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Industrial Hygiene Survey of Northwestern States Cement

Mason City, Iowa

Cement Workers Morbidity Study

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16. Abstract (Limit: 200 words) As part of the Cement Workers Morbidity Study, an industrial hygiene survey was conducted at the Northwestern States Cement facility in Mason City, Iowa. Environmental sampling was undertaken to determine the presence and concentration of various contaminants. For most jobs at the site the respirable and total dust levels were below the recommended exposure levels. Four samples from a mill helper, a laborer, and two dust collectors exceeded the American Conference of Governmental Industrial Hygienists recommended level for respirable nuisance particulate. Two samples from a primary crusher operator and a repairman exceeded levels for nuisance dust. Three samples exceeded levels for respirable quartz (14808607). The authors recommend measures to reduced exposures, including a routine surveillance program, engineering controls, ventilation design, improved clean up operations, and the use of personal protective equipment.

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Executive Summary

The Northwestern States Cement Plant in Mason City, Iowa was surveyed by a NIOSH team of industrial hygienists, on July 27 through July 30, 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. However, four samples exceeded the ACGIH recommended level of 5 mg/m^3 for respirable nuisance particulate and two samples exceeded the MSHA-PEL of 10 mg/m^3 for total nuisance dust. Of the dust contaminants measured, only quartz is considered to be present in excessive concentrations. Exposure to quartz was observed 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. Northwestern States Cement in Mason City, Iowa was the eleventh 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 Northwestern States Cement plant in Mason City, Iowa was surveyed on Monday, July 27 through Thursday, July 30, 1981 by Al Dieffenbach, Cathy Davidson, Thomas Wood, and Wayne Sanderson. The plant is located one mile northwest of downtown Mason City. The plant began operations in 1960. Limestone is quarried and initially crushed a few miles from the plant. Also, clay is quarried by dragline in a pit near the plant. Other raw materials, sand as a silica source and mill scale as an iron source, are brought in from other companies. Today, cement clinkers are produced in three kilns by the dry process method. All three kilns are fueled by pulverized coal. During our survey only one kiln was operating. Seven types of finished cement are manufactured here, and are bagged or loaded out as bulk in trucks or railcars. Approximatly 260 workers are employed at the Northwestern States plant.

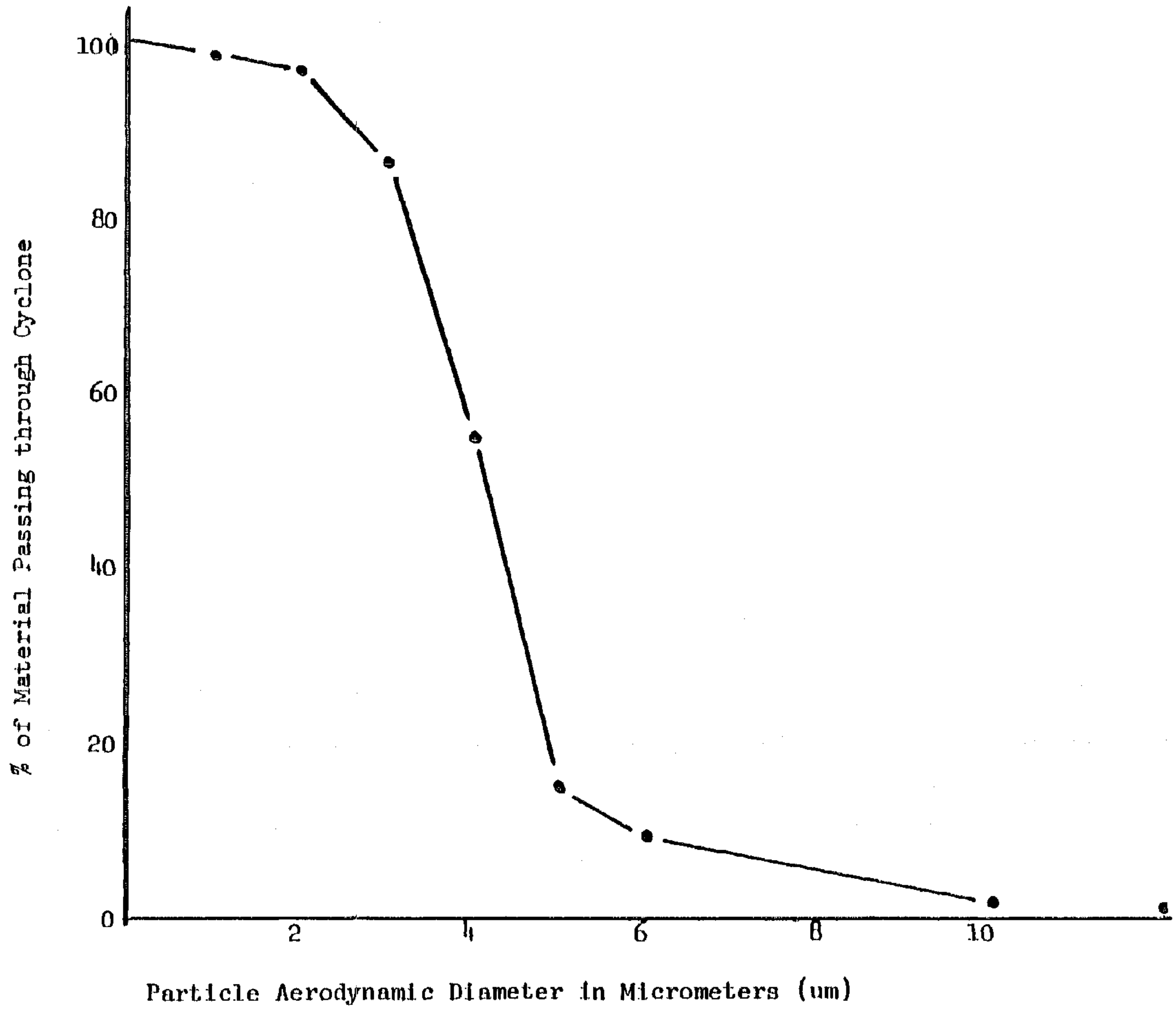
Methods and Results

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 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

Figure 1 COLLECTION EFFICIENCY OF THE PERSONAL RESPIRABLE DUST CYCLONE



"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_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. No cobalt was detected on any of these area samples.

