PB94-158367

Industrial Hygiene Survey of Marquette Cement Co.

Rockmart, Georgia

Cement Workers Morbidity Study

Wayne T. Sanderson and Cathy Davidson

August 1982

Environmental Investigations Branch
Division of Respiratory Disease Studies
National Institute for Occupational Safety and Health

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipi[ent's Accession No.] PB94-158367

4. Title and Subtitle Industrial Hygiene Survey of Marquette Cement Co., Rockmart, Georgia. Cement Workers Morbidity Study	5. Report Date 1982/08/00
	6.
7. Author(s) Sanderson, W. T., and C. Davidson	8. Performing Organization Rept. No.
9. Performing Organization Name and Address Environmental Investigations Branch, Division of Respiratory Disease Studies, NIOSH, U.S. Department of Health and Human Services, Cincinnati, Ohio	10. Project/Task/Work Unit No.
	11. Contract (C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address	13. Type of Report & Period Covered
	14.

15. Supplementary Notes

16. Abstract (Limit: 200 words) As part of the Cement Workers Morbidity Study, an industrial hygiene survey was conducted at the Marquette Cement Company in Rockmart, Georgia. Environmental sampling was conducted to determined respirable and total dust concentrations of various contaminants. For most jobs at this site the levels of respirable and total dust were below the permissible limits. Four respirable dust samples from workers in the packhouse exceeded the ACGIH recommended levels for nuisance particulates. Nineteen respirable dust samples form workers associated with raw materials contained detectable levels of quartz (14808607). Eight of these samples contained concentrations greater than 100 micrograms/cubic meter. Possible overexposure to welding fumes were noted for welders. The authors recommendations for reducing exposures included improving the design of the ventilation system, using proper clean up procedures, using personal protective equipment, and monitoring welding fumes.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms NIOSH-Publication, NIOSH-Author, NIOSH-Survey, Field-Study, Region-4, Airborne-particles, Occupational-exposure, Quartz-dust, Dust-exposure, Dust-inhalation, Cement-industry

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages 46
	22. Security Class (This Page)	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272(4-77) (Formerly NTIS-35) Department of Commerce

Executive Summary

The Marquette Cement Plant in Rockmart, Georgia was surveyed by a NIOSH team of industrial hygienists, on March 2 through March 5, 1981. Samples were collected and analyzed for respirable and total dust, free crystalline silica, aluminum, cobalt, magnesium, manganese, nickel, other trace elements, asbestos, and oxides of sulfur.

The respirable and total dust levels for most jobs are below recommended exposure levels. However, four respirable and three total dust samples exceed the ACGIH recommended levels for nuisance particulate. Four of these samples were from workers in the packhouse. Of the dust contaminants measured, only quartz is present in excessive concentrations. Exposure to quartz was primarily observed in areas of raw material handling. Welders may need to be monitored for overexposure to welding fumes.

Introduction

The National Institute for Occupational Safety and Health (NIOSH) has undertaken a study to determine the effects of materials found in Portland Cement facilities on the human respiratory system. A representative group of plants in the United States has been randomly chosen for inclusion in this study. Marquette Cement in Rockmart, Georgia was the fifth of sixteen plants to be surveyed.

Each plant survey consisted of:

1. Medical testing of employees to determine the prevalence of respiratory disease.

2. Environmental sampling to determine the presence and concentration of various contaminants.

Medical and environmental testing were not done during the same week.

This report deals with the environmental aspect of the study. The environmental surveys are primarily concerned with the composition and concentration of airborne dust particles. It is important to characterize the presence of toxic contaminants as completely as possible, so that, if respiratory problems are discovered, the proper contaminant may be implicated as the cause of disease. Therefore, toxic gases and metals are also monitored. A major weakness of much of the past medical research of worker populations in Portland cement plants is the lack of complete documentation of the respiratory hazards to which workers are exposed. For these reasons, comprehensive industrial hygiene surveys are a very important aspect of the Cement Workers Morbidity Study.

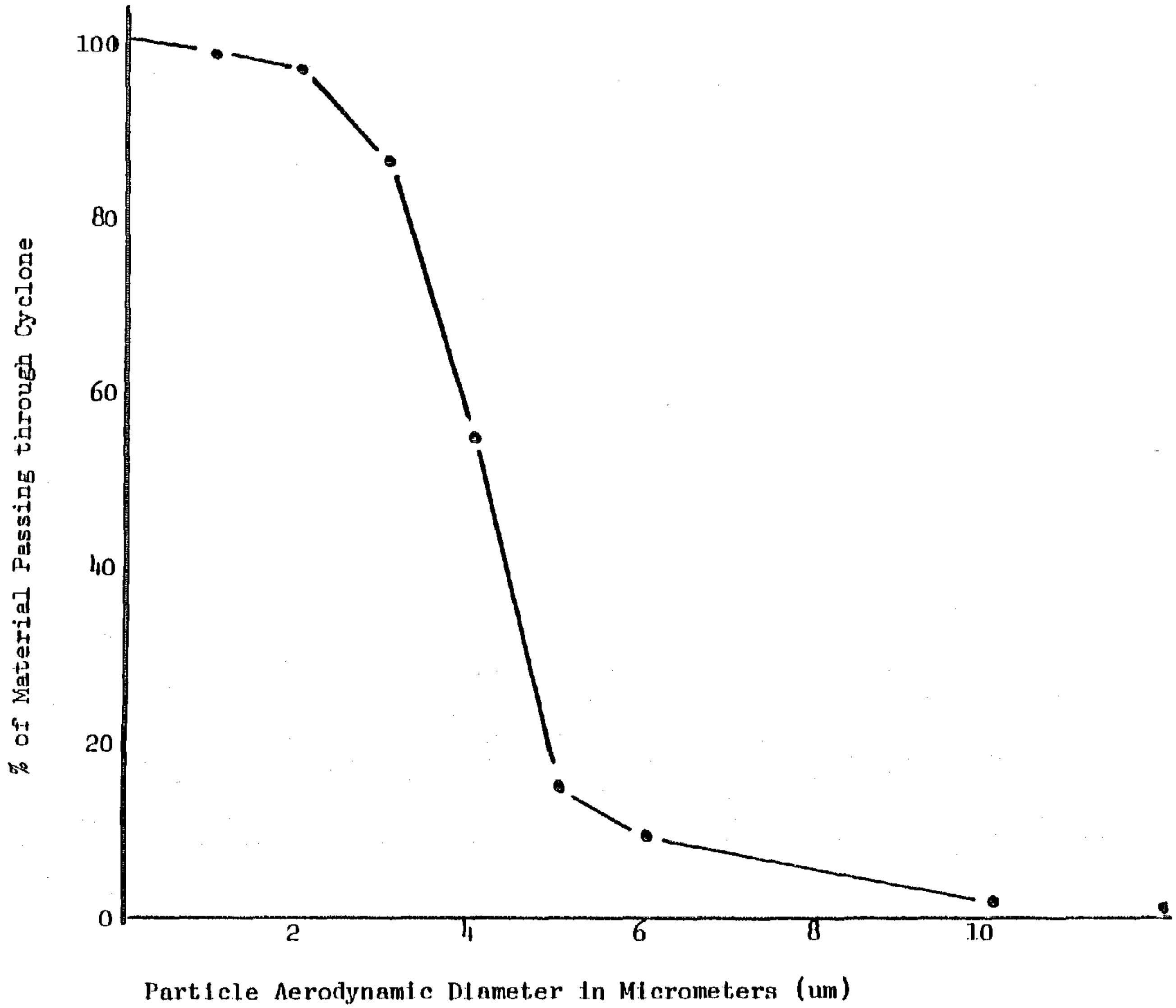
The Marquette Cement plant in Rockmart, Georgia was surveyed on Monday, March 2 through Thursday, March 5, 1981 by Charles Connors, Wally Carr, and Wayne Sanderson. The Marquette Cement plant is located about one mile north of Rockmart. The original plant began operation in 1902, but in 1955 a new kiln was built which replaced 8 old kilns. This kiln is fueled by coal and is the only one in use today. The dry process method of cement production is used. In 1976 the original limestone quarry was abandoned; since that time crushed limestone has been trucked in from Rome, Georgia. The plant operates a shale quarry near the plant and a silica sand quarry 8 miles from the plant. The remaining raw materials, iron ore, gypsum, alumina dross, and coal are brought in by rail. The plant operates two raw and two finish ball mills. Two types of cement are produced here: a general Portland cement and masonry cement.

