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Industrial Hygiene Survey of General Cement Co.

Fredonia, Kansas

Cement Workers Morbidity Study

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An industrial hygiene survey was conducted at the General Cement Company, Fredonia, Kansas as part of a study of the effects of materials found in Portland Cement facilities on the human respiratory system. At this facility the respirable and total dust levels for most of the individual jobs were below recommended exposure levels. There were four respirable dust samples which exceeded the 5mg/m3 ACGIH recommended level for respirable nuisance particulate. Quartz (14808607) was detected in four respirable dust samples, of which three exceeded the MSHA-PEL for respirable quartz. Quartz exposure was noted primarily in the areas of the facility which are associated with raw materials. The authors recommend that surveillance monitoring be used on a periodic basis to assure that exposures remain within acceptable limits. Suggested engineering controls included the use of ventilation fans, and helmets attached to ventilation hoses. The substitution of a vacuum system for the currently used brooms and shovels to clean up dust spills is also recommended. Personal protective equipment may be used by workers whenever engineering controls are not available or during maintenance, repair and clean up operations. Engines should be shut off or parked outside when not in use in the packhouse and truck load silo.

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Executive Summary

The General Cement Plant in Fredonia, Kansas was surveyed by a NIOSH team of industrial hygienists, on October 19 through October 22, 1981. Samples were collected and analyzed for respirable and total dust, free crystalline silica, aluminum, cobalt, magnesium, manganese, nickel, other trace elements, asbestos, nitrogen dioxide, and oxides of sulfur.

The respirable and total dust levels for most jobs were below recommended exposure levels. However, three samples exceeded the ACGIH recommended level of 5 mg/m^3 for respirable nuisance particulate. Of the dust contaminants measured only quartz is considered to be present in excessive concentrations. Exposure to quartz is primarily in association with raw materials. Three respirable dust samples exceeded the MSHA-PEL for respirable quartz.

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. General Cement in Fredonia, Kansas was the twelfth 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.

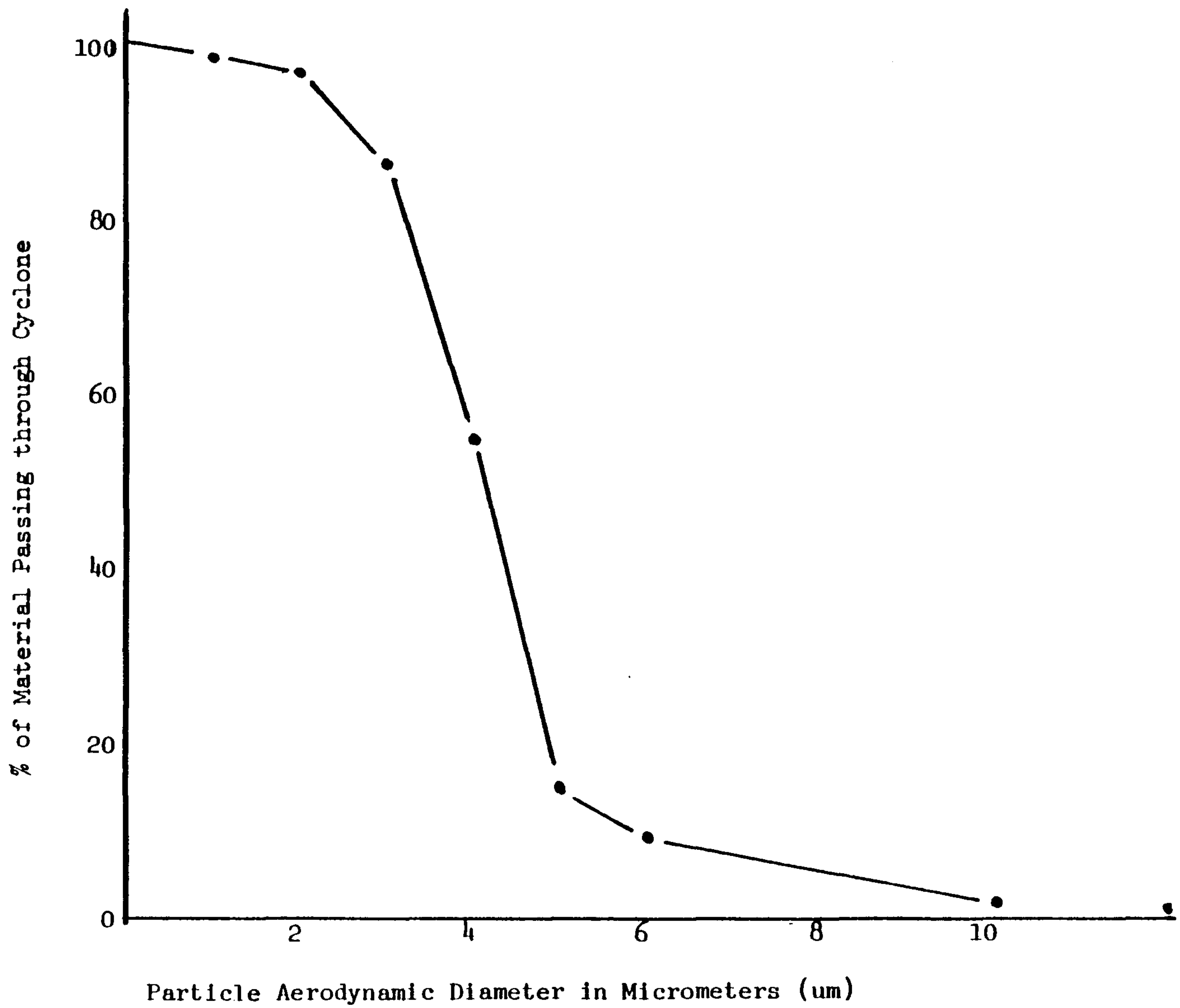
The General Cement plant in Fredonia, Kansas was surveyed on Monday, October 19 through Thrusday, October 22, 1981 by William Jones, Paul Hewett, and Wayne Sanderson. The original General plant was built in 1907 just outside of Fredonia, adjacent to a limestone quarry. The quarry serves as a calcium source, and a clay quarry which is just a few miles from the facility as an aluminum source for cement production. Other raw materials such as iron ore and sand are trucked in by other companies. The limestone is crushed at the quarry site and transferred to raw material silos. Cement clinkers are produced by the wet process method. At the plant site the raw materials are mixed and milled in rotating ball mills into a slurry, and this slurry is pumped into one of two kilns for clinker production. Currently there are two kilns in operation; one was built in 1936 and the other in 1956. Both kilns are fueled by pulverized coal. The clinkers are milled in ball mills to increase fineness; this ground material is Portland cement. Two types of finished cement are manufactured here. The finished cement is bagged or loaded as bulk in trucks for railcars for distribution. Approximately 140 workers are employed here, including workers in the limestone and clay quarries.

