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WEST VIRGINIA UNIVERSITY
POTTERY SHOP
MORGANTOWN, WEST VIRGINIA

NIOSH INVESTIGATOR:
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I. SUMMARY

In March 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request from the West Virginia University, Creative Arts Center to evaluate possible health hazards resulting from exposure to silica dusts during clay mixing operations in the Department's Pottery Shop.

In October 1990, an initial site visit of the facility was conducted. On February 26, 1991 an environmental survey was conducted. Personal and area air samples, and bulk material were collected during clay mixing operations.

Only one of the collected samples showed quantifiable levels of quartz. The sample concentration of respirable quartz collected on the class instructor was 169.5 micrograms of respirable quartz per cubic meter of air ($\mu g/m^3$). None of the samples collected in the mixing room showed any detectable levels of respirable quartz. However, exposure to respirable dust was considerable for such a short exposure duration.

Due to the crystalline silica content of the clay and related products used in the pottery shop, and the potential for high dust exposures, it would be prudent to install a dust control system in the mixing room, to control exposures during mixing and weighing operations.

It appears that the best method of reducing and preventing exposures in the pottery shop mixing room would be through the installation of proper engineering controls and not reliance on respiratory protection. A properly installed and maintained engineering control system is a passive protector and requires no involvement from the students or instructors, as is needed in respirator usage.

On the basis of the data obtained in this investigation, the NIOSH investigator has determined that a potential health hazard exists at the Pottery Shop. Since the mixing operation and studio work are not conducted eight hours a day, 40 hours per week, exposure to crystalline silica does not exceed exposure criteria. However, due to the crystalline silica content of the materials used, it would be prudent to install dust control systems in the mixing room.

Keywords: SIC 3269 (Pottery, not elsewhere classified), silica, pottery, ceramics

II. INTRODUCTION

On March 20, 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from the West Virginia University's Office of Environmental Health and Safety. This request identified a potential silica exposure at the College of Creative Arts and Science's Pottery Shop. The primary concern was silica exposure during the batch mixing of clay materials.

This HHE request was prompted as a result of a preliminary investigation conducted by NIOSH's Environmental Investigation Branch, Division of Respiratory Disease Studies. In that report, exposure to silica was based on the percent quartz estimated from microscopic identification. Quartz exposures were then estimated to be in excess of the NIOSH and OSHA exposure criteria.

Due to the summer recess, a walkthrough survey was not conducted until October 1990. Environmental sampling for the estimation of silica exposure was conducted in February 1991.

III. BACKGROUND

The Pottery/Ceramics shop is located in the College of Creative Arts of West Virginia University. As part of the curriculum for a Bachelors of Fine Arts degree, students may take classes in both ceramics and sculpture. Both classes are taught at the pottery shop located in Room 2339 of the Creative Arts Center on the Evansdale campus. Typically classes meet twice a week for the duration of a semester. In addition, a night class may be offered once a week.

Instruction is provided to students which encompasses the full realm of both ceramics and pottery. Much of the materials used in both classes are either purchased in bulk or mixed on site. The purpose of this health hazard evaluation was to determine silica exposures during clay mixing operations.

Clay is mixed on an as needed basis. Generally, large batches are made up in advance and stored for student use. The clay is mixed in a separate mixing room located next to the main classroom. The mixing room was estimated to be approximately 10'x 26'x 14' high. The mixing process involves the placing of wet recycled clay in the electric mixer as a starter base, dry ingredients are weighed out on a weighing table and the added into the mixer. Water is carried into the room in 5 gallon pails and add to the mixture as needed. After the mixing process, the clay is removed from the mixer by hand and placed into a storage box for use. Once completed, the mixing room is cleaned by sweeping. Total time observed from start to finish, for mixing a 400 pound batch of clay was 30 minutes.

There is no local exhaust ventilation for control of dusts generated during either the weighing or mixing of dry ingredients. A disc type fan with a 2' x 2' baffle has been installed on the back wall of the mixing room. This fan is located approximately in the center of the wall, which is some 6 feet above and 4.5 feet to the left of the mixer and weighing table. The door to the mixing room is usually left open during mixing to aid in adding dilution air.

IV. EVALUATION AND DESIGN METHODS

Samples for the estimation of respirable dusts and respirable quartz dust exposure, were collected on pre-weighed, 37 mm (diameter), 5 µm (pore size) PVC membrane filters, mounted in series with 10 mm nylon cyclones. Air was drawn through the filter at an approximate flow rate of 1.7 liters per minute (lpm) using a battery powered sampling pump. Time-integrated samples were collected in the breathing zone for a full shift on the pottery shop instructor; and for the duration of mixing operations conducted by a graduate assistant. In addition to the personal samples, area samples were collected in close proximity to mixing operations.

