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Industrial Hygiene Survey of Coplay Cement Co.

Nazareth, Pennsylvania

Cement Workers Morbidity Study

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16. Abstract (Limit: 200 words) A survey was conducted at the Coplay Cement Company, Nazareth, Pennsylvania as part of a study of the effects of materials found in Portland Cement facilities on the human respiratory system. Personal and area samples were collected and analyzed for total and respirable dust, quartz (14808607), trace elements, and toxic gases. For most of the jobs at this site the respirable and total dust levels were below recommended exposure limits. The ACGIH recommended level of 5mg/m3 for respirable nuisance particulate was exceeded in four samples. Quartz was detected in 18 personal respirable dust samples, with six of these exceeding the MSHA-PEL levels. Exposure to quartz occurred primarily in the quarry and in areas associated with the raw materials and coal. The authors recommend that measures be taken to reduce exposures, including the increased use of personal protective equipment in the areas with raw material and coal exposures.

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Executive Summary

The Coplay Cement Plant in Nazareth, Pennsylvania was surveyed by a NIOSH team of industrial hygienists, on June 16 through June 19, 1981. Samples were collected and analyzed for respirable and total dust, free crystalline silica, aluminum, cobalt, magnesium, manganese, nickel, other trace elements, asbestos, oxides of sulfur, and nitrogen dioxide.

The respirable and total dust levels for most jobs are below recommended exposure levels. Four respirable samples exceeded the ACGIH recommended exposure level for nuisance particulate. Six repirable dust samples contained quartz in excess of the MSHA-PEL for respirable quartz. Of the dust contaminants measured only quartz was present in excessive concentrations.

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. Coplay Cement in Nazareth, Pennsylvania was the ninth 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 Coplay Cement facilities in Nazareth, Coplay, and Egypt, Pennsylvania were surveyed on Tuesday, June 16 through Friday, June 19, 1981, by Charles Connors, Joe Burkhart, and Wayne Sanderson. The present kiln and mill system in Nazareth began operation in 1978, but was built on the site of an old plant which dates back to 1920. Most of the present workforce had been employed in the old plant. The plant was built adjacent to a cement rock quarry which serves as the source of raw material. The main plant in Nazareth is also supported by two other quarries in Egypt and Coplay, Pennsylvania. Raw materials are crushed at the quarries and transported to the plant at Nazareth where they are milled and blended with other raw materials such as iron ore and sand. Cement clinkers are produced from the raw materials in one kiln - preheater system by the dry process method. The kiln is fueled by pulverized coal. Gypsum is added to the clinker and it is milled at the Nazareth and Egypt plants to increase fineness; the ground powder is Portland Cement. Eleven types of Portland cement are manufactured by Coplay cement, and are bagged in Egypt or loaded out as bulk in trucks or railcars in Nazareth. Approximately 200 workers are employed at Coplay Cement.

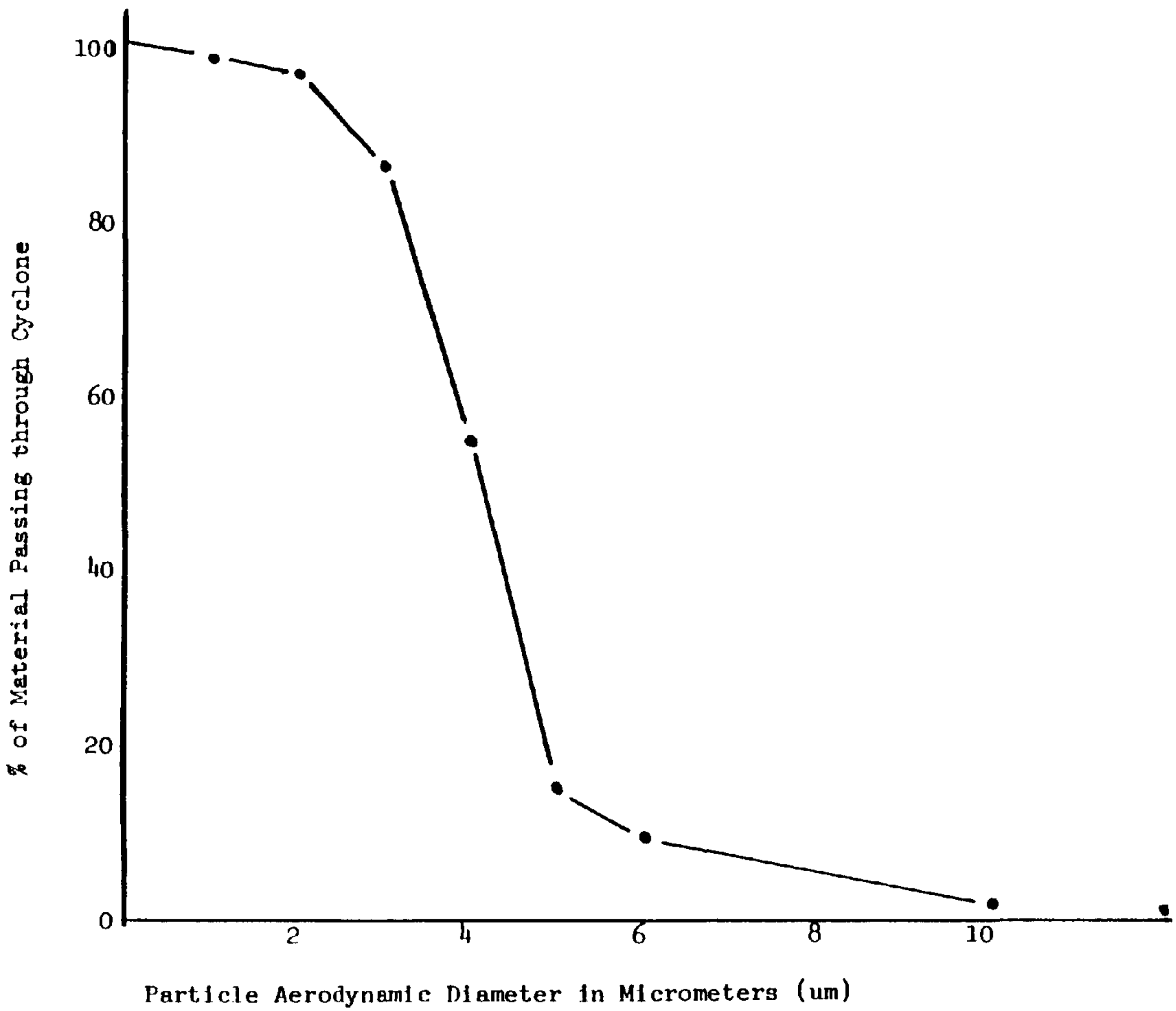
There are two other cement plants in Nazareth. The Coplay Cement facilities are located in the Lehigh Valley along with several other cement producing companies. Portland cement was first produced in the United States at Coplay, Pennsylvania. The area continues to be a major source of Portland cement.