Methods and Results

Personal Respirable and Total Dust Samples

It was not feasible nor statistically necessary to monitor all individuals at the plant. Using a random numbers table, a subset of workers was chosen to participate in the study. These selected workers were requested to wear a respirable or total dust sampler. To collect respirable dust, air was pulled through a 10 mm nylon cyclone and a polyvinyl chloride filter (PVC) at a flow rate of 1.7 liters per minute (lpm) by a personal sampling pump. At this flow rate, the cyclone separates the collected airborne dust into two fractions. Those particles considered respirable pass through the cyclone and are collected on the filter; larger particles or those considered to be non-respirable drop to the bottom of the cyclone and are discarded. The collection efficiency curve for this cyclone is presented in Figure 1. As defined by this curve, particles greater than 10 micrometers in aerodynamic diameter theoretically would not pass through the cyclone and be deposited on the filter. Whereas, almost all the particles smaller than 1.5 micrometers in aerodynamic diameter would be collected on the filter. (1) The basic sampling apparatus for respirable dust, minus the size selector, is used to collect total airborne dust. Air is pulled through a PVC filter mounted in a polystyrene filter holder at a flow rate of 1.7 lpm. Those particles 20 um and below are collected fairly efficiently on the filter media. This of course depends also on the direction, speed, density, and nearness of the particles to the filter. The filters were weighed on a precision balance to the nearest 0.01 milligram (mg), before and after sampling. The weight gain

Figure 1 COLLECTION EFFICIENCY OF THE PERSONAL RESPIRABLE DUST CYCLONE



of the filters, the sampling flow rates, and the sampling times were used to calculate airborne dust levels.

Respirable dust levels are reported in Table 2 as milligram per cubic meter (DUSTMGM3). The results from the respirable dust sampling are also summarized in Table 3, with summary statistics computed for each exposure category. The "MEAN" value is an arithmetic average of all values obtained in each area; the "STD" values are the standard deviations, which is a measure of the variability of the data. "GM" and "GSD" are the geometric means and geometric standard deviations of the same data respectively. Geometric values sometimes give a better estimate of expected values than do normal arithmetic averages because the effect of an occasional high value is diminished in calculating geometric means. The NLOD values are the number of samples which were less than the limit of detection. "MAX" and "MIN" values are maximum and minimum observed values for samples that had detectable amounts of materials. Arithmetic mean respirable dust levels are also charted in Figures 2 and 3 by process area and job category respectively. These are presented to provide easy recognition of the highest exposure areas and job categories.

After weighing, the respirable filters were subjected to analysis by x-ray diffraction to determine their content of the crystalline silica polymorphs, quartz and cristobalite. (2) Crystalline silica is reported in Table 4 as microgram per cubic meter (QUARTZ) and percent quartz (PCT_SIO2). A value of "N" indicates that the measured quantity was below the analytical limit of detection. Limits of detection for each method are given in Table 1. Samples with detectable quartz concentrations are also shown on Table 5 with their calculated MSHA-PEL. This will be discussed in detail in the Discussion Section.

Total dust levels are presented in Table 6. These results are summarized in Table 7. As with the respirable dust levels, arithmetic mean total dust levels are charted in Figures 4 and 5 by process area and job category respectively.

After weighing, the total dust filters were ashed in acid and analyzed by atomic absorption (3) to detect the amount of aluminum (AL), chromium (CR), cobalt (CO), magnesium (MG), manganese (MN), and nickel (NI) present. The trace metal concentrations are reported in Table 8 as micrograms per cubic meter of air (___ UGM3). Once again, a value of "N" indicates that the measured quantity was below the limit of detection. The limits of detection for each element are listed in Table 1. Trace metal analyses are summarized in Table 9. The MEAN is the arithmetic mean of all the samples with detectable levels of the particular elements. STD DEV is the standard deviation of these samples and is an expression of the variability of the elemental concentrations. No cobalt was detected on any of the personal total samples. Only two samples contained chromium, and one sample nickel.

Area Total Dust Samples

Airborne total dust samples were collected at fixed locations throughout the plant. These areas were selected based on how well they represented the work station of the employees. These filters were also analyzed for amount of aluminum, chromium, cobalt, magnesium, manganese, and nickel.

The trace metal concentrations are reported in Table 10 as micrograms per cubic meter of air (___UGM3). The JOB column defines the area in which the sample was collected. The six trace metal concentrations are then given in the next six columns. The results of the trace metal analysis of the area total samples are summarized in Table 11. No cobalt or nickel was detected on any of these area samples.

One area sample from each exposure category was analyzed for content of 30 metals. These samples were ashed using nitric and perchloric acids and the residues dissolved in dilute nitric acid. The resulting solutions were analyzed for trace metal content by inductively coupled plasma - atomic emission spectroscopy (ICP-AES). (4) The results of the analysis are reported in Table 12. For this analysis technique, the lower limit of detection is 1.0 ug/filter for all elements.

Airborne Fiber Samples

Samples for airborne fibers and asbestos were collected on cellulose ester filters. These samples are taken with the front of the filters completely open to the environment. Air is drawn through the filters at a flow rate of 1.7 lpm. These filters are optically analyzed using a phase contrast microscope. (5) If fibers were detected, they would have been analyzed by polarized light and dispersion staining, and transmissin electron microscopy to determine whether they were asbestos fibers.

In this survey 13 samples were collected for fibers. These samples were collected in the raw material crushing and milling areas, storage areas, kiln and clinker cooler areas, and along transfer belts. No fibers were detected on any of the filters.

Bulk Material Samples

Samples of raw material dust, clinker, finished product, and mixtures of dust were collected for analysis. These samples were generally collected from dust settled on ledges or objects several feet above the floor. For this reason, it is suspected that these particles were at one time suspended in air before coming to rest. These bulk material samples cannot, however, be considered airborne samples. This material was analyzed for content of quartz and cristobalite by x-ray diffraction; aluminum, chromium, cobalt, magnesium, manganese, and nickel content by atomic absorption; and asbestos content by polarized light and dispersion staining microscopy.

The results of these analyses are presented in Table 13. The AREA column lists from what exposure category the samples were taken. The JOB column lists whether the material was felt to be predominantly raw material, clinker, finished cement, a mixture of dusts, or other materials such as insulation. The results of analysis are presented as percent by weight of material. For example, if 1% of the raw material is quartz, there is 0.01 gram of quartz in each gram of raw material. The value "N" indicates that the measured quantity was below the analytical limit of detection.

Oxides of Sulfur Samples

Samples for sulfate and sulfite particulates and sulfur dioxide gas were collected by drawing a known volume of air through a filter train consisting of two cellulose ester filters in series. Particulate matter, including sulfates and sulfites, is collected on the first filter. Sulfur dioxide passes through the first filter and is collected on the second filter which has been impregnated with potassium hydroxide. (6) The filters were extracted with deionized water and the extracts analyzed by ion-chromotography.

The results of the oxides of sulfur analyses are listed in Table 14. The JOB column tells where the sample was collected. The SO4_UGM3 and SO3_UGM3 columns give the sulfate and sulfite concentrations in micrograms per cubic meter; the SO2_PPM column give the sulfur dioxide levels in parts per million. No sulfite particultes were detected on any of the samples. The analytical limits of detection for these analyses are listed in Table 1.

General Comments and Schedule

Control filters were collected on site during the survey. These filters received treatment identical to dust laden filters, except no air was drawn through the control filters. During each shift, each personal and area sampler was periodically checked for proper operation. If the sampler was not operating within specifications, sampler adjustments and appropriate notations were made and, if necessary, the results of such samples were voided.

The environmental investigations team began sampling Monday, March 2, 1981. The sampling schedule was as follows:

Monday, March 2	- 2nd shift
Tuesday, March 3	- 1st shift
Wednesday, March 4	- 1st shift
Wednesday, March 4	- 3rd shift
Thursday, March 5	- 1st shift

This schedule was used in order to adequately measure environmental concentration differences due to day-to-day and shift-to-shift variations.

Plant areas and the work force were separated into four exposure categories based on the type of airborne dust each was subjected to. The categories were:

raw - exposure to raw materials dust

clinker - exposure to clinker dust

finish - exposure to finished Portland cement dust

mix - exposure to a mixture of two or more types of dust

Although these categories are somewhat artificial, they are very important to the design of the study. Generally, the dust particles within a category area are chemically and physically similar; however, between categories the dusts are significantly different. The mix category serves to "catch" those jobs such as laborers and repairmen who work throughout the plant or are exposed to more than one type of dust.

Discussions and Conclusions

This study is designed to determine if the normal function of respiratory tissue is impaired because of exposure to gases or particulates found in Portland cement plants. Samples of airborne particulate were collected in conjunction with a medical examination that included x-rays, spirometry tests, and symptoms questionnaires. Respiratory problems associated with exposure to airborne particulate are influencd by four factors: (7)

1. The type of dust involved
2. The length of exposure time
3. The concentration of airborne dusts in the breathing zone
4. The size of the dust particles

The intent of the environmental portion of the study is to determine the types and concentration of airborne materials to which cement workers are exposed.

