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Industrial Hygiene Survey of California Cement Co.

Colton, California

Cement Workers Morbidity Study

Wayne T. Sanderson and Cathy Davidson

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Environmental Investigations Branch
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16. Abstract (Limit: 200 words) A walk through survey was conducted of the California Cement Company, Colton, California, to determining the presence of materials harmful to the health of workers at that and similar sites. For most jobs at the site the respirable and total dust levels were below recommended limits. There were eight respirable dust samples which exceeded the 5.0mg/m3 recommended ACGIH levels for respirable nuisance particulate. Detectable levels of quartz (14808607) were found in 11 respirable dust samples. Six total dust samples exceeded the Mine Safety and Health Administration limit of 10mg/m3. Exposure to quartz dust was associated with raw materials. The authors recommend that personal respirators should be provided for workers involved in maintenance and clean up operations. Substitution of a vacuum system for the currently used compressed air would greatly lessen the current exposure to dust during clean up operations. The use of disposable paper or cloth respirators is not suitable for protecting the worker from dust levels. The exposures to carbon-monoxide (630080) and nitrogen oxides can be reduced by turning off engines when not in use.

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Executive Summary

The California Cement Plant in Colton, California was surveyed by a NIOSH team of industrial hygienists, on December 7 through December 10, 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 are below recommended exposure levels. However, eight samples exceeded the ACGIH recommended level of 5.0 mg/m^3 for respirable nuisance particulate. Six total dust samples exceeded the MSHA standard of 10 mg/m^3 for nuisance dust. Of the dust contaminants measured, only quartz is considered to be present in excessive concentrations. Exposure to quartz was observed in all areas of the plant, particularly in association with raw materials. Eleven 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. California Cement in Colton, California was the fifteenth 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.