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

Figure 1 COLLECTION EFFICIENCY OF THE PERSONAL RESPIRABLE DUST CYCLONE



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 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. 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 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 which had 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.

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.

One area sample from each exposure category was analyzed for content of 28 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 transmission electron microscopy to determine whether they were asbestos fibers.

In this survey 11 samples were collected for fibers. These samples were collected in the raw material crushing and milling areas, storage areas, kiln 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, or whether the material was felt to be predominantly raw material, clinker, finished Portland cement, or a mixture of two or more types of dust. 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 12 samples collected for sulfate and sulfite particulates and sulfur dioxide gas are presented in Table 14. The JOB column indicates where the sample was collected. The SO4_UGM3 and SO3_UGM3 columns indicate the sulfate and sulfite concentrations in micrograms per cubic meter. The SO2_PPM column indicates the sulfur dioxide concentration in parts per million. The analytical limits of detection are listed in Table 1.

Nitrogen Dioxide Samples

Nitrogen dioxide sampling was done using passive dosimeters for both area and personal sampling. Full shift time-weighted average exposures were determined. Dosimeters were constructed by cutting lengths of acrylic tubing to give a length-to-area ratio of 10 to 1. One end of the tube was fitted with a removable cap-plug and the other end was sealed with a cap containing he collection grids. These grids were coated with triethanolamine which quantitatively absorbs NO_2. During exposure, the cap-plug was removed and the contaminant gas diffused to the collection grid according to Fick's Law of Diffusion. After collection a sulfanilamide-phosphoric acid-NEDA solution was added to the dosimeter, where a red color complex with NO_2 was formed. The solution was transferred to a spectrophotometer and the absorbtivity is measured at 540 nm. This was compared against a standard curve to give nanomoles NO_2, from which the concentration was calculated as: (20, 21)

$$\text{Conc, ppm} = \frac{\text{nanomoles } NO_2}{2.3 \times \text{Hours of Exposure}}$$

These samples were collected for periods between 6 and 8 hours. The measurements reflect the average concentration over this period. The results of the analysis are presented in Table 15. Nitrogen dioxide is produced from the combustion of organic compounds, such as coal and diesel fuel, which contain nitrogen.

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 properly, sampler adjustments and appropriate notations were made and, if necessary, the results of such samples were voided.

The environmental investigations team began sampling Tuesday, June 16, 1981. The sampling schedule was as follows:

Tuesday, June 16 - 2nd shift
Wednesday, June 17 - 1st shift
Thursday, June 18 - 1st shift
Thursday, June 19 - 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:

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

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 5.0 mg/m^3. Three of these samples were from workers in finished cement areas. They were worn by a tunnelman, a clean-up worker, and a mill operator. The tunnelman is also called the kitcher at the Nazareth plant; he has the extremely dusty job of forcing a compressed air line into the bottom of finished cement silos in order to maintain product flow. The clean-up worker spent most of his shift tapping silos in the silo tunnel of the Egypt plant. The mill operator was oiling and maintaining two ball mills that were making light velvet cement. A millwright (maintenance worker), who was repairing dust collectors at the Egypt mill and bagging operations, had a respirable dust measurement of 4.99 mg/m^3. Another sample was from a laborer in the quarry who was primarily working around the crushers. He was exposed to raw material dust. No personal samples from the clinker or mixed dust areas were greater than 5.0 mg/m^3. For all workers the geometric mean dust level was 0.70 mg/m^3.

The personal total dust levels, Table 4, were all below 10.0 mg/m^3. For all workers, the geometric mean was 1.71 mg/m^3.

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, clean-up workers, tunnelman, and mill operators 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

A coal, Dark Velvet Cement, and five raw material bulk samples contained quartz. Quartz is a common constituent of limestone, clay, and sand, and frequently is found as a contaminant in coal dust. From 5.6 to 8.3% quartz was detected in crushed and milled raw material from the Nazareth plant; 1.7% quartz was detected in dust from the kiln feed area of the preheater tower. Quartz is generally not found in clinker or finished cement, because after quartz passes through the high kiln temperatures, it is transformed from its free crystalline form into silicates. However, 4.0% quartz was detected in a sample of Dark Velvet Cement. A quartz containing material may be added during the grinding process to produce this type of finished cement. The coal sample contained 3.2% quartz.

Eighteen personal resirable dust samples contained detectable levels of quartz. Ten of these samples were from workers who had spent most of their shift in the quarry or crushers exposed to raw material dust. The other eight samples were from workers who were exposed to a mixture of two or more types of dust. The highest percentage of quartz found on any filter was from an oiler (43.7%). He oiled the kiln and in the preheater tower.

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 1.3 - 43.7%.

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. Six of the eighteen samples exceed the permissible exposure limit. All of these samples were from workers in the quarry. Five of the eighteen 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, chromium, cobalt and nickel are occasionally found. 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, and sodium.

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 in the range of 0.01-0.04 ppm were found in the preheater building and the back end of the kiln. 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 Coplay. (1, 12, 13)

Nitrogen Dioxide

Nitrogen dioxide is a reddish-brown gas which is a common contaminant in the exhaust of internal combustion engines. It is an irritant to the mucous membranes and its inhalation may cause coughing, sometimes severe, which may be accompanied by mild or transient headache.

Based on animal studies, a ceiling limit (the concentrations, not to be exceeded even instantaneously) of 5 ppm has been recommended. (23) This level was considered sufficiently low to insure against immediate injury or adverse physiologic effects from prolonged daily exposures. The present federal standard (MSHA and OSHA) for nitrogen dioxide is 5 ppm as an 8-hour time-weighted average (TWA). (24) This was based upon the ACGIH TLV except that the ceiling designation was omitted. (27) A number of human experiments and animal studies suggest that humans with normal respiratory function may be affected by exposure at or below this level and that the conditions of workers with disease such as bronchitis may be aggravated by such exposures. (25,26,27,28) NIOSH recommends a ceiling of 1 ppm to protect workers with pre-existing chronic bronchitis. ACGIH maintains a STEL of 5 ppm and a TWA of 3 ppm.