This survey was not conducted for regulation compliance purposes. This data presented here is to be used for correlation with employee medical data for occupational health research. Air quality and physical agents in Portland cement plants are currently regulated by Title 30, section 56.5 of the Mineral Resources Code of Federal Regulations. The 1973 Threshold Limit Values, (TLV's), adopted by the American Conference of Governmental Industrial Hygienists, (ACGIH), are cited as the standards which airborne contaminants are not allowed to exceed. In this report these standards serve only as reference levels in order for plant personnel to compare the environmental conditions of their facility.

Personal Respirable and Total Dust Samples

Portland Cement is presently considered to be a "nuisance" dust. "Nuisance" particulates, by definition, have "little adverse effect on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. Generally, the lung-tissue reaction caused by inhalation of nuisance dusts has the following characteristics:

1. The architecture of the air spaces remains intact.
2. Collagen (scar tissue) is not formed to a significant extent.
3. The tissue reaction is potentially reversible." (8)

If airborne particulates contain greater than 1% crystalline silica, then they are no longer considered nuisance particulates; they are mineral dusts. The MSHA standard for nuisance dusts is 10 milligrams per cubic meter of total suspended dust. The MSHA standard for mineral dusts employs the formula:

$$PEL = \frac{10\ mg/m^3}{\%\ \text{respirable quartz} + 2}$$

where the "% respirable quartz" is the precent by weight of quartz in each sample, and "PEL" is the permissible exposure level. Therefore, each respirable dust sample for mineral dust has an exposure limit based on its content of quartz.

The emphasis of this survey was on respirable dust sampling. It is difficult to compare respirable dust measurements to the currently employed MSHA nuisance dust standard which is based on total dust levels. We recommend comparison of the respirable dust levels to the 5 mg/m^3 TLV for respirable nuisance dust recommended by the ACGIH.

Examining the personal respirable samples collected from the various jobs, Table 2, four samples exceeded 5 mg/m^3. Three of these samples were collected from workers in the packhouse. Since no crystalline silica was detected in these samples, they are considered samples of nuisance dust. The other sample was from a shift repairman who was working in the mill room and at the feed end of the kiln. Since this sample contained 1.7% quartz, it is a mineral dust sample. For all workers the geometric mean respirable dust level was 1.41 mg/m^3.

Three personal total dust levels, Table 6, exceeded 10 mg/m^3. One sample was collected from a packer, one from the plant oiler who works in many areas of the plant, and the highest sample was obtained from a welder who spent most of his time in the maintenance shop cutting and welding metal. Sampling methods for nuisance and mineral dusts were used in this survey. The high gravimetric weight of the welder's sample is due to particles of heavy metal fume and not nuisance or mineral dust. Since there was such a high gravimetric weight on this lapel collected sample, welders may need to be monitored with samplers specifically for welding fume. To collect a welding fume sample, a cellulose acetate filter in a closed-faced cassette is placed inside the welder's helmet. After a known volume of air is drawn through the filter, it is analyzed by x-ray fluorescence spectrometry for content of metals (chromium, manganese, iron, nickel, copper, zine, and cadmium). (20) According to ACGIH, welding fume should not exceed 5.0 mg/m^3 for an 8-hour time weighted average.

Because of the differences in worker duties and activities, some jobs consistently encounter higher or lower dust levels than other jobs. However, within a given job category, variability is often slight. Figures 3 and 5 chart the means of the respirable and total dust measurements respectively, for each job. Repairmen, laborers, packhouse workers, mill helpers, and oilers had the highest dust exposures. Activities of these workers either generate considerable amounts of dust, or take them into areas of heavy dust exposure. Most of the other jobs involve activities that do not generate much dust, or the workers were isolated from the dust source by enclosures.

Crystalline Silica

All of the raw material bulk samples contained quartz, which is a common constituent of limestone, shale, and sand. Ground raw material from the raw mills and the feed end of the kiln contained 6-7% quartz. The highest concentration of quartz (48%) was found in a sample from the raw material crane.

Twenty personal respirable dust samples contained detectable levels of quartz. Nineteen of the twenty samples were collected from workers known to have spent either all or part of their shift exposed to raw material dusts. All of the repairmen and one of the laborers with detectable quartz had spent time working on the raw mills. Another laborer spent the entire shift cleaning at the feed end of the kiln. The oiler had spent time in several areas of the plant, including the backend of the kiln and the raw mills. Although the welder was not observed working in plant areas exposed to raw material dust, silica is a common coating of welding rods. It is possible that his low level quartz exposure came from these welding operations. All other quartz exposures probably came from association with raw materials, since no quartz was detected in any of the clinker or finished cement bulk samples.

There may be some variation in quartz concentration depending on the composition of the raw materials that employees are working with. Also, the mixing and grinding of various materials containing quartz will result in a range of concentrations. Therefore, the free silica concentrations may vary with area and time. The calculated percent of quartz on the respirable filters (Table 4) have a range of 1.1 - 22.2%.

Table 5 lists the jobs with detectable levels of quartz, the percent quartz by weight in each sample, and the concentration of that dust allowed by MSHA. Twelve of the nineteen samples exceed the permissible exposure limit. Eight of the twenty samples with detectable levels of quartz, contained concentrations greater than 100 ug/m^3. Exposures below this level have been suggested in past research as safe levels of exposure. (9,10,11)

Trace Metals

The personal total dust samples were analyzed for the six trace metals: aluminum, chromium, cobalt, magnesium, manganese, and nickel. From the personal samples, none of the metals were found in concentrations greater than the MSHA permissible exposure levels or the ACGIH recommended TLV's. Area total dust samples were collected throughout the plant and analyzed for the same six trace metals. Although we attempted to place the area samples in locations representative of work areas, these stationary samples should not be considered estimates of personal exposure. Their purpose is to document the presence of these metals in airborne particulates and their relative concentrations. Aluminum and magnesium are commonly found in the dust particles. Manganese is occasionally found. Only a few samples contained detectable amounts of chromium or nickel. No cobalt was detected. Aluminum is present in the greatest concentration, followed by magnesium. Raw material, clinker, and finished cement dust all contain aluminum and magnesium. Variation in the presence of metals and their concentration may be caused by differences in milling or processing. We chose to measure these six metals because nickel and chromium are suspected carcinogens, and aluminum, magnesium, manganese, and cobalt are suspected pneumoconiosis or bronchitis producing agents. There are no past studies to indicate that these elements will cause any disease in the form or concentrations found in a cement plant. This study will look for correlations between respiratory health problems and exposures to these elements.

The four samples analyzed by ICP-AES were also for purposes of documenting the presence of these metals in airborne particulates and their relative concentrations. The metals primarily found in all the dust types are: aluminum, calcium, iron, magnesium, sodium, and potassium.

Asbestos

In this survey we found no asbestos present in the raw materials. NIOSH has surveyed quarries and raw materials associated with cement plants, as well as other limestone quarries. No asbestos has been found during any of these surveys. It is possible that quarried rock may be contaminated with asbestos fibers due to the occurrence of small deposits of asbestos-bearing rock in the overburden or the quarried strata. If this occurs at all, we expect it to be extremely rare.

Oxides of Sulfur

Sulfur dioxide concentrations of 0.01 to 0.02 ppm were found at the feed end of the kiln, kiln room, and raw mills. These levels are below the ACGIH TLV of 2 ppm, and MSHA PEL of 5 ppm. These measurements show however that exposure to sulfur dioxide does occur. Exposures to greater concentrations may occur because of breakdowns or breaches in the kiln exhaust system. Also, if the sulfur content of the kiln fuel increases, more sulfur dioxide may be produced. Sulfate particulates have not been documented to cause irritation or chronic disease. However, there is strong evidence that aerosols of these water soluble salts catalyze the conversion of sulfur dioxide to sulfuric acid, thus potentiating the irritant and reflex bronchoconstrictive effects of sulfur dioxide. (14) Nevertheless, workers should not experience irritation or respiratory changes attributable to SO_2 or sulfates at levels detected at Marquette. (1, 12, 13)

Background Samples

Samples placed upwind of the cement plant exhibit very low levels of dust. No trace metals, asbestos, or crystalline silica were detected on these background samples. The background respirable and total dust levels may fluctuate with changes in atmospheric conditions. These dust levels represent the dust exposures people would experience by just being in the community. One approach to data analysis might be to subtract these dust levels from measured plant concentrations. This would give values which represent the additional dust burden attributed to the operation of this plant. Tables 2 and 3 list the background respirable dust levels and their descriptive statistics.

