar and not cristobalite. The LOD and the Limit of Quantification (LOQ)[b] were stated to be 0.015 mg and 0.03 mg per portion, respectively.

In this study, only significant amounts of alpha quartz was determined to be present in any of the raw materials, final products, or airborne dust samples. In this report, all references to silica dust concentrations refer to the crystalline quartz content of the respirable fraction of airborne dust.

4. Ventilation rates and airflow pattern evaluations were made to determine the effectiveness of locally exhausted spray booths. Velocity measurements were made with an Air Velocity Meter, Model 1650, manufactured by (TSI, Inc., St. Paul, Minnesota).

B. Observational Evaluations

Other control measures, such as the methods used to reduce lifting stress, the respirator protection program, the medical monitoring program, the environmental monitoring program, housekeeping, and equipment maintenance were also observed. Also a review of these areas was made with the Manager of Industrial Relations and Safety Coordination, the Plant Engineer, and the Plant Superintendent.

V. RESULTS AND DISCUSSION

A. Changes in Controls

This facility has fully or partially implemented all but one of the recommendations made by ECTB in 1988. The recommendations (shown in *italics*) and the actions taken:

1. *Install an enclosed automatic material handling system, in the Slip House.* The company had been planning this change in 1988 and had completed installation of the new system prior to the 1991 study. The new system is designed to reduce atmospheric dust dispersion during

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[b] The Limit of Quantitation (LOQ) is the lowest mass that can be reported with acceptable precision. LOQ is the larger of: (a) the mass corresponding to the mean field blank signal + $10\sigma_b$ (i.e., ± 30% precision) (b) the mass above which recovery is ≥ 75%.[13]

silo loading and transfer to the blungers. A programmable logic controller (PLC) automatically weighs and pneumatically conveys the raw materials for making the slip through an enclosed system to four receiving bins above the blungers.

2. *Substitute a noncrystalline silica mold release for the glaze overspray material used as a parting compound.* Perlite, an amorphous silica is now used.

3. *Where possible, cleaning of "green" castings[c] should be done rather than cleaning "white" castings[d]. If feasible, wiping the white pieces with a damp sponge or misting them with a water sprayer prior to cleaning should reduce dust generation.* While it is not possible to completely eliminate "white" casting cleaning, the "white" castings are now wetted with a non-abrasive sponge prior to cleaning.

4. *The charged fogger being tested in the Glaze Preparation Department did not effectively control dust exposures and should not be permanently installed as a means of suppressing dust.* The fogger has been removed and is no longer being used.

5. *"Man-cooler" fans in the Glaze Spray Department reduced the effectiveness of the local exhaust ventilation into the spray and inspection booths and can also reentrain settled dust. These fans should be eliminated.* These fans are no longer used in the Glaze Spray Department.

6. *Reduce the pressure in the spray guns at the glaze spray booths and increase the ventilation in these booths to at least an average of 100 fpm air velocity at the face to contain the sprayed-on glaze.* The average face velocities were increased approximately 100 fpm; they now average 145 to 260 fpm. This meets and exceeds the guidelines set in the ACGIH Industrial Ventilation Manual which recommends a minimum of 100 to 150 fpm. No changes were made in the pressure to the spray guns.

7. *Conduct scheduled maintenance and repair of dust control systems, including exhaust ventilation systems.* Holes in the booths had been repaired and the ventilation system to the booths is balanced at least once each year. One manual booth has been eliminated. Ventilation to this booth was blocked off resulting in increased face velocities at the remaining two booths. (Note: If it is necessary to use a third booth, additional ventilation must be installed.)

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[c]Castings made the previous day.

[d]Castings that have dried for two or more days.

8. *Improve the method for filling the pebble mills such as a ventilated dump station on a platform above the mills or a ventilated dump station on the floor using semibulk containers to be hoisted above the mills and dumped.* Due to expense and the age of the mills, no changes were made in this area.

9. *Establish a more effective health and safety program.* The existing program was expanded. A staff member has been designated as the Health and Safety Coordinator and is responsible for developing and implementing programs, operations, and procedures directed at the improvement of employee health and safety conditions.

10. *Obtain and review resource materials listed in the 1988 report.* Some of these materials have been acquired.

11. *Implement a comprehensive respirator program and vigorously enforce the use of respirators until silica dust exposure levels can be reduced to at least below the OSHA PEL of 0.1 mg/m^3 or, preferably, below the NIOSH REL of 0.05 mg/m^3 for crystalline silica dust by engineering controls and work practices.* A written program has been created and is enforced by the safety coordinator. Each employee is assigned to a respirator, fit tested, and trained to clean, maintain, and wear it properly. Respirators are stored in sealable bags in clean areas. In the Casting Department, they are stored in the employee's locker in the change room. In other departments, they are stored in the Foreman's Shop or some other clean area.

12. *Reduce cross contamination from other activities in the plant as well as reentrainment of dust from scrap and waste on the floor and other surfaces.* Curtains have been hung in one area of the Casting Department. There is also now a wall separating the crusher at the Slip recycler from the Casting Department.

13. *Institute an ongoing program of medical surveillance to validate the effectiveness of the dust control program.* The company has switched from a private physician to the local hospital for their medical surveillance program. Employees are given annual physical examinations which include chest X-rays and a pulmonary function test.

14. *Examine all lifting operations and install mechanical aids or redesign work areas to reduce lifting injuries.* In the Casting Department, mechanical lifting benches have been increased from two to four, and two roller conveyor lines for bowls have been installed. Also, the company is investigating the use of lifting belts to be worn by the worker. In the Glaze Spray Department, the Bowl Inspector was relocated at the entrance to the semi-automatic spray station. This makes it possible for the inspector and the operator at the bowl loading/unloading station to share in lifting and placing the bowls on the bowl loop. This results in approximately a 25 percent reduction in the number of bowls each has to lift.

15. *Improved housekeeping throughout the plant. Dry sweeping should be eliminated and improved methods for cleaning up scrap material such as using a HEPA equipped vacuum cleaner are needed.* Dry sweeping with brooms is being eliminated by the use of squeegee-type brooms. One worker is permanently assigned to cleaning. Additional employees, those assigned to light duty, also assist in cleaning. Attempts at using a vacuum cleaner with a HEPA filter have so far proven to be unsuccessful. Because of the heavy usage required, the motors in the unit burns out in a few months. The company is looking at other units in a continuing effort to find one that can be used.

16. *Set up an Environmental Monitoring Program to include periodic air monitoring and dust control systems monitoring to validate the effectiveness of the dust control program. Direct-reading monitors would help locate major dust sources in need of control.* The ventilation system is monitored on a quarterly basis by an outside firm. The company does not have a direct-reading monitor and calls upon NJDOH OSHA Consultative Service to do periodic air monitoring.

    As the plant's facilities expand, there are plans to replace manual casting operations with conveyor lines, to replace manual and semi-automatic spray operations with robotic sprays, to relocate and modernize the Glaze Preparation Department, and to make other changes to improve material handling processes throughout the operation.

B. Environmental Evaluations

1. Bulk Material Sample Analyses

Quantitative analysis for crystalline silica was made on bulk samples collected in each of the four departments studied. The bulk sample consisted of material that had accumulated on the floor in each of these areas. The crystalline silica content ranged from 16 to 25 percent as shown in Table I. Similar silica contents were measured by the airborne area samples (ranging from 16 to 37 percent silica) and the personal samples (ranging from 14 to 16 percent silica). No detectable silica was found in a bulk sample of the parting compound.

Table I: Comparison of Silica (Quartz) Content from Bulk and Air Samples.

Department	1988			1991		
	Bulk[a]	Personal	Area	Bulk[b]	Personal	Area
Slip House	16% to 98%[c]	-	30%	16%	-	37%
Casting	22%	27%	29%	21%	16%	16%
Glaze Spraying	-	13%	21%	25%	15%	17%
Glaze Preparation	23%	32%	39%	22%	14%	26%
Parting Compound	23%	-	-	n.d.[d]	-	-

(a) Bulk samples of raw materials going into the product.
(b) Bulk samples of accumulated dirt on the floor.
(c) Feldspar (16% quartz content), Flint (98% quartz content).
(d) n. d. - None detected (<0.75%).

2. Air Sample Analyses and Comparisons

Personal samples were collected on workers having the same job titles as those sampled in 1988. Although the area sample sites of 1988 were duplicated as nearly as possible, no effort was made to sample the same workers.

All the air samples contained quantifiable masses of respirable dust, that is, more than the analytical LOD of 0.015 mg per sample. (With the 1988 samples, clay and feldspar interferences necessitated the use of the secondary quartz peaks with a LOD of 0.08 mg per sample and a LOQ of 0.16 mg per sample. Many of these 1988 samples contained less than the LOD for silica.) With the 1991 samples, the bulk samples showed possible feldspar interferences. Because of these interferences, the extremely low levels of cristobalite indicated in a few samples can probably be attributed to feldspar interferences rather than cristobalite. It was possible to use the primary quartz peaks with an LOD and LOQ of 0.015 mg and 0.03 mg per sample, respectively, on these air samples. Only two of the air samples contained trace quantities of cristobalite, between the LOD and the LOQ.