All of the 32 samples taken at Coplay Cement were below the recommended standard.

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. Since Coplay Cement is situated among other industries, 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 1 and 2 list the background respirable dust levels and their descriptive statistics.

Conclusion

The respirable and total dust levels for most jobs at the Coplay Cement Plant in Nazareth, Pennsylvania are below recommended exposure levels. Four samples exceeded the ACGIH recommended level for respirable nuisance particulate. Eighteen personal respirable dust samples contained detectable levels of quartz. Six of these samples exceeded the MSHA-PEL for respirable quartz. Of. the dust contaminants measured, only quartz is considered to be present in excessive concentrations. Exposure to quartz occurs primarily in the quarry and in areas associated with the raw materials and coal. Protective measures should be taken.

Recommendations

Workers may need to be periodically monitored with respirable dust samplers to determine worker exposures to respirable dust and quartz. A routine surveillance program would indicate areas of overexposure for directing dust control measures, and ensure that worker exposures are being maintained below recommended levels.

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. The kitcher has an unusual task, which creates a great deal of airborne dust. This practice should be eliminated or modified so that the worker does not have to stand in the generated dust cloud. Since six samples collected in the quarry exceeded the MSHA-PEL for respirable quartz, this would be an area 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.

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.

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Table 1

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Coplay Cement - Nazareth, Pennsylvania

Number of Samples With Detectable Levels of Contaminants

Contaminant	# Samples Collected	# Samples With Detectable Conc.	Limit of Detection
Respirable dust	73	73	0.01 mg
Total dust	13	13	0.01 mg
Quartz	75	18	0.03 mg
Cristobalite	75	0	0.03 mg
Aluminum	27	20	0.20 mg
Chromium	27	18	0.004 mg
Cobalt	27	0	0.005 mg
Magnesium	27	27	0.002 mg
Manganese	27	4	0.002 mg
Nickel	27	2	0.004 mg
Asbestos	11	0	4500 fibers
Sulfates	12	12	0.005 mg
Sulfites	12	0	0.01 mg
Sulfur dioxide	12	12	0.005 mg
Nitrogen dioxide	30	27	0.02 ppm

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
LABORER (QUARRY)	16JUN81	2	6.13
MECHANIC (QUARRY)	16JUN81	2	2.88
FRONT END LOADER	16JUN81	2	1.74
FRONT END LOADER	16JUN81	2	1.78
LABORER (QUARRY)	17JUN81	1	0.56
MECHANIC (QUARRY)	17JUN81	1	0.61
QUARRY TRUCK DRIVER	17JUN81	1	0.28
FRONT END LOADER	17JUN81	1	0.24
DRILLER	17JUN81	1	0.69
QUARRY TRUCK DRIVER	18JUN81	1	1.10
QUARRY TRUCK DRIVER	18JUN81	1	0.25
FRONT END LOADER	18JUN81	1	0.39
FRONT END LOADER	18JUN81	1	0.57
QUARRY TRUCK DRIVER	18JUN81	1	0.53
PRIMARY CRUSHER OPERATOR	18JUN81	1	0.77
CONVEYOR OPERATOR	19JUN81	1	3.92
PRIMARY CRUSHER OPERATOR	19JUN81	1	0.69

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
TRUCK DRIVER (CLINKER)	16JUN81	2	0.28
TRUCK DRIVER (CLINKER)	16JUN81	2	0.34
EQUIPMENT OPERATOR	16JUN81	2	0.85
EQUIPMENT OPERATOR	18JUN81	2	2.70

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
BULK LOADER	16JUN81	2	0.30
TUNNELMAN (FINISH)	17JUN81	1	19.57
BULK LOADER	17JUN81	1	1.79
CLEAN UP	18JUN81	1	18.88
MAINTENANCE (FINISH)	18JUN81	1	4.99
MAINTENANCE (FINISH)	18JUN81	1	1.68
CLEAN UP	18JUN81	1	0.41
MAINTENANCE (FINISH)	18JUN81	1	2.37
UTILIYMAN (FINISH)	18JUN81	1	0.87
FORKLIFT OPERATOR (FINISH)	18JUN81	1	0.34
FORKLIFT OPERATOR (FINISH)	18JUN81	1	0.49
PACKER	18JUN81	1	1.53
PACKER	18JUN81	1	2.55
PACKER	18JUN81	1	1.94
CLEAN UP	18JUN81	1	1.02
CLEAN UP	18JUN81	1	1.16
MILL OPERATOR (FINISH)	18JUN81	2	8.23

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
REPAIRMAN	16JUN81	2	0.22
UTILITY (SHIFT)	16JUN81	2	1.34
LABORATORY WORKER	16JUN81	2	0.09
CONSOLE OPERATOR	16JUN81	2	0.07
REPAIRMAN	16JUN81	2	0.15
UTILITY (SHIFT)	16JUN81	2	1.64
REPAIRMAN	17JUN81	1	0.50
REPAIRMAN	17JUN81	1	0.73
WELDER	17JUN81	1	0.27
JANITOR	17JUN81	1	0.20
UTILITY (SHIFT)	17JUN81	1	0.44
PIPEFITTER	17JUN81	1	0.37
REPAIRMAN	17JUN81	1	2.90
MASON LABORER	17JUN81	1	0.29
OILER (GENERAL)	17JUN81	1	0.37
MOBILE EQUIPMENT OPER (PLANT)	17JUN81	1	0.26
LABORER	19JUN81	1	0.54
MACHINIST	19JUN81	1	0.27
LABORER	19JUN81	1	0.68
DUST COLLECTOR	19JUN81	1	1.22
REPAIRMAN	19JUN81	1	0.48
LABORER	19JUN81	1	0.63
MASON	19JUN81	1	0.44
REPAIRMAN	19JUN81	1	0.43
MOBILE EQUIPMENT OPER (PLANT)	19JUN81	1	0.88
CONSOLE OPERATOR	19JUN81	1	0.04
YARD WORKERS	19JUN81	1	1.10
OILER (GENERAL)	19JUN81	1	0.20
LABORER	19JUN81	1	0.16
UTILITY (SHIFT)	19JUN81	1	2.30
REPAIRMAN	19JUN81	1	0.60
WELDER	19JUN81	1	0.49
YARD WORKERS	19JUN81	1	0.70
MACHINIST	19JUN81	1	0.26
REPAIRMAN	19JUN81	1	0.26

