U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT HE 77-115-473

HEPPENSTALL COMPANY
PITTSBURGH, PENNSYLVANIA

MARCH 1978

I. TOXICITY DETERMINATION

A Health Hazard Evaluation was conducted at the Heppenstall Company, Pittsburgh, Pennsylvania on September 12-15, 1977, to evaluate worker exposure to Fiberfrax® ceramic fiber. The bricklayers and welders are experiencing short term toxicity characterized by irritation of exposed skin areas, and less frequent symptoms of mucous membrane irritation. Health effects data concerning long term exposure to airborne Fiberfrax® was not available to NIOSH. Therefore, worker exposure to airborne Fiberfrax® should be minimized.

Two bricklayers also were exposed to airborne quartz levels exceeding the Federal Standard for quartz in total dust and to excessive levels of total particulate during replacement of two gas burners in heat treat furnace No. 4. The welders were not exposed to toxic concentrations of metallic oxide fume during repair of a cracked die block.

Part V of this report offers suggested industrial hygiene practices that can help minimize dermal and respiratory exposures to the contaminants apparent in the operations evaluated.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22150. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Heppenstall Company, 4620 Hatfield Street, Pittsburgh, Pennsylvania 15201

2. Authorized representative of United Steelworkers of America, Local Union No. 1601, 149 Forty-Fifth Street, Pittsburgh, Pennsylvania 15201

3. International Headquarters of the United Steelworkers of America, 5 Gateway Center, Pittsburgh, Pennsylvania 15222

4. U.S. Department of Labor - OSHA - Region III

5. NIOSH - Region III

For the purpose of informing the approximately "six affected employees", this Determination Report shall be "posted" for a period of at least thirty calendar days in a prominent place(s) readily available to the workers.

III. INTRODUCTION

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

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of Local Union No. 1601, United Steelworkers of America concerning worker exposure to Fiberfrax®, a ceramic fiber insulation. The request alleges that bricklayers and helpers, and occasionally laborers, during the installation of Fiberfrax® in heat treat furnaces complain of coughing spasms, sore throats, and skin irritation. Because Fiberfrax® was being used in the Tong Shop as a thermal berrier during welding repair of die blocks, the evaluation was expanded to include this operation. The workers complained of skin irritation during handling of Fiberfrax®.

IV. HEALTH HAZARD EVALUATION

A. Process Evaluation - Conditions of Exposure

The Heppenstall Company manufactures steel forgings. This Health Hazard Evaluation involves Heat Treat Area No. 1, where steel ingots are heat treated; and the Tong Shop where cracked die blocks are repaired and general material handling equipment is assembled.

To minimize thermal conductivity through the ceilings, doors, and walls of the heat treat furnaces, the company lines the inside of the furnaces with a ceramic fiber veneer system termed Fiberfrax® consisting of a Lo-Con Felt and Lo-Con Blanket. Both have the form of batting with dimensions of approximately 1" thick by 24" wide and varying lengths. Their chemical composition is identical except that the Felt fibers are bonded together by a phenolic resin (<2 percent by weight) and the Blanket fibers are mechanically bonded with water. Fiberfrax® is an alumina-silica fiber with an amorphous structure.[1] Fiberfrax® originates from alumina (51.7 percent by weight) and silica (47.6 percent by weight) grains, melted in an electric furnace, and blasted by high velocity gases into light fluffy fibers. It retains its temperature stability to 2300° F and under some conditions up to 3000° F.[1]

The mode of installation is as follows: Anchor mounting holes are drilled into the refractory brick using an electro-pneumatic hammer and standard alloy studs are inserted. (In dense brick, studs are simply tapped into the sidewalls.) Once the studs are in place, the fiber layers (Felt then Blanket) are impaled over the studs and secured with standard washers.

In addition to being exposed to the alumina-silica fibers during handling of Fiberfrax®, the bricklayer's also are exposed to other particulates during preparatory and general repair work prior to installation of the thermal insulation. General repair work may include replacement of door jams and refractory bricks. Most likely the primary constituent of the particulate would be silica resulting from the siliceous refractory brick.