Because of the greater interferences in the respirable quartz of the 1988 samples, respirable dust results were used to compare the exposures and levels between the 1988 and 1991 studies. The respirable quartz changes were used to indicate trends in levels and exposures from 1988 to 1991. The 1991 results accurately depict the current exposures and levels at this facility during this study.

In 1988, four departments (Casting, Glaze Spraying, Glaze Preparation, and Slip House) had the highest personal exposures and highest dust levels. The results for 1988 and 1991 air samples are shown in Table II, Respirable Dust, and Table III, Respirable Crystalline Silica. The sample ranges and the percent of the samples exceeding the OSHA PEL and the NIOSH REL are shown in Table IV, Area Dust Levels, and Table V, Personal Exposures.

Table II: Comparison of the 1988 and 1991 Geometric Means (GM) of the **Respirable Dust** of the Personal and Area Samples.

Department	Respirable Dust (mg/m^3)				
	No. of Samples	1988 (GM)	No. of Samples	1991 (GM)	Change
PERSONAL SAMPLES					
Casting	15	0.58	24	0.30	- 48%[a]
Glaze Spraying	18	1.94	20	0.30	- 85%[a]
Glaze Preparation	6	0.54	6	0.74	+ 37%
All	39	0.98	50	0.34	- 65%[a]
AREA SAMPLES					
Slip House	6	0.80	9	0.17	- 79%[a]
Casting	7	0.30	12	0.14	- 54%
Glaze Spraying	6	0.25	6	0.05	- 79%
Glaze Preparation	3	0.47	6	0.06	- 86%
All	22	0.40	33	0.12	- 70%[a]

(a) Statistically significant difference at a 95% confidence level using a paired t-test.[14]

Table III: Comparison of the 1988 and 1991 Geometric Means of the Crystalline Silica of the Personal and Area Samples.

Department	Respirable Crystalline Silica Dust (mg/m³)				
	No. of Samples	1988 (GM)	No. of Samples	1991 (GM)	Change
PERSONAL SAMPLES					
Casting	15	0.13	24	0.03	- 79%
Glaze Spraying	18	0.22	20	0.03	- 85%
Glaze Preparation	6	0.15	6	0.18	+ 17%
All	39	0.17	50	0.04	- 78%
AREA SAMPLES					
Slip House	6	0.25	9	0.02	- 92%
Casting	7	0.10	12	0.01	- 89%
Glaze Spraying	6	0.07	6	0.02	- 79%
Glaze Preparation	3	0.16	6	0.01	- 91%
All	22	0.12	33	0.01	- 88%

Table IV: **Area dust level ranges.** See Table III for the number of samples collected in each department.

Year	1988			1991		
Department	RANGE	% EXCEEDING		RANGE	% EXCEEDING	
	mg/m³	PEL[a]	REL[b]	mg/m³	PEL[a]	REL[b]
Slip House	0.06 - 1.16	83	100	<0.01 - 0.04	0	0
Casting	0.04 - 1.16	88	88	<0.01 - 0.02	0	0
Glaze Spraying	0.02 - 0.14	17	66	<0.01 - <0.02	0	0
Glaze Preparation	0.06 - 0.48	66	100	<0.01 - <0.02	0	0
General	-	-	-	-	-	-

(a) Based on the September 1, 1989 OSHA PEL = 0.1 mg/m³.
(b) The NIOSH REL = 0.05 mg/m³.

Table V: **Personal exposure** ranges. See Table III for the number of samples collected in each department.

Year	1988			1991		
Department	RANGE mg/m³	% EXCEEDING PEL[a]	% EXCEEDING REL[b]	RANGE mg/m³	% EXCEEDING PEL[a]	% EXCEEDING REL[b]
Slip House	-	-	-	-	-	-
Casting	0.06 - 0.18	95	100	<0.01 - 0.24	8	29
Glaze Spraying	0.11 - 0.67	100	100	<0.01 - 0.51	5	25
Glaze Preparation	0.08 - 0.29	83	100	<0.02 - 0.69	50	83
General[c]	-	-	-	0.01 - 0.10	33	66

(a) Based on the September 1, 1989 OSHA PEL = 0.1 mg/m³.
(b) The NIOSH REL = 0.05 mg/m³.
(c) Three (3) samples collected on worker cleaning in all departments.

a. Slip House Department

(1) Area Samples

Area samples were collected in the Slip House near the storage bins and mix tanks (blungers) indicated by numbers three and four as shown in Figure 3. The respirable dust level averaged 0.17 mg/m³ (range 0.07 to 0.39 mg/m³). The respirable silica level averaged 0.02 mg/m³ (range < 0.01 to 0.04 mg/m³). All samples contained detectable quantities of silica. None of the area samples exceeded the OSHA PEL or the NIOSH REL for silica dust.

Comparing the geometric means of the respirable dust levels, there was a statistically significant difference (at a 95 percent confidence level) -- from 0.80 mg/m³ in 1988 to 0.17 mg/m³ in 1991, a 79 percent decrease. There was not a statistically significant difference between the average respirable silica levels, from 0.25 mg/m³ to 0.02 mg/m³, a 92 percent decrease. The silica content of the respirable dust averaged 30 percent (range 26 to 33 percent) in 1988, 37 percent (range 15 to 57 percent) in 1991.

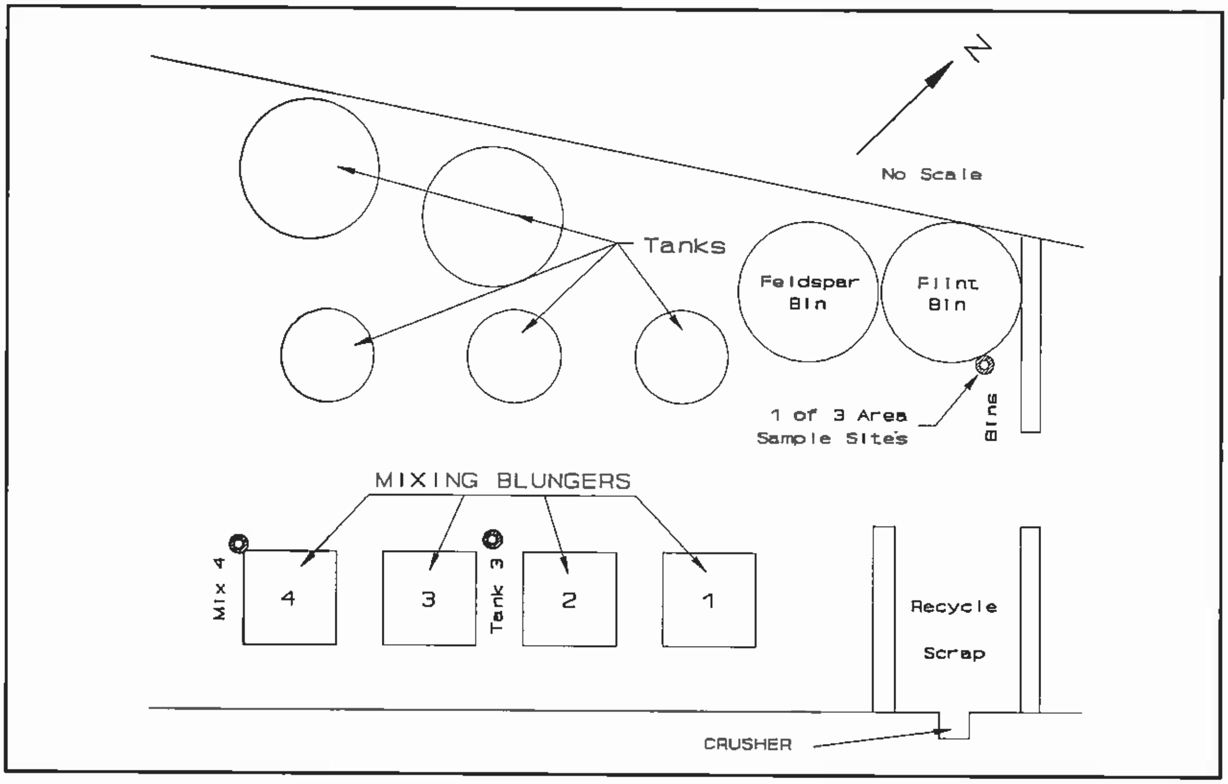

Figure 3: Slip House.

b. Casting Department

(1) Area Samples

Area samples were collected at four locations in the tank/bowl/lavatory casting area as shown in Figure 4. The respirable dust level averaged 0.14 mg/m^3 (range 0.06 to 0.24 mg/m^3). The respirable silica level averaged 0.01 mg/m^3 (range < 0.01 to 0.02 mg/m^3). Six of the twelve samples contained detectable quantities of silica. None of the area samples exceeded the OSHA PEL or the NIOSH REL for silica dust.