Table 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
RAW	17	1.36	1.59	0.85	2.59	0	0.24	6.13
CLINKER	4	1.04	1.13	0.68	2.81	0	0.28	2.70
FINISH	17	4.01	6.06	1.77	3.56	0	0.30	19.57
MIX	35	0.61	0.62	0.41	2.55	0	0.04	2.90
PLANTWIDE	73	1.60	3.29	0.70	3.22	0	0.04	19.57

Figure 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

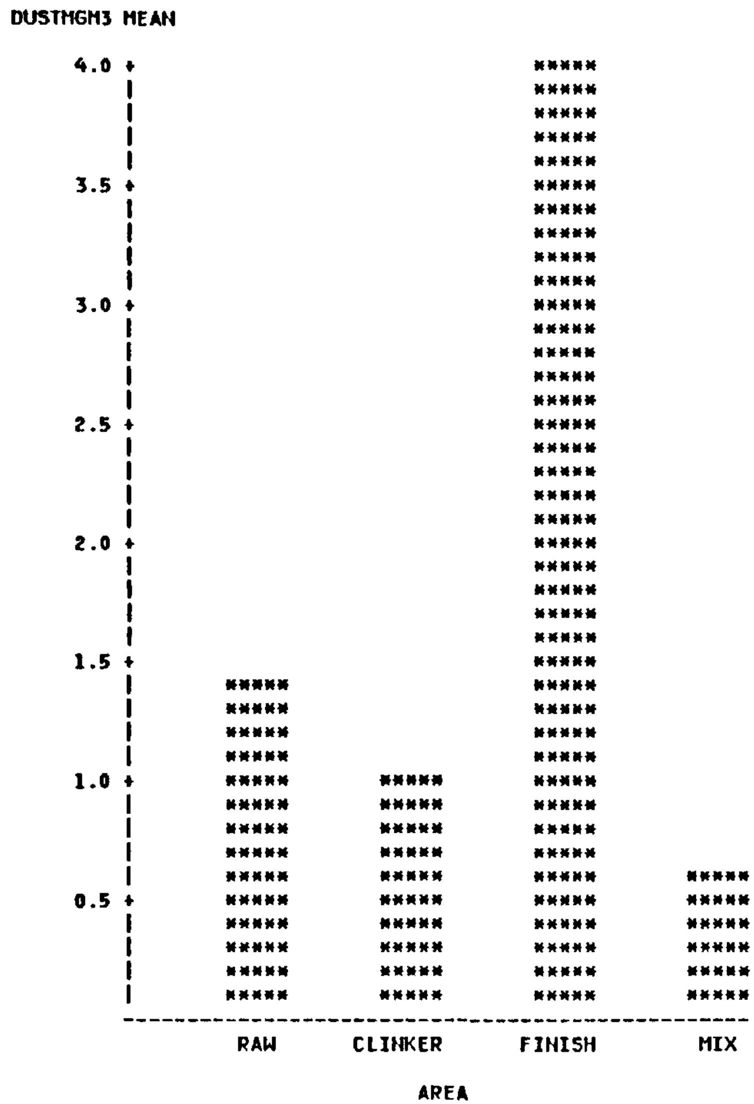

Figure 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

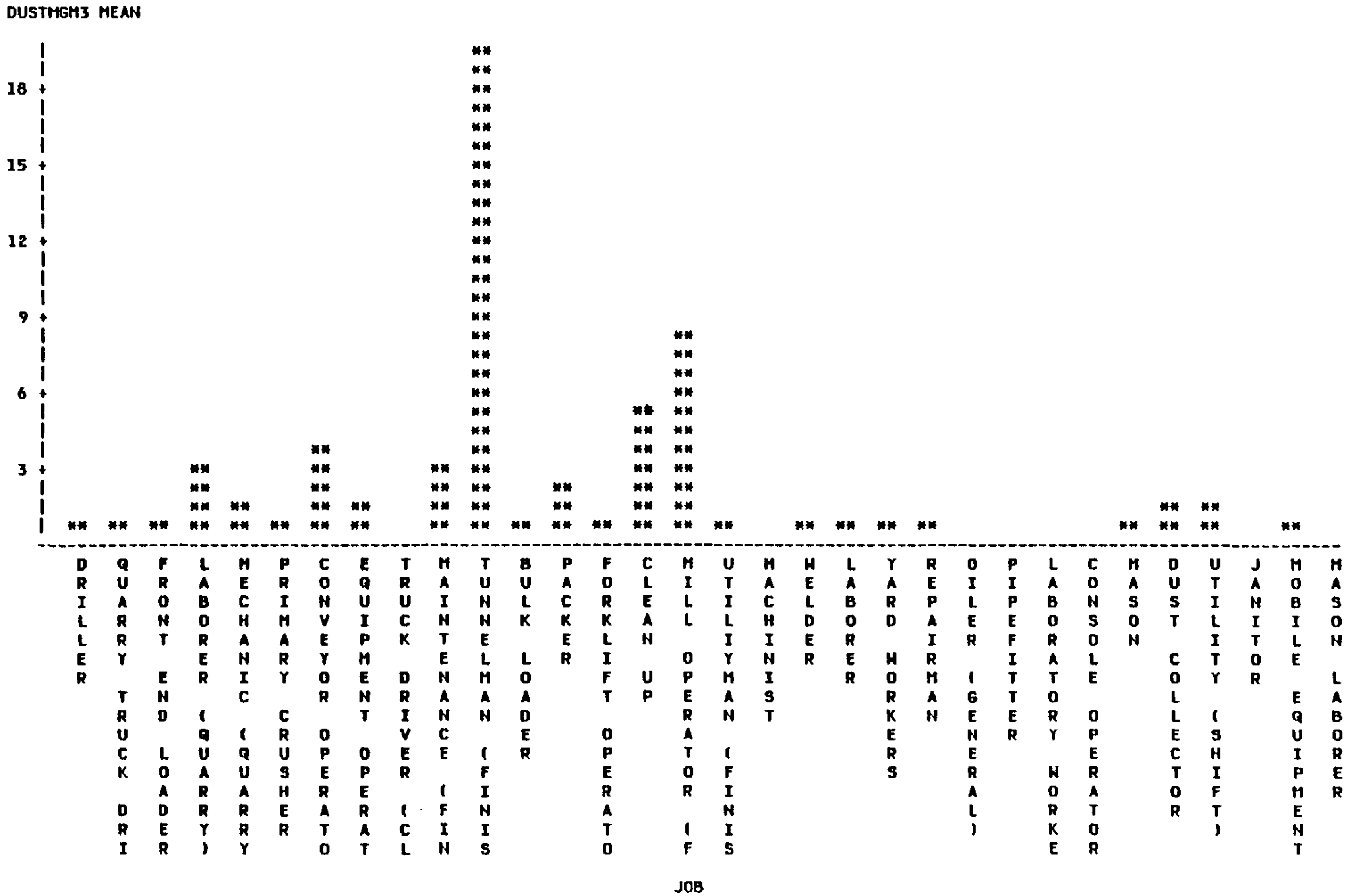

Table 4

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

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
FRONT END LOADER	16JUN81	2	N	N	RAW
MECHANIC (QUARRY)	16JUN81	2	N	N	RAW
FRONT END LOADER	16JUN81	2	N	N	RAW
LABORER (QUARRY)	16JUN81	2	1.3	79.18	RAW
QUARRY TRUCK DRIVER	17JUN81	1	N	N	RAW
FRONT END LOADER	17JUN81	1	N	N	RAW
LABORER (QUARRY)	17JUN81	1	8.9	49.48	RAW
MECHANIC (QUARRY)	17JUN81	1	N	N	RAW
DRILLER	17JUN81	1	12.3	85.03	RAW
FRONT END LOADER	18JUN81	1	26.9	105.49	RAW
QUARRY TRUCK DRIVER	18JUN81	1	17.6	44.87	RAW
FRONT END LOADER	18JUN81	1	N	N	RAW
QUARRY TRUCK DRIVER	18JUN81	1	N	N	RAW
PRIMARY CRUSHER OPERATOR	18JUN81	1	18.6	143.42	RAW
QUARRY TRUCK DRIVER	18JUN81	1	19.5	102.52	RAW
PRIMARY CRUSHER OPERATOR	19JUN81	1	16.7	115.75	RAW
CONVEYOR OPERATOR	19JUN81	1	8.9	347.92	RAW
TRUCK DRIVER (CLINKER)	16JUN81	2	N	N	CLINKER
TRUCK DRIVER (CLINKER)	16JUN81	2	N	N	CLINKER
EQUIPMENT OPERATOR	16JUN81	2	N	N	CLINKER
EQUIPMENT OPERATOR	18JUN81	2	N	N	CLINKER
BULK LOADER	16JUN81	2	N	N	FINISH
TUNNELMAN (FINISH)	17JUN81	1	N	N	FINISH
BULK LOADER	17JUN81	1	N	N	FINISH
CLEAN UP	18JUN81	1	N	N	FINISH
FORKLIFT OPERATOR (FINISH)	18JUN81	1	N	N	FINISH
FORKLIFT OPERATOR (FINISH)	18JUN81	1	N	N	FINISH
MAINTENANCE (FINISH)	18JUN81	1	N	N	FINISH
CLEAN UP	18JUN81	1	N	N	FINISH
PACKER	18JUN81	1	N	N	FINISH
PACKER	18JUN81	1	N	N	FINISH
CLEAN UP	18JUN81	1	N	N	FINISH
CLEAN UP	18JUN81	1	N	N	FINISH
PACKER	18JUN81	1	N	N	FINISH
MAINTENANCE (FINISH)	18JUN81	1	N	N	FINISH
UTILIYMAN (FINISH)	18JUN81	1	N	N	FINISH
MAINTENANCE (FINISH)	18JUN81	1	N	N	FINISH
MILL OPERATOR (FINISH)	18JUN81	2	N	N	FINISH
BULK LOADER	19JUN81	1	N	N	FINISH
UTILITY (SHIFT)	16JUN81	2	N	N	MIX
REPAIRMAN	16JUN81	2	N	N	MIX