Fiberfrax® batting is used as a personal thermal guard during repair of the cracked die blocks. Fiberfrax® is draped over the heated die block to prevent body contact. Repair involves gouging with an arc-air rod and/or abrasive grinding of the cracked area; the resulting depression is built up to the desired specification by deposition of metal alloy from an electric arc electrode. The welders are exposed to the alumina-silica fibers during handling of Fiberfrax® and metallic fumes during welding.

B. Evaluation Design and Methods

A NIOSH field survey was conducted during September 12 and 15, 1977. The potential exposures to silica, and total and respirable particulate by bricklayers during general repair activities of heat treat furnaces 4 and 11, and installation of Fiberfrax® in furnace 4 were evaluated. Additionally, exposure to iron oxide fume by welders during repair of a cracked die block were evaluated.

Total dust levels were measured by drawing air at a flow rate of 1.5 lpm through a tared FWS-B filter mounted in a closed face cassette and then weighing the amount of dust collected. Respirable dust levels were measured by drawing air at a flow rate of 1.7 lpm through a size-selective sampler. The device consisted of a 10 mm nylon cyclone to remove the non-respirable fraction of the total dust prior to collection of the respirable portion on a tared FWS-B filter for weight determination. The quartz and cristobalite content (2 forms of crystalline silica) were determined for each total and respirable dust sample using x-ray powder diffraction.[2] Iron oxide fume level was measured by drawing air at a flow rate of 1.5 lpm through a PVC filter mounted in a 3-piece closed face cassette and analyzed by atomic absorption spectrophotometry.[3]

A health questionnaire was completed on each person directly affected by the alleged hazards, which totaled 6. All employees were interviewed concerning past occupational history and present or recent medical symptoms.

C. Evaluation Study Criteria

The environmental criteria used to assess the workroom concentrations of the contaminants evaluated are contained in the respective table of results (Tables 1 and 3). The criteria are based on the current state of knowledge concerning the toxicity of the substances for an 8-hour or up to a 10-hour workday, 40-hour workweek over a normal lifetime. Because of wide variation in individual susceptibility, however, a small percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

A brief review of the known health effects of the substances determined to be causing a toxic or potentially toxic exposure to the workers under conditions used or found follows:

1. Fiberfrax®: Published literature on the toxic effects of Fiberfrax® is indeed meager. The only data available to NIOSH was that contained in a Technical Information Bulletin provided by the manufacturer[4], who contracted with an independent laboratory to test the toxicological characteristics of this material. Animal testing indicated that it caused irritation to exposed skin and mucous membranes, which was reportedly mechanical in nature. It was toxicologically inert by oral administration. The report did not make mention of specific inhalation studies, but recommended that Fiberfrax® be categorized as a nuisance particulate.

2. Crystalline Silica: Excessive inhalation of crystalline silica results in an increased potential for developing a form of pneumoconiosis (dusty lung) termed silicosis.[5] Silicosis is a disease due to breathing air containing silica, characterized anatomically by generalized fibrotic changes in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever unless secondary infection ensues, increased susceptibility to tuberculosis (some or all of which symptoms may be present), and by characteristic x-ray findings. This form of pneumoconiosis usually develops after at least 7 years of exposure, although a few cases have developed in as short a period of time as 1.5 years from inhalation of very high levels of silica with a high quartz content. At the other extreme, with exposure to low levels, 20 years may have to elapse before the disease develops to a stage when it can be diagnosed. Early silicosis termed "simple silicosis" is usually first diagnosed by chest x-ray examination. At this stage there is little if any, functional impairment, and there are often no associated symptoms and signs. Symptoms occur when silicosis advances and becomes complicated by infection and emphysema. These changes are marked by intolerance to exertion, episodes of coughing, and production of thick sputum. When silicosis has progressed to this point, the chest x-ray is usually read as "conglomerate silicosis". Conglomerate silicosis many times progresses in spite of termination of exposure, becomes incapacitating to the affected worker, and is irreversible.