One area sample from each exposure category was analyzed for content of 24 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 6 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 four samples collected for sulfate and sulfite particulates and sulfur dioxide gas are presented in Table 14. The JOB column indicates the location that the samples were collected. The SO4_UGM3 and SO3_UGM3 columns list the concentrations of sulfate and sulfite in micrograms per cubic meter, respectively. The SO2_PPM column lists the sulfur dioxide concentration in parts per million.

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)

$$\text{Conc, ppm} = \frac{\text{nanomoles NO2}}{2.3 \times \text{Hours of Exposure}}$$

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 reported in Table 15. Nitrogen dioxide is produced from the combustion of organic compounds containing nitrogen, such as coal and diesel fuel.

Direct Reading Indicator Tubes for Toxic Gases

Drager direct reading indicator tubes were used to sample for carbon monoxide (CO), nitrogen dioxide (NO_2), and oxides of nitrogen (NOX). 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 $\pm25\%$ of the true concentration at levels between one and five times the TLV, and within $\pm35\%$ 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 properly, sampler adjustments and appropriate notations were made and, if necessary, the results of such samples were voided.

The environmental investigations team began sampling Monday, July 27, 1981. The sampling schedule was as follows:

Monday, July 27	- 2nd shift
Tuesday, July 28	- 1st shift
Wednesday, July 29	- 1st shift
Thursday, July 30	- 1st shift
Thursday, July 30	- 3rd shift

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

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

raw - exposure to raw materials dust

clinker - exposure to clinker dust

finish - exposure to finished Portland cement dust

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

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

Discussions and Conclusions

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

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

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

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

Personal Respirable and Total Dust Samples

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

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

If airborne particulates contain greater than 1% crystalline silica, then they are no longer considered nuisance particulates; they are mineral dusts. The

MSHA standard for nuisance dusts is 10 milligrams per cubic meter of total suspended dust. The MSHA standard for mineral dusts employs the formula:

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

where the "% respirable quartz" is the 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, four samples exceeded 5 mg/m^3. These samples were worn by a mill helper, laborer, and two dust collectors. The laborer, who had the highest respirable dust exposure (46.22 mg/m^3), was sweeping and cleaning in the mill and kiln area. The mill helper was using a compressed air hose to clean a downed mill and catwalk. Both dust collectors were changing bags in the clinker cooler baghouses. All four samples were from workers involved in maintenance or clean-up operations. For all workers the geometric mean dust level was 0.57 mg/m^3.

Examining the personal total dust samples collected from the various jobs, Table 6, two samples exceeded 10 mg/m^3. These samples were worn by a primary crusher operator and a repairman. The primary crusher operator controlled the crusher in the quarry and the repairman was doing maintenance work in the millroom and at the coal plant. For all workers the geometric mean total dust level was 1.70 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. Repairman, packers, laborers, dust collectors, and primary crusher 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

Quartz was detected in bulk samples of clay (17.7%), kiln feed dust (3.0-3.7%), raw mill feed (4.7%), and a rafter sample high up in the mill room on the raw side (2.6%). Quartz is a common constituent of 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. All workers associated with raw material dusts are potentially exposed to concentrations of quartz.

All personal respirable dust samples except those with less than 0.2 mg of dust on the filter were analyzed for content of the crystalline mineral types, quartz and cristobalite. Quartz concentrations on filters with less than 0.2 mg of material were probably below the analytical limit of detection. Five of fifty-five personal respirable samples contained detectable levels of quartz. Four of the five samples were from workers who had spent part of their shift exposed to raw material dust. Only the dust collector had spent his shift exposed to clinker dust while changing bags in clinker cooler dust collectors. The laborer on July 28 was cleaning up under the raw and finish mills and at both ends of the kilns. The laborer on July 30 was cleaning up along raw material conveyor belts in the mills and storage silos. The mill helper was cleaning up around finish and raw mills. The repairman was inspecting the clay apron, and the coal mill under kiln #1.

There may be some variation in quartz concentration depending on the composition of the raw materials that employees are working with. Also, the mixing and grinding of various materials containing quartz will result in a range of concentrations. Therefore, the free silica concentrations may vary with area and time. The calculated percent of quartz on the respirable filters (Table 4) have a range of 1.1 - 11.0%.

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 five samples exceeded the permissible exposure limit. Two of the five 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. Only one sample contained detectable amounts of chromium, cobalt, or nickel. Aluminum is present in the greatest concentration, followed by magnesium. Raw material, clinker, and finished cement dust all contain aluminum and magnesium. Variation in the presence of metals and their concentration may be caused by differences in milling or processing. We chose to measure these six metals because nickel and chromium are suspected carcinogens, and aluminum, magnesium, manganese, and cobalt are suspected pneumoconiosis or bronchitis producing agents. There are no past studies to indicate that these elements will cause any disease in the form or concentrations found in a cement plant. This study will look for correlations between respiratory health problems and exposures to these elements.

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

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 sulfite particulates were detected and only trace amounts of sulfur dioxide. 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 Northwestern States. (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 accompained 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. (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 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 of 5 ppm and a TWA of 3 ppm.

All of the 27 samples taken at Northwestern States cement were below the recommended standard.

Toxic Gases

No nitrogen dioxide was detected. Carbon monoxide was detected in the bagged cement warehouse and palletizing building, and inside one of the kilns which was being rebricked. Gasoline powered forklifts were operating in both of these areas during sample collection. Trace amounts of oxides of nitrogen were also detected in these areas. Carbon monoxide and oxides of nitrogen 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 were fired with pulverized coal. When the coal and nitrogen containing compounds are oxidized in the combustion process, these gases are produced. Gasoline and diesel powered engines of locomotives, quarry equipment, transport trucks, and fork lifts release carbon monoxide and oxides of nitrogen in their exhausts. It is possible that when diesel or gasoline powered engines are run in enclosed spaces, excessive levels of carbon monoxide may build up. The MSHA PEL for carbon monoxide and nitrogen dioxide are 50 and 5 ppm, respectively. A sample of 40 ppm for carbon monoxide was collected in the palletizing area. This is approaching the MSHA PEL.