LABORATORY WORKER	16JUN81	2	N	N	MIX
UTILITY (SHIFT)	16JUN81	2	N	N	MIX
REPAIRMAN	16JUN81	2	N	N	MIX
CONSOLE OPERATOR	16JUN81	2	N	N	MIX
PIPEFITTER	17JUN81	1	N	N	MIX
MOBILE EQUIPMENT OPER (PLANT)	17JUN81	1	N	N	MIX
JANITOR	17JUN81	1	N	N	MIX
UTILITY (SHIFT)	17JUN81	1	N	N	MIX
WELDER	17JUN81	1	N	N	MIX
OILER (GENERAL)	17JUN81	1	N	N	MIX
REPAIRMAN	17JUN81	1	N	N	MIX

Table 4

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

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
MASON LABORER	17JUN81	1	N	N	MIX
REPAIRMAN	17JUN81	1	N	N	MIX
REPAIRMAN	17JUN81	1	N	N	MIX
REPAIRMAN	19JUN81	1	N	N	MIX
LABORER	19JUN81	1	N	N	MIX
REPAIRMAN	19JUN81	1	N	N	MIX
WELDER	19JUN81	1	N	N	MIX
LABORER	19JUN81	1	N	N	MIX
REPAIRMAN	19JUN81	1	N	N	MIX
MACHINIST	19JUN81	1	18.2	48.39	MIX
YARD WORKERS	19JUN81	1	6.9	48.09	MIX
DUST COLLECTOR	19JUN81	1	N	N	MIX
MOBILE EQUIPMENT OPER (PLANT)	19JUN81	1	7.4	64.36	MIX
LABORER	19JUN81	1	11.4	61.25	MIX
MASON	19JUN81	1	N	N	MIX
YARD WORKERS	19JUN81	1	3.3	35.99	MIX
UTILITY (SHIFT)	19JUN81	1	N	N	MIX
OILER (GENERAL)	19JUN81	1	43.7	85.57	MIX
UTILITY (SHIFT)	19JUN81	1	1.7	39.22	MIX
LABORER	19JUN81	1	8.6	58.31	MIX
MACHINIST	19JUN81	1	N	N	MIX
REPAIRMAN	19JUN81	1	9.1	38.87	MIX
CONSOLE OPERATOR	19JUN81	1	N	N	MIX

Table 5

Environmental Investigations Branch

Cement Workers Morbidity Study
Coplay Cement - Nazareth, Pennsylvania

Detectable Quartz Compared to MSHA Permissible Exposure Levels

Job	Levels of Dust Conc. Mg/m^3	Quartz % Quartz	Ug/M^3	MSHA PEL mg/m^3
Laborer (quarry)	6.13*	1.3	79.18	3.03
Laborer (quarry)	0.56	8.9	49.48	0.92
Driller	0.69	12.3	85.03	0.70
Frontend loader	0.39*	26.9	105.49	0.35
Quarry truck driver	0.25	17.6	44.87	0.51
Primary crusher oper.	0.77*	18.6	143.42	0.49
Quarry truck driver	0.53*	19.5	102.52	0.47
Primary crusher oper.	0.69*	16.7	115.75	0.53
Conveyor oper.	3.92*	8.9	347.92	0.92
Machinist	0.27	18.2	48.39	0.50
Yard worker	0.70	6.9	48.09	1.12
Mobile equipment oper.	0.88	7.4	64.36	1.06
Laborer	0.54	11.4	61.25	0.75
Yard worker	1.10	3.3	35.99	1.89
Oiler	0.20	43.7	85.57	0.22
Utility	2.3	1.7	39.22	2.70
Laborer	0.68	8.6	58.31	0.94
Repairman	0.43	9.1	38.87	0.90

*Indicates measured concentration exceeds the MSHA Permissible Exposure Limit.