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 quartz and cristobalite. (2) Crystalline silica is reported in Table 4 as microgram per cubic meter (QUARTZ) and percent quartz (PCT_SI02). 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 ae also shown on Table 5 with their calculated MSHA-PEL. This will be discussed further 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 chromium, cobalt, or nickel was detected on any of the personal total samples.

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 tells where 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 chromium or cobalt was detected on any of these area samples.

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 12 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 the analysis are reported in Table 14. The JOB column lists where the sample was collected. The SO4_UGM3 and SO3_UGM3 columns give the sulfate and sulfite particulate concentrations in micrograms per cubic meter. The SO2_PPM column gives the sulfur dioxide concentrations in parts per millions. The limits of detection for these analyses 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 the 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. Nitrogen dioxide is produced from the combustion of organic compounds containing nitrogen such as coal and diesel fuel. The results of the analyses are reported in Table 15.

Direct Reading Indicator Tubes for Toxic Gases

Draeger direct reading indicator tubes were used to sample for carbon monoxide (CO), nitrogen dioxide (NO_2), oxides of nitrogen (NOX), and sulfur dioxide (SO_2). Air is drawn through these tubes by a hand-held bellows pump. These tubes contain reactive indicator materials which change color when they are exposed to specific gases. The length of stain indicates the concentration of gas present in the environment. On this survey, NIOSH Certified Detector

Tubes were used. They are certified to produce results within ± 25% of the true concentration of levels between one and five times the TLV, and within ± 35% of one-half of the TLV. For purposes of this study, this level of precision is adequate since a 25% variation around a given exposure level is not likely to produce significant differences in physiological response. The results of the detector tube samples are listed in Table 16.

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, October 19, 1981. The sampling schedule was as follows:

Monday, October 19 - 2nd shift

Tuesday, October 20 - 1st shift

Wednesday, October 21- 1st shift

Thursday, October 22 - 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 percent 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, only three samples exceeded 5 mg/m^3. These samples were worn by a finish mill helper, an electrician/oiler, and a repairman. The finish mill helper assists the mill operator, cleans up around the mills, and performs routine maintenance checks of the finish mill. The electrician/oiler "blows" off electrical motors with compressed air and oils the motors and drive connectors; during the shift which the sample was collected, he was blowing down the coal mill. The repairman was doing preventive maintenance on the elevators in the mill room and changing bags in dust collectors of the mill room. For all workers the geometric mean respirable dust level was 0.58 mg/m^3.

The personal total dust levels, Table 6, were all below 10.0 mg/m^3. The geometric mean was 2.20 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, oilers, electricians, mill workers, and packers 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

Quartz was detected in bulk samples of sand (85.5%), crushed limestone (10.9-16.7%), raw mill feed (18.0%), precipitator dust (1.0%), and masonry cement (1.0%). Quartz is a common constituent in limestone, shale, clay, and sand, but is rarely found in clinker or finished cement. As silicon dioxide passes through the high kiln temperatures, it is transformed from free crystalline forms into silicates. A quartz containing material may have been added during the milling process of masonry cement production. All workers associated with raw material dusts are potentially exposed to concentrations of quartz.

Personal respirable dust samples from 35 workers were analyzed for content of the crystalline mineral types, quartz and cristobalite. Four of the 35 samples contained detectable levels of quartz. The raw mill helper was checking and oiling the pumps in the raw mill area and maintaining the raw mill feed. The conveyor operator (crusher utility) was in charge of filling raw storage silos with crushed limestone. Both of these jobs are routinely exposed to raw material dust. The laborer on the 19th was cleaning and oiling bearings in the raw and finish mill areas, along the kiln, and in the clinker cooler area. The laborer on the 20th was cleaning up around the coal mill. Although no quartz was detected in a coal bulk sample collected at this plant, quartz is a common contaminant of coal.

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 2.2 - 11.5%.

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. Three of the four samples exceed the permissible exposure limit. None of the 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 one area sample contained detectable amounts of nickel; chromium and cobalt were not detected on any filters. 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

No sulfate or sulfite particulates were detected on any of the samples. Sulfur dioxide gas was detected in areas associated with kiln exhaust. Levels ranging from 0.08 to 0.1 ppm were detected downwind of the stack plume on October 20 and 22. On the 20th the wind was moderate from the south, and samples were collected on a silo at approximately the same level as the top of the older kiln stack. On the 22nd the wind was moderate from the northeast and samples were collected at the entrance of the labortatory which was in line with the kiln stack plume. These levels are below the NIOSH recommended standard of 0.5 ppm, the ACGIH TLV of 2 ppm, and the 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. At levels indicated from our sampling, workers should not experience irritation or respiratory changes attributable to SO_2 exposure. (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. (22)

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. (22) 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 diseases 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 (exposure limit not to be exceeded over a 15-minute period) of 5 ppm and a TWA of 3 ppm.