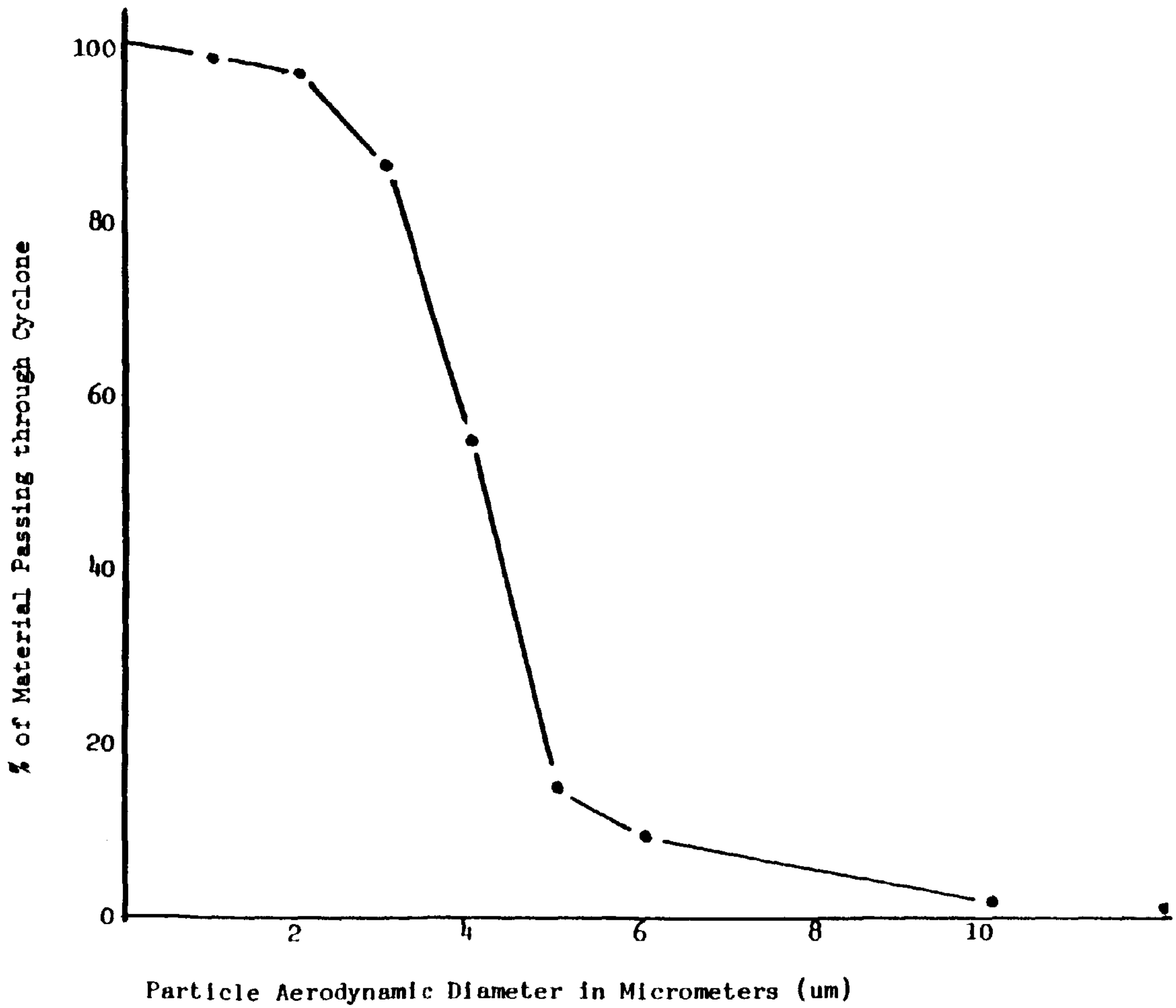
The California Cement plant in Colton, California was surveyed on Monday, December 7 through Thursday, December 10, 1981, by Laurie Piacitelli, Michael McCawley, John Gamble, and Wayne Sanderson. The original cement plant was established in the 1890's adjacent to a limestone quarry, one mile southwest of Colton. Today, the limestone quarry serves not only as a calcium source for cement production, but as a source for commercial lime which is also processed at the plant site. The rock is crushed in gyratory and impactor crushers, and then stored for use in cement or lime production. Other materials for cement production (shale, sand, gypsum, and coal) are trucked in by other companies. The limestone, shale, and sand are blended and milled in rotating ball mills into a powder. The raw material powder is pumped into the kilns for clinker production. Cement clinkers are produced by the dry process method in two kilns which were built in 1963. The kilns are fueled by pulverized coal. Gypsum is added to the clinker and it is milled in ball mills to increase fineness; this ground material is Portland cement. The four types of finished cement manufactured here, are bagged, or loaded out as bulk in trucks or railcars.

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

Figure 1 COLLECTION EFFICIENCY OF THE PERSONAL RESPIRABLE DUST CYCLONE



the nearest 0.01 milligram (mg), before and after sampling. The weight gain of the filters, the sampling flow rates, and the sampling times were used to calculate airborne dust levels.

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

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

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

After weighing, the total dust filters were ashed in acid and analyzed by atomic absorption (3) to detect the amount of aluminum (AL), chromium (CR), cobalt (CO), magnesium (MG), manganese (MN), and nickel (NI) present. The trace metal concentrations are reported in Table 8 as micrograms per cubic meter of air (___ UGM3). Once again, a value of "N" indicates that the measured quantity was below the limit of detection. The limits of detection for each element are listed in Table 1. Trace metal analyses are summarized in Table 9. The MEAN is the arithmetic mean of all the samples with detectable levels of the particular elements. STD DEV is the standard deviation of these samples and is an expression of the variability of the elemental concentrations.

Area Total Dust Samples

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

The trace metal concentrations are reported in Table 10 as micrograms per cubic meter of air (___UGM3). The JOB column defines the area in which the sample was collected. The six trace metal concentrations are then given in the next six columns. The results of the trace metal analysis of the area total samples are summarized in Table 11.

One area sample from each exposure category was analyzed for content of 28 metals. These samples were ashed using nitric and perchloric acids and the residues dissolved in dilute nitric acid. The resulting solutions were analyzed for trace metal content by inductively coupled plasma - atomic emission spectroscopy (ICP-AES). (4) The results of the analysis are reported in Table 12. For this analysis technique, the lower limit of detection is 1.0 ug/filter for all elements.