Conclusion

The respirable and total dust levels for most jobs at the Marquette Cement plant in Rockmart, Georgia are below recommended exposure levels. Four samples from workers in the packhouse exceeded the ACGIH recommended levels for nuisance particulates. Nineteen respirable dust samples from workers associated with raw materials contained detectable levels of quartz. Twelve of these samples exceeded the MSHA-PEL for respirable quartz. Maintenance welders may need to be monitored for possible overexposure to welding fume. Of the dust contaminants measured, only quartz is considered to be present in excessive concentrations. Exposure to quartz occurs primarily in raw material areas of the plant. Protective measures should be taken.

Recommendations

Engineering controls are the most effective means of reducing worker exposure to airborne dust. These controls should be maintained in efficient working order. Ventilation design to remove the dust from the air once it is generated and separation from the dust by enclosing either the worker or the dust are effective means of control. The priority for implementing dust control measures should begin with areas of highest exposure. Since 12 samples from workers exposed to raw material particulates exceeded the permissible exposure limit for quartz, the kiln feed and the raw mill areas would be plces to initiate control efforts.

During clean-up operations, workers often use compressed air to "blow down" the work areas. This process resuspends a great deal of dust. Substitution with a vacuum system would eliminate this problem.

Although engineering controls are the recommended course of action, personal protective equipment (respirators and goggles) may be used by workers whenever engineering controls are not available or during maintenance, repair, and clean-up operations. The disposable paper or cloth respirators do not form an occlusive seal between the respirator and the face. Dust particles would be able to pass through leaks between the respirator and the face. Whenever workers are potentially exposed to excessive quartz concentrations, quarter or half mask dust-fume-mist respirators should be used. The disposable respirators will, however, provide some protection to workers exposed to nuisance particulates. If workers complain of eye irritation, full-face piece respirators may be used instead of half or quarter mask respirators to alleviate the problems. It is suggested that workers be involved in the selection of a comfortable NIOSH/MSHA approved dust-fume-mist respirator and be fit-tested to ensure that they are adequately protected.

Welders may need to be monitored for overexposure to welding fume. Methods for collecting welding fume samples are discussed in the Discussion Section and Reference 20.

The corrective actions recommended should be viewed as scientific guidance. There is no legal requirement that you implement any of these recommendations, and no assurance that these actions, if implemented, would be sufficient to prevent future citations for non-compliance. Nevertheless, it is anticipated that implementation of the recommendations listed in this report will reduce airborne dust levels at this facility, and improve the environmental conditions of the workplace.

References

1. Caplan, K., Doemeny, L., Sorensen, S. "Performance Characteristics of the 10 mm cyclone respirable mass sampler," American Industrial Hygiene Assoc. Journal, Vol. 38, Feb. 77, p. 87.

2. NIOSH Manual of Analytical Methods. "Free Silica (Quartz, Cristobalite, Tridymite) in Airborne Dust," 2nd Edition, USDHEW Publication, 1977, P & CAM 259.

3. NIOSH Manual of Analytical Methods. "General Procedure for Metals, " P & CAM 173.

4. NIOSH Manual of Analytical Methods. "Trace Elements", Volume 7, P & CAM 351, 1981.

5. NIOSH Manual of Analytical Methods. "Asbestos Fiber in Air," P & CAM 239.

6. NIOSH Manual of Analytical Methods. "Sulfates, Sulfites, and Sulfur Dioxide," Volume 5, P & CAM 268.

7. Olishifski, J., Fundamentals of Industrial Hygiene, 2nd Edition, National Safety Council, 1979.

8. American Conference of Governmental Industrial Hygienists, Documentation of the Threshold Limit Values, Fourth Edition, Cincinnati, Ohio, 1980.

9. Ayer, H., "The Proposed ACGIH Mass Limits for Quartz: Review and Evaluation," American Industrial Hygiene Journal, 30: 117, 1969.

10. Hosey, A.D., Ashe, H. and Trasko, V.: "Control of Silicosis in Vermont Granite Industry. PHS Publication 557, Washington, D.C., (1957).

11. Sutton, G.W. and Reno, S.J. "Respirable Mass Concentrations Equivalent to Impinger Count Data, Barre, VT Granite sheds." Presented at 1968 annual meeting, Amer. Ind. Hyg. Assoc., St. Louis, MO.

12. Frank, et. al., Journal of Applied Physiology, 17:252 (1962).

13. Tomono, Y., Japan Journal Industrial Health, 3:77 (1966).

14. Amdur, M.O., The Effect of various aerosols on the response of guinea pigs to sulfur dioxide. Archives Environ. Health, 16:460-68, 1968.

15. K. Morgan and A. Seaton. Occupational Lung Diseases, W.B. Saunders Co., 1975.

16. American Conference of Governmental Industrial Hygienists. "TLV's for Chemical Substances and Physical Agents in the Workroom Environment," 1980.

17. U.S. Department of Health Education and Welfare. "Pocket Guide to Chemical Hazards," Sept. 1978.

18. Snedecor, W. and Cochran, G., Statistical Methods, 6th Edition, Iowa State University, ames, Iowa. 1974.

19. Hatch, T.F. "Developments in the Sampling of Airborne Dust," Archives Industrial Hygiene and Occupational Med., 11:212-217 (1955).

20. NIOSH Manual of Analytical Methods. "Welding Fume," Volume 7, P & CAM 345, 1981.

Table 1

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Marquette Cement, Rockmart, Georgia

Number of Samples With Detectable Levels of Contaminants

Contaminant	# Samples Collected	# Samples with Detectable Conc.	Limit of Detection
Respirable dust	63	63	0.01 mg
Total dust	20	20	0.01 mg
Quartz	62	20	0.03 mg
Cristobalite	62	0	0.03 mg
Aluminum	36	20	0.20 mg
Chromium	36	4	0.004 mg
Cobalt	36	0	0.005 mg
Magnesium	36	36	0.002 mg
Manganese	36	7	0.002 mg
Nickel	36	1	0.004 mg
Asbestos	13	0	4500 fibers
Sulfate	8	8	0.005 mg
Sulfite	8	0	0.01 mg
Sulfur dioxide	8	7	0.005 mg

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	02MAR81	2	0.00
BACKGROUND	03MAR81	1	0.00

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
KILN FEED OPERATOR	02MAR81	2	0.32
QUARRY TRUCK DRIVER	03MAR81	1	0.24
CRANE OPERATOR (RAW)	03MAR81	1	1.02
FRONT END LOADER	03MAR81	1	0.24
KILN FEED OPERATOR	03MAR81	1	1.22
LABORER (RAW)	04MAR81	3	3.79
KILN FEED OPERATOR	04MAR81	3	2.31

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
KILN HELPER	02MAR81	2	1.07
KILN BURNER	02MAR81	2	2.25
KILN BURNER	03MAR81	1	1.66
KILN BURNER	04MAR81	3	0.75
KILN BURNER	05MAR81	1	0.53

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
BULK LOADER	03MAR81	1	0.27
PACKER	03MAR81	1	5.00
PACKER	03MAR81	1	6.96
BULK LOAD SCALEHOUSE	03MAR81	1	0.28
PACKHOUSE FOREMAN	04MAR81	1	5.52
CLEAN UP	05MAR81	1	0.58
BULK LOADER	05MAR81	1	0.23
PACKER	05MAR81	1	2.05

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

------------------------------ AREA=MIX ------------------------------

JOB	DATE	SHIFT	DUSTMGM3
REPAIRMAN	02MAR81	2	2.40
REPAIRMAN	02MAR81	2	3.63
MIX CHEMIST	02MAR81	2	0.12
REPAIRMAN	02MAR81	2	2.06
CRANE OPERATOR	02MAR81	2	0.47
MILL HELPER (MIX)	02MAR81	2	2.53
LABORER	02MAR81	2	1.34
MIX CHEMIST	02MAR81	2	0.61
MILL OPERATOR	02MAR81	2	1.11
SHIFT FOREMAN (MIX)	02MAR81	2	0.79
REPAIRMAN	02MAR81	2	7.24
REPAIRMAN	03MAR81	1	0.57
OILER (GENERAL)	03MAR81	1	0.79
MILL HELPER (MIX)	03MAR81	1	4.80
CRANE OPERATOR	03MAR81	1	0.13
MILL OPERATOR	03MAR81	1	0.83
LABORER	03MAR81	1	1.16
LABORER	03MAR81	1	1.03
OFFICE WORKER	03MAR81	1	0.00
MIX CHEMIST	04MAR81	1	0.72
MIX CHEMIST	04MAR81	1	0.67
MACHINIST	04MAR81	1	0.75
LABORER	04MAR81	1	0.93
REPAIRMAN	04MAR81	1	0.82
REPAIRMAN	04MAR81	1	0.63
LABORATORY WORKER	04MAR81	1	0.55
ELECTRICIAN	04MAR81	1	0.42
COKE COAL HANDLER	04MAR81	1	0.55
REPAIRMAN	04MAR81	1	1.20
SHIFT FOREMAN	04MAR81	1	0.27
SHIFT FOREMAN	04MAR81	3	0.51
CRANE OPERATOR	04MAR81	3	0.21
REPAIRMAN	04MAR81	3	0.78
MIX CHEMIST	04MAR81	3	0.40
MILL OPERATOR	04MAR81	3	2.50
MILL HELPER (MIX)	04MAR81	3	3.59
REPAIRMAN	05MAR81	1	0.66
REPAIRMAN	05MAR81	1	0.83
MILL HELPER (MIX)	05MAR81	1	1.69
OILER (GENERAL)	05MAR81	1	0.82
ELECTRICIAN	05MAR81	1	0.23
CRANE OPERATOR	05MAR81	1	0.53
LABORER	05MAR81	1	0.34