All of the 32 samples taken at General Cement were below the recommended standards.

Toxic Gases

No sulfur dioxide was detected at the front or back of either kiln by detector tubes. No carbon dioxide or oxides of nitrogen were detected in the truck load silo, but trucks are generally shut off while they are being loaded. Carbon monoxide was detected at 10 ppm in the packing department while a gasoline-powered forklift was being operated. This is below the MSHA-PEL and ACGIH-TLV of 50 ppm, and the NIOSH recommended standard of 35 ppm. Carbon monoxide, oxides of nitrogen, and sulfur dioxide are common contaminants in exhaust gases from the burning of fossil fuels. Portland cement plants have several areas which may be contaminated with these exhaust gases. At this facility the kilns are fired with pulverized coal. When coal, containing sulfur and nitrogen compounds is burned in the kiln, sulfur dioxide and oxides of nitrogen are produced. Gasoline and diesel powered engines of locomotives, quarry equipment, transport trucks, and forklifts release carbon monoxide and oxides of nitrogen in their exhaust. Our measurements indicate very low or insignificant levels of these gases.

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 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 General Cement Plant in Fredonia, Kansas are below recommended exposure levels. Four respirable dust samples exceeded the ACGIH recommended level for respirable nuisance particulate. Four respirable dust samples contained detectable levels of quartz. Three 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 areas associated with the raw materials. Protective measures should be taken.

Recommendations

Since the raw material mined in the quarry and used in cement production contains crystalline silica (quartz), we recommend surveillance monitoring on a periodic basis to assure that exposures remain within acceptable limits. The following discussion presents some guidance on available control strategies when necessary.

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. Workers with the highest dust exposures were generally involved in maintenance and clean-up operations. Since it is difficult to control dust exposures during these operations, personal respirators may need to be provided. Packers, however, are generally stationary. Ventilation fans may be placed above or behind packers to blow fugitive dust away from their breathing zone. Helmets attached to ventilation hoses, which supply air to cool the workers and prevent dust from entering the helmet, are an effective control measure for stationary workers who cannot be enclosed from dust sources.

During clean-up operations, workers often use compressed air to "blow down" the work areas, and brooms and shovels to clean up dust spills. 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 insure that they are adequately protected.

When gasoline-powered engines are operated in enclosed areas, excessive concentrations of exhaust gases may build up. We recommend that when engines are operated in the packhouse and truck load silo, exhaust gas concentrations be occasionally monitored. To avoid excessive exhaust concentrations, engines should be shut off or parked outside when not in use. Increased general room ventilation in the packing building would also reduce exhaust gas concentrations.

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
General Cement, Fredonia, Kansas

Number of Samples With Detectable Levels of Contaminants

Contaminant	# Samples Collected	# Samples with Detectable Conc.	Limit of Detection
Respirable dust	48	48	0.01 mg
Total dust	8	8	0.01 mg
Quartz	35	4	0.03 mg
Cristobalite	35	0	0.03 mg
Aluminum	26	14	0.20 mg
Chromium	26	0	0.004 mg
Cobalt	26	0	0.005 mg
Magnesium	26	25	0.002 mg
Manganese	26	10	0.002 mg
Nickel	26	1	0.004 mg
Asbestos	12	0	4500 fibers
Sulfates	6	0	0.005 mg
Sulfites	6	0	0.01 mg
Sulfur dioxide	6	6	0.005 mg
Nitrogen dioxide	32	26	0.02 ppm

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	19OCT81	2	0.05
BACKGROUND	20OCT81	1	0.07
BACKGROUND	21OCT81	1	0.02

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
MILL HELPER (RAW)	19OCT81	2	1.70
DOZER OPERATOR	20OCT81	1	0.25
DRAGLINE OPERATOR (CLAY)	20OCT81	1	0.13
CONVEYOR OPERATOR	20OCT81	1	0.83
FRONT END LOADER	20OCT81	1	0.10
DRILLER	21OCT81	1	0.46
MILL HELPER (RAW)	21OCT81	1	0.13
SLURRY TANKMAN	21OCT81	1	0.19
QUARRY TRUCK DRIVER	22OCT81	1	0.39

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
KILN BURNER	19OCT81	2	0.14
KILN HELPER	19OCT81	2	0.42
KILN BURNER	20OCT81	1	0.24

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
TUNNELMAN (FINISH)	19OCT81	2	0.46
BULK LOADER	19OCT81	2	0.16
FINISH MILL HELPER	19OCT81	2	0.63
PACKER	20OCT81	1	2.15
TUNNELMAN (FINISH)	20OCT81	1	0.16
BULK LOADER	20OCT81	1	0.58
PACKER	20OCT81	1	2.43
FINISH MILL HELPER	20OCT81	1	1.31
CHECKER	21OCT81	1	0.84
FINISH MILL HELPER	22OCT81	1	5.96