Airborne Fiber Samples

Samples for airborne fibers and asbestos were collected on cellulose ester filters. These samples are taken with the front of the filters completely open to the environment. Air is drawn through the filters at a flow rate of

1.7 lpm. These filters are optically analyzed using a phase contrast microscope. (5) If fibers were detected, they would have been analyzed by polarized light and dispersion staining, and transmission electron microscopy to determine whether they were asbestos fibers.

In this survey 26 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, and the SO2_PPM column gives the sulfur dioxide concentrations in parts per million. The analytical limits of detection for these compounds 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. The results of the analysis are presented in Table 15. Nitrogen dioxide is produced from the combustion of organic compounds such as coal and diesel fuel, which contain nitrogen.

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), ammonia (NH_3), and hydrochloric acid (HCl). 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 at 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, December 7, 1981. The sampling schedule was as follows:

Monday, December 7	- 2nd shift
Tuesday, December 8	- 1st shift
Wednesday, December 9	- 1st shift
Thursday, December 10	- 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:

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

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, eight samples exceeded 5 mg/m^3. The powder limestone operator was operating the lime mill and loading transport trucks with lime. The kiln helper was exposed to mineral dust and not nuisance dust because his sample contained greater than 1% quartz (see Table 4). He had been working on a choked air slide in the raw feed silo. The finish dust collector, utilityman, and mill operator were all cleaning up a large dust spill in the special grinding area, and trying to get the mills operational. The clean-up worker in the finish area was cleaning floors and equipment with compresed air at the truck load silos. The vacuum truck driver was cleaning up spills in the finish and raw silos. The welder was welding pipes in the finish product silos. The weight on his sample may have been from heavy metal fume rather than cement particles. For all workers the geometric mean respirable dust level was 0.83 mg/m^3.

Six personal total dust samples, Table 6, exceeded 10 mg/m^3. The rock sorter was removing rocks by hand as they passed on a conveyor belt. The finish mill operator was operating mills in the special grind area. The packer was bagging cement and assisting other baggers. The electrician was working in many areas of the plant. The yard worker was collecting overflow and waste material and hauling it to the waste lake. For all workers the geometric mean total dust level was 4.62 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, powder limestone operators, laborers and yardworkers, packhouseworkers, mill operators, kiln helpers, and electricians 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 raw material from the primary and secondary crushers (5.2-6.3%), raw mill area (8.1%), and raw storage silos (12.5%). 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.

Respirable dust samples from 30 workers were analyzed for concentration of the crystalline mineral types quartz and cristobalite. Eleven of the samples contained detectable quantities of quartz. All of the workers had spent all or part of their shift exposed to raw materials except the finish mill dust collector and the packer. These two samples also contained the lowest percentages of quartz. The quarry laborer was cleaning up spills along the crusher belts and in the rock storage areas. The crusher oiler was cleaning and greasing the primary and secondary crushers. The front end loader operator was loading quarry trucks. The rock sorter was removing rocks from a conveyor belt. The dust collector on December 9 was working on the raw silo dust collection system. These five workers had spent their entire shift exposed to raw material dust. The kiln helpers spent part of their shift at the raw end of the kiln and part at the clinker end. The worker with the highest concentration of quartz (1380.4 ug/m^3) was a kiln helper who was working on a choked up air slide in the kiln feed silos. The mill helper was cleaning and checking both the raw and finish mills. The dust collector on December 10 was working on the collection systems in several areas of the plant.

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 0.7 - 8.7%.