Table 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	2	0.00	0.00	0.01	1.00	0	0.00	0.00
RAW	7	1.31	1.32	0.79	3.07	0	0.24	3.79
CLINKER	5	1.25	0.70	1.10	1.79	0	0.53	2.25
FINISH	8	2.61	2.78	1.19	4.38	0	0.23	6.96
MIX	43	1.22	1.39	0.74	3.04	0	0.00	7.24
PLANTWIDE	63	1.41	1.61	0.82	3.07	0	0.00	7.24

Figure 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

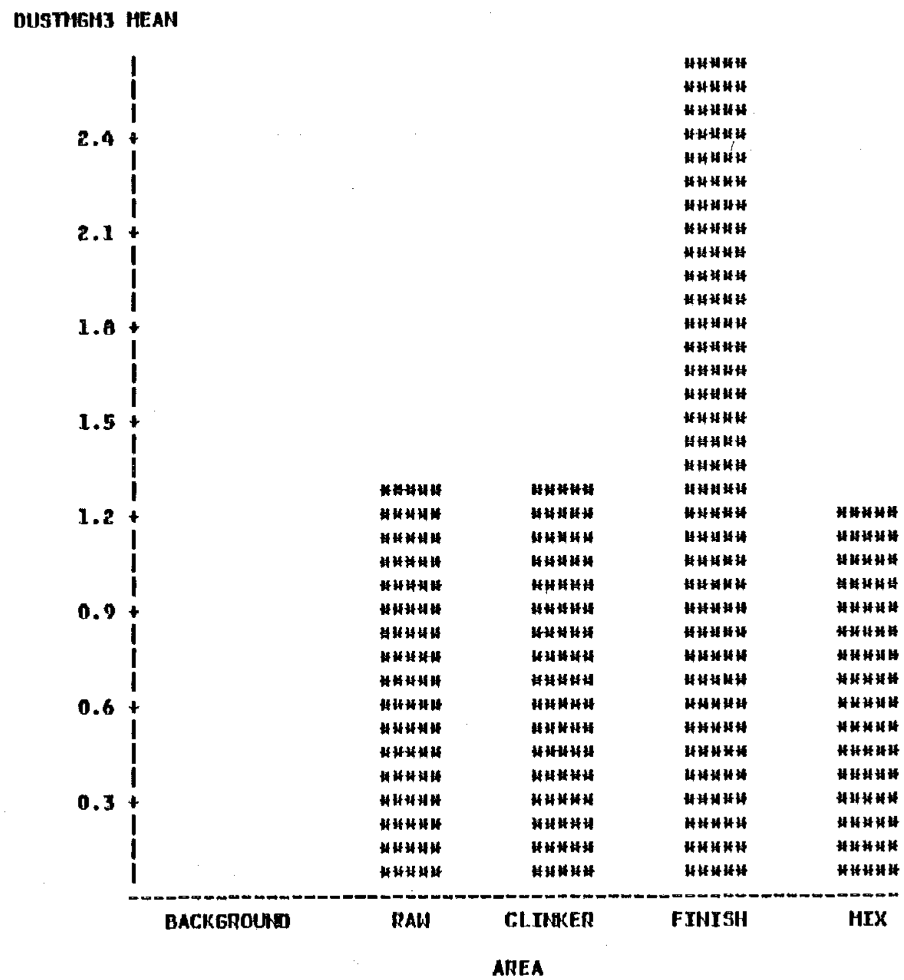


Figure 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

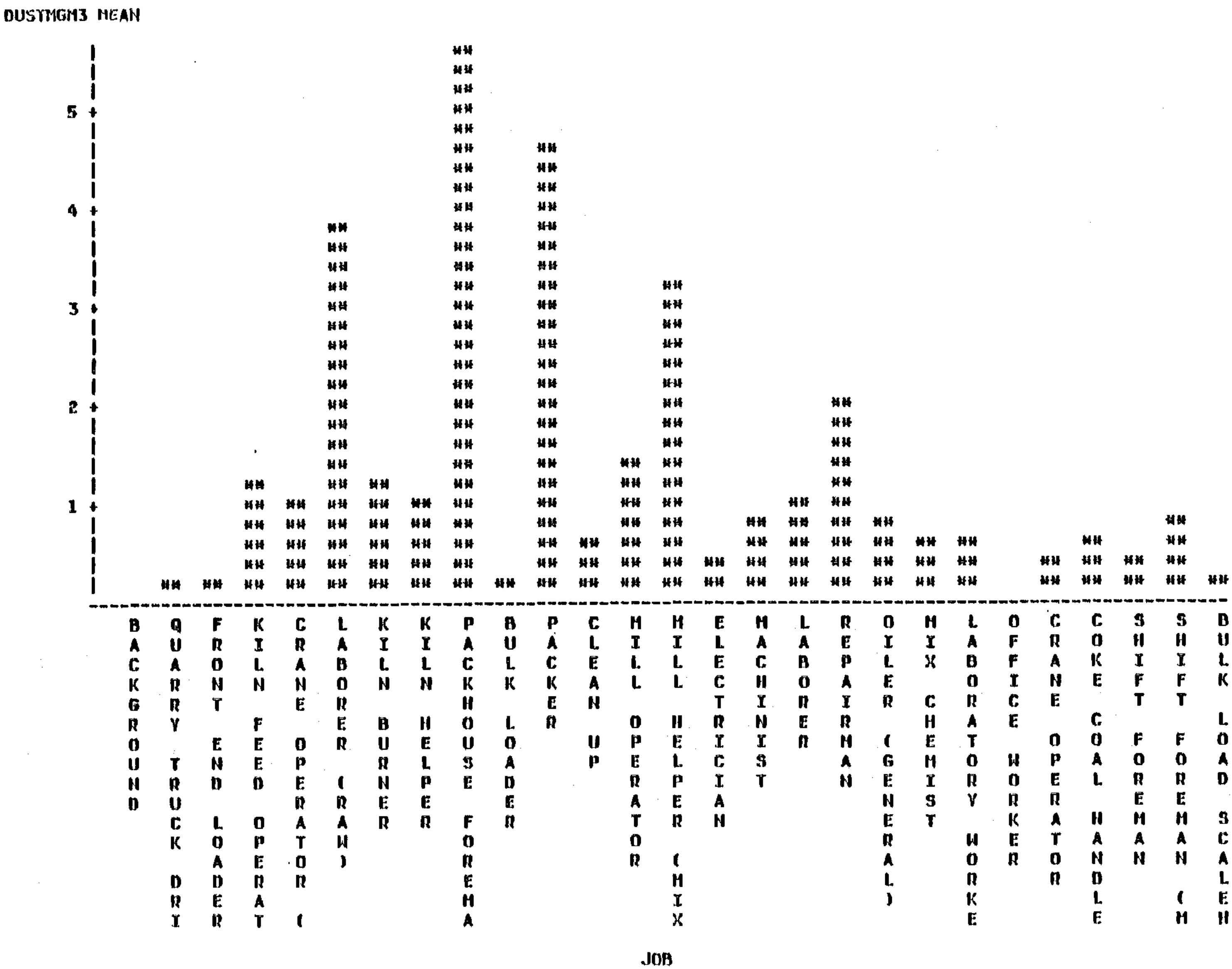


Table 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
QUARTZ CONCENTRATION OF PERSONAL RESPIRABLE DUST SAMPLES
QUARTZ CONCENTRATION IN MICROGRAMS PER CUBIC METER (UG/M3)