Comparing the geometric means of the respirable dust levels, there was not a statistically significant difference (at a 95 percent confidence level) -- from 0.30 mg/m^3 in 1988 to 0.14 mg/m^3 in 1991, a 54 percent decrease. There was not a statistically significant difference between the average respirable silica levels -- from 0.10 mg/m^3 in 1988 to 0.01 mg/m^3 in 1991, an 89 percent decrease. The silica content of the respirable dust averaged 29 percent (range 8 to 50 percent) in 1988, versus 16 percent (range 7 to 35 percent) in 1991.

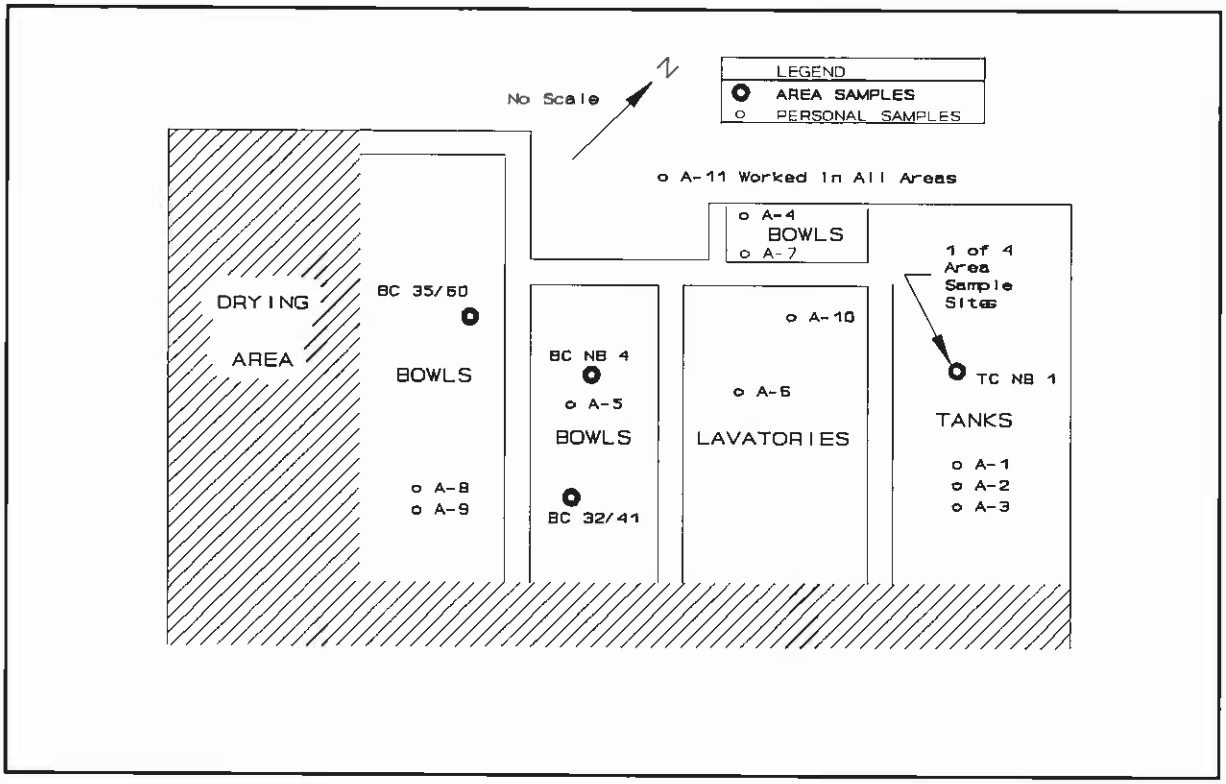

Figure 4: Casting Shop Department.

(2) Personal Samples

Personal samples were collected on eleven different workers in the tank/bowl/lavatory casting area. The respirable dust exposure averaged 0.30 mg/m^3 (range 0.01 to 1.80 mg/m^3). The respirable silica exposure averaged 0.03 mg/m^3 (range < 0.01 to 0.24 mg/m^3). Twenty of twenty-four samples contained detectable quantities of silica. Two (8 percent) exceeded the OSHA PEL and seven (29 percent) exceeded the NIOSH REL for silica dust.

Comparing the geometric means of the respirable dust exposures, there was not a statistically significant difference (at a 95 percent confidence level) -- from 0.58 mg/m^3 in 1988 to 0.30 mg/m^3 in 1991, a 48 percent decrease. There was not a statistically significant difference between the average respirable silica exposures -- from 0.13 mg/m^3 to 0.03 mg/m^3, a 79 percent decrease. The silica content of the respirable dust samples averaged 27 percent (range 8 to 80 percent) in 1988, 16 percent (range 6 to 40 percent) in 1991.

c. Glaze Spray Department

(1) Area Samples

Area samples were collected at two locations in the glaze spraying area as shown in Figure 5. The respirable dust level averaged 0.05 mg/m^3 (range 0.01 to 0.13 mg/m^3). The respirable silica level averaged 0.02 mg/m^3 (range < 0.01 to 0.02 mg/m^3). One of six area samples contained detectable quantities of silica. None of the area samples exceeded the OSHA PEL or the NIOSH REL for silica dust.

Comparing the geometric means of the respirable dust levels, there was not a statistically significant difference (at a 95 percent confidence level) -- from 0.25 mg/m^3 in 1988 to 0.05 mg/m^3 in 1991, a 79 percent decrease. There was not a statistically significant difference between the average respirable silica levels -- from 0.07 mg/m^3 to 0.02 mg/m^3, a 79 percent decrease. The silica content of the respirable dust samples averaged 21 percent (range 15 to 45 percent) in 1988, 17 percent (range 9 to 24 percent) in 1991.

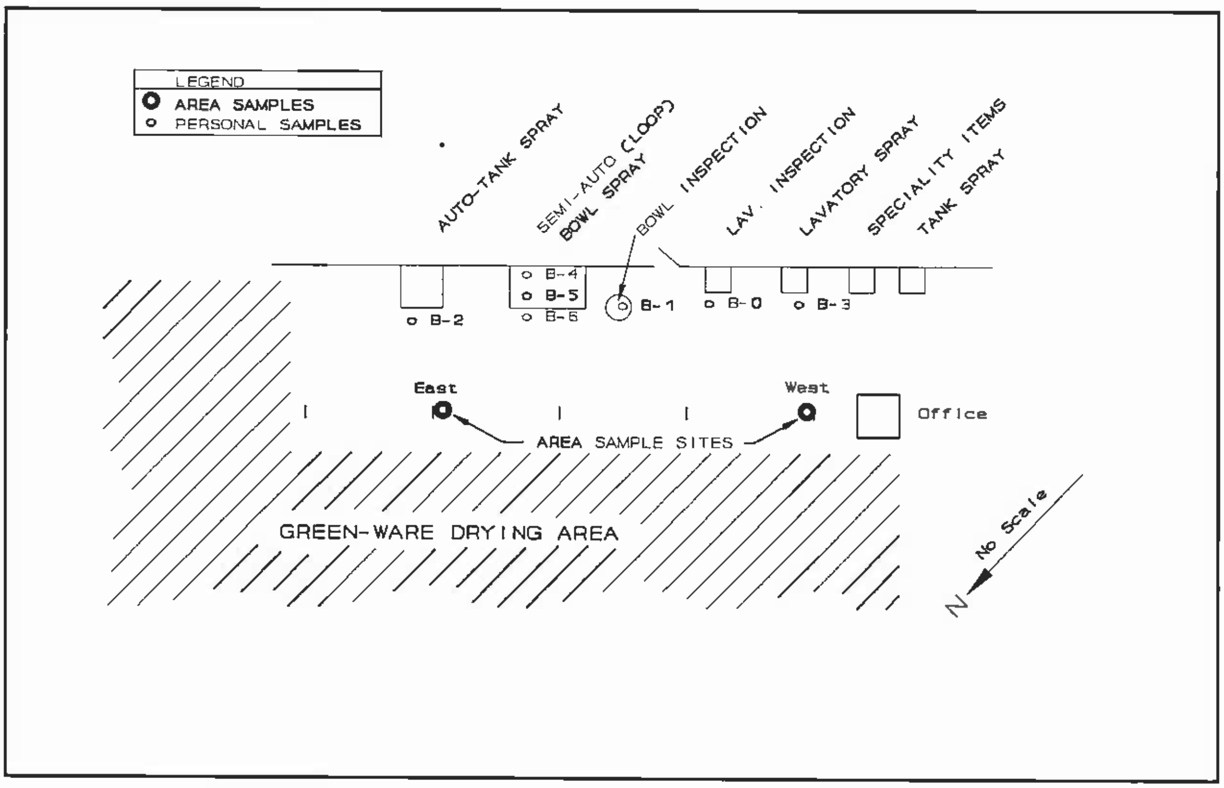

Figure 5: Glaze Spray Department.