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
MIX CHEMIST	19OCT81	2	0.33
MILL OPERATOR	19OCT81	2	0.23
LABORER	19OCT81	2	0.75
LABORER	19OCT81	2	0.60
MOBILE EQUIPMENT OPER (PLANT)	19OCT81	2	0.45
LABORER	20OCT81	1	2.51
YARD WORKERS	20OCT81	1	0.35
LABORER	20OCT81	1	0.49
INSTRUMENT DEPARTMENT	20OCT81	1	0.28
ELECTRICIAN	21OCT81	1	0.36
OILER (GENERAL)	21OCT81	1	0.45
COKE COAL HANDLER	21OCT81	1	0.11
WELDER	21OCT81	1	3.80
REPAIRMAN	21OCT81	1	1.35
REPAIRMAN	21OCT81	1	0.62
ELECTRICIAN/OILER	21OCT81	1	15.42
MACHINIST	22OCT81	1	0.48
LABORER	22OCT81	1	2.17
STOREROOM SUPERINTENDENT	22OCT81	1	0.45
OFFICE WORKER	22OCT81	1	0.25
MIX CHEMIST	22OCT81	1	0.50
MILL OPERATOR	22OCT81	1	0.43
LABORATORY WORKER	22OCT81	1	0.60
REPAIRMAN	22OCT81	1	7.89
YARD WORKERS	22OCT81	1	1.18
REPAIRMAN	22OCT81	1	0.49

Table 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	3	0.05	0.03	0.04	2.00	0	0.02	0.07
RAW	9	0.46	0.52	0.30	2.56	0	0.10	1.70
CLINKER	3	0.27	0.14	0.24	1.73	0	0.14	0.42
FINISH	10	1.47	1.76	0.82	3.20	0	0.16	5.96
MIX	26	1.64	3.24	0.70	3.08	0	0.11	15.42
PLANTWIDE	48	1.30	2.55	0.58	3.09	0	0.10	15.42