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
BACKGROUND	02MAR81	2	N	N	BACKGROUND
BACKGROUND	03MAR81	1	N	N	BACKGROUND
KILN FEED OPERATOR	02MAR81	2	N	N	RAW
QUARRY TRUCK DRIVER	03MAR81	1	N	N	RAW
FRONT END LOADER	03MAR81	1	N	N	RAW
KILN FEED OPERATOR	03MAR81	1	6.0	73.40	RAW
CRANE OPERATOR (RAW)	03MAR81	1	22.2	226.07	RAW
KILN FEED OPERATOR	04MAR81	3	6.2	143.51	RAW
LABORER (RAW)	04MAR81	3	6.3	240.10	RAW
KILN HELPER	02MAR81	2	N	N	CLINKER
KILN BURNER	02MAR81	2	N	N	CLINKER
KILN BURNER	03MAR81	1	N	N	CLINKER
KILN BURNER	04MAR81	3	N	N	CLINKER
KILN BURNER	05MAR81	1	N	N	CLINKER
BULK LOADER	03MAR81	1	N	N	FINISH
PACKER	03MAR81	1	N	N	FINISH
PACKER	03MAR81	1	N	N	FINISH
BULK LOAD SCALEHOUSE	03MAR81	1	N	N	FINISH
PACKHOUSE FOREMAN	04MAR81	1	N	N	FINISH
BULK LOADER	05MAR81	1	N	N	FINISH
PACKER	05MAR81	1	N	N	FINISH
CLEAN UP	05MAR81	1	N	N	FINISH
REPAIRMAN	02MAR81	2	2.8	68.56	MIX
REPAIRMAN	02MAR81	2	4.0	82.79	MIX
MIX CHEMIST	02MAR81	2	N	N	MIX
CRANE OPERATOR	02MAR81	2	N	N	MIX
SHIFT FOREMAN (MIX)	02MAR81	2	N	N	MIX
MILL OPERATOR	02MAR81	2	N	N	MIX
MILL HELPER (MIX)	02MAR81	2	4.2	105.92	MIX
LABORER	02MAR81	2	5.0	66.34	MIX
MIX CHEMIST	02MAR81	2	N	N	MIX
REPAIRMAN	02MAR81	2	1.1	41.40	MIX
REPAIRMAN	02MAR81	2	1.7	123.41	MIX
OILER (GENERAL)	03MAR81	1	N	N	MIX
MILL HELPER (MIX)	03MAR81	1	2.2	107.44	MIX
REPAIRMAN	03MAR81	1	7.7	43.59	MIX
LABORER	03MAR81	1	N	N	MIX
LABORER	03MAR81	1	N	N	MIX
CRANE OPERATOR	03MAR81	1	N	N	MIX
MILL OPERATOR	03MAR81	1	N	N	MIX
OFFICE WORKER	03MAR81	1	N	N	MIX
OFFICE WORKER	03MAR81	1	N	N	MIX
MILL HELPER (MIX)	04MAR81	3	2.5	89.09	MIX
MACHINIST	04MAR81	1	N	N	MIX
MIX CHEMIST	04MAR81	3	N	N	MIX
REPAIRMAN	04MAR81	1	N	N	MIX
MILL OPERATOR	04MAR81	3	7.1	176.65	MIX
WELDER	04MAR81	1	.	40.79	MIX
MIX CHEMIST	04MAR81	1	N	N	MIX
REPAIRMAN	04MAR81	1	N	N	MIX
SHIFT FOREMAN	04MAR81	1	N	N	MIX
LABORER	04MAR81	1	8.7	81.08	MIX

Table 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT   ROCKMART, GEORGIA
QUARTZ CONCENTRATION OF PERSONAL RESPIRABLE DUST SAMPLES
QUARTZ CONCENTRATION IN MICROGRAMS PER CUBIC METER (UG/M3)

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
SHIFT FOREMAN	04MAR81	3	N	N	MIX
LABORATORY WORKER	04MAR81	1	N	N	MIX
ELECTRICIAN	04MAR81	1	N	N	MIX
MIX CHEMIST	04MAR81	1	N	N	MIX
COKE COAL HANDLER	04MAR81	1	N	N	MIX
REPAIRMAN	04MAR81	1	4.7	56.02	MIX
CRANE OPERATOR	04MAR81	3	N	N	MIX
REPAIRMAN	04MAR81	3	5.8	45.23	MIX
LABORER	05MAR81	1	N	N	MIX
REPAIRMAN	05MAR81	1	N	N	MIX
MILL HELPER (MIX)	05MAR81	1	9.8	165.44	MIX
OILER (GENERAL)	05MAR81	1	6.9	56.49	MIX
ELECTRICIAN	05MAR81	1	N	N	MIX
REPAIRMAN	05MAR81	1	N	N	MIX
CRANE OPERATOR	05MAR81	1	N	N	MIX

Table 5

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Marquette Cement, Rockmart, Georgia

Detectable Quartz Compared to MSHA Permissible Exposure Levels

Job	Levels of Dust Conc. Mg/m^3	Quartz Conc. % Quartz	ug/m^3	MSHA PEL
Kiln Feed Op.	1.22	6.0	73.40	1.25
Crane Oper.	1.02 *	22.2	226.87	0.41
Kiln Feed Op.	2.31 *	6.2	143.51	1.22
Laborer (Raw)	3.79 *	6.3	240.10	1.20
Repairman	2.48 *	2.8	68.56	2.08
Repairman	3.63 *	4.0	82.79	1.67
Mill Helper (Mix)	2.53 *	4.2	105.92	1.61
Laborer	1.34	5.0	66.34	1.43
Repairman	2.06	1.1	41.40	3.23
Repairman	7.24 *	1.7	123.41	2.70
Mill Helper (Mix)	4.80 *	2.2	107.44	2.38
Repairman	0.57	7.7	43.59	1.03
Mill Helper (Mix)	3.59 *	2.5	89.09	2.22
Mill Operator	2.50 *	7.1	176.65	1.10
Laborer	0.93 *	8.7	81.08	0.93
Repairman	1.20	4.7	56.02	1.49
Repairman	0.78	5.8	45.23	1.28
Mill Helper (Mix)	1.69 *	9.8	165.44	0.85
Oiler (General)	0.82	6.9	56.49	1.12

*Indicates measured concentration exceeds the MSHA Permissible Exposure Limit.

Table 6

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	02MAR81	2	0.00
BACKGROUND	03MAR81	1	0.00
BACKGROUND	04MAR81	1	0.10

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
PRIMARY CRUSHER	03MAR81	1	6.01
KILN FEED OPERATOR	04MAR81	1	3.54
QUARRY TRUCK DRIVER	05MAR81	1	3.99
CRANE OPERATOR (RAW)	05MAR81	1	4.93
KILN FEED OPERATOR	05MAR81	1	1.15
FRONT END LOADER	05MAR81	1	1.64

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
KILN BURNER	04MAR81	1	0.99

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
CLEAN UP	03MAR81	1	5.28
BULK LOADER	03MAR81	1	1.22
BULK LOADER	04MAR81	1	0.79
PACKER	04MAR81	1	11.30

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
OILER (GENERAL)	03MAR81	1	10.67
ELECTRICIAN	03MAR81	1	1.89
WELDER	03MAR81	1	47.00
OVERHEAD CRANE	03MAR81	1	1.12
MILL OPERATOR	04MAR81	1	2.58
CRANE OPERATOR	04MAR81	1	4.31
REPAIRMAN	05MAR81	1	4.85
LABORER	05MAR81	1	3.15
SHIFT FOREMAN	05MAR81	1	0.96

Table 7

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	3	0.03	0.06	0.02	3.80	0	0.00	0.10
RAW	6	3.54	1.87	3.04	1.92	0	1.15	6.01
CLINKER	1	0.99	.	0.99	.	0	0.99	0.99
FINISH	4	4.65	4.87	2.76	3.46	0	0.79	11.30
MIX	9	8.50	14.73	3.82	3.32	0	0.96	47.00
PLANTWIDE	20	5.87	10.13	3.12	2.79	0	0.79	47.00