3. Nuisance Particulate: Inhalation of excessive amounts cause no adverse effects in the lungs; elevated concentrations reduce visibility and may result in unpleasant deposits in the eyes and nose, plus injury to the mucous membranes through mechanical action.[6]

D. Results

a. Environmental

Personal breathing zone samples were collected during September 15-22, to evaluate the bricklayers' and helpers' exposures to quartz and cristobalite, and respirable and total dust. The results of four consecutive days of sampling, during which time different furnace repair activities occurred are presented in Table 1. Neither quartz nor cristobalite were detected in any of the respirable dust samples. The minimum detectable amount of quartz and cristobalite per filter was 0.03 and 0.04 milligrams. The 8-hour time-weighted average (TWA) respirable dust concentrations were all less than 12.5 percent of the respective environmental criteria of 5 mg/M^3. On September 12, the 8-hour TWA exposure of bricklayer 2 and helper 1 to quartz generated during replacement of 2 gas burners in Furnace 4 exceeded the calculated Federal OSHA standard for quartz in total dust. Cristobalite was not detected in any of the total dust samples. Additionally, during the same period, the 8-hour TWA exposure of bricklayer 2 to total dust exceeded the respective environmental criteria of 10 mg/M^3.

The percent crystalline silica and asbestos were determined for each of 5 bulk powder samples collected from the miscellaneous dust on the floor and from the refractory bricks of furnaces 4 and 11 (Table 2). The average percent crystalline silica was 23 (range 4 to 35 percent; median 22 percent). Microscopic examination of the samples did not reveal the presence of asbestos, a prospective constituent of the refractory brick. Less than 2 percent crystalline silica was reported for bulk samples analysis of Fiberfrax® Lo-Con Felt and Lo-Con Blanket.

The personal breathing zone concentrations of iron oxide fume experienced by 2 welders generated during electric-arc welding of a 20 ton die block are presented in Table 3. The 8-hour TWA exposure concentrations were less than 11.5 percent of the 5 mg/M^3 criteria.

b. Medical

Health questionnaires were completed on 6 workers (4 bricklayers and 2 welders). This constituted 100 percent of the total workers (6 males) exposed. Their average age was 54.5 (range 48-60) and 46 (range 37-55) years, respectively. Their average length of working time in their present capacity was 12.7 (range .2 - 29.5) and 9.5 (range 5-14) years, respectively.

There were 2 (2/6) workers who had no health complaints. The remaining 4 workers had complaints of irritation of the exposed skin areas (primarily neck and wrists, and arms when long sleeve clothing was not worn) during handling of the Fiberfrax® Felt or Blanket. There were less frequent complaints of throat irritation, which primarily occurred during periods of Fiberfrax® installation.

E. Discussion

It is apparent that the extent of exposure to the contaminants evaluated varies with each particular furnace repair activity. The highest exposure concentrations, which exceeded the OSHA Standard for quartz in total dust and the ACGIH criteria for total dust, were measured during burner replacement and the lowest during Fiberfrax® Felt and Blanket installation.

The personal sampling data indicates that the majority of the airborne particles (on a mass per volume basis) are of the non-respirable size (>10 um aerodynamic equivalent diameter) and that the silica content is significantly higher in the non-respirable fraction. This variation in silica composition is related to variation in particle size, and continues even within the size range of airborne dust. For instance, Drinker and Hatch[7] quote an example where the crystalline silica content of an airborne foundry dust varied from 72.3 percent for particles over 10 um in diameter,

28.2 percent between 5 um and 10 um, 22 percent between 2 um and 5 um down to 3.3 percent below 2 um. However, because of the relatively high percent crystalline silica found in the bulk powder and personal total dust samples, and the toxicity potential of crystalline silica, measures to minimize worker exposure should be promptly instituted.

The symptoms associated with handling Fiberfrax® are compatible with short term exposure to the materials involved and the airborne dust generated. The alumina-silica ceramic fiber product is known to cause skin and mucous irritation as were reported by the affected workers.

Based on the chemical composition and exposure temperature (<2300° F) of Fiberfrax® during welding, it is doubtful that any toxic compounds would be evolved. However, this does not preclude the apparent dermatologic effects caused by direct skin contact with the fibers themselves.

V. RECOMMENDATIONS

The following are suggested industrial hygiene practices that can help minimize the respiratory and dermal exposures to the contaminants apparent in the operations evaluated.

A. Environmental

1. Every effort should be made to control the dust at the source of generation. A portable local exhaust ventilation system should be used during high dust generation activities such as replacement of furnace burners, door jams, etc. Measures should be taken to insure such exhausts do not discharge into other work areas.