Figure 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

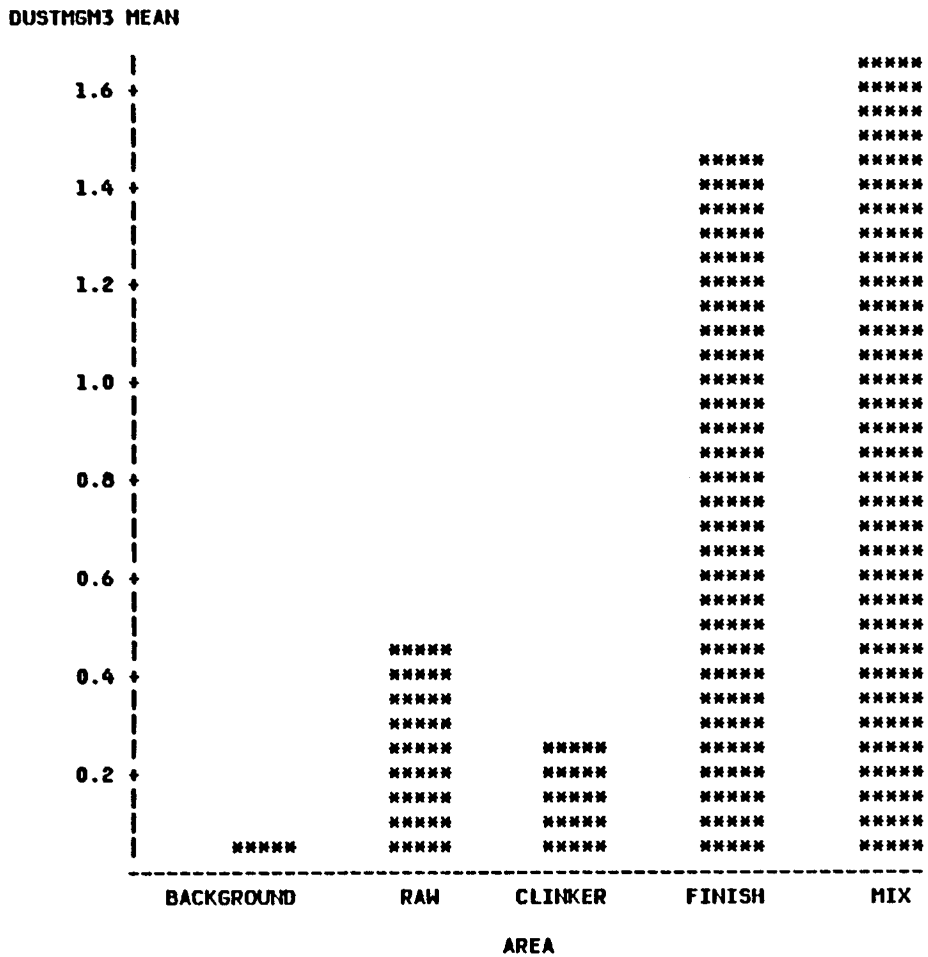

Figure 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

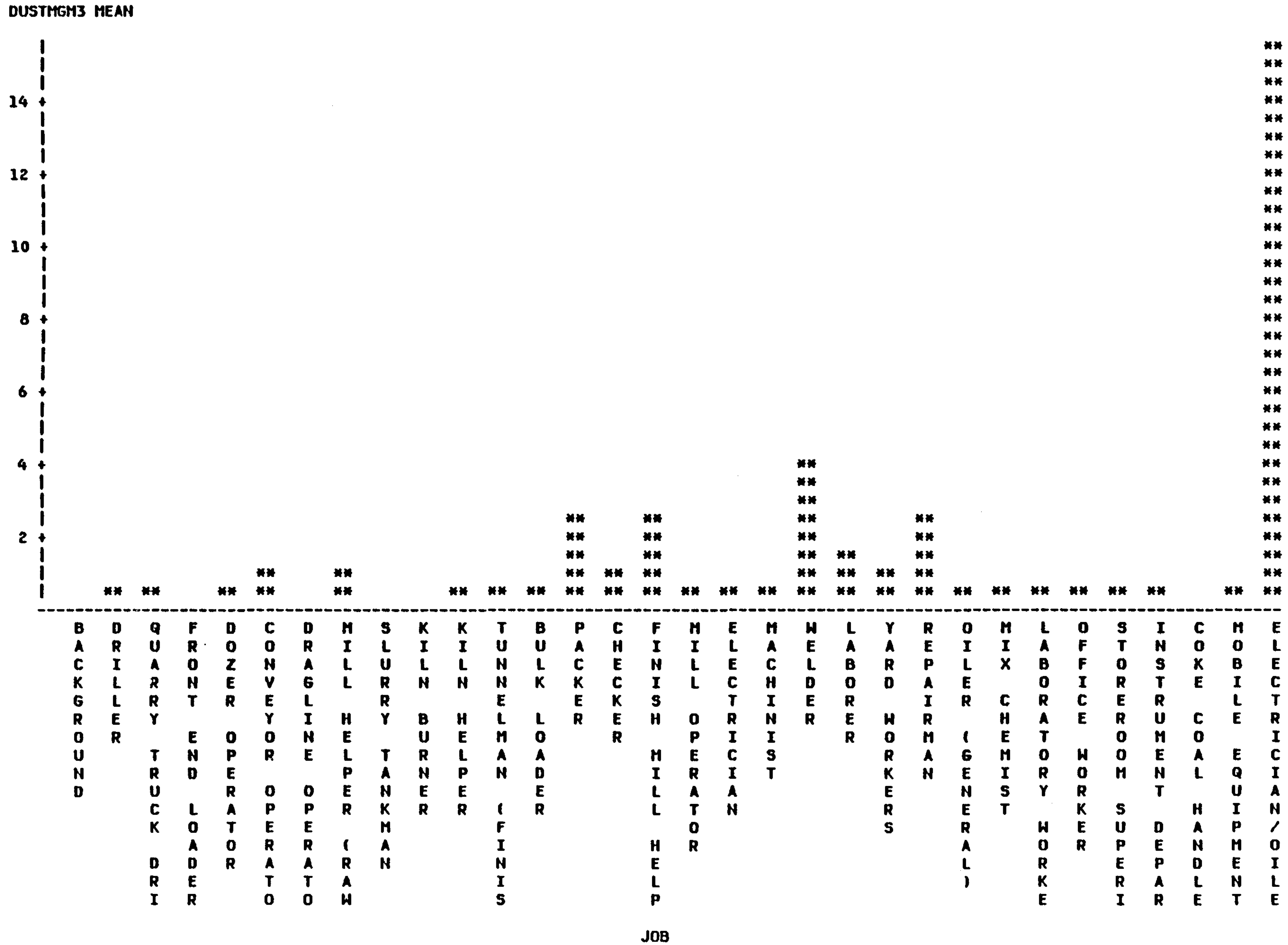

Table 4

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

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
MILL HELPER (RAW)	19OCT81	2	5.8	98.92	RAW
CONVEYOR OPERATOR	20OCT81	1	5.6	45.90	RAW
FRONT END LOADER	20OCT81	1	N	N	RAW
DOZER OPERATOR	20OCT81	1	N	N	RAW
DRILLER	21OCT81	1	N	N	RAW
MILL HELPER (RAW)	21OCT81	1	N	N	RAW
SLURRY TANKMAN	21OCT81	1	N	N	RAW
QUARRY TRUCK DRIVER	22OCT81	1	N	N	RAW
TUNNELMAN (FINISH)	19OCT81	2	N	N	FINISH
FINISH MILL HELPER	19OCT81	2	N	N	FINISH
PACKER	20OCT81	1	N	N	FINISH
TUNNELMAN (FINISH)	20OCT81	1	N	N	FINISH
FINISH MILL HELPER	20OCT81	1	N	N	FINISH
PACKER	20OCT81	1	N	N	FINISH
CHECKER	21OCT81	1	N	N	FINISH
FINISH MILL HELPER	22OCT81	1	N	N	FINISH
MILL OPERATOR	19OCT81	2	N	N	MIX
LABORER	19OCT81	2	N	N	MIX
MOBILE EQUIPMENT OPER (PLANT)	19OCT81	2	N	N	MIX
LABORER	19OCT81	2	11.5	87.08	MIX
LABORER	20OCT81	1	N	N	MIX
LABORER	20OCT81	1	2.2	55.41	MIX
YARD WORKERS	20OCT81	1	N	N	MIX
REPAIRMAN	21OCT81	1	N	N	MIX
REPAIRMAN	21OCT81	1	N	N	MIX
ELECTRICIAN/OILER	21OCT81	1	N	N	MIX
WELDER	21OCT81	1	N	N	MIX
OILER (GENERAL)	21OCT81	1	N	N	MIX
ELECTRICIAN	21OCT81	1	N	N	MIX
LABORER	22OCT81	1	N	N	MIX
YARD WORKERS	22OCT81	1	N	N	MIX
LABORER	22OCT81	1	N	N	MIX
REPAIRMAN	22OCT81	1	N	N	MIX
LABORATORY WORKER	22OCT81	1	N	N	MIX
REPAIRMAN	22OCT81	1	N	N	MIX

Table 5

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
General Cement, Fredonia, Kansas

Detectable Quartz Compared to MSHA Permissible Exposure Levels

Job	Levels of Dust Conc. Mg/m^3	Quartz Conc. % Quartz	ug/m^3	MSHA PEL mg/m^3
Laborer	0.75*	11.5	87.08	0.74
Laborer	2.51*	2.2	55.41	2.38
Mill helper (raw)	1.7*	5.8	98.92	1.28
Conveyor operator	0.83	5.6	45.9	1.32

*Indicates measured concentration exceeds the MSHA Permissible Exposure Limit.