All air samples were analyzed for respirable dusts and total respirable crystalline free silica (alpha quarts, tridymite and cristobalite). Respirable dust content was analyzed gravimetrically according to NIOSH Method 0500 with the following modifications: (1) The filters were stored in an environmentally controlled room (21 ± 3◦C and 40 ± 3% RH) and were subjected to the room conditions for a long duration for stabilization. Therefore, the method's 8- to 16-hour time for stabilization between tare weights was reduced to 5 to 10 minutes. (2) The filter and back-up pads were not vacuum desiccated. The total weight of each sample was determined by weighing the sample on an electrobalance and subtracting the previously determined tare weight of the filter.[1] The Limit of Detection (LOD) for this method was determined to be 0.01 mg per sample. (The LOD is defined as the smallest amount of analyte which can be distinguished from background.)

Respirable crystalline silica dust content was analyzed by NIOSH Method 7500, using X-ray diffraction with the following modifications: (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 analysis of some of the samples for quartz and cristobalite required additional modifications due to interference problems in the primary quartz region. These samples were analyzed on a Siemems D-5000 that used a profile fitting program to remove the interference. The LOD and Limit of Quantification (LOQ) for quartz, cristobalite and tridymite were determined to be 0.015 milligrams (mg) and 0.03 mg, respectively. (The LOQ is defined as the mass of analyte equal to ten times the standard error of the calibration graph; or approximately the mass of analyte for which the relative standard error, s_r,equals 0.01).[1]

V. ENVIRONMENTAL CRITERIA

A. Exposure Criteria

As a guide to the evaluation of the hazard posed by workplace exposures, NIOSH field staff employ environmental evaluations criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary source of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH recommended exposure limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures. The NIOSH REL for a time weighted average occupational exposure to respirable silica (quartz) is 50 micrograms per cubic meter of air ($\mu g/m^3$).[2] Both the ACGIH TLV[3] and the OSHA PEL[4] for a time weighted average occupational exposure to respirable silica (quartz) are 100 $\mu g/m^3$.

B. Toxicology

This section describes the possible toxicological and physiological effects in workers exposed to the substances monitored during this survey. These effects are described so workers will be familiar with the symptoms and health consequences of overexposure.

Crystalline silica, referred to as free silica, is defined as silicon dioxide (SiO_2) in the form of quartz, tridymite, and cristobalite. The chief concern of excessive free silica exposure is the development of silicosis. This form of pneumoconioses is characterized by a nodular pulmonary fibrosis caused by the deposition of fine particles of crystalline silica in the lungs. In silicosis as in many other pneumoconiosis, the various stages of progression of silicotic lesions are related to the degree of exposure to free silica, the duration of exposure and the length of time the dust is permitted to react with the lung tissue. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and nonspecific chest illnesses. Silicosis usually appears after years of exposure, but may appear in a shorter time if exposure concentrations are very high. This latter form is referred to as rapidly-developing silicosis, and its etiology and pathology are not as well understood. Silicosis is usually diagnosed through chest X-rays, occupational histories, and pulmonary function tests. There is evidence that cristobalite and tridymite, which have different crystalline form from that of quartz, have a greater capacity to produce silicosis. NIOSH now considers all crystalline forms of silica as potential human carcinogens capable of causing lung cancers. [5]

VI. RESULTS

A. Respirable Dust and Quartz

The results of the silica sampling are shown in Table 1. To summarize, 6 respirable dust samples, two personal breathing zone and four area, were collected and analyzed for quartz content. Three samples, one personal breathing zone and two area, were collected in the mixing room during clay mixing operations. Sampling duration for these samples were only 53 minutes, the time required to mix two batches of clay. Three additional samples, one personal breathing zone and two area, were collected inside the studio (Pottery Shop) during class.

Only one of the collected samples showed quantifiable levels of quartz. The sample concentration of respirable quartz collected on the class instructor was 169.5 micrograms of respirable quartz per cubic meter of air ($\mu g/m^3$). The other two samples collected in the studio showed no respirable quartz and very little dust (Table 1).

None of the samples collected in the mixing room showed detectable levels of respirable quartz. However, exposure to respirable dust was considerable for such a short exposure duration. Respirable dust measurements ranged from 0.44 to 1.55 milligrams per cubic meter (mg/m^3), with the highest level collected on the graduate assistant mixing the clay.

A bulk sample of the settled dust was also collected from a window ledge, below the exhaust fan in the mixing room. The analysis of the settled dust showed it to contain 7.7 percent of quartz.

B. Ventilation

As previously mentioned, a disc fan was installed in the mixing room to exhaust dusts generated from the weighing of dry powder and mixer operations. Face velocity measurements were taken on that fan using a Alnor Jr. heated-wire anemometer.