2. The use of commercially available wetting agents for water used to spray furnace areas under repair will help control the airborne dust level. However, this should not be done as a substitute for, but in conjunction with positive engineering controls.

3. Although the metal fume concentrations generated during electric-arc welding of the die block were below the environmental criteria, it is recommended that the available portable exhaust system be maintained and used. During the survey the exhauster was not operative. An employee stated that if it were operative, it would have been used.

B. Respiratory Protection

1. The bricklayers and helpers involved in furnace repair activities such as replacement of furnace burners and doors should wear a NIOSH approved half mask respirator with a replaceable dust filter until the exposure to quartz is reduced below the OSHA standard. This respirator will also provide protection against the excessive levels of total dust. A suitable dust mask should also be worn during installation of Fiberfrax®.

2. The selected respirator must be approved under provisions of 30 CFR 11, i.e. only those respirators should be used which have a Tested and Certification number issued by NIOSH to the manufacturer of the device.

3. A respiratory protection program meeting the requirements of OSHA as outlined in 29 CFR 1910.134 should be established and enforced by management with support from the union. A NIOSH document titled A Guide to Industrial Respiratory Protection[8], will serve as reference source with information for establishing and maintaining a respiratory protection program which meets the requirements of 29 CFR 1910.134.

4. Respirators should be issued with caution. There might be individuals in the group for whom wearing a respirator carries certain specific dangers, i.e. highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. Therefore, pulmonary function testing should be carried out prior to requiring any person to wear a respirator.

C. Protective Clothing

Employees involved with handling the Fiberfrax® Felt or Blanket should wear appropriate clothing to minimize skin contact. Gloves with liners and long sleeve shirts should be worn. The possibility of using loose fitting disposable coveralls should be investigated. Tight fitting clothing such as collars and cuffs encourages the entrapment of any airborne fibrous spicules and may result in skin irritation. Disposable coveralls are commercially available.

D. Barrier Creams

In operations where protective clothes such as gloves would hinder the work or endanger a significant safety problem barrier creams can also be used as an effective prophylactic measure.

VI. REFERENCES

1. Hawley, G.G., The Condensed Chemical Dictionary. 8th Ed. pg. 388, Van Nostrand Reinhold Company, 1971.

2. P&CA Method 259, NIOSH Manual of Analytical Methods, 2nd Edition, HEW Publication (NIOSH) No. 77-157-A, 1977.

3. Ibid. P&CA Method 173.

4. Technical Information Bulletin - Fiberfrax® Bulk Ceramic Fiber. Carborundum Company, Niagra Falls, N.Y.

5. Criteria for a Recommended Standard ... Occupational Exposure to Crystalline Silica. HEW Publication (NIOSH) No. 75-120, 1974.

6. Documentation of Threshold Limit Values. American Conference of Governmental Industrial Hygienists, pg. 190, 1975.

7. Drinker, P. and T. Hatch. Industrial Dust. pg. 162, McGraw - Hill, New York, 1936.

8. A Guide to Industrial Respiratory Protection. HEW Publication (NIOSH) No. 76-189, 1976.

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Table I

Airborne Concentrations of Quartz, Cristobalite, and Respirable and Total Dust Measured at the Breathing Zone of Bricklayers and Helpers During General Repair of Refractory Furnaces in Heat Treat Area No. 1