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 Northwestern States 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 Northwestern States Cement Plant in Mason City, Iowa are below recommended exposure levels. Four samples from a mill helper, a laborer, and two dust collectors exceeded the ACGIH recommended level for respirable nuisance particulate. Two samples from a primary crusher operator and a repairman exceeded the MSHA standard for nuisance dust. Five respirable dust samples contained detectable levels of quartz. Three of these samples exceeded the MSHA-PEL for respirable quartz. Exposure to quartz occurs primarily in association with raw materials.

Recommendations

Workers may need to be periodically monitored for exposures to respirable dust and quartz, and total dust. A routine surveillance program will indicate areas of overexposure for directing dust control measures, and ensure that exposures remain below recommended levels. The palletizing area may also need to be monitored for levels of carbon monoxide. 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. In the case of the primary crusher operator, his control station might be enclosed. This would protect the operator from dust, as well as noise.

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. To reduce the emission of carbon monoxide from engine exhaust, engines should be shut off or parked out of doors when not in use. During the loading of bulk material trucks, engines should be shut off to avoid a build up of gases in the silo control rooms. Increased general room ventilation in the palletizing 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
Northwestern States Cement, Mason City, Iowa

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	17	17	0.01 mg
Quartz	55	5	0.03 mg
Cristobalite	55	0	0.03 mg
Aluminum	32	23	0.20 mg
Chromium	32	18	0.004 mg
Cobalt	32	1	0.005 mg
Magnesium	32	28	0.002 mg
Manganese	32	12	0.002 mg
Nickel	32	17	0.004 mg
Asbestos	6	0	4500 fibers
Sulfates	4	2	0.005 mg
Sulfites	4	0	0.010 mg
Sulfur dioxide	4	3	0.005 mg
Nitrogen dioxide	27	26	0.02 ppm

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	28JUL81	1	0.00
BACKGROUND	30JUL81	1	0.02

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
KILN FEED OPERATOR	27JUL81	2	0.15
QUARRY TRUCK DRIVER	28JUL81	1	0.07
KILN FEED OPERATOR	28JUL81	1	0.46
FRONT END LOADER	28JUL81	1	0.17
FRONT END LOADER	28JUL81	1	0.21
QUARRY TRUCK DRIVER	28JUL81	1	0.25
DOZER OPERATOR	30JUL81	1	0.14
LABORER (CLAY)	30JUL81	1	0.27
QUARRY TRUCK DRIVER	30JUL81	1	0.24
CONVEYOR OPERATOR	30JUL81	1	0.18
KILN FEED OPERATOR	30JUL81	3	0.25

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
REBRICKER	27JUL81	2	0.34
REBRICKER	27JUL81	2	0.30
KILN BURNER	27JUL81	2	0.29
KILN HELPER	27JUL81	2	0.21
REBRICKER	28JUL81	1	0.73
KILN BURNER	28JUL81	1	0.56
KILN HELPER	28JUL81	1	0.48
KILN HELPER	28JUL81	1	0.94
KILN HELPER	28JUL81	1	0.50
KILN HELPER	30JUL81	1	0.22
KILN HELPER	30JUL81	3	0.23
KILN BURNER	30JUL81	3	0.03

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
FORKLIFT OPERATOR (FINISH)	27JUL81	2	0.52
FORKLIFT OPERATOR (FINISH)	27JUL81	2	0.62
PACKER	27JUL81	2	1.43
PACKER	27JUL81	2	3.36
PACKER	27JUL81	2	2.41
BULK LOADER	29JUL81	1	1.06
PACKER	29JUL81	1	1.86

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT MASON CITY, IOWA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
BULK LOADER	29JUL81	1	0.46
PACKER	29JUL81	1	4.25
LOCOMOTIVE OPERATOR	29JUL81	1	0.25
BULK LOADER	30JUL81	1	0.48
BULK LOADER	30JUL81	1	1.40
BULK LOADER	30JUL81	1	0.80
PALLETIZER OPER	30JUL81	1	1.79
CLEAN UP	30JUL81	1	0.71

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
MACHINIST	27JUL81	2	3.43
MACHINIST	27JUL81	2	0.73
MIX CHEMIST	27JUL81	2	0.50
MILL OPERATOR	27JUL81	2	0.25
MILL HELPER (MIX)	27JUL81	2	2.23
MILL HELPER (MIX)	27JUL81	2	1.24
MILL HELPER (MIX)	27JUL81	2	7.98
DOZER OPERATOR (MIX)	27JUL81	2	0.32
DUST COLLECTOR	27JUL81	2	0.26
UTILITY (SHIFT)	28JUL81	1	0.18
MILL HELPER (MIX)	28JUL81	1	0.70
MILL OPERATOR	28JUL81	1	0.54
MILL HELPER (MIX)	28JUL81	1	1.66
REPAIRMAN	28JUL81	1	2.11
LABORER	28JUL81	1	1.96
LABORER	28JUL81	1	1.26
DUST COLLECTOR	28JUL81	1	0.58
YARD WORKERS	29JUL81	1	0.12
STOREROOM SUPERINTENDENT	29JUL81	1	0.08
REPAIRMAN	29JUL81	1	0.74
DUST COLLECTOR	29JUL81	1	10.81
REPAIRMAN	29JUL81	1	0.19
REPAIRMAN	29JUL81	1	0.73
REPAIRMAN	30JUL81	1	0.88
PIPEFITTER	30JUL81	1	0.16
DUST COLLECTOR	30JUL81	1	23.82
SWEEPER DRIVER	30JUL81	1	1.78
ELECTRICIAN	30JUL81	1	0.23
LABORER	30JUL81	1	46.22
SWEEPER DRIVER	30JUL81	1	0.59
MILL HELPER (MIX)	30JUL81	3	0.30
UTILITY (SHIFT)	30JUL81	3	0.17
COKE COAL HANDLER	30JUL81	3	0.14
MILL OPERATOR	30JUL81	3	0.08
MIX CHEMIST	30JUL81	3	0.72

Table 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	2	0.01	0.01	0.00	5.39	0	0.00	0.02
RAW	11	0.22	0.10	0.20	1.61	0	0.07	0.46
CLINKER	12	0.40	0.25	0.31	2.46	0	0.03	0.94
FINISH	15	1.43	1.16	1.06	2.24	0	0.25	4.25
MIX	35	3.25	8.67	0.75	4.61	0	0.03	46.22
PLANTWIDE	73	1.95	6.12	0.57	3.73	0	0.03	46.22