Results indicate that the fan does pull a considerable amount of air, 330 cubic feet per minute (cfm). However, the location of the fan is too far from the weighing or mixing operation to effectively capture and remove the dusts. Once the dusts rise to the height of the fan they are removed. However, the dusts must rise up through the operators breathing zone before reaching the fan. The fan installed in the mixing room is not a effective dust control measure.

An additional problem observed with the location of the fan was its exhaust port. The fan exhausts onto an outside terrace. This terrace is used by students as a break, smoking, and gathering place. Exhaust of the dust generated during mixing operation may inadvertently expose students to silica dusts.

C. Respiratory Protection

Two half mask particulate respirators (a Wilson and a Eastern Safety) were available for use in the pottery shop. On inspection, one respirator was found to be in very poor shape. The Eastern Safety respirator was missing inhalation valves and the head straps were worn out. The Wilson respirator was found to be in fair shape, but was unavailable for public use.

If students wish to use respiratory protection, they must purchase their own respirators. No instruction is provided on the proper care, storage, fit testing or use of respiratory protection. The graduate student mixing the clay was observed using the Eastern respiratory (which he purchased), but was using it over a full beard, thereby limiting its effectiveness.

VII. CONCLUSIONS/RECOMMENDATIONS

On the basis of the data obtained in this investigation, NIOSH has determined that there is a potential for a health hazard to exist at the Pottery Shop. However, because the mixing operation and studio work are not conducted on a regular eight hour day, 40 hours per week, levels of crystalline silica do not exceed any recommended exposure criteria.

However, due to the crystalline silica content of the clay and related products used in the pottery shop, along with the potential for high dust exposures occurring during mixing, it would be prudent to properly control dust exposures during mixing operations, which would include the weighing of dry products. Also, the control measures should not discharged outdoors in a way that would produce a health hazard to humans, animals, or plants.

Respirators suitable for protection against silica dusts should be available to any student who desires to use a respirator. A respiratory protection program should be in place which meets the requirements of 29 CFR 1910.134 of the OSHA standard.

Cleaning by blowing with compressed air or dry sweeping should be prohibited and dustless methods of cleaning such as vacuuming or washing down with water should be substituted. This would require the installation of plumbing fixtures and drains in the mixing room. Also, emphasis should be placed upon cleanup of spills, preventive maintenance and repair of equipment, proper storage of materials, and collection of dusts containing free silica.

The following warning should be posted to be readily visible at or near entrances or access ways to work areas where there is potential exposure to free silica.[5]

WARNING!

FREE SILICA WORK AREA

Unauthorized Persons Keep Out

It appears that the best method of reducing and preventing exposures in the pottery shop mixing room would be through the installation of proper engineering controls and not reliance on respiratory protection. A properly installed and maintained engineering control system is a passive protector and requires no involvement from the students or instructors, as is needed in respirator usage.

Proper engineering controls should be installed in the mixing room. This is especially important since current plans are to install a second mixer in the room. The controls should be installed around the mixing bowls as well as the weighing table. Although there is no specific design for clay mixers, the American Conference of Governmental Industrial Hygienists' Industrial Ventilation[6] manual offers a number of proven designs which could be easily adapted to the Pottery Shop clay mixing operations. Probably the best adaptation would be the design for a barrel filling operation. Figure 1 shows a control method for a barrel filling operation, which could be easily adapted to control the dust at its source of generation. Also, a work bench similar to that used for welding can be designed with a slotted hood at the back to pull the dust generated during dry weighing operations away from the breathing zone. Figure 2 shows a typical slotted hood work bench which could also easily be modified and adapted for use in the pottery shop.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 3rd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. (DHHS (NIOSH) publication no. 84-100).

2. National Institute for Occupational Safety and Health. NIOSH Pocket Guide to Chemical Hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1990. (DHHS publication no. (NIOSH) 90-117).

3. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment and biological exposure indices with intended changes for 1990-91. Cincinnati, Ohio: ACGIH, 1987.

4. Occupational Safety and Health Administration. Air Contaminant Standard, 29 CFR 1910.1000, updated January, 1989.

5. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to crystalline silica. Cincinnati, OH: NIOSH 1975. DHHS Publication No. 75-120.

6. American Conference of Governmental Industrial Hygienists. Industrial Ventilation Manual, A Guide of Recommended Practices, 18th Ed. Cincinnati, Ohio, 1984.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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Copies of this report have been sent to:

1. West Virginia University, Environmental Health and Safety Office
2. College of Creative Arts, West Virginia University
3. OSHA, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

POTTERY SHOP
College of Creative Arts
West Virginia University
Morgantown, WV

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Worker Exposure to Respirable Dusts and Crystalline Silica