Table 6

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	20OCT81	1	0.07
BACKGROUND	21OCT81	1	0.01

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
DRAGLINE OPERATOR (CLAY)	21OCT81	1	1.22

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
KILN BURNER	22OCT81	1	2.16

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
FINISH MILL HELPER	21OCT81	1	6.70

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
FRONT END LOADER (YARD)	20OCT81	1	1.25
ELECTRICIAN	20OCT81	1	2.01
REPAIRMAN	20OCT81	1	2.87
UTILITY (SHIFT)	20OCT81	1	0.95
OILER (GENERAL)	22OCT81	1	4.61

Table 7

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT   FREDONIA, KANSAS
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	2	0.04	0.04	0.03	3.85	0	0.01	0.07
RAW	1	1.22	.	1.22	.	0	1.22	1.22
CLINKER	1	2.16	.	2.16	.	0	2.16	2.16
FINISH	1	6.70	.	6.70	.	0	6.70	6.70
MIX	5	2.34	1.47	1.99	1.89	0	0.95	4.61
PLANTWIDE	8	2.72	1.99	2.20	1.98	0	0.95	6.70

Figure 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

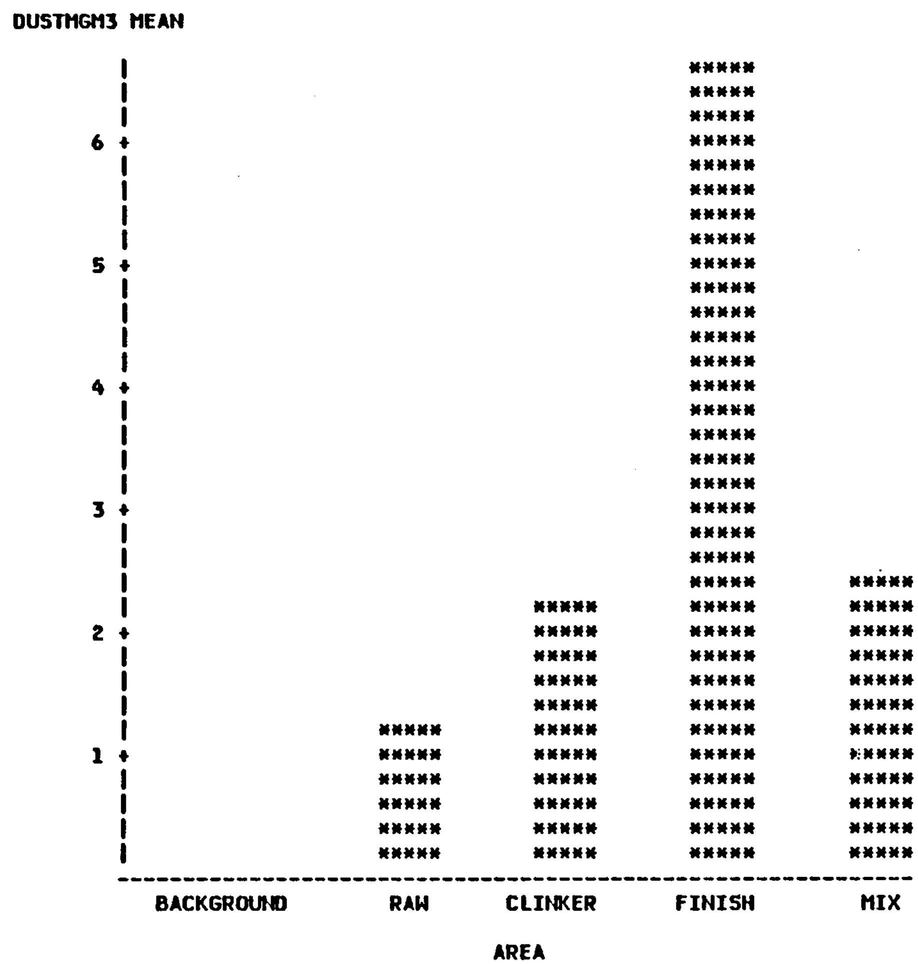

Figure 5

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT   FREDONIA, KANSAS
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