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

Trace Metals

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

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

Sulfur dioxide concentrations of 0.01 ppm were found at the back end of the kiln. These levels are below the ACGIH TLV of 2 ppm, and MSHA PEL of 5 ppm. These measurements show however that exposure to sulfur dioxide does occur. Only one sample detected sulfate particulates at the back end of the kiln. Exposures to greater concentrations may occur because of breakdowns or breaches in the kiln exhaust system. Also, if the sulfur content of the kiln fuel increases, more sulfur dioxide may be produced. Sulfate particulates have not been documented to cause irritation or chronic disease. However, there is strong evidence that aerosols of these water soluble salts catalyze the conversion of sulfur dioxide to sulfuric acid, thus potentiating the irritant and reflex bronchoconstrictive effects of sulfur dioxide. (14) Nevertheless, workers should not experience irritation or respiratory changes attributable to SO_2 or sulfates at levels detected at California Cement. (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. (27) A number of human experiments and animal studies suggest that humans with normal respiratory function may be affected by exposure at or below this level and that the conditions of workers with disease such as bronchitis may be aggravated by such exposures. (25,26,27,28) NIOSH recommends a ceiling of 1 ppm to protect workers with pre-existing chronic bronchitis. ACGIH maintains a STEL of 5 ppm and a TWA of 3 ppm.

All of the 34 samples taken at California Cement were below the recommended standard.

Toxic Gases

Carbon monoxide and oxides of nitrogen were detected in areas where diesel and gasoline powered forklifts and trucks were being operated (see Table 16). 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. It is possible that when diesel or gasoline powered engines are run in enclosed spaces, excessive levels of carbon monxide and oxides of nitrogen may build up. The MSHA PEL for carbon monoxide and nitrogen dioxide are 50 and 5 ppm, respectively for an 8-hour time-weighted average.

Samples for hydrochloric acid and ammonia in the laboratory indicate that workers are exposed to these two gases during wet chemical analyses of minerals. The wet chemical tests are generally run only once and seldom more than twice per shift. These gases were detected for no more than four or five minutes during a portion of the laboratory procedure. The MSHA PEL for hydrochloric acid and ammonia are 5 and 25 pppm for an 8-hour time-weighted average.

Background Samples

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

Conclusion

The respirable and total dust levels for most jobs at the California Cement Plant in Colton, California are below recommended exposure levels. Eight respirable dust samples exceeded the ACGIH recommended level for respirable nuisance particulate. Six total dust samples exceeded the 10 mg/m^3 MSHA standard for nuisance dust. Eleven respirable dust samples contained detectable levels of quartz. All 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 association with the raw materials. Protective measures should be taken.

Recommendations

Engineering controls are the most effective means of reducing worker exposure to airborne dust. These controls should be maintained in efficient working order. Ventilation design to remove the dust from the air once it is generated and separation from the dust by enclosing either the worker or the dust are effective means of control. The priority for implementing dust control measures should begin with areas of highest exposure. You can use Figures 3 through 5 to identify the jobs and areas with the highest exposures.

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.

During clean-up operations, workers often use compressed air to "blow down" the work areas and themselves. 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 or nitrogen oxides from engine exhaust, engines should be shut off or parked outside 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 scalehouse. 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
California Cement, Colton, California

Number of Samples With Detectable Levels of Contaminants

Contaminant	# Samples Collected	# Samples with Detectable Conc.	Limit of Detection
Respirable dust	71	71	0.01 mg
Total dust	15	15	0.01 mg
Quartz	30	11	0.03 mg
Cristobalite	30	0	0.03 mg
Aluminum	33	25	0.20 mg
Chromium	33	4	0.004 mg
Cobalt	33	4	0.005 mg
Magnesium	33	32	0.002 mg
Manganese	33	19	0.002 mg
Nickel	33	4	0.004 mg
Asbestos	26	0	4500 fibers
Sulfate	3	1	0.005 mg
Sulfite	3	0	0.01 mg
Sulfur dioxide	3	2	0.005 mg
Nitrgen dioxide	34	33	0.02 ppm

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	07DEC81	2	0.21
BACKGROUND	08DEC81	1	0.01
BACKGROUND	09DEC81	1	0.01
BACKGROUND	10DEC81	1	0.01