Figure 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT MASON CITY, IOWA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

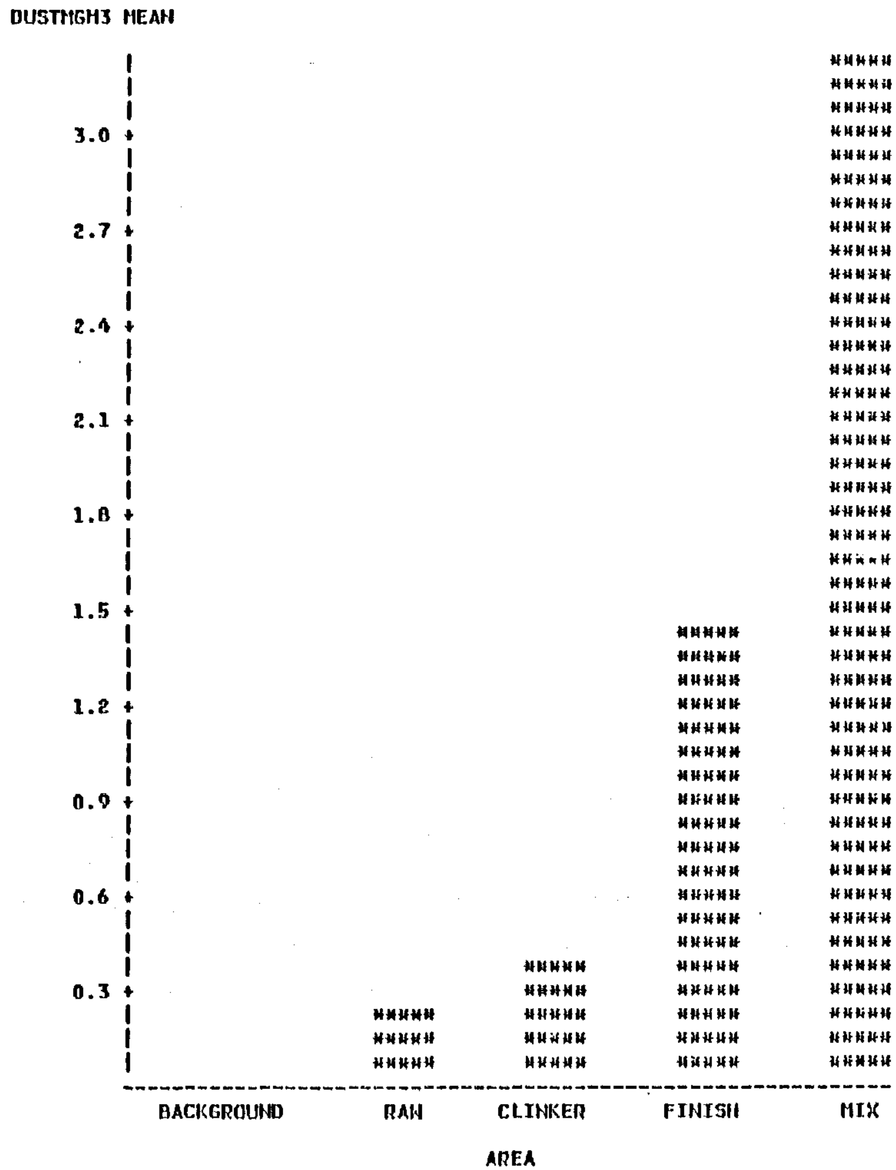

Figure 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

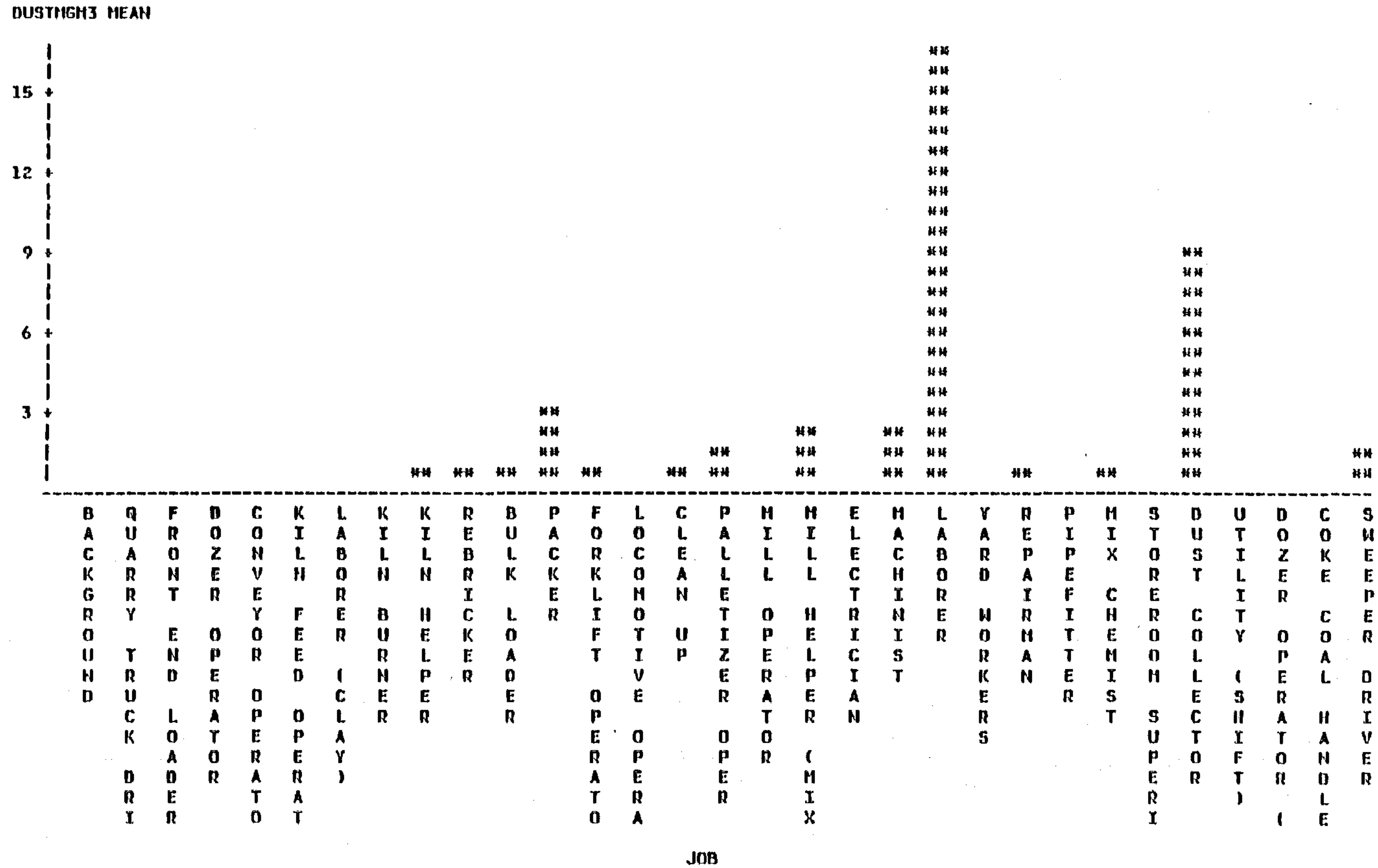

Table 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT MASON CITY, IOWA
QUARTZ CONCENTRATION OF PERSONAL RESPIRABLE DUST SAMPLES
QUARTZ CONCENTRATION IN MICROGRAMS PER CUBIC METER (UG/M3)

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
QUARRY TRUCK DRIVER	28JUL81	1	N	N	RAW
KILN FEED OPERATOR	28JUL81	1	N	N	RAW
KILN FEED OPERATOR	30JUL81	3	N	N	RAW
QUARRY TRUCK DRIVER	30JUL81	1	N	N	RAW
LABORER (CLAY)	30JUL81	1	N	N	RAW
REBRICKER	27JUL81	2	N	N	CLINKER
REBRICKER	27JUL81	2	N	N	CLINKER
KILN BURNER	27JUL81	2	N	N	CLINKER
KILN BURNER	28JUL81	1	N	N	CLINKER
KILN HELPER	28JUL81	1	N	N	CLINKER
KILN HELPER	28JUL81	1	N	N	CLINKER
KILN HELPER	28JUL81	1	N	N	CLINKER
REBRICKER	28JUL81	1	N	N	CLINKER
KILN HELPER	30JUL81	3	N	N	CLINKER
PACKER	27JUL81	2	N	N	FINISH
FORKLIFT OPERATOR (FINISH)	27JUL81	2	N	N	FINISH
PACKER	27JUL81	2	N	N	FINISH
FORKLIFT OPERATOR (FINISH)	27JUL81	2	N	N	FINISH
PACKER	27JUL81	2	N	N	FINISH
LOCOMOTIVE OPERATOR	29JUL81	1	N	N	FINISH
PACKER	29JUL81	1	N	N	FINISH
PACKER	29JUL81	1	N	N	FINISH
BULK LOADER	29JUL81	1	N	N	FINISH
BULK LOADER	30JUL81	1	N	N	FINISH
PALLETIZER OPER	30JUL81	1	N	N	FINISH
BULK LOADER	30JUL81	1	N	N	FINISH
BULK LOADER	30JUL81	1	N	N	FINISH
CLEAN UP	30JUL81	1	N	N	FINISH
MILL HELPER (MIX)	27JUL81	2	N	N	MIX