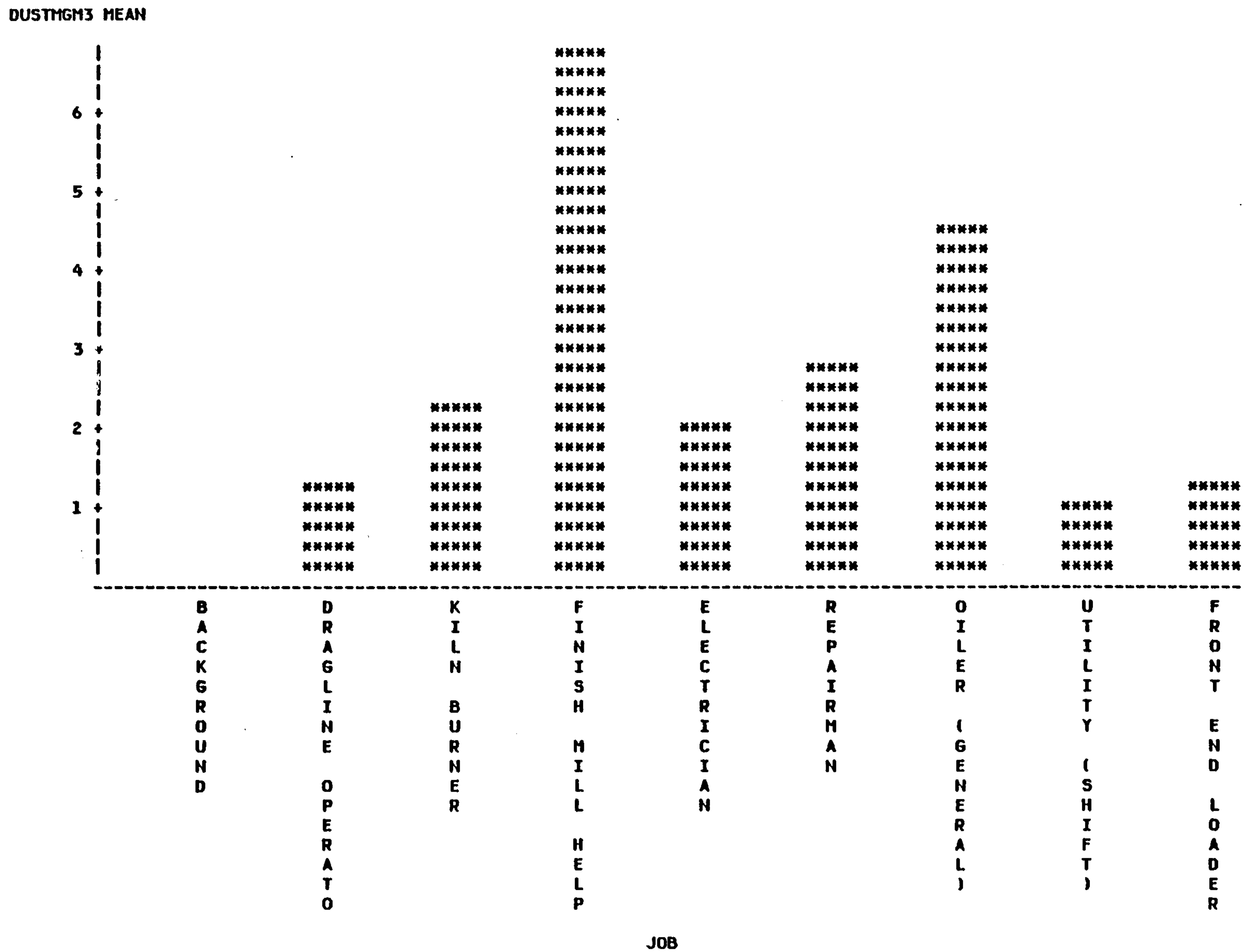

Table 8

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
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	21OCT81	1	DRAGLINE OPERATOR (CLAY)	N	N	N	6	N	N
CLINKER	22OCT81	1	KILN BURNER	N	N	N	20	N	N
FINISH	21OCT81	1	FINISH MILL HELPER	36	N	N	27	N	N
FINISH	22OCT81	1	BULK LOADER	85	N	N	63	4	N
MIX	20OCT81	1	REPAIRMAN	39	N	N	21	4	N
MIX	20OCT81	1	UTILITY (SHIFT)	N	N	N	9	N	N
MIX	20OCT81	1	ELECTRICIAN	N	N	N	12	N	N
MIX	20OCT81	1	FRONT END LOADER (YARD)	N	N	N	7	N	N
MIX	22OCT81	1	OILER (GENERAL)	70	N	N	46	2	N

Table 9

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
General Cement, Fredonia, Kansas

Summary for Personal Trace Metal Concentrations in
Micrograms per Cubic Meter

Metal	N	Means	Std.dev.	Minimum	Maximum
Aluminum	4	57	23.77	36	85
Magnesium	9	24	19.44	6	63
Manganese	3	3	1.37	2	4

Table 10

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
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	20OCT81	1	BACKGROUND	N	N	N	9	N	N
BACKGROUND	21OCT81	1	BACKGROUND	N	N	N	N	N	N
MIX	20OCT81	1	WELDER	39	N	N	28	83	N
RAW	19OCT81	2	RAW MILLS	37	N	N	19	N	N
RAW	20OCT81	1	PRIMARY CRUSHER	267	N	N	210	8	N
RAW	21OCT81	1	RAW STORAGE	166	N	N	150	5	N
CLINKER	19OCT81	2	CLINKER COOLER	1120	N	N	665	26	5
CLINKER	20OCT81	1	FRONT END OF KILN	N	N	N	10	N	N
CLINKER	21OCT81	1	CLINKER TRANSFER TUNNEL	197	N	N	126	6	N
CLINKER	22OCT81	1	FRONT END OF KILN	N	N	N	7	N	N
CLINKER	22OCT81	1	CLINKER TRANSFER TUNNEL	25856	N	N	18100	646	N
FINISH	19OCT81	2	FINISH BALL MILLS	N	N	N	13	N	N
FINISH	19OCT81	2	BULK LOADING SILOS	N	N	N	5	N	N
FINISH	20OCT81	1	BAGGING	120	N	N	54	2	N
FINISH	21OCT81	1	FINISH SILO TUNNEL	66	N	N	31	N	N
MIX	21OCT81	1	LABORATORY	49	N	N	35	N	N
MIX	22OCT81	1	MAINTENANCE SHOP	N	N	N	16	N	N

Table 11

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
General Cement, Fredonia, Kansas

Summary for Area Trace Metal Concentrations in
Micrograms per Cubic Meter

Metal	N	Means	Std. Dev.	Minimum	Maximum
Aluminum	10	2792	8110.57	37	25857
Magnesium	16	1217	4504.91	5	18100
Manganese	7	111	237.85	2	646
Nickel	1	5		5	5

Table 12

Environmental Investigaions Branch
Cement Workes Morbidity Study
General Cement, Fredonia,Kansas

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

Metals	Rock Bin	2^o Crusher	Finish Mill	Clinker Cooler Pit
Aluminum	30.9	20.0	28.0	1075.0
Calcium	1415.2	1304.2	563.9	24146.0
Iron	42.8	37.7	24.8	783.0
Lithium	1.0	1.0	1.0	4.9
Magnesium	41.7	39.4	16.8	628.8
Manganese	1.0	1.0	1.0	26.0
Sodium	9.1	10.0	3.49	96.6
Phsophorus	2.6	1.0	1.0	24.3
Titanium	1.0	1.0	1.4	55.2
Zinc	1.0	1.0	46.5	16.6