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
POWDER LIMESTONE OPER	07DEC81	2	2.45
RAYMOND MILLER	08DEC81	1	2.52
LABORER (QUARRY)	08DEC81	1	3.02
TRUCK DRIVER (LIME PLANT)	08DEC81	1	0.91
DRILLER	08DEC81	1	0.38
PRIMARY CRUSHER OPERATOR	08DEC81	1	0.30
FRONT END LOADER	08DEC81	1	0.02
QUARRY TRUCK DRIVER	08DEC81	1	0.42
BAGGING (LIME)	09DEC81	1	0.73
WATER TRUCK OPERATOR	09DEC81	1	0.43
BAGGING (LIME)	09DEC81	1	1.20
POWDER LIMESTONE OPER	09DEC81	1	7.41
QUARRY TRUCK DRIVER	10DEC81	1	0.36
DRILLER	10DEC81	1	0.23
FRONT END LOADER	10DEC81	1	0.73
FRONT END LOADER	10DEC81	1	1.68
OILER (SHOVEL)	10DEC81	1	2.40
ROCK SORTER (LIME PLANT)	10DEC81	1	3.08

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
KILN HELPER	07DEC81	2	2.39
KILN HELPER	08DEC81	1	18.85
KILN BURNER	08DEC81	1	0.33
KILN HELPER	09DEC81	1	0.76
CRANE OPER (CLINKER)	10DEC81	1	0.36
KILN HELPER	10DEC81	1	1.54

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
PACKER	07DEC81	2	3.60
MAINTENANCE (FINISH)	07DEC81	2	1.05
FORKLIFT OPERATOR (FINISH)	07DEC81	2	0.54
PACKER	07DEC81	2	1.03
UTILIYMAN (FINISH)	07DEC81	2	2.06
DUST COLLECTOR (FINISH)	07DEC81	2	6.60
UTILIYMAN (FINISH)	07DEC81	2	6.19
MILL OPERATOR (FINISH)	07DEC81	2	6.08
CLEAN UP	07DEC81	2	13.70
SCALEHOUSE CLERK	07DEC81	2	0.15
UTILIYMAN (FINISH)	08DEC81	1	1.31
FINISH MILL HELPER	08DEC81	1	3.19
UTILIYMAN (FINISH)	08DEC81	1	0.01
CLEAN UP	08DEC81	1	0.03
BULK LOADER	09DEC81	1	0.45
PACKER	09DEC81	1	2.23
FORKLIFT OPERATOR (FINISH)	09DEC81	1	0.41
FORKLIFT OPERATOR (FINISH)	10DEC81	1	0.71

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
LABORER	07DEC81	2	0.13
MOBILE EQUIPMENT OPER (PLANT)	07DEC81	2	0.55
REPAIRMAN	07DEC81	2	0.38
MILL HELPER (MIX)	07DEC81	2	1.77
FRONT END LOADER (YARD)	07DEC81	2	0.30
CONSOLE OPERATOR	07DEC81	2	0.92
MACHINIST	07DEC81	2	2.27
MIX CHEMIST	07DEC81	2	0.09
LABORATORY WORKER	08DEC81	1	0.33
REPAIRMAN	08DEC81	1	0.01
OILER (GENERAL)	08DEC81	1	0.10
VACUUM TRUCK DRIVER	08DEC81	1	7.86
LABORATORY WORKER	09DEC81	1	0.25
YARD WORKERS	09DEC81	1	0.28
LABORER	09DEC81	1	2.13
STOREROOM SUPERINTENDENT	09DEC81	1	0.44
MACHINIST	09DEC81	1	0.58
CARPENTER	09DEC81	1	0.32
VACUUM TRUCK DRIVER	09DEC81	1	3.09
DUST COLLECTOR	09DEC81	1	2.67
LABORER	10DEC81	1	4.74
DUST COLLECTOR	10DEC81	1	3.51
OILER (GENERAL)	10DEC81	1	0.52
JANITOR	10DEC81	1	0.32
LABORER	10DEC81	1	2.41
ELECTRICIAN	10DEC81	1	0.80