(2) Personal Samples

Personal samples were collected on five operators and two inspectors at the manual spray, semiautomatic spray, automatic spray, and inspection booths in the glaze spraying area. The respirable dust exposure averaged 0.30 mg/m^3 (range 0.06 to 4.94 mg/m^3). The respirable silica exposure averaged 0.03 mg/m^3 (range < 0.01 to 0.51 mg/m^3). Ten of twenty personal samples contained detectable quantities of silica. One (5 percent) exceeded the PEL and five (25 percent) exceeded the REL for silica dust.

Comparing the geometric means of the respirable dust exposures, there was a statistically significant difference (at a 95 percent confidence level) -- from 1.94 mg/m^3 in 1988 to 0.30 mg/m^3 in 1991, an 85 percent decrease. There was not a statistically significant difference between the average respirable silica exposures -- from 0.22 mg/m^3 to 0.03 mg/m^3, an 85 percent decrease. The silica content of the respirable dust samples averaged 13 percent (range 7 to 32 percent) in 1988, 15 percent (range 9 to 24 percent) in 1991.

(3) Local Exhaust Ventilation Systems

According to recommendations from the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Manual, effective control of small spray booths requires control face velocities from 100 to 150 feet per minute (fpm) when the operator works outside the booth.[15]

Glaze is applied at five ventilated spray booth stations as shown in Figure 5. Comparison of the 1988 and 1991 face velocities are shown in Table VI. The effectiveness of the ventilation systems was evaluated at three of these booths.

(3.1) Automatic Tank Spray Booth

Pieces are placed on a rotating table and rotated while applying an even coat of spray. From 1988 and 1991, the average face velocity of the booth increased 56 percent to 140 fpm. The average respirable dust exposure for the automatic spray booth operator decreased 49 percent, -- from 0.81 mg/m^3 in 1988 to 0.41 mg/m^3 in 1991. The average respirable silica exposure was 0.05 mg/m^3 in 1991. None of the exposures exceeded the OSHA PEL, but two (66 percent) exceeded the NIOSH REL for silica.

Table VI: Comparison of Ventilation at Booths in the Spray Department.

Location of Opening	Booth Opening (w. x h.) (ft)	1988 Velocity (fpm) Range	1988 Velocity (fpm) Avg.	1991 Velocity (fpm) Range	1991 Velocity (fpm) Avg.
Automatic	8 x 4	30-140	90	100-170	140
Semi-auto Entrance[a]	3.5 x 2.5	15-220	65	20-110	85
Semi-auto 1st Sta.	4 x 4.3	10-60	50	210-310	250
Semi-auto 2nd Sta.	4 x 4.5	20-80	40	60-210	145
Manual Spray Booth	4.5 x 4.3	120-170	150	180-310	260
Inspection Booth[b]	4 x 4.5	40-100	60	180-320	260

(a) No spraying takes place at this opening.
(b) This was a bowl inspection booth in 1988 and is a lavatory inspection booth in 1991.

(3.2) Semiautomatic Bowl Spraying Line

At the Semiautomatic Bowl Spraying Line, there are four workers; three rotating through three workstations (loading/unloading station on the west end, first spray station, and second spray station) and a fourth worker, the bowl inspector. The two spray stations are part of a common enclosure as shown in Figure 6. The four stations are described below.

Bowl Loading/Unloading Station

After the sprayed bowls on the conveyor line exit from the second spray station and the common enclosure, they are removed at the bowl loading/unloading station and placed on a transport cart. An unglazed bowl is placed on the bowl loop and conveyed to the enclosure. From 1988 to 1991, the average face velocity at the enclosure entrance increased 31 percent to 85 fpm. No spraying is performed at the enclosure entrance.

Inspector's Station

Since 1988, the bowl inspector's station was moved, from what is now the lavatory inspection booth, near the entrance to the semi-automatic spray enclosure. The inspector takes an unglazed bowl from a rack, places it on a stand, vacuums

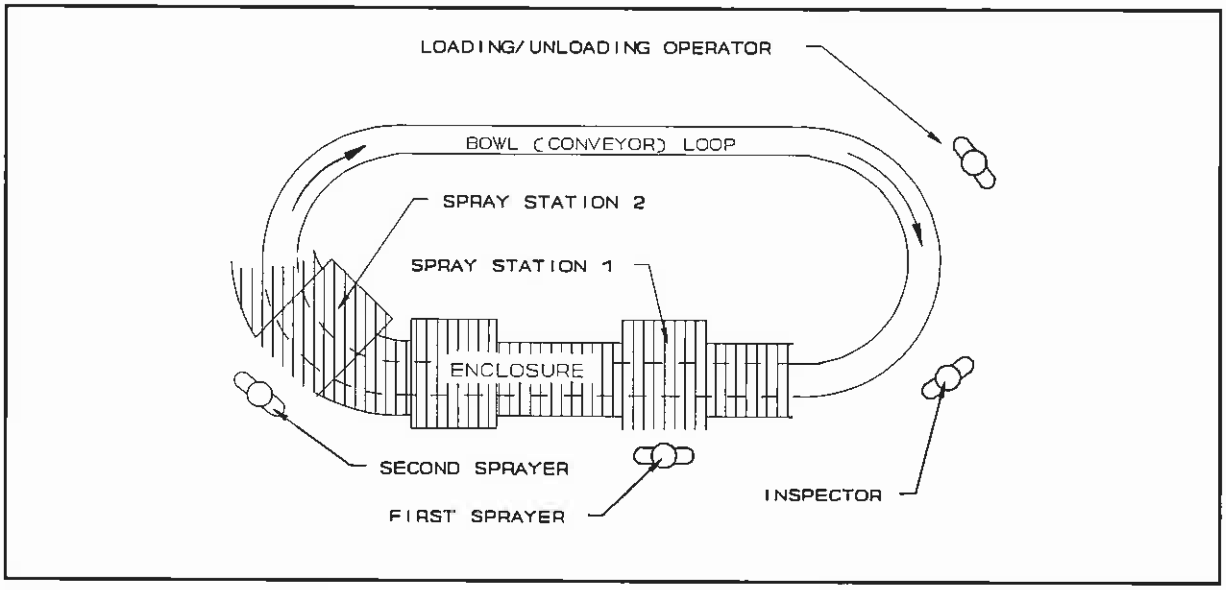

Figure 6: Semi-automatic Spray Line (Loop) and Bowl Inspector.

loose dust from the bowl, and wipes areas of the bowl with a wet sponge, inspecting for flaws. Either the inspector or the operator at the bowl loading/unloading station places the bowl on the bowl loop.

First Spray Booth

At the first spray booth, the operator applies the first coat of glaze by manually spinning the bowl and spraying all exposed surfaces. From 1988 to 1991, the average face velocity at this booth entrance increased 400 percent to 250 fpm.

Second Spray Booth

At the second spray booth, a second coat of glaze is applied as the bowl is manually rotated. The average face velocity at this booth entrance increased 262 percent to 145 fpm.

From 1988 to 1991, the average respirable dust exposures for the three semi-automatic spray booth operators decreased 90 percent -- from 2.54 mg/m^3 in 1988 to 0.26 mg/m^3 in 1991. The average respirable silica exposure was < 0.03 mg/m^3 in 1991. None of the exposures exceeded the PEL and one (11 percent) exceeded the REL for silica. The bowl inspector's average respirable dust exposure decreased by 70 percent -- from 1.40 mg/m^3 to 0.42 mg/m^3. His average silica exposure was < 0.03 mg/m^3 in 1991. None of the exposures exceeded the PEL and one (33 percent) was at the REL for silica.

(3.3) Manual Lavatory Spray Booth

At the manual lavatory spray booth, the operator removes lavatory sinks from a transport cart and places them on a stand in the booth. He removes dust from the sink with an air hose and then spins the sink and sprays glaze on the exposed surfaces. Normally, he points his spray gun down and away from himself toward the booth. From 1988 to 1991, the average face velocity increased 73 percent to 260 fpm. The average respirable dust exposure for the manual spray booth operator decreased 41 percent -- from 4.48 mg/m^3 in 1988 to 2.63 mg/m^3 in 1991. The average respirable silica exposure was < 0.27 mg/m^3 in 1991. One (50 percent) of the exposures exceeded the PEL and one (50 percent) exceeded the REL for silica.

(3.4) Lavatory Inspector's Booth

At the lavatory inspector's booth, the operator places the piece in the hood and uses compressed air to blow off dust. He then wipes areas with a wet sponge, inspecting for flaws. The average face velocity of this hood increased 333 percent to 260 fpm (ranging from 180 to 320 fpm). The average dust exposure of the inspector decreased 80 percent -- from 1.40 mg/m^3 in 1988 to 0.28 mg/m^3 in 1991. The average respirable silica exposure was < 0.03 mg/m^3 in 1991. None of the samples exceeded the PEL or the REL for silica.

d. Glaze Preparation Department

(1) Area Samples

Area samples were collected at two locations in the glaze preparation area as shown in Figure 7. The respirable dust level averaged 0.06 mg/m^3 (range 0.02 to 0.20 mg/m^3). The respirable silica levels averaged 0.01 mg/m^3 (range < 0.01 to < 0.02 mg/m^3). Two of six area samples contained detectable quantities of silica. None of the area samples exceeded the OSHA PEL or the NIOSH REL for silica dust.