SAMPLE TYPE	SAMPLE NUMBER	JOB CLASSIFICATION	RESPIRABLE DUST(mg/m3)	QUARTZ (ug/m3)	CRISTOBALITE (ug/m3)
		POTTERY STUDIO			
AREA	FW4538	BACK OF STUDIO	0.22	ND	ND
AREA	FW4554	FRONT OF STUDIO	0.09	ND	ND
PERSONAL	FW4555	CLASS INSTRUCTOR	0.34	169.5	ND
		MIXING ROOM			
AREA	FW4539	OVER MIXER	1.28	ND	ND
AREA	FW4556	OVER MIXING TABLE	0.44	ND	ND
PERSONAL	FW4551	GRADUATE ASSIST.	1.55	ND	ND

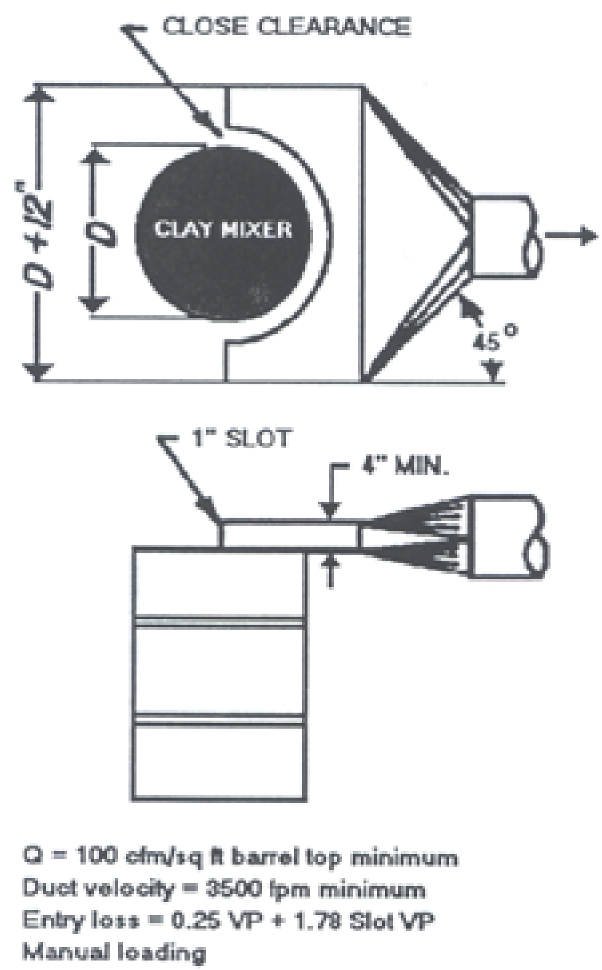

Figure 1.

POTTERY SHOP
College of Creative Arts
West Virginia University
Morgantown, WV

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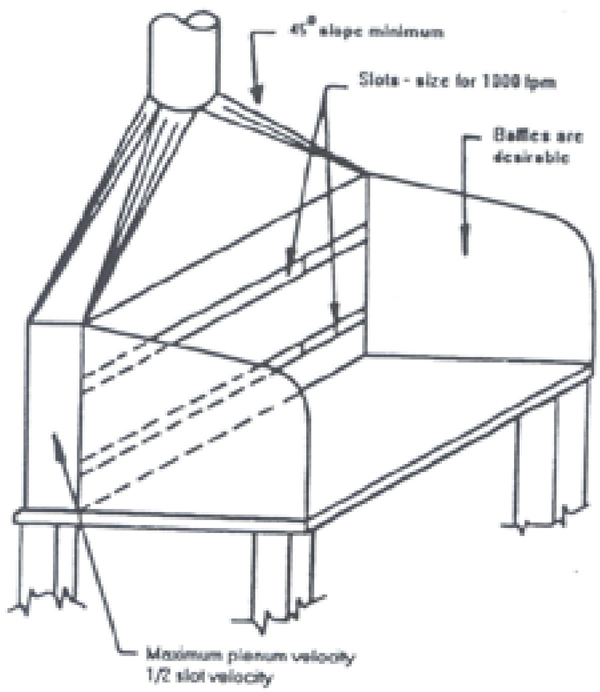
ADAPTABLE DESIGN OF AN ENGINEERING CONTROL SYSTEM FOR CLAY MIXING OPERATIONS

SOURCE: American Conference of Governmental Industrial Hygienists, Industrial Ventilation, A Manual of Recommended Practices. 18 Ed., 1984.



Q = 350 cfm/lineal ft of hood
Hood length = required working space
Bench width = 24 " maximum
Duct Velocity = 1000 - 3000 fpm
Entry loss = 1.78 slot VP + 0.25 duct VP

Figure 2.

POTTERY SHOP
College of Creative Arts
West Virginia University
Morgantown, WV

RDHETA 90-208

ADAPTABLE DESIGN OF AN ENGINEERING CONTROL SYSTEM FOR WEIGHING OPERATIONS

SOURCE: American Conference of Governmental Industrial Hygienists, Industrial Ventilation, A Manual of Recommended Practices. 18 Ed., 1984.