Table 6

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
QUARRY TRUCK DRIVER	17JUN81	1	0.62
FRONT END LOADER	17JUN81	1	0.52

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
BULK LOADER	17JUN81	1	0.60

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
UTILITY (SHIFT)	17JUN81	1	2.43
ELECTRICIAN	17JUN81	1	1.22
REPAIRMAN	17JUN81	1	6.64
ELECTRICIAN	17JUN81	1	0.51
ELECTRICIAN	18JUN81	1	7.72
ELECTRICIAN	19JUN81	1	4.30
ELECTRICIAN	19JUN81	1	3.16
LABORER	19JUN81	1	2.62
UTILITY (SHIFT)	19JUN81	1	2.31
ELECTRICIAN	19JUN81	1	0.91

Table 7

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT   NAZARETH, PENNSYLVANIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
RAW	2	0.57	0.07	0.57	1.13	0	0.52	0.62
FINISH	1	0.60	.	0.60	.	0	0.60	0.60
MIX	10	3.18	2.39	2.38	2.36	0	0.51	7.72
PLANTWIDE	13	2.58	2.37	1.71	2.64	0	0.51	7.72

Figure 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

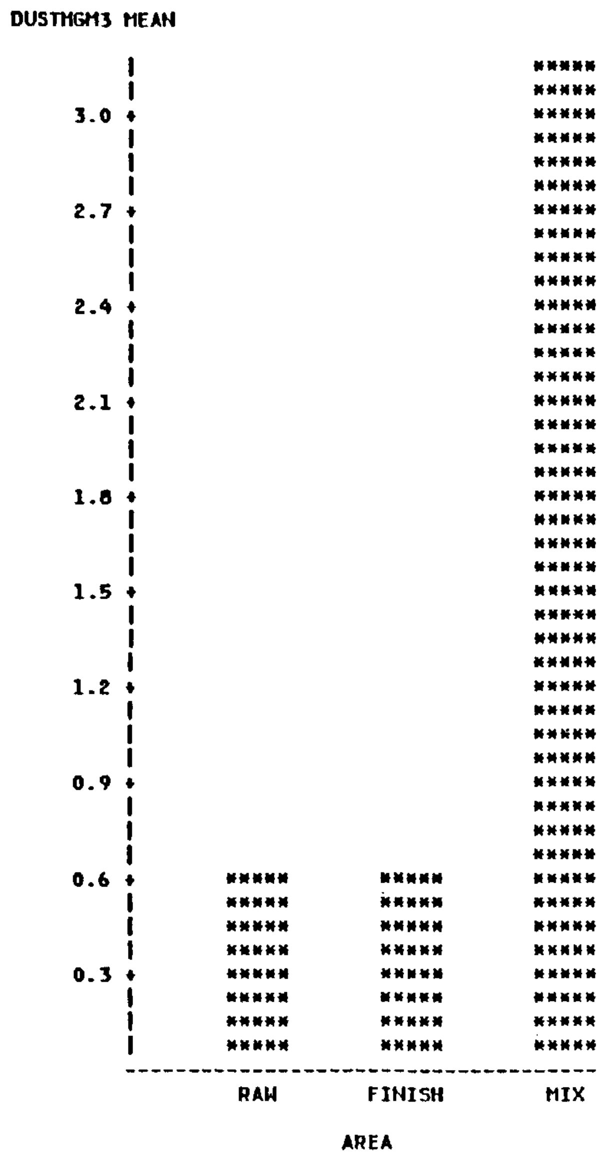

Figure 5

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT   NAZARETH, PENNSYLVANIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