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

Table 13

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
ANALYSIS OF BULK MATERIAL PRESENTED AS PERCENT BY WEIGHT

AREA	JOB	QUARTZ	CRISTB	AL	CR	CO	MG	MN	NI	ASBEST
RAW	RAW MATERIAL	13.1	N	1.50	N	N	1.20	0.04	N	0.0
RAW	RAW MATERIAL	10.9	N	1.50	N	N	1.20	0.03	N	0.0
RAW	RAW MATERIAL	16.7	N	1.30	N	N	1.20	0.04	N	0.0
RAW	RAW MATERIAL	12.4	N	0.81	N	N	0.84	0.03	N	0.0
RAW	RAW MATERIAL	18.0	N	1.20	N	N	0.84	0.04	N	0.0
RAW	COKE OR COAL	N	N	0.20	N	N	0.07	N	N	0.0
RAW	RAW MATERIAL	85.5	N	0.22	N	N	0.53	N	N	0.0
RAW	RAW MATERIAL	1.0	N	1.80	N	N	0.79	0.04	N	0.0
CLINKER	CLINKER	N	N	1.90	N	N	1.20	0.05	N	0.0
CLINKER	CLINKER	N	N	1.90	N	N	1.20	0.05	N	0.0
CLINKER	CLINKER	N	N	3.20	N	N	1.40	0.07	0.02	0.0
FINISH	FINISH	N	N	2.80	N	N	1.30	0.06	N	0.0
FINISH	FINISH	1.0	N	1.90	N	N	1.10	0.05	N	0.0
FINISH	FINISH	N	N	2.80	N	N	1.30	0.06	N	0.0
MIX	CLINKER FINISH	N	N	2.60	N	N	1.30	0.06	N	0.0
MIX	CLINKER FINISH	N	N	2.10	N	N	1.20	0.05	N	0.0
MIX	RAW CLINKER FINISH	N	N	2.30	N	N	1.20	0.05	N	0.0
RAW	VERMSOL	N	N	N	N	N	0.01	N	N	0.0

Table 14

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
SOX CONCENTRATIONS

JOB	DATE	SHIFT	AREA	SO4_UGM3	SO3_UGM3	SO2_PPM
BACK END OF KILN	19OCT81	2	RAW	N	N	0.02
BACK END OF KILN	19OCT81	2	RAW	N	N	0.01
YARD	20OCT81	1	MIX	N	N	0.08
YARD	20OCT81	1	MIX	N	N	0.10
YARD	22OCT81	1	MIX	N	N	0.09
YARD	22OCT81	1	MIX	N	N	0.10

Table 15

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
GENERAL CEMENT FREDONIA, KANSAS
NO2 CONCENTRATIONS IN PPM

JOB	DATE	SHIFT	AREA	CONC
BACKGROUND	20OCT81	1	BACKGROUND	0.08
BACKGROUND	21OCT81	1	BACKGROUND	0.11
DOZER OPERATOR	20OCT81	1	RAW	N
DRAGLINE OPERATOR (CLAY)	20OCT81	1	RAW	0.01
CONVEYOR OPERATOR	20OCT81	1	RAW	0.03
FRONT END LOADER	20OCT81	1	RAW	0.07
DRILLER	21OCT81	1	RAW	0.02
QUARRY TRUCK DRIVER	22OCT81	1	RAW	N
KILN BURNER	20OCT81	1	CLINKER	0.04
PACKER	20OCT81	1	FINISH	0.04
TUNNELMAN (FINISH)	20OCT81	1	FINISH	0.09
BULK LOADER	20OCT81	1	FINISH	0.04
FINISH MILL HELPER	20OCT81	1	FINISH	0.05
CHECKER	21OCT81	1	FINISH	N
LABORER	20OCT81	1	MIX	0.06
YARD WORKERS	20OCT81	1	MIX	0.04
LABORER	20OCT81	1	MIX	N
INSTRUMENT DEPARTMENT	20OCT81	1	MIX	0.03
OILER (GENERAL)	21OCT81	1	MIX	0.06
COKE COAL HANDLER	21OCT81	1	MIX	0.12
WELDER	21OCT81	1	MIX	0.09
REPAIRMAN	21OCT81	1	MIX	0.02
REPAIRMAN	21OCT81	1	MIX	0.02
ELECTRICIAN/OILER	21OCT81	1	MIX	N
MACHINIST	22OCT81	1	MIX	0.04
LABORER	22OCT81	1	MIX	0.09
LABORER	22OCT81	1	MIX	0.02
MIX CHEMIST	22OCT81	1	MIX	0.05
MILL OPERATOR	22OCT81	1	MIX	N
REPAIRMAN	22OCT81	1	MIX	0.07
YARD WORKERS	22OCT81	1	MIX	0.03
BULK LOADING SILOS	20OCT81	1	FINISH	0.03
BULK LOAD SCALEHOUSE	20OCT81	1	FINISH	0.05
MAINTENANCE SHOP	22OCT81	1	MIX	0.10

Table 16

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
General Cement - Fredonia, Kansas

Direct Reading Indicator Tube Concentrations in
Parts Per Million-ppm

Area	Date	CO	Nox	NO2	SO2
Fire end of Kiln #1	Nov 19				ND
Feed end of Kiln #1					ND
Fire end of Kiln #2					ND
Feed end of Kiln #2					ND
Bulk load silos for trucks	Nov 20	ND	ND		
		ND	ND		
Packing Department while gasoline powered forklift is operating		10	0.5	0.5	
		10			

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.