Figure 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

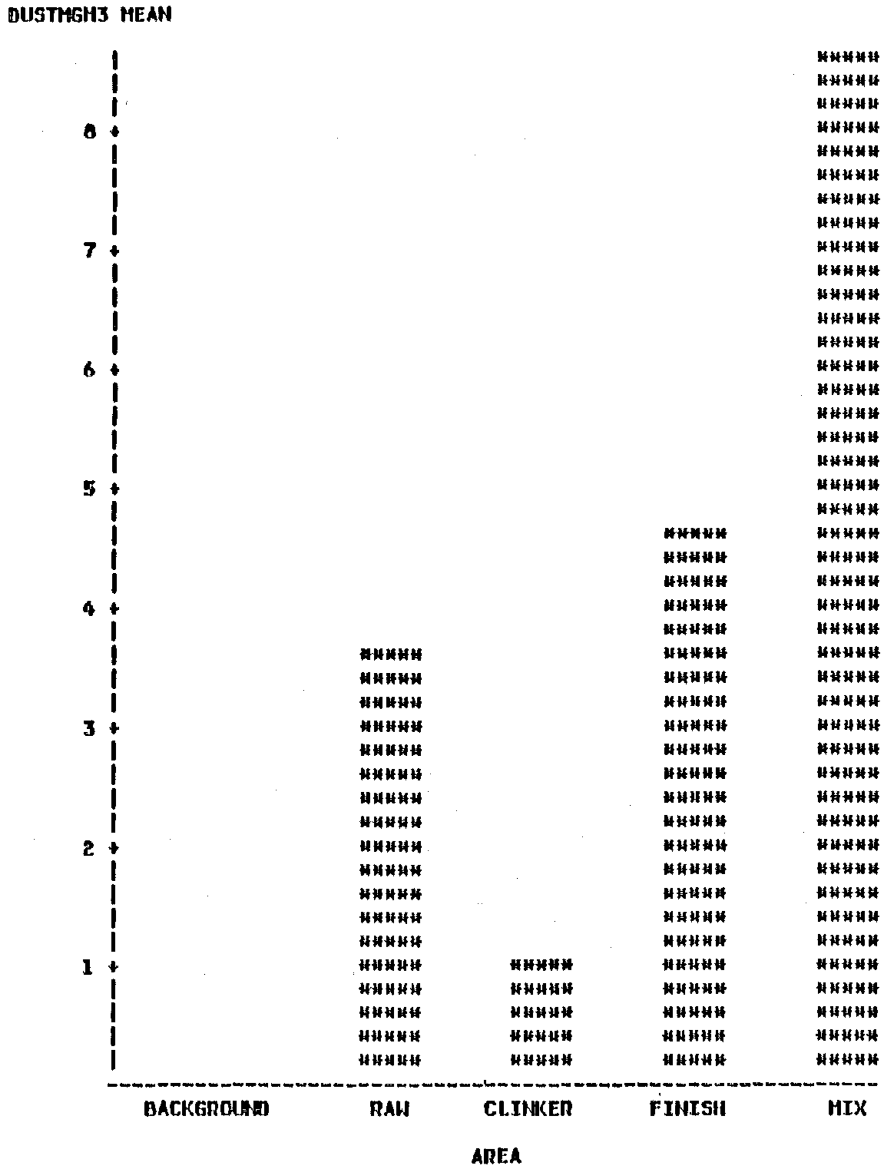


Figure 5

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

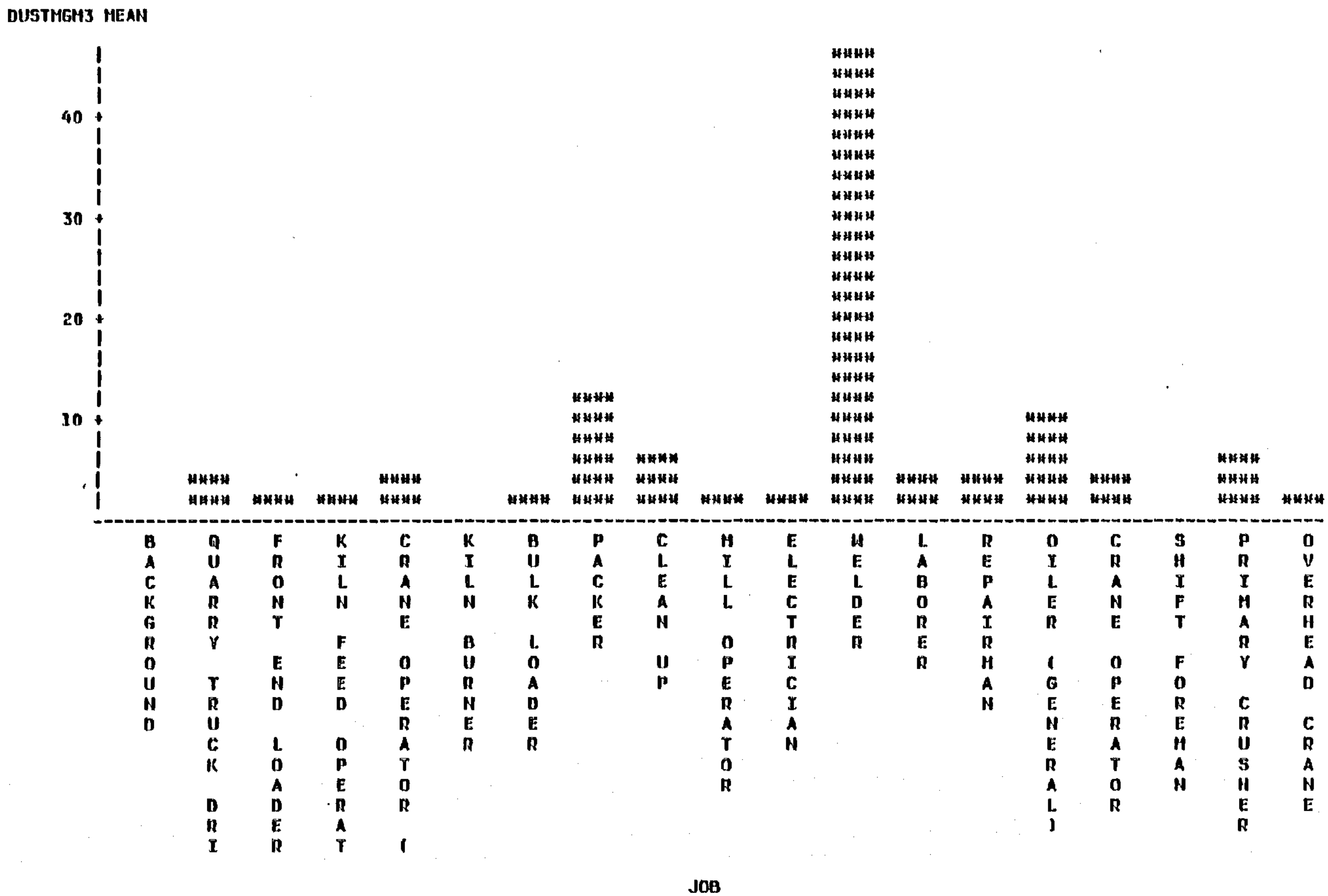


Table 8

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
TRACE METAL CONCENTRATIONS OF PERSONAL TOTAL DUST SAMPLES
CONCENTRATIONS IN MICROGRAMS PER CUBIC METER (UG/M3)

AREA	DATE	SHIFT	JOB	AL_UGM3	CR_UGM3	CO_UGM3	MG_UGM3	MN_UGM3	NI_UGM3
RAW	04MAR81	1	KILN FEED OPERATOR	34	N	N	16	N	N
RAW	05MAR81	1	FRONT END LOADER	N	N	N	8	N	N
RAW	05MAR81	1	CRANE OPERATOR (RAW)	100	N	N	21	N	N
RAW	05MAR81	1	KILN FEED OPERATOR	N	N	N	7	N	N
RAW	05MAR81	1	QUARRY TRUCK DRIVER	32	N	N	9	N	N
CLINKER	04MAR81	1	KILN BURNER	N	N	N	5	N	N
FINISH	03MAR81	1	CLEAN UP	77	N	N	40	N	N
FINISH	03MAR81	1	BULK LOADER	N	N	N	7	N	N
FINISH	04MAR81	1	BULK LOADER	N	N	N	7	4	N
FINISH	04MAR81	1	PACKER	93	N	N	101	N	N
MIX	03MAR81	1	OILER (GENERAL)	174	N	N	78	2	N
MIX	03MAR81	1	ELECTRICIAN	N	N	N	12	N	N
MIX	03MAR81	1	WELDER	671	11	N	366	49	5
MIX	04MAR81	1	CRANE OPERATOR	47	N	N	23	N	N
MIX	04MAR81	1	MILL OPERATOR	N	N	N	9	N	N
MIX	05MAR81	1	LABORER	35	N	N	30	N	N
MIX	05MAR81	1	SHIFT FOREMAN	N	N	N	4	N	N
MIX	05MAR81	1	REPAIRMAN	68	7	N	31	26	N

Table 9

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Marquette Cement, Rockmart, Georgia