MILL HELPER (MIX)	27JUL81	2	N	N	MIX
DOZER OPERATOR (MIX)	27JUL81	2	N	N	MIX
MILL OPERATOR	27JUL81	2	N	N	MIX
MIX CHEMIST	27JUL81	2	N	N	MIX
DUST COLLECTOR	27JUL81	2	N	N	MIX
MILL HELPER (MIX)	27JUL81	2	N	N	MIX
MACHINIST	27JUL81	2	N	N	MIX
MACHINIST	27JUL81	2	N	N	MIX
MILL OPERATOR	28JUL81	1	N	N	MIX
REPAIRMAN	28JUL81	1	N	N	MIX
LABORER	28JUL81	1	2.8	54.94	MIX
MILL HELPER (MIX)	28JUL81	1	N	N	MIX
LABORER	28JUL81	1	N	N	MIX
MILL HELPER (MIX)	28JUL81	1	5.0	82.78	MIX
DUST COLLECTOR	28JUL81	1	N	N	MIX
REPAIRMAN	29JUL81	1	N	N	MIX
REPAIRMAN	29JUL81	1	N	N	MIX
DUST COLLECTOR	29JUL81	1	1.1	123.97	MIX
REPAIRMAN	30JUL81	1	5.8	51.16	MIX
ELECTRICIAN	30JUL81	1	N	N	MIX
LABORER	30JUL81	1	11.0	5084.2	MIX
DUST COLLECTOR	30JUL81	1	N	N	MIX
SWEEPER DRIVER	30JUL81	1	N	N	MIX

Table 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
QUARTZ CONCENTRATION OF PERSONAL RESPIRABLE DUST SAMPLES
QUARTZ CONCENTRATION IN MICROGRAMS PER CUBIC METER (UG/M3)

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
SWEEPER DRIVER	30JUL81	1	N	N	MIX
MIX CHEMIST	30JUL81	3	N	N	MIX
MILL HELPER (MIX)	30JUL81	3	N	N	MIX

Table 5

Environmental Investigations Branch

Cement Workers Morbidity Study
Northwestern States Cement, Mason City, Iowa

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	1.96	2.8	54.94	2.08
Repairman	0.88	5.8	51.16	1.28
Mill Helper	1.66*	5.0	82.78	1.43
Laborer	46.22*	11.0	5084.25	0.77
Dust Collector	10.81*	1.1	123.97	3.23

*Indicates the measured dust concentration exceeds the Permissible Exposure Limit.