Comparing the geometric means of the respirable dust levels, there was not a statistically significant difference (at a 95 percent confidence level) -- from 0.47 mg/m^3 in 1988 to 0.06 mg/m^3 in 1991, an 86 percent decrease. There was not a statistically significant difference between the average respirable silica levels -- from 0.16 mg/m^3 to 0.01 mg/m^3, a 91 percent decrease. The silica content of the respirable dust samples averaged 39 percent (range 22 to 65 percent) in 1988, 26 percent (range 14 to 32 percent) in 1991.

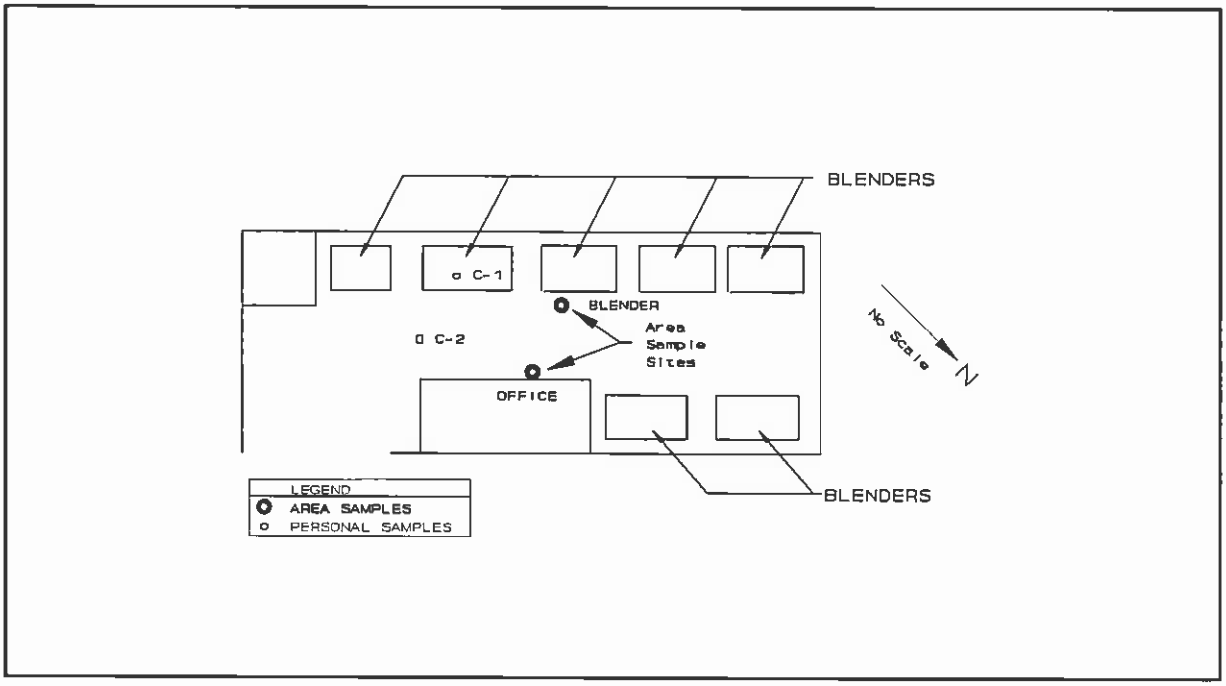

Figure 7: Glaze Preparation Department.

(2) Personal Samples

Personal samples were collected on two different workers in the glaze preparation area. The respirable dust exposure averaged 0.74 mg/m^3 (range 0.10 to 2.54 mg/m^3). The average respirable silica exposure was 0.18 mg/m^3 (range 0.02 to 0.69 mg/m^3). Five of six personal samples contained detectable quantities of silica. Three (50 percent) exceeded the PEL and five (83 percent) exceeded the REL for silica dust.

Comparing geometric means of the respirable dust exposures, there <u>was not</u> a statistically significant difference (at a 95 percent confidence level) -- from 0.54 mg/m^3 in 1988 to 0.74 mg/m^3 in 1991, a 37 percent increase. There <u>was not</u> a statistically significant difference between the average respirable silica exposures -- from 0.15 mg/m^3 to 0.18 mg/m^3, a 17 percent increase. The silica content of the respirable dust samples averaged 39 percent (range 25 to 34 percent) in 1988, 14 percent (range 9 to 27 percent) in 1991.

e. General Area

One worker spent part of each day in several departments mostly cleaning but also transporting materials or products. Three personal samples were collected on this worker. The respirable dust exposure averaged 0.44 mg/m^3 (range 0.23 to 0.61 mg/m^3). The average respirable silica exposure was 0.06 mg/m^3 (range 0.05 to 0.10 mg/m^3). All three personal samples contained detectable quantities of silica. One exceeded the PEL and two exceeded the REL for silica dust. The silica content of the respirable dust samples averaged 14 percent (range 10 to 17 percent).

C. Observational Evaluations

1. Evaluation of Lifting Stress

The company has made several changes in an effort to reduce the lifting stresses a worker encounters. One inspector's station was relocated, four roller conveyor lines and two additional mechanical assist benches have been installed, and lifting belts are being used. Changes observed in the Casting and Glaze Spray Departments were:

a. In 1988, the inspector in the Glaze Spray Department lifted 50-pound, pre-cured clay bowls from floor level to knuckle height. As of the 1991 study, the bowl inspector was relocated at the entrance to the semi-automatic spray enclosure. As a result, the inspector and the loading/unloading operator for the enclosure share the task of lifting bowls and placing them on the belt loop. This reduces, by approximately one-quarter, the number of bowls these two workers must lift. No other changes involving lifting were evident in the Glaze Spray Department.

b. In the Cast Shop, the worker lifts 50-pound, pre-cured clay bowls. As of the 1991 study, a second and third conveyor line had been installed for bowl casting. Mechanical assist benches were doubled to four. As the plant expands, additional roller conveyor lines and mechanical assist benches are scheduled to be installed. Also, several of the workers now wear weight lifter's belts. The company conducts lifting training and is looking into other types of belts the operator could wear.

Several industries use various intervention strategies such as the use of personal protective equipment (i.e. lifting belts), ergonomic control programs, lifting aids, worker training, and employee selection in an effort to reduce overexertion injuries due to manual materials handling (MMH). Over the past decade, injuries from MMH have increased dramatically and the cost to industry has been estimated to be in the billions of dollars annually.[16,17] Because of the perceived benefits and low costs for lifting belts, several industries have purchased these devices in order to reduce overexertion injuries to the back.

In a pilot study to evaluate the biomechanical and physiological data from manual lifting task, it was determined that the use of a certain type of lifting belt resulted in lower spinal forces during the lift due to support of the abdominal compartment during the lift.[18] This study appears to show some promise for lifting belts. However, it may have some methodological flaws for the data collected and may need further testing with improved methodology on larger worker populations. In another study, to evaluate the effectiveness productivity and lifting of loads using lifting belts, it was determined that no significant difference was found in the amount of work the subjects were willing to perform when lifting devices were used.[19]

2. Respiratory Protection Program

The company continues to improve their Respiratory Protection Program. The program is under the direction of the Manager of Industrial Relations and Safety Coordinator. The requirements for a minimal acceptable program have been prescribed by OSHA.[21] Some of the aspects of the Company's program are:

a. Respirators presently in use are MSA's Dust Foe, Model 77 and 78; and Comfo II, Type F. These half facepiece respirators have a protection factor of 10 and are approved for use against pneumoconiosis dusts by MSHA/NIOSH.

b. In the Slip Area, clean respirators are provided to the workers daily. In other areas, workers store their respirators in a sealable bag at their workstation. Maintenance and cleaning of respirators are the responsibility of the worker.

c. During the course of this study, respirator usage was observed to have improved since the 1988 study but still was not consistent. Even though reoccurring emphasis is placed on the wearing of respirators, it appears that the actual wearing is still left mainly to the initiative of the worker.

3. Medical Monitoring Program

Management is developing a revised Medical Monitoring Program. Medical protocols have been developed by NIOSH[22] and the National Industrial Sand Association.[23] Medical consultation is provided by a medical group at the local hospital which specialize in pulmonary physiology. All new hires are given medical examinations, which include pulmonary evaluations (X-rays and pulmonary function testing). The company provides annual pulmonary function testing for all employees by contract with a physiological testing service.

a. As part of the company's health and hygiene program, a safety committee, representing management and union, meets monthly and conducts monthly inspections. Items covered in this inspection include plant cleanliness, labeling of drums and other containers, and proper storage, condition, and <u>use</u> of respirators. Violation of standing safety procedures are recorded and warnings (verbal followed by written) are issued.

b. Each worker is provided a locker for storage of street/work clothing and a clean bag at his workstation for storage of his respirator. Workers are allowed a 15-minute period for showering at the end of their work shift and a 10-minute period before lunch to wash their hands and face.

c. Many major dust-producing plants indicate that good housekeeping procedures and maintenance of equipment can reduce dust exposures by more than 50 percent.[24] Housekeeping has improved at this plant but continues to be a major problem. Slip spills occur throughout the shift and are cleaned up at the end of each shift by dry sweeping and shoveling. Bristle-type brooms are being replaced by squeegee-type brooms. One worker is permanently assigned to cleaning and, when available, is assisted by other employees assigned to light duty. The company purchased a vacuum cleaner with a HEPA filter, but the heavy debris causes the motors to burn out after only a few months use. They are looking at other units that would be more durable.

d. A clean lunchroom has been constructed in the warehouse area and ventilated, keeping it under slight positive pressure.