Summary for Personal Trace Metal Concentrations in
Milligrams per Cubic Meter

Metal	N	Means	Std.dev.	Minimum	Maximum
Aluminum	10	133 ug/m^3	193.79	32	671
Chromium	2	9	2.52	7	11
Magnesium	18	43	84.73	4	366
Manganeese	4	20	22.13	2	49
Nickel	1	5	0	5	5

Table 10

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GEORGIA
TRACE METAL CONCENTRATIONS OF AREA TOTAL DUST SAMPLES
CONCENTRATIONS IN MICROGRAMS PER CUBIC METER (UG/M3)

AREA	DATE	SHIFT	JOB	AL_UGM3	CR_UGM3	CO_UGM3	MG_UGM3	MN_UGM3	NI_UGM3
BACKGROUND	02MAR81	2	BACKGROUND	N	N	N	N	N	N
BACKGROUND	03MAR81	1	BACKGROUND	N	N	N	1	N	N
BACKGROUND	04MAR81	1	BACKGROUND	N	N	N	1	N	N
RAW	02MAR81	2	BACK END OF KILN	36	N	N	19	N	N
RAW	03MAR81	1	PRIMARY CRUSHER	1378	7	N	261	13	N
RAW	04MAR81	1	FEED END RAW MILLS	37	N	N	19	N	N
RAW	05MAR81	1	RAW MILLS	57	N	N	25	N	N
RAW	05MAR81	1	PRIMARY CRUSHER	164	N	N	30	N	N
RAW	05MAR81	1	FEED END RAW MILLS	N	N	N	8	N	N
CLINKER	02MAR81	2	CLINKER COOLER	N	N	N	5	N	N
CLINKER	03MAR81	1	FRONT END OF KILN	N	N	N	2	N	N
CLINKER	04MAR81	1	KILN ROOM	N	N	N	10	N	N
FINISH	02MAR81	2	BAGGING	N	N	N	3	N	N
FINISH	03MAR81	1	BAGGING	132	N	N	63	N	N
FINISH	04MAR81	1	FINISH SILO TUNNEL	314	N	N	130	N	N
FINISH	05MAR81	1	BAGGING	160	N	N	91	N	N
FINISH	05MAR81	1	FINISH BALL MILLS	N	N	N	6	N	N
FINISH	05MAR81	1	FINISH BALL MILLS	85	N	N	37	2	N
MIX	02MAR81	2	MILL ROOM	N	N	N	9	N	N
MIX	03MAR81	1	OVERHEAD CRANE	231	N	N	101	N	N
MIX	04MAR81	1	MAINTENANCE SHOP	N	15	N	2	5	N

Table 11

Environmental Investigations Branch
Industrial Hygiene Survey of Cement Workers
Marquette Cement, Rockmart, Georgia

Summary for Personal Trace Metal Concentrations Per Cubic Meter Micrograms

Metal	N	Means	Std. Dev.	Minimum	Maximum
Aluminum	10	259 mg/m^3	402.86	36	1378
Chromium	2	11	5.66	7	15
Magnesium	20	41	63.82	1	261
Manganeese	3	7	5.65	2	13

Table 12

Environmental Investigations Branch
Industrial Hygiene Survey of Cement Workers
Marquette Cement, Rockmart, Georgia

Trace Metals Concentrations as Measured by ICP-AES
Concentrations in Micrograms per Cubic Meter (ug/m^3)

Exposure Areas

Metals	Feed End of Kiln	Clinker-Cooler	Packhouse	Mill Room
Aluminum	13.37	133.71	20.50	28.17
Calcium	320.65	1709.10	554.72	587.80
Chromium	N	5.68	N	16.02
Copper	N	4.45	N	N
Iron	12.75	81.81	17.68	33.77
Magnesium	3.70	55.61	12.58	26.24
Phosphorus	N	N	N	3.86
Potassium	29.82	108.75	9.62	16.40
Sodium	8.64	45.72	8.77	13.89
Titanium	N	10.87	N	N
Zinc	N	702.17	N	47.66

Table 13

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT   ROCKMART, GEORGIA
ANALYSIS OF BULK MATERIAL PRESENTED AS PERCENT BY WEIGHT

AREA	JOB	QUARTZ	CRISTB	AL	CR	CO	MG	MN	NI	ASBEST
RAW	INSULATION	3.0	N	4.1	0.01	N	3.7	0.13	N	0.0
RAW	RAW MATERIAL	7.0	N	1.3	0.02	N	0.7	0.02	0.008	0.0
RAW	RAW MATERIAL	6.0	N	0.8	0.02	N	0.7	0.02	N	0.0
RAW	RAW MATERIAL	6.0	N	1.0	0.02	N	0.7	0.02	N	0.0
RAW	RAW MATERIAL	2.0	N	0.4	N	N	0.7	0.01	N	0.0
RAW	RAW MATERIAL	48.0	N	1.7	0.04	N	0.1	0.02	N	0.0
RAW	RAW MATERIAL	7.0	N	1.2	0.01	N	0.6	0.02	N	0.0
RAW	RAW MATERIAL	7.0	N	0.5	0.01	N	0.6	0.01	N	0.0
CLINKER	CLINKER	N	N	2.2	0.03	N	1.1	0.02	0.010	0.0
CLINKER	CLINKER	N	N	N	0.01	0.01	0.9	0.02	0.010	0.0
CLINKER	CLINKER	N	N	2.3	0.02	0.01	1.1	0.02	0.010	0.0
CLINKER	CLINKER	N	N	1.7	0.01	N	1.0	0.02	0.008	0.0
CLINKER	CLINKER	N	N	1.8	0.02	0.01	1.0	0.02	0.009	0.0
FINISH	FINISH	N	N	2.7	0.02	N	1.1	0.02	0.010	0.0
FINISH	FINISH	N	N	2.4	0.02	N	1.1	0.02	0.010	0.0
FINISH	FINISH	N	N	1.0	0.01	N	1.3	0.01	0.010	0.0

Table 14

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
MARQUETTE CEMENT ROCKMART, GA.
SOX CONCENTRATIONS

JOB	DATE	SHIFT	AREA	SO4_UGM3	SO3_UGM3	SO2_PPM
BACK END OF KILN	03MAR81	1	RAW	33.51	N	0.01
BACK END OF KILN	03MAR81	1	RAW	35.38	N	0.01
FEED END RAW MILLS	03MAR81	1	RAW	88.75	N	0.02
BAG HOUSE	04MAR81	1	RAW	38.21	N	0.01
FEED END RAW MILLS	04MAR81	1	RAW	15.70	N	0.01
FEED END RAW MILLS	05MAR81	1	RAW	18.94	N	N
DISCHARGE STACK (BOTTOM)	05MAR81	1	RAW	16.50	N	0.01
KILN ROOM	05MAR81	1	CLINKER	69.48	N	0.01

APPENDIX

Physiological Response

The main function of the lungs is to keep the oxygen and carbon dioxide content of the arterial blood within a certain narrow range. In order to accomplish this, the lungs must bring the blood in contact with the air. The lungs are ventilated by a bellows action, when the chest cavity is expanded by the contraction of the diaphragm. This creates a negative pressure in the lungs causing air to rush in.

When a person breathes, air is drawn through the nose into the nasopharynx and trachea. From there it reaches the alveoli or area of gas exchange through a system of ducts: the bronchi, respiratory bronchioles, and the terminal bronchioles. It is in the alveoli where the blood is oxygenated and carbon dioxide diffuses into the lungs to be excreted. Deposition of airborne particles occurs as a consequence of several different physical processes. Of primary concern are sedimentation, inertial impaction, and diffusion. Sedimentation is simply the settling out of particles onto respiratory tissue under the influence of gravity. Inertial impaction occurs when the momentum of particles being carried along in an air current carries them along their original path when the air current changes direction. The particles may then be deposited on the surface of respiratory tissue. Besides sedimentation and impaction, very small particles are affected by diffusion. Since movement of small particles in air is completely random, those that are in close proximity to the alveolar wall are likely to collide with it and hence be deposited. (15)

In order to remove particles from the respiratory system, two separate mechanisms are present. Those particles deposited in the upper airways are removed by the mucociliary escalator. In the upper airways there is a series of tiny hairs or cilia which are continually sweeping mucous and particles upward toward the throat. The mucous provides a sticky layer to capture and hold the particulate, while the cilia remove it from the respiratory system. In the terminal bronchioles and the alveoli, deposited material is removed by phagocytes; or cells which actually consume the particles and digest them.

Problems arise, however, when the respiratory system is overcome. Whenever there is a high concentration of dust, the mucociliary escalator and the phagocytes may not be able to remove all of the particles. Also, the particles may possess unique properties which prevent the natural defenses of the lung from eliminating them.

It is the intent of this study to determine which materials may be toxic to the respiratory system, and what concentration and duration of exposure may produce physiological changes.