Table 6

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	28JUL81	1	0.08
BACKGROUND	30JUL81	1	0.04

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
QUARRY TRUCK DRIVER	28JUL81	1	1.62
PRIMARY CRUSHER OPERATOR	28JUL81	1	35.16
QUARRY TRUCK DRIVER	30JUL81	1	0.80
FRONT END LOADER	30JUL81	1	0.73

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
KILN BURNER RELIEF	29JUL81	1	2.00
KILN HELPER	30JUL81	1	1.49
KILN HELPER	30JUL81	1	0.88

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
LOCOMOTIVE OPERATOR	29JUL81	1	2.28
PACKHOUSE FOREMAN	29JUL81	1	1.16

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
MACHINIST	28JUL81	1	0.78
ELECTRICIAN	28JUL81	1	2.00
REPAIRMAN	28JUL81	1	28.96
MIX CHEMIST	28JUL81	1	1.73
UTILITY (SHIFT)	29JUL81	1	0.04
REPAIRMAN	30JUL81	1	3.95

Table 7

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT MASON CITY, IOWA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	2	0.06	0.03	0.06	1.54	0	0.04	0.08
RAW	4	9.58	17.06	2.40	6.20	0	0.73	35.16
CLINKER	3	1.45	0.56	1.38	1.52	0	0.88	2.00
FINISH	2	1.72	0.79	1.62	1.61	0	1.16	2.28
MIX	6	6.24	11.21	1.53	8.56	0	0.04	28.96
PLANTWIDE	15	5.57	10.86	1.70	4.78	0	0.04	35.16

Figure 4

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY AREA

BAR CHART OF MEANS

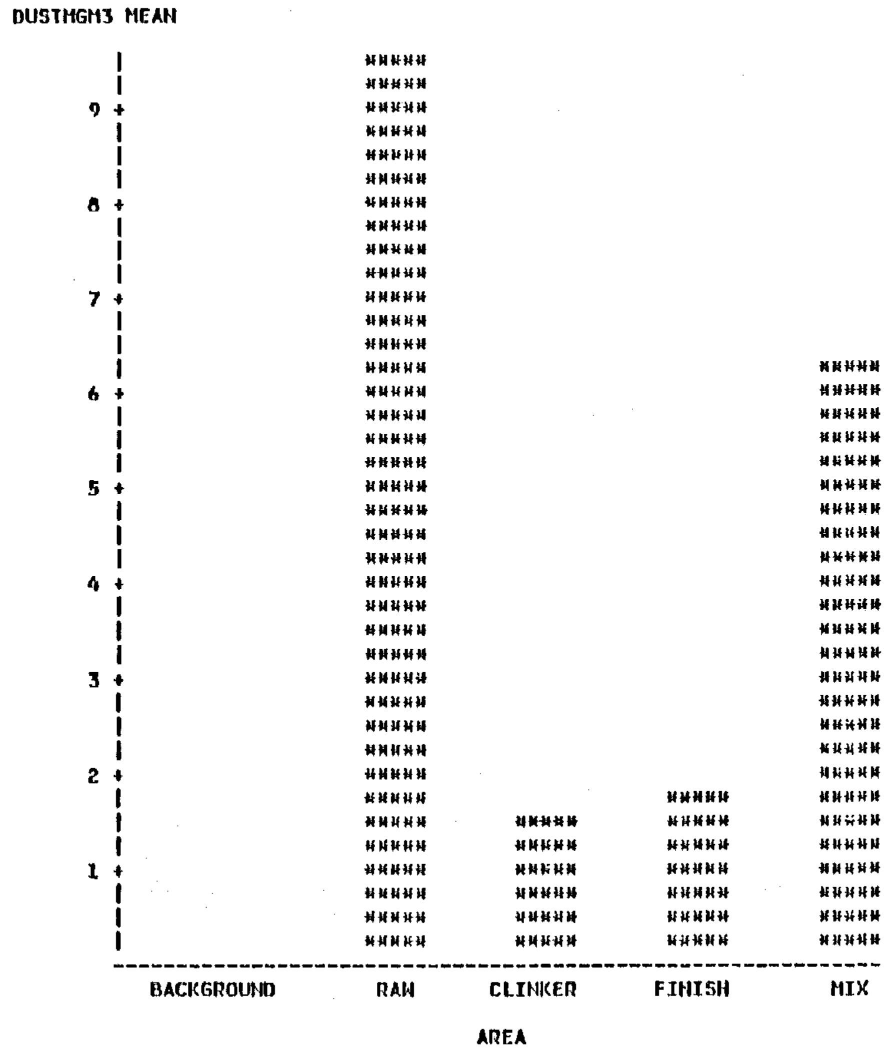

Figure 5

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
ARITHMETIC MEAN VALUES BY JOB CATEGORY