4. Environmental Monitoring Program

a. No routine or periodic environmental monitoring program (involving monitoring of both atmospheric exposures and dust control systems) is presently in effect.

VI. CONCLUSIONS AND RECOMMENDATIONS

Woodbridge has implemented all but one of the recommendations made by ECTB in 1988. In the departments where some or all of the recommendations for improved dust controls were applied, dust exposures and dust levels were lowered 80 to 90 percent. In the Glaze Preparation Department, where no changes were made, personal exposures remained essentially unchanged. However, improvements in the other areas were reflected by a 90 percent decrease in the dust levels in this department. The following recommendations are proposed to further protect the workers at this facility.

A. From Section V, Part A, Number 6 (V.A.6) of this report: Reduce the pressure in the spray guns at the glaze spray booths. Even though the ventilation has been increased to these booths and the face velocities average 145 to 260 fpm, 5 percent of the personal exposures still exceed the OSHA PEL, 25 percent exceeding the NIOSH REL. This may be due to excessive pressure to the spray guns and/or poor work practices in aiming the gun during spraying. When aiming the gun directly at the product, excessive gun pressure could result in some of the spray rebounding off the surface and out of the booth into the worker's breathing zone. Aiming the gun away from the booth, allowing spray to escape, is a poor work practice. The company needs to determine which of these factors is taking place at these booths and take corrective action. The workers' exposure to the spray at the Glaze Spray booth stations could be further reduced by the installation of automated spray robots.

B. (V.A.8): Improve the method for filling the pebble mills. A fixed platform with a ventilated dump station on top of the mills is one option, although the roof height may not allow this. An alternative is to fill reusable semi-bulk containers on the floor at a ventilated dump station with the powder and liquid charge. The container could then be hoisted above the mill and the liquid emptied through a flexible spout into the mill.

C. (V.A.10): Review the resource materials listed in Appendix B and obtain those materials that are not in the company's library.

D. (V.A.11): Follow the "NIOSH Respirator Decision Logic"[25] to implement a comprehensive respirator program and vigorously enforce the use of respirators until silica dust exposures can be reduced to at least below the OSHA PEL of 0.1 mg/m^3 for respirable crystalline silica quartz dust (0.05 mg/m^3 for crystalline silica cristobalite dust) or, preferably, below the NIOSH REL of 0.05 mg/m^3 for crystalline silica dust by engineering controls and work practices. Silica exposure continues to be a major problem. The percentage of personal samples exceeding the NIOSH REL for crystalline silica is 83 percent in Glaze Preparation, 29 percent in Casting, and 25 percent in Glaze Spraying. Even though reoccurring emphasis has been placed on the wearing of respirators, it appears that the actual wearing is still left mainly to the initiative of the worker. Also, respirators should not be stored at the work site. It was observed that several of the respirators were not stored in a closed sealable bag but left in the open and contaminated by airborne dust in the area. Management needs to take a more active role in seeing that the use of respirators is vigorously enforced.

E. (V.A.14): Examine all lifting operations and install mechanical aids or redesign work areas to reduce lifting injuries. The roller conveyor lines installed are an improvement. Additional improvements would be to avoid the use of three-tiered storage shelves for the greenware. The long-term benefits of a lifting belt worn by the worker has yet to be proven. While benefits of lifting belts appear to give the worker some psychological benefit during manual materials handling, the biomechanical and psychophysical benefits have not been supported in the literature. Industries considering the use of lifting belts as an intervention measure to control back injuries may find some transient improvement which may be due to the novelty of these devices. The best approach to control back injuries in manually intensive lifting tasks is to determine the risk of injury by using the NIOSH Work Practices Guide for Manual Lifting Model[20], then, based on the outcome, apply the appropriate control (i.e., administrative and/or engineering). Generally, the best long-term solution is through engineering controls such as lifting devices and automation.

F. (V.A.15): Improve the methods for cleaning spills of slip, scrap material waste, and dust. For slip spillage, a system is needed to keep it off the floor where traffic can spread it to other areas. Ditches and pits 6 to 12 inches deep covered with expanded metal grates could be used to handle the slip and scrap. Ditches, 1 to 2 feet wide, running the length in work areas where most spills occur and pits in the areas where most scrap accumulates would reduce dust from these sources by keeping this material below the floor level and out of traffic. These ditches and pits would be shoveled out at the end of shift as part of routine cleaning. For dust and possibly scrap material, a centralized vacuum system or portable vacuum cleaners with HEPA filters, would significantly reduce dust from these sources. A centralized vacuum system having outlets at each workstation would allow each worker to keep his area clean. If a vacuum system can be found to handle the scrap, the pits for scrap may not be needed.

G. (V.A.16) Set up an Environmental Monitoring Program to include periodic air monitoring and dust control systems monitoring to validate the effectiveness of the dust control program. Direct-reading monitors would help locate major dust sources in need of control.

The preceding recommendations are all intended for use by the Woodbridge Sanitary Pottery Corporation to improve the working environment at that facility. These recommendations are believed to be both specific and feasible and should also be implemented, as appropriate, at the two other plants operated by the parent company. These recommendations may be appropriate for any other sanitary ware plant, which may have problems similar to those observed in this study.

VII. REFERENCES

1. Amorphous Silica. Documentation of the Threshold Limit Values, Fourth Edition, ACGIH, 1980.

2. Occupational Health Guideline for Amorphous Silica, NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, January 1981.

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

4. Fulton W.B., F.E. Butters, A.E. Dooley, F.B. Koppenhaver, J.L. Matthews, R.M. Kirk: A Study of silicosis in the silica brick industry. Commonwealth of Pennsylvania, Dept. of Health, Bureau of Industrial Hygiene, Harrisburg, 60 pp, 1941.

5. Vigliani E.C., G. Mottura: Diatomaceous Earth Silicosis. Br. J. Ind. Med. 5:148-60, 1948.

6. Cooper W.C., L.J. Cralley: Pneumoconiosis in diatomite mining and processing. Public Health Service, Publication No. 601. U.S. Dept. HEW, PHS, Occupational Health Program, 1958, 96 pp.

7. Cralley L.J., W.C. Cooper, P.E. Caplan: A 10-year epidemiologic follow-up of workers in the diatomite industry in the United States. Proceedings of the Fifteenth International Congress on Occupational Health, Vienna 1966.

8. Documentation of the Threshold Limit Values, Fourth Edition. ACGIH, pages 106-107, 1980.

9. NIOSH (1988). NIOSH Testimony on the Occupational Safety and Health Administration proposed rule on air contaminants: 29 CFR Part 1910, August 1, 1988, OSHA Docket No. H-020. NIOSH Policy statements, Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

10. Criteria for a Recommended Standard - Occupational Exposure to Crystalline Silica. U.S. Dept. HEW, PHS, CDC, National Institute for Occupational Safety and Health, 1974.

11. OSHA Safety and Health Standards (29 CFR 1910) US Dept. of Labor, OSHA 2206 1910.100; Air Contaminants, Permissible Exposure Limits, Table Z-3, p. 2951, Rev. January 19, 1989.

12. NIOSH Manual of Analytical Methods, Third Edition. P&CAM Method 7500. Silica, Crystalline, Respirable; issued 2/15/84; and P&CAM Method 0600, Nuisance Dust, Respirable, issued 2/15/84.

13. ACS Subcommittee on Environmental Improvement: Principles of Environmental Analysis. Anal. Chem. 55:2210-2218 (1983), Revision September 27, 1991.

14. Miller, I., J.E. Freund: Probability and Statistics for Engineers. Prentice Hall, Inc., 1965.

15. Industrial Ventilation - A Manual of Recommended Practice 19th Edition. American Conference of Governmental Industrial Hygienists, pages 5-76, 77, 1986.

16. National Safety Council, Accident Facts, 1988. National Safety Council, Chicago, Illinois.

17. McGlothlin J.D., T.J. Pizatella, D. Badger, D. Habes, R. Jensen, R. Nelson: Occupational Back Injuries - Controlling the Epidemic. Proceedings of the IEEE/Engineering Meeting in Medicine and Biology Society, Seventh Annual Conference, pg. 35-39, September, 1985.