Heppenstall Company
Pittsburgh, Pennsylvania
September 12-15, 1977

Sample Date	Sample No.	Job Description and/or Classification	Sampling Period	Samp.Vol. Liters	Respirable Dust mg/M³[a]				Total Dust mg/M³				
					Quartz	Cristo-balite	Dust level	8-hr.[b] TWA	Quartz	Cristo-balite	Dust level	8-hr. TWA	OSHA[c] Quartz Std
9/12	1324	Bricklayer 1:Furnace 4-replacing 2 burners	0740-1103	566	LLD[d]	LLD	0.30	0.21					
			1150-1400										
9/12	1313	" " " "	" "	499					0.14	LLD	3.8	2.6	5.7
9/12	1325	Bricklayer 2:Furnace 4-replacing 2 burners	0744-1103	338	LLD	LLD	1.5	0.62					
9/12	1319	" " " "	" "	298					1.1	LLD	26.2	10.9	4.7
9/12	1323	Helper 1:Furnace 4-replacing 2 burners	0744-1103	338	LLD	LLD	0.97	0.40					
9/12	1315	" " " "	" "	298					0.97	LLD	19.9	8.2	4.4
9/13	1307	Bricklayer 2:Furnace 4-installing felt	0728-1102	363	LLD	LLD	0.55	0.24					
9/13	1326	" " " "	" "	321					LLD	LLD	2.5	1.1	
9/13	1316	Helper 1:Furnace 4-installing felt	0749-1102	328	LLD	LLD	0.06	0.02					
9/13	1318		" "	289					LLD	LLD	0.69	0.31	
9/14	1320	Bricklayer 1:Furnace 4-installing blanket	1240-1405	127					LLD	LLD	0.24	0.04	
9/14	1305	Bricklayer 2:Furnace 4-installing blanket	1240-1416	144					LLD	LLD	0.07	0.01	
9/14	1311	Helper 1:Furnace 4-installing blanket	1240-1417	145					LLD	LLD	0.28	0.06	
9/15	1317	Bricklayer 2:Furnace 11-digging-out door jam	0800-1130	544	LLD	LLD	0.06	0.04					
			1200-1350										
9/15	1312	" " " "	1200-1350	480					0.33	LLD	2.6	1.7	2.0
9/15	1309	Helper 1:Furnace 11-digging-out door jam	0755-1050	434	LLD	LLD	0.12	0.06					
			1235-1355										
9/15	1308	" " " "	1235-1355	382					0.42	LLD	2.9	1.5	1.8
Environmental Criteria								5 mg/M³[e]				10 mg/M³[e]	

a. Denotes milligrams of contaminant per cubic meter of contaminated air sampled.
b. Denotes 8-hour time-weighted average.
c. Occupational Health Standard promulgated by U.S. Dept. of Labor - OSHA - Federal Register July 1, 1975, Volume 39, Title 29, Part 1910, Subpart Z, Section.1000. The silica standard for quartz in total dust is calculated by dividing 30 mg/M³ by the % quartz + 2, 8-hr. TWA.
d. Denotes lower limit of detection for quartz and cristobalite which was 0.03 and 0.04 milligrams per filter, respectively.
e. Recommended and Proposed Threshold Limit Values and Their Supporting Documentation setforth by the American Conference of Governmental Industrial Hygienists, 1977.

Table 2

Determination of Percent Crystalline Silica (100 μm fraction), and Asbestos in Bulk Powder Samples

Heppenstall Company
Pittsburgh, Pennsylvania
September 15, 1977

Sample Number	Sample Description	% Crystalline Silica[a] (100 μm fraction)	% Asbestos
BS-03	Furnace No. 4: Sample of an intact wall brick	4	0
BS-04	Furnace No. 4: Sample of miscellaneous dust on furnace floor	24	0
BS-05	Furnace No. 4: Sample of new brick to be installed	22	0
BS-08	Furnace No. 11: Sample of miscellaneous dust on furnace floor	35	0
BS-09	Furnace No. 11: Sample of dust from pulverized "SOAP" brick - estimated age of brick 15+ years	32	0

a. Each sample was sieved by a 100 micrometer sieve prior to analysis for crystalline silica.

Table 3

Measurement of Personal Breathing Zone Concentrations of Iron Oxide Fume
Produced During Electric Arc Welding

Heppenstall Company
Pittsburgh, Pennsylvania
September 15, 1977

Sample Number	Job Classification and Description	Sampling Period	Samp.Vol. Liters	Airborne Concentrations Data mg/M^3 (a) Iron Oxide Fume	8-Hr. TWA
V-4597	Welder No. 1: Repair of a 20 ton Super Hardtem steel die block	0745-1205 1235-1450	592	0.57	0.47
V-4598	Welder No. 2: " " " " " "	0745-1200 1235-1450	585	0.68	0.56
Environmental Criteria					5 mg/M^3(b)

a. Denotes milligrams of contaminant per cubic meter of contaminated air sampled.
b. Recommended and Proposed Threshold Limit Values and Their Supporting Documentation, American Conference of Governmental Industrial Hygienists, 1977.