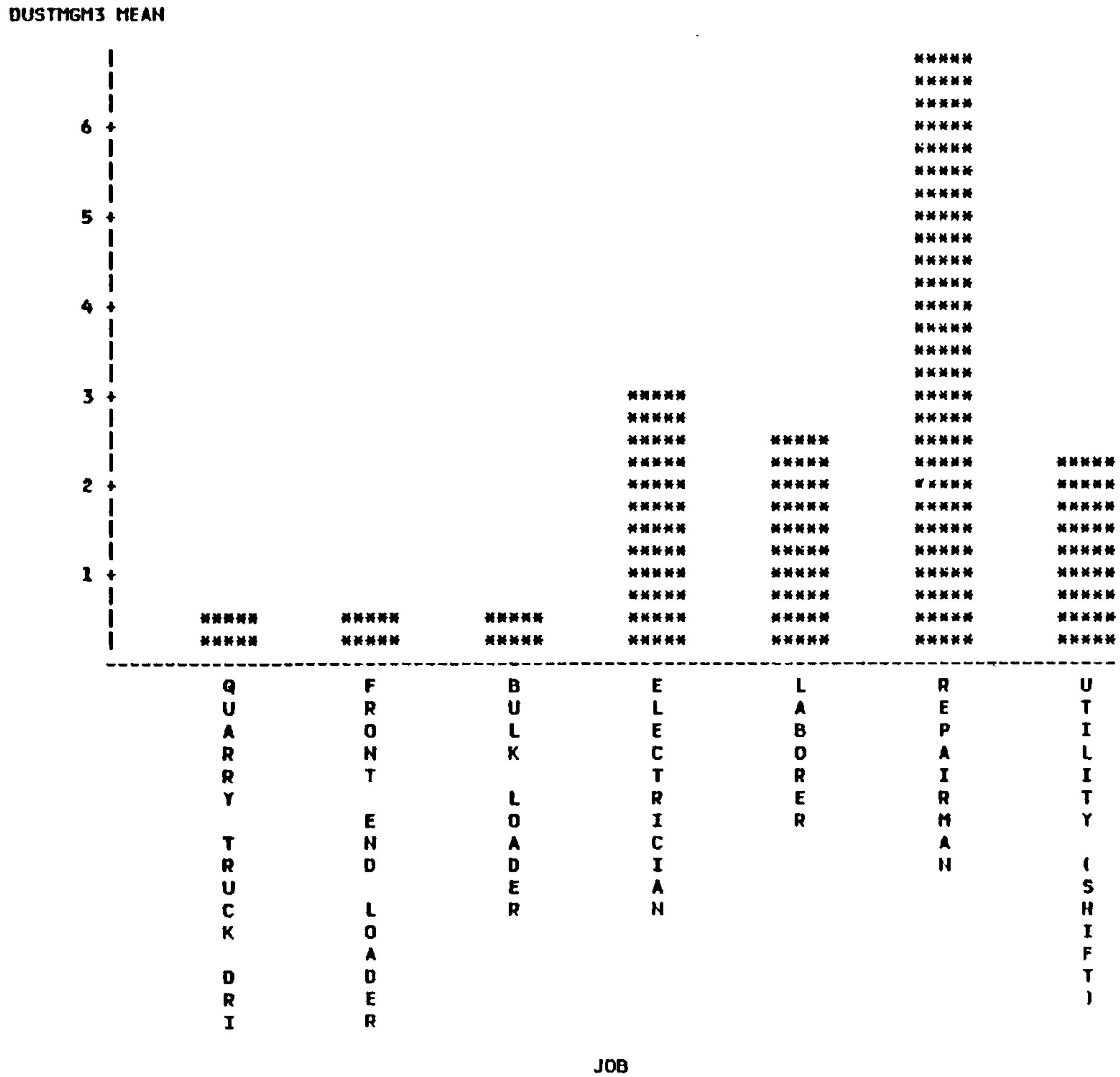

Table 8

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
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	17JUN81	1	QUARRY TRUCK DRIVER	16	5	N	14	N	N
RAW	17JUN81	1	FRONT END LOADER	N	N	N	7	N	N
FINISH	17JUN81	1	BULK LOADER	N	N	N	8	N	N
MIX	17JUN81	1	REPAIRMAN	45	N	N	55	N	N
MIX	17JUN81	1	MOBILE EQUIPMENT OPER (PLANT)	802	9	N	880	14	N
MIX	17JUN81	1	ELECTRICIAN	20	N	N	20	N	N
MIX	17JUN81	1	UTILITY (SHIFT)	16	N	N	19	N	N
MIX	18JUN81	1	ELECTRICIAN	89	N	N	97	3	N
MIX	19JUN81	1	UTILITY (SHIFT)	1528	11	N	1754	23	N
MIX	19JUN81	1	ELECTRICIAN	40	N	N	37	N	N
MIX	19JUN81	1	ELECTRICIAN	16	N	N	7	N	N
MIX	19JUN81	1	LABORER	45	5	N	32	N	N
MIX	19JUN81	1	ELECTRICIAN	67	9	N	95	N	N

Table 9

Environmental Investigations Branch

Cement Workers Morbdity Study
Coplay Cement, Nazareth, Pennsylvania

Summary for Personal Trace Metal Concentrations
In Micrograms per Cubic Meter (ug/m^3)

Metal	N	Means	Std. Dev.	Minimum	Maximum
Aluminum	11	244	483.95	16	1528
Chromium	5	8	2.57	5	11
Magnesium	13	233	514.32	7	1754
Manganese	3	13	10.16	3	23

Table 10

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT   NAZARETH, PENNSYLVANIA
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
RAW	16JUN81	2	RAW MILLS	64	7	N	4	N	N
RAW	16JUN81	2	PREHEATER BUILDING	172	7	N	162	3	N
RAW	17JUN81	1	RAW STORAGE	12	5	N	3	N	N
RAW	19JUN81	1	RAW MILLS	39	6	N	42	N	N
RAW	19JUN81	1	PRIMARY CRUSHER	24	9	N	29	N	N
RAW	19JUN81	1	PREHEATER BUILDING	N	5	N	3	N	N
RAW	19JUN81	1	RAW STORAGE	N	7	N	4	N	N
CLINKER	16JUN81	2	FRONT END OF KILN	N	N	N	1	N	N
FINISH	16JUN81	2	FINISH BALL MILLS	166	7	N	187	N	38
FINISH	17JUN81	1	BULK LOADING SILOS	N	10	N	5	N	N
FINISH	17JUN81	1	FINISH SILO TUNNEL	43	6	N	35	N	N
FINISH	18JUN81	1	BAGGING	21	7	N	21	N	N
FINISH	18JUN81	1	FINISH BALL MILLS	237	23	N	30	N	11
MIX	17JUN81	1	MAINTENANCE SHOP	N	6	N	5	N	N

Table 11

Environmental Investigations Branch

Cement Workers Morbidity Study
Coplay Cement - Nazareth, Pennsylvania

Summary for Area Trace Metal Concentrations in
Micrograms per Cubic Meter

Metal	N	Means	Std. Dev.	Minimum	Maximum
Aluminum	9	86	82.59	12	237
Chromium	13	8	4.59	5	23
Magnesium	14	38	59.93	1	187
Manganese	1	3	---	3	3
Nickel	2	24	19.29	11	38

Table 12

Environmental Investigations Branch

Cement Workers Morbidity Study
Coplay Cement - Nazareth, Pennsylvania

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

Exposure Categories

Metals	Clinker Silos	Preheater Bldg.	Clinker Silos	Packhouse	1° Crusher
Aluminum	7700.0	7.62	7375.0	73.5	74.3
Calcium	123700.0	102.77	74320.4	1597.4	4106.5
Chromium	N	N	3.75	N	1.0
Iron	7150.0	5.6	6837.5	52.9	326.5
Lithium	N	N	36.2	N	1.1
Magnesium	8100.0	5.0	7875.0	78.2	336.4
Manganese	145.0	N	135.0	1.3	7.5
Molybdenum	N	N	23.8	N	N
Sodium	1358.5	2.11	1094.6	11.0	8.6
Phosphorus	150.0	N	155.0	1.8	16.9
Titanium	265.0	N	233.8	2.6	N
Zinc	N	N	22.5	N	0.9
Zirconium	N	N	15.0	N	N

The following elements were analayzed for, but were less than 1.0 ug/filter in all samples: arsenic, beryllium, cadmium, cobalt, copper, nickel, lead, platinum, selenium, tin, tellurium, thallium, vanadium, yttrium, and silver.