18. Hilgen T.H., L.A. Smith, J.E. Lander: The minimum Abdominal Belt-Aided Lifting Weight. Advances in Industrial Ergonomics and Safety III. Ed. Karwowski W, Yates JW: pg. 217-224, 1991.

19. Amendola A.A.: An Investigation of Effects of External Supports on Manual Lifting. Dissertation, Texas A&M University, 1987.

20. National Institute for Occupational Safety and Health, Work Practices Guide for Manual Lifting, Publication No. 81-122. U.S. Dept. of Health and Human Services, Centers for Disease Control, 1981.•35

21. OSHA Safety and Health Standards (29 CFR 1910), OSHA 2206, Revised March 11, 1983, Section 1910.134, page 271.

22. SILICA FLOUR: SILICOSIS (CRYSTALLINE SILICA), NIOSH Current Intelligence Bulletin 36, June 30, 1981. DHHS (NIOSH) Publication No. 81-137.

23. Occupational Health Program for Exposure to Free Crystalline Silica, prepared for The National Industrial Sand Association, Silver Spring, Maryland, by Clayton Environmental Consultants, Southfield, Michigan, 1977.

24. Caplan P.E., L.D. Reed, A.A. Amendola, T.C. Cooper: Health Hazard Control Technology Assessment of the Silica Flour Milling Industry. DHHS (NIOSH) Pub. No. 84-110, October 1984.

25. NIOSH (1987). NIOSH Respiratory Decision Logic. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-108.

A. Environmental Data

Appendix A: Woodbridge Sanitary Pottery Environmental Data

					RESPIRABLE DUST			CRYSTALLINE SILICA				
								QUARTZ			CRISTOBALITE	
LOCATION	JOB TITLE	DATE	FLOW (L/m)	RUN TIME (min)	MASS (mg)	CORR. MASS (mg)	CONC (ug/m3)	MASS (mg)	CORR. MASS (mg)	CONC (ug/m3)	MASS (mg)	CONC (mg/m3)
SLIP HOUSE DEPARTMENT												
AREA	SLIP HOUSE TANK 3	11-Jun-91	1.7	468	0.17	0.16	201	0.04	0.025	31		
AREA	SLIP HOUSE MIX 4	11-Jun-91	1.7	468	0.27	0.26	327	0.04	0.025	31		
AREA	SLIP HOUSE BINS	11-Jun-91	1.7	469	0.32	0.31	389	0.03	0.015	6		
AREA	SLIP HOUSE TANK 3	12-Jun-91	1.7	481	0.24	0.23	281	0.05	0.035	43		
AREA	SLIP HOUSE MIX 4	12-Jun-91	1.7	481	0.12	0.11	135	0.02	0.005	6		
AREA	SLIP HOUSE BINS	12-Jun-91	1.7	481	0.2	0.19	232	0.03	0.015	18		
AREA	SLIP HOUSE MIX 4	13-Jun-91	1.7	492	0.07	0.06	72	0.04	0.025	30		
AREA	SLIP HOUSE BINS	13-Jun-91	1.7	490	0.07	0.06	72	0.04	0.025	30		
AREA	SLIP HOUSE TANK 3	13-Jun-91	1.7	491	0.09	0.08	96	0.04	0.025	30		
CASTING DEPARTMENT												
A6 B	CASTING BOWLS	11-Jun-91	1.7	346	0.74	0.73	1241	0.1	0.085	145		
AREA	CASTING B 32/41	11-Jun-91	1.7	514	0.21	0.2	229	0.02	0.005	6		
A5 B	CASTING BOWLS	11-Jun-91	1.7	412	0.09	0.08	114	ND	ND	< 21		
A7 B	CASTING BOWLS	11-Jun-91	1.7	25	0.03	0.02	471	ND	ND	<353		
A2 T	CASTING TANKS	11-Jun-91	1.7	389	0.89	0.88	1331	0.06	0.045	68		
AREA	CASTING T NB 1	11-Jun-91	1.7	511	0.17	0.16	184	ND	ND	< 17		
AREA	CASTING B 35/60	11-Jun-91	1.7	510	0.14	0.13	150	0.02	0.005	6		
A1 T	CASTING TANKS	11-Jun-91	1.7	285	0.39	0.38	784	0.04	0.025	52		
A8 B	CASTING BOWLS	11-Jun-91	1.7	463	0.39	0.38	483	0.03	0.015	19	0.03	< 25
A10 L	CASTING LAVATORIES	11-Jun-91	1.7	385	0.08	0.07	107	0.02	0.005	8		
A9 B	CASTING BOWLS	11-Jun-91	1.7	394	0.3	0.29	433	0.03	0.015	22		

Limit of Detection (LOD) 0.015mg, Limit of Quantitation (LOQ) 0.03mg.

Appendix A: Woodbridge Sanitary Pottery Environmental Data

A4 B	CASTING BOWLS	11-Jun-91	1.7	444	0.23	0.22	291	0.02	0.005	7		
AREA	CASTING B NB 4	11-Jun-91	1.7	513	0.1	0.09	103	ND	ND	< 17		
A3 T	CASTING TANKS	11-Jun-91	1.7	431	0.69	0.68	928	0.04	0.025	34		
A8 B	CASTING BOWLS	12-Jun-91	1.7	462	0.22	0.21	267	0.02	0.005	19		
A10 L	CASTING LAVATORIES	12-Jun-91	1.7	413	0.04	0.03	43	ND	ND	< 21		
A2 T	CASTING TANKS	12-Jun-91	1.7	374	0.15	0.14	204	0.02	0.005	8		
AREA	CASTING B 35/60	12-Jun-91	1.7	496	0.06	0.05	59	ND	ND	< 18		
A4 B	CASTING BOWLS	12-Jun-91	1.7	459	0.05	0.04	51	0.02	0.005	6		
AREA	CASTING B NB 4	12-Jun-91	1.7	488	0.1	0.09	108	ND	ND	< 18		
A3 T	CASTING TANKS	12-Jun-91	1.7	473	0.14	0.13	174	0.02	0.005	6		
A7 B	CASTING BOWLS	12-Jun-91	1.7	431	0.52	0.51	696	0.05	0.035	48		
A6 B	CASTING BOWLS	12-Jun-91	1.7	436	0.02	0.01	13	ND	ND	< 20		
AREA	CASTING T NB 1	12-Jun-91	1.7	486	0.07	0.06	73	ND	ND	< 18		
AREA	CASTING B 32/41	12-Jun-91	1.7	492	0.16	0.15	179	ND	ND	< 18		
A5 B	CASTING BOWLS	12-Jun-91	1.7	403	0.38	0.37	540	0.06	0.045	66	0.04	< 44
A9 B	CASTING BOWLS	12-Jun-91	1.7	458	0.21	0.2	257	0.04	0.025	32		
A8 B	CASTING BOWLS	13-Jun-91	1.7	443	0.3	0.29	385	0.04	0.025	33		
A4 B	CASTING BOWLS	13-Jun-91	1.7	475	0.24	0.23	285	0.05	0.035	43		
A6 B	CASTING BOWLS	13-Jun-91	1.7	408	1.26	1.25	1802	0.18	0.165	238		
AREA	CASTING B NB 4	13-Jun-91	1.7	483	0.14	0.13	158	0.02	0.005	6		
A3 T	CASTING TANKS	13-Jun-91	1.7	448	0.42	0.41	538	0.06	0.045	59		
AREA	CASTING T NB 1	13-Jun-91	1.7	498	0.21	0.2	236	0.02	0.005	6		
A5 B	CASTING BOWLS	13-Jun-91	1.7	433	0.12	0.11	149	0.02	0.005	7		
AREA	CASTING B 35/60	13-Jun-91	1.7	488	0.1	0.09	108	0.02	0.005	6		
A7 B	CASTING BOWLS	13-Jun-91	1.7	410	0.51	0.5	717	0.06	0.045	65		
AREA	CASTING B 32/41	13-Jun-91	1.7	469	0.2	0.19	238	0.03	0.015	19		
GLAZE SPRAY DEPARTMENT												
AREA	SPRAY, EAST END	11-Jun-91	1.7	516	0.08	0.07	80	ND	ND	< 17		

Limit of Detection (LOD) 0.015mg, Limit of Quantitation (LOQ) 0.03mg.