BAR CHART OF MEANS

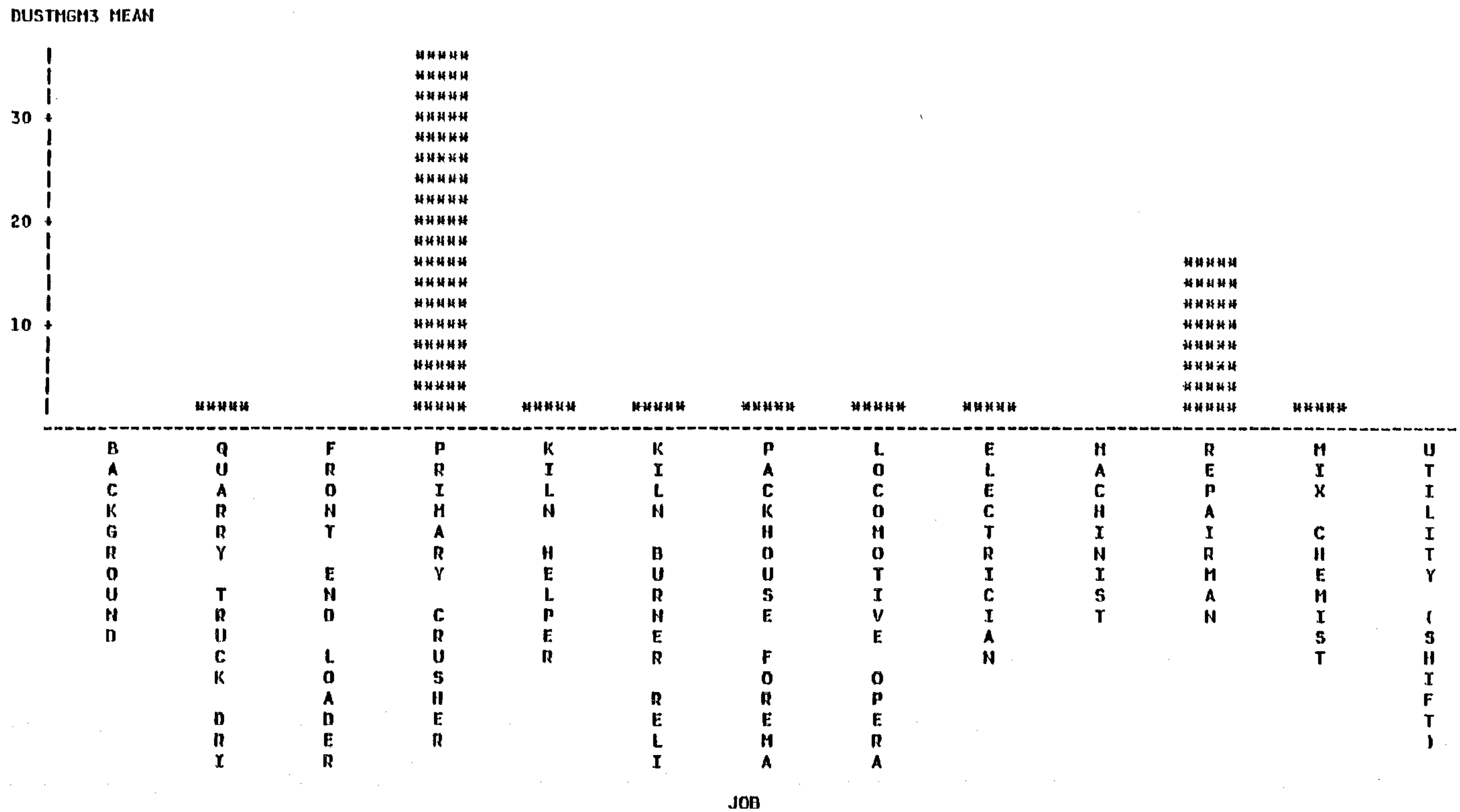

Table 8

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
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	28JUL81	1	QUARRY TRUCK DRIVER	15	62	N	24	N	10
RAW	28JUL81	1	PRIMARY CRUSHER OPERATOR	84	66	N	201	3	31
RAW	30JUL81	1	QUARRY TRUCK DRIVER	13	112	N	14	N	49
RAW	30JUL81	1	FRONT END LOADER	N	104	N	11	N	8
CLINKER	29JUL81	1	KILN BURNER RELIEF	34	72	N	19	N	N
CLINKER	30JUL81	1	KILN HELPER	N	N	N	1	N	N
CLINKER	30JUL81	1	KILN HELPER	23	6	N	15	N	15
FINISH	29JUL81	1	LOCOMOTIVE OPERATOR	13	71	N	8	N	8
FINISH	29JUL81	1	PACKHOUSE FOREMAN	14	68	N	8	N	N
MIX	28JUL81	1	DUST COLLECTOR	1387	26	21	1387	79	31
MIX	28JUL81	1	MACHINIST	N	91	N	6	N	N
MIX	28JUL81	1	ELECTRICIAN	31	62	N	18	N	N
MIX	28JUL81	1	REPAIRMAN	267	122	N	197	10	225
MIX	29JUL81	1	UTILITY (SHIFT)	N	N	N	N	N	19
MIX	30JUL81	1	REPAIRMAN	34	N	N	21	42	6
MIX	30JUL81	1	LABORER	1034	4	N	523	10	11

Table 9

Environmental Investigations Branch

Cement Workers Morbidity Study
Northwestern States Cement, Mason City, Iowa

Summary for Personal Trace Metal Concentrations in
Milligrams per Cubic Meter

Metal	N	Means	Std.dev.	Minimum	Maximum
Aluminum	12	246	462.37	13	1387
Chromium	13	67	37.21	4	122
Cobalt	1	21	---	21	21
Magnesium	15	164	366.31	1	1387
Manganese	5	29	32.05	3	79
Nickel	11	38	63.61	6	225

Table 10

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT MASON CITY, IOWA
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	28JUL81	1	BACKGROUND	N	115	N	N	N	8
BACKGROUND	30JUL81	1	BACKGROUND	N	31	N	N	N	108
MIX	28JUL81	1	MIX CHEMIST	25	67	N	11	N	8
RAW	28JUL81	1	CLAY DRYER	N	N	N	N	N	N
RAW	28JUL81	1	SHAKERS/BELT TRANSFER	143	N	N	195	2	58
CLINKER	27JUL81	2	FEED END OF FINISH MILLS	956	N	N	546	8	N
CLINKER	27JUL81	2	FRONT END OF KILN	39	N	N	20	N	N
CLINKER	29JUL81	1	CLINKER COOLER	204	N	N	120	2	N
CLINKER	30JUL81	1	FEED END OF FINISH MILLS	320	N	N	171	4	N
CLINKER	30JUL81	1	CLINKER CONVEYOR	69	N	N	50	N	N
FINISH	27JUL81	2	BAGGING	162	N	N	147	2	N
FINISH	28JUL81	1	BULK LOADING SILOS	N	N	N	5	N	N
FINISH	29JUL81	1	BAGGING	101	N	N	47	N	N
FINISH	30JUL81	1	BULK LOADING SILOS	84	N	N	42	N	N
MIX	28JUL81	1	WELDING SHOP	N	37	N	5	10	47
MIX	29JUL81	1	WELDING SHOP	78	13	N	130	260	17

Table 11

Environmental Investigations Branch

Cement Workers Morbidity Study
Northwestern States Cement, Mason City, Iowa

Summary for Area Trace Metal Concentrations in
Milligrams per Cubic Meter

Metal	N	Means	Std. Dev.	Minimum	Maximum
Aluminum	11	198	265.15	25	956
Chromium	5	53	39.87	13	115
Magnesium	13	114	145.71	5	546
Manganese	7	41	96.7	2	260
Nickel	6	41	39.05	8	108

Table 12

Environmental Investigations Branch
Cement Workers Morbidity Study
Northwestern States Cement, Mason City, Iowa

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

	Exposure Categories			
Metals	Finish Mill	Packhouse	2° Crusher	Clinker Conveyor Belt
Aluminum	1490.53	141.57	9.46	249.34
Calcium	28796.79	4374.06	2877.45	4516.3
Iron	785.40	291.61	11.13	125.92
Magnesium	719.79	90.8	31.86	132.0
Manganese	13.90	N	N	N
Sodium	158.45	9.74	N	35.13
Phosphorus	4.28	N	N	1.24
Titanium	69.52	6.55	N	12.53
Zinc	32.09	N	N	N

The following elements were less than 1.0 ug/filter in the above samples: silver, arsenic, beryllium, cadmium, cobalt, litanium, molybdenum, platinum, selenium, tin, tellurium, thallium, vanadium, yttrium, and zirconium.