Table 13

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
ANALYSIS OF BULK MATERIAL PRESENTED AS PERCENT BY WEIGHT

AREA	JOB	QUARTZ	CRISTB	AL	CR	CO	MG	MN	NI	ASBEST
RAW	RAW MATERIAL	1.7	N	1.60	N	N	2.90	N	N	0.0
RAW	RAW MATERIAL	N	N	2.00	N	N	3.20	0.02	N	0.0
RAW	RAW MATERIAL	5.6	N	0.23	N	N	2.10	N	N	0.0
RAW	IRON	N	N	N	0.14	N	1.00	1.00	N	0.0
RAW	RAW MATERIAL	6.0	N	0.11	N	N	1.70	N	N	0.0
RAW	RAW MATERIAL	8.3	N	0.30	N	N	1.90	0.04	N	0.0
RAW	RAW MATERIAL	6.7	N	0.20	N	N	1.90	N	N	0.0
CLINKER	CLINKER	N	N	2.00	N	N	2.70	0.03	N	0.0
CLINKER	CLINKER	N	N	2.40	N	N	3.50	0.04	N	0.0
CLINKER	CLINKER	N	N	2.50	N	N	3.10	0.03	N	0.0
CLINKER	CLINKER	N	N	2.00	N	N	3.30	0.03	N	0.0
FINISH	FINISH	N	N	2.60	N	N	4.00	0.04	N	0.0
FINISH	FINISH	N	N	N	N	N	0.08	N	N	0.0
FINISH	FINISH	N	N	N	N	N	0.08	N	N	0.0
FINISH	FINISH	4.0	N	1.40	N	N	2.00	0.04	N	0.0
FINISH	FINISH	N	N	2.10	N	N	3.60	0.03	N	0.0
FINISH	FINISH	N	N	2.20	N	N	3.80	0.03	N	0.0
FINISH	FINISH	N	N	2.00	N	N	3.90	0.05	N	0.0
FINISH	FINISH	N	N	2.20	N	N	2.90	0.03	N	0.0
FINISH	FINISH	N	N	2.10	N	N	2.80	0.03	N	0.0
FINISH	FINISH	N	N	2.30	N	N	2.90	0.03	N	0.0
FINISH	FINISH	N	N	1.30	N	N	2.90	0.02	N	0.0
FINISH	FINISH	N	N	1.50	N	N	2.80	0.03	N	0.0
FINISH	FINISH	N	N	1.50	N	N	2.80	0.02	N	0.0
FINISH	FINISH	N	N	1.70	0.03	N	3.10	0.04	N	0.0
MIX	COKE OR COAL	3.2	N	0.20	N	N	1.20	N	N	0.0
MIX	CLINKER FINISH	N	N	2.00	N	N	3.50	0.03	N	0.0
MIX	CLINKER FINISH	N	N	1.50	N	N	3.10	0.03	N	0.0

Table 14

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COPLAY CEMENT NAZARETH, PENNSYLVANIA
SOX CONCENTRATIONS

JOB	DATE	SHIFT	AREA	SO4_UGM3	SO3_UGM3	SO2_PPM
BACK END OF KILN	16JUN81	2	RAW	51.93	N	N
BACK END OF KILN	16JUN81	2	RAW	67.62	N	0.01
PREHEATER BUILDING	16JUN81	2	RAW	173.10	N	0.01
PREHEATER BUILDING	16JUN81	2	RAW	134.51	N	0.01
PREHEATER BUILDING	17JUN81	1	RAW	28.84	N	0.01
PREHEATER BUILDING	17JUN81	1	RAW	38.55	N	0.01
BACK END OF KILN	17JUN81	1	RAW	55.21	N	0.01
BACK END OF KILN	17JUN81	1	RAW	71.45	N	0.01
PREHEATER BUILDING	19JUN81	1	RAW	33.88	N	0.02
PREHEATER BUILDING	19JUN81	1	RAW	55.40	N	0.04
PREHEATER BUILDING	19JUN81	1	RAW	33.88	N	0.02
PREHEATER BUILDING	19JUN81	1	RAW	51.44	N	0.03

Table 15

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
COLPAY CEMENT NAZARETH, PENNSYLVANIA
NO2 CONCENTRATIONS IN PPM

JOB	DATE	SHIFT	AREA	CONC
LABORER (QUARRY)	17JUN81	1	RAW	0.03
MECHANIC (QUARRY)	17JUN81	1	RAW	0.03
QUARRY TRUCK DRIVER	17JUN81	1	RAW	0.08
FRONT END LOADER	17JUN81	1	RAW	0.18
DRILLER	17JUN81	1	RAW	N
QUARRY TRUCK DRIVER	18JUN81	1	RAW	0.05
QUARRY TRUCK DRIVER	18JUN81	1	RAW	0.07
FRONT END LOADER	18JUN81	1	RAW	0.04
QUARRY TRUCK DRIVER	18JUN81	1	RAW	0.01
PRIMARY CRUSHER OPERATOR	18JUN81	1	RAW	N
CONVEYOR OPERATOR	19JUN81	1	RAW	0.09
PRIMARY CRUSHER OPERATOR	19JUN81	1	RAW	0.01
EQUIPMENT OPERATOR	18JUN81	2	CLINKER	N
BULK LOADER	17JUN81	1	FINISH	0.03
MAINTENANCE (FINISH)	18JUN81	1	FINISH	0.13
MAINTENANCE (FINISH)	18JUN81	1	FINISH	0.11
UTILIYMAN (FINISH)	18JUN81	1	FINISH	0.08
REPAIRMAN	17JUN81	1	MIX	0.06
WELDER	17JUN81	1	MIX	0.01
UTILITY (SHIFT)	17JUN81	1	MIX	N
PIPEFITTER	17JUN81	1	MIX	N
REPAIRMAN	17JUN81	1	MIX	0.01
OILER (GENERAL)	17JUN81	1	MIX	0.14
MOBILE EQUIPMENT OPER (PLANT)	17JUN81	1	MIX	0.09
MACHINIST	19JUN81	1	MIX	0.13
REPAIRMAN	19JUN81	1	MIX	0.06
LABORER	19JUN81	1	MIX	N
MOBILE EQUIPMENT OPER (PLANT)	19JUN81	1	MIX	0.06
OILER (GENERAL)	19JUN81	1	MIX	0.09
WELDER	19JUN81	1	MIX	0.01
YARD WORKERS	19JUN81	1	MIX	0.01
MACHINIST	19JUN81	1	MIX	0.12

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.