Appendix A: Woodbridge Sanitary Pottery Environmental Data

B3	MANUAL SPRAY	11-Jun-91	1.7	400	3.37	3.36	4941	0.36	0.345	507
B0	LAVATORY INSPECTOR	11-Jun-91	1.7	418	0.4	0.39	549	0.04	0.025	35
AREA	SPRAY, WEST END	11-Jun-91	1.7	518	0.11	0.1	114	0.03	0.015	6
B1	INSPECTOR	11-Jun-91	1.7	311	0.23	0.22	416	0.02	0.005	9
B6	SEMI-AUTO SPRAY	11-Jun-91	1.7	396	0.12	0.11	163	ND	ND	< 22
B2	AUTOMATIC SPRAY	11-Jun-91	1.7	384	0.32	0.31	475	0.04	0.025	38
B5	SEMI-AUTO SPRAY	11-Jun-91	1.7	400	0.64	0.63	926	0.06	0.055	66
B4	SEMI-AUTO SPRAY	11-Jun-91	1.7	249	0.14	0.13	307	ND	ND	< 35
AREA	SPRAY, EAST END	12-Jun-91	1.7	467	0.02	0.01	13	ND	ND	< 19
AREA	SPRAY, WEST END	12-Jun-91	1.7	469	0.05	0.04	50	ND	ND	< 19
B2	AUTOMATIC SPRAY	12-Jun-91	1.7	391	0.21	0.2	301	0.05	0.035	53
B3	MANUAL SPRAY	12-Jun-91	1.7	389	0.22	0.21	318	0.04	0.025	38
B1	INSPECTOR	12-Jun-91	1.7	378	0.23	0.22	342	0.02	0.005	23
B5	SEMI-AUTO SPRAY	12-Jun-91	1.7	347	0.13	0.12	203	ND	ND	< 25
B4	SEMI-AUTO SPRAY	12-Jun-91	1.7	348	0.15	0.14	237	ND	ND	< 25
B0	LAVATORY INSPECTOR	12-Jun-91	1.7	395	0.16	0.15	223	ND	ND	< 22
B6	SEMI-AUTO SPRAY	12-Jun-91	1.7	343	0.12	0.11	189	ND	ND	< 26
B6	SEMI-AUTO SPRAY	13-Jun-91	1.7	388	0.09	0.08	121	ND	ND	< 23
B2	AUTOMATIC SPRAY	13-Jun-91	1.7	413	0.33	0.32	456	0.06	0.045	64
B4	SEMI-AUTO SPRAY	13-Jun-91	1.7	390	0.11	0.1	151	ND	ND	< 23
B0	LAVATORY INSPECTOR	13-Jun-91	1.7	414	0.05	0.04	57	ND	ND	< 21
AREA	SPRAY, WEST END	13-Jun-91	1.7	461	0.03	0.02	26	ND	ND	< 19
B1	INSPECTOR	13-Jun-91	1.7	410	0.37	0.36	516	0.05	0.035	50
AREA	SPRAY, EAST END	13-Jun-91	1.7	464	0.11	0.1	127	ND	ND	< 19
B5	SEMI-AUTO SPRAY	13-Jun-91	1.7	388	0.06	0.05	76	ND	ND	< 23
GLAZE PREPARATION DEPARTMENT										
AREA	GLAZE PREP'N BLENDER	11-Jun-91	1.7	501	0.06	0.05	59	0.03	0.015	6
AREA	GLAZE PREP'N OFFICE	11-Jun-91	1.7	502	0.18	0.17	199	ND	ND	< 18

Limit of Detection (LOD) 0.015mg, Limit of Quantitation (LOQ) 0.03mg.

Appendix A: Woodbridge Sanitary Pottery Environmental Data

C1	FORMULATOR	11-Jun-91	1.7	365	0.07	0.06	97	ND	ND	< 24
C2	OPERATOR	11-Jun-91	1.7	366	1.33	1.32	2122	0.42	0.405	651
AREA	GLAZE PREP'N OFFICE	12-Jun-91	1.7	490	0.11	0.1	120	ND	ND	< 18
AREA	GLAZE PREP'N BLENDER	12-Jun-91	1.7	491	0.03	0.02	24	ND	ND	< 18
C2	OPERATOR	12-Jun-91	1.7	361	0.35	0.34	554	0.05	0.035	57
C1	FORMULATOR	12-Jun-91	1.7	395	1.48	1.47	2189	0.48	0.465	692
AREA	GLAZE PREP'N BLENDER	13-Jun-91	1.7	501	0.03	0.02	23	ND	ND	< 18
AREA	GLAZE PREP'N OFFICE	13-Jun-91	1.7	501	0.09	0.08	94	0.02	0.005	6
C2	OPERATOR	13-Jun-91	1.7	398	1.73	1.72	2542	0.48	0.465	687
C1	FORMULATOR	13-Jun-91	1.7	415	0.2	0.19	269	0.07	0.055	78
GENERAL (WORKER IN ALL DEPARTMENTS)										
A11	SLIP&SCRAP (CLEANING)	11-Jun-91	1.7	277	0.12	0.11	234	0.02	0.005	11
A11	SLIP&SCRAP (CLEANING)	12-Jun-91	1.7	385	0.32	0.31	474	0.05	0.035	53
A11	SLIP&SCRAP (CLEANING)	13-Jun-91	1.7	378	0.4	0.39	607	0.08	0.065	101
FIELD BLANKS										
	BLANK	11-Jun-91			-0.02	-0.01		ND	0	-
	BLANK	11-Jun-91			0.02	0.01		ND	0	-
	BLANK	11-Jun-91			0.04	0.03		ND	0	-
	BLANK	12-Jun-91			0	-0.01		ND	0	-
	BLANK	12-Jun-91			0	-0.01		ND	0	-
	BLANK	12-Jun-91			0.02	0.01		ND	0	-
	BLANK	13-Jun-91			-0.02	-0.01		ND	0	-
	BLANK	13-Jun-91			0	-0.01		ND	0	-
	BLANK	13-Jun-91			-0.01	-0.01		ND	0	-
		13-Jun-91			0.02	0.01		ND	0	-

Limit of Detection (LOD) 0.015mg, Limit of Quantitation (LOQ) 0.03mg.

B. Health and Safety Resource Publications the company should have on hand:

"Occupational Exposure to Crystalline Silica - Criteria for a Recommended Standard." U.S. Department of HEW, PHS, CDC, National Institute for Occupational Safety and Health, 1974. HEW Pub No. (NIOSH) 75-120. National Technical Information Center (NTIS) No. PB-246-697/A07. Tel. (703) 487-4650.

"Silica Flour: Silicosis (Crystalline Silica)." NIOSH Current Intelligence Bulletin 36. June 1981. DHHS (NIOSH) Pub. No. 81-137, NTIS No.PB 83-101-758/A02.

"Occupational Health Guidelines for Crystalline Silica." Sept. 1978. NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards. U.S. Depts. HHS/DOL, Jan. 1981. DHHS (NIOSH) Pub. No. 81-123, NTIS No. PB 83-154-609/A99.

Current Issues of "Threshold Limit Values and Biological Exposure Indices 1988-89." American Conference of Governmental Industrial Hygienists (ACGIH), 6500 Glenway, Bldg. D-7, Cincinnati, OH 45211. (513) 661-7881. (Booklet is updated annually).

"Occupational Health Program for Exposure to Free Crystalline Silica." 1977. National Industrial Sand Association, 900 Spring Street, Silver Spring, MD 20910. (202) 587-1400.

"NIOSH Respiratory Decision Logic." 1987. DHHS(NIOSH) Pub. No.87-108. NIOSH Publication Dissemination, 4676 Columbia Parkway, Cincinnati, OH 45226-1998. (513) 533-8287.

"NIOSH Guide to Respiratory Protection." 1987. DHHS(NIOSH) Pub. No.87-116. NIOSH Publication Dissemination, 4676 Columbia Parkway, Cincinnati, OH 45226-1998. (513) 533-8287.

General Industry Standards, Part 1910. OSHA 2206, Rev. March 8, 1983. USDOL/OSHA Sub Part I - Personal Protective Equipment, pg. 270-276; and Sub Part Z - Toxic and Hazardous Substances, pg. 598-604. NTIS.

"Practices for Respiratory Protection." ANSI Z 88.2,1980. American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018. (212) 354-3300.

"Key Elements of a Sound Respiratory Protection Program." Bulletin 1000-16. Mine Safety Appliances Company, 600 Penn Center Boulevard, Pittsburgh, PA 15235. (416) 967-3000.

Current Issues of "Industrial Ventilation - A Manual of Recommended Practice." ACGIH (Last issue 21st Ed. 1990. ACGIH. (Manual is updated every two years).

"Industrial Ventilation Workbook." 1988. D. Jeff Burton, DJBA Inc., P.O. Box 520545, Salt Lake City, UT 84152.

"An Evaluation of Control Technology for Bag Opening, Emptying, and Disposal. The Self-Contained Filter/Bag Dump Station - Manufactured by the Young

Industries, Inc., Muncy, PA 17756" by William Heitbrink et al. Nov. 1983. Report No. 114-19. NIOSH-DPSE, 4676 Columbia Parkway, Cincinnati, OH 45226. (513) 841-4221.

"Work Practices Guide for Manual Lifting." NIOSH Technical Report. March 1981. DHHS (NIOSH) Pub. No. 81-122. NTIS PB 82-178-948/A09.

"An Evaluation of the NIOSH Guidelines for Manual Lifting, with Special Reference to Horizontal Distance" by Arun Garg. AIHAJ. 50(3):157-164(1989).

"Analysis of Manual Lifting Tasks: A Qualitative Alternative to the NIOSH Work Practices Guide" by W. Monroe Keyserling.