Table 13

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT MASON CITY, IOWA
ANALYSIS OF BULK MATERIAL PRESENTED AS PERCENT BY WEIGHT

AREA	JOB	QUARTZ	CRISTB	AL	CR	CO	MG	MN	NI	ASBEST
RAW	RAW MATERIAL	3.7	N	0.77	N	N	0.64	0.014	N	0.0
RAW	RAW MATERIAL	3.0	N	1.20	N	N	1.00	0.016	N	0.0
RAW	RAW MATERIAL	4.7	N	1.80	N	N	0.99	0.023	N	0.0
RAW	RAW MATERIAL	N	N	0.41	N	N	0.84	0.010	N	0.0
RAW	RAW MATERIAL	N	N	0.36	N	N	0.66	0.009	N	0.0
RAW	RAW MATERIAL	N	N	0.47	N	N	0.90	0.011	N	0.0
RAW	RAW MATERIAL	17.7	N	2.20	N	N	1.10	0.042	N	0.0
CLINKER	CLINKER	N	N	2.60	N	N	1.00	0.022	N	0.0
CLINKER	CLINKER	N	N	1.80	N	N	1.00	0.020	N	0.0
CLINKER	CLINKER	N	N	2.10	N	N	0.97	0.021	N	0.0
CLINKER	CLINKER	N	N	2.00	N	N	0.93	0.019	N	0.0
CLINKER	CLINKER	N	N	2.60	N	N	1.10	0.022	N	0.0
FINISH	FINISH	N	N	1.40	N	N	0.76	0.015	N	0.0
FINISH	FINISH	N	N	1.80	N	N	0.90	0.017	N	0.0
FINISH	FINISH	N	N	2.40	N	N	0.94	0.020	N	0.0
FINISH	FINISH	N	N	2.30	N	N	1.10	0.021	N	0.0
FINISH	FINISH	N	N	2.20	N	N	1.30	0.026	N	0.0
FINISH	FINISH	N	N	2.40	N	N	1.20	0.021	N	0.0
FINISH	FINISH	N	N	2.50	N	N	1.20	0.022	N	0.0
MIX	COKE OR COAL	N	N	0.25	N	N	0.04	N	N	0.0
MIX	CLINKER FINISH	N	N	2.00	N	N	1.40	0.021	N	0.0
MIX	RAW CLINKER FINISH	2.6	N	0.96	N	N	1.10	0.015	N	0.0

Table 14

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT   MASON CITY, IOWA
SOX CONCENTRATIONS

JOB	DATE	SHIFT	AREA	SO4_UGM3	SO3_UGM3	SO2_PPM
BAGHOUSE BACK END OF KILN	27JUL81	2	RAW	N	N	0.01
DISCHARGE STACK (BOTTOM)	27JUL81	2	RAW	N	N	N
BACK END OF KILN	30JUL81	1	RAW	35.40	N	0.01
FRONT END OF KILN	30JUL81	1	CLINKER	18.98	N	0.01

Table 15

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
NORTHWESTERN STATES CEMENT MASON CITY, IOWA
NO2 CONCENTRATIONS IN PPM

JOB	DATE	SHIFT	AREA	CONC
QUARRY TRUCK DRIVER	28JUL81	1	RAW	0.09
KILN FEED OPERATOR	28JUL81	1	RAW	0.01
FRONT END LOADER	28JUL81	1	RAW	0.12
FRONT END LOADER	28JUL81	1	RAW	0.02
QUARRY TRUCK DRIVER	28JUL81	1	RAW	0.19
DOZER OPERATOR	30JUL81	1	RAW	0.02
LABORER (CLAY)	30JUL81	1	RAW	0.10
QUARRY TRUCK DRIVER	30JUL81	1	RAW	0.10
CONVEYOR OPERATOR	30JUL81	1	RAW	0.11
REBRICKER	28JUL81	1	CLINKER	0.03
KILN BURNER	28JUL81	1	CLINKER	0.03
KILN HELPER	28JUL81	1	CLINKER	0.11
KILN HELPER	28JUL81	1	CLINKER	0.04
KILN HELPER	30JUL81	3	CLINKER	N
BULK LOADER	30JUL81	1	FINISH	0.07
BULK LOADER	30JUL81	1	FINISH	0.13
BULK LOADER	30JUL81	1	FINISH	0.14
PALLETIZER OPER	30JUL81	1	FINISH	0.02
CLEAN UP	30JUL81	1	FINISH	0.03
UTILITY (SHIFT)	28JUL81	1	MIX	0.10
LABORER	28JUL81	1	MIX	0.07
DUST COLLECTOR	28JUL81	1	MIX	0.06
MILL HELPER (MIX)	30JUL81	3	MIX	0.02
SWEEPER DRIVER	30JUL81	1	MIX	0.09
MIX CHEMIST	30JUL81	3	MIX	0.02
LABORER	30JUL81	1	MIX	0.06
SWEEPER DRIVER	30JUL81	1	MIX	0.05

Table 16

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Northwestern States Cement, Mason City, Iowa

Direct Reading Indicator Tube Concentrations in
Parts Per Million (PPM)

Date	Area	CO	NOx	NO2
July 29	Bag storage (gasoline powered forklifts)	11	trace	0
	(are moving pallets)	6	trace	0
	up on palletizerin bag storage	40	0.1	0
	Truck bulk load silos	0	0	0
	Inside Kiln #2 Forklift bringing bricks in for rebricking operation	5	0	0

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.