Table 2

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

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

JOB	DATE	SHIFT	DUSTMGM3
WELDER	10DEC81	1	5.97
YARD WORKERS	10DEC81	1	0.53
MAINTENANCE SHOP	10DEC81	1	0.57

Table 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT   COLTON, CALIFORNIA
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	4	0.06	0.10	0.02	4.62	0	0.01	0.21
RAW	18	1.57	1.78	0.84	3.74	0	0.02	7.41
CLINKER	6	4.04	7.30	1.35	4.52	0	0.33	18.85
FINISH	18	2.74	3.50	0.99	6.50	0	0.01	13.70
MIX	29	1.51	1.94	0.67	4.19	0	0.01	7.86
PLANTWIDE	71	2.05	3.11	0.83	4.57	0	0.01	18.85

Figure 2

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

BAR CHART OF MEANS

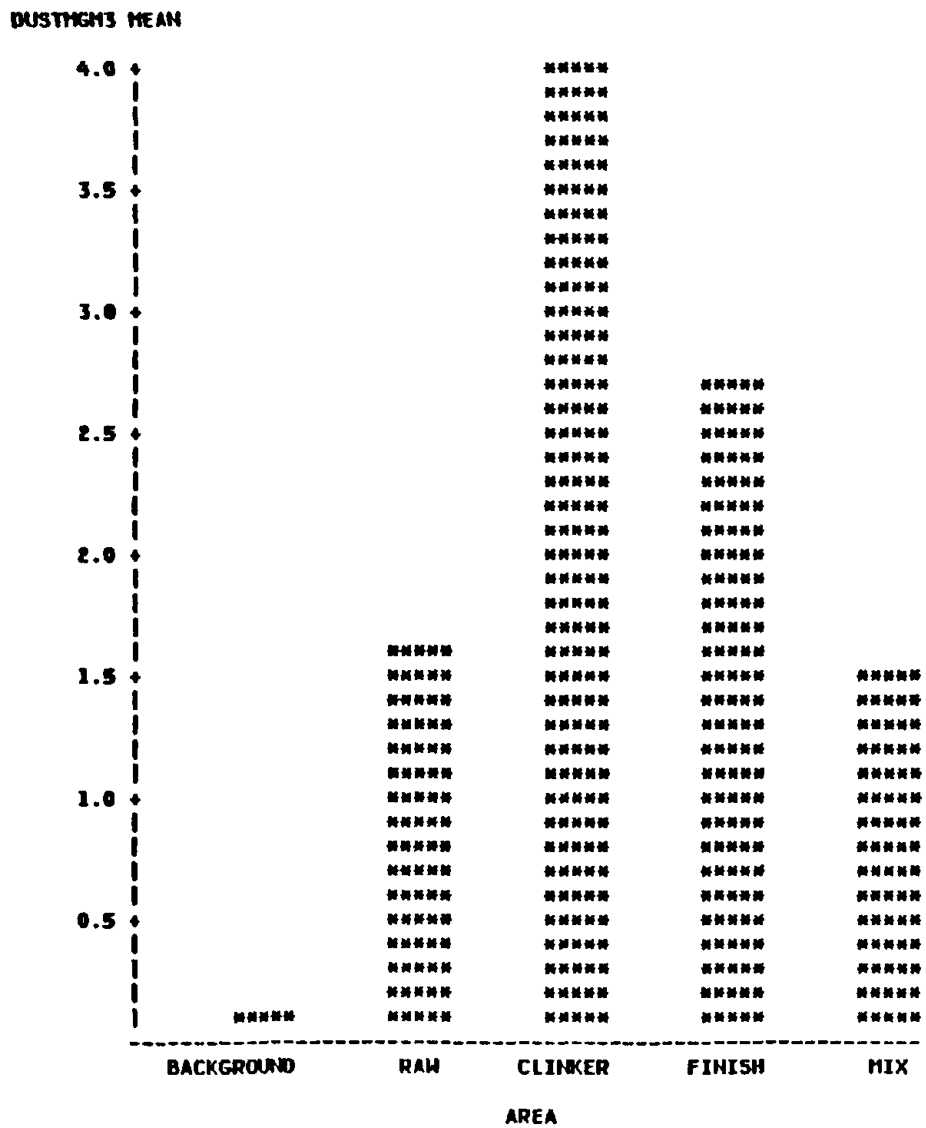

Figure 3

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

BAR CHART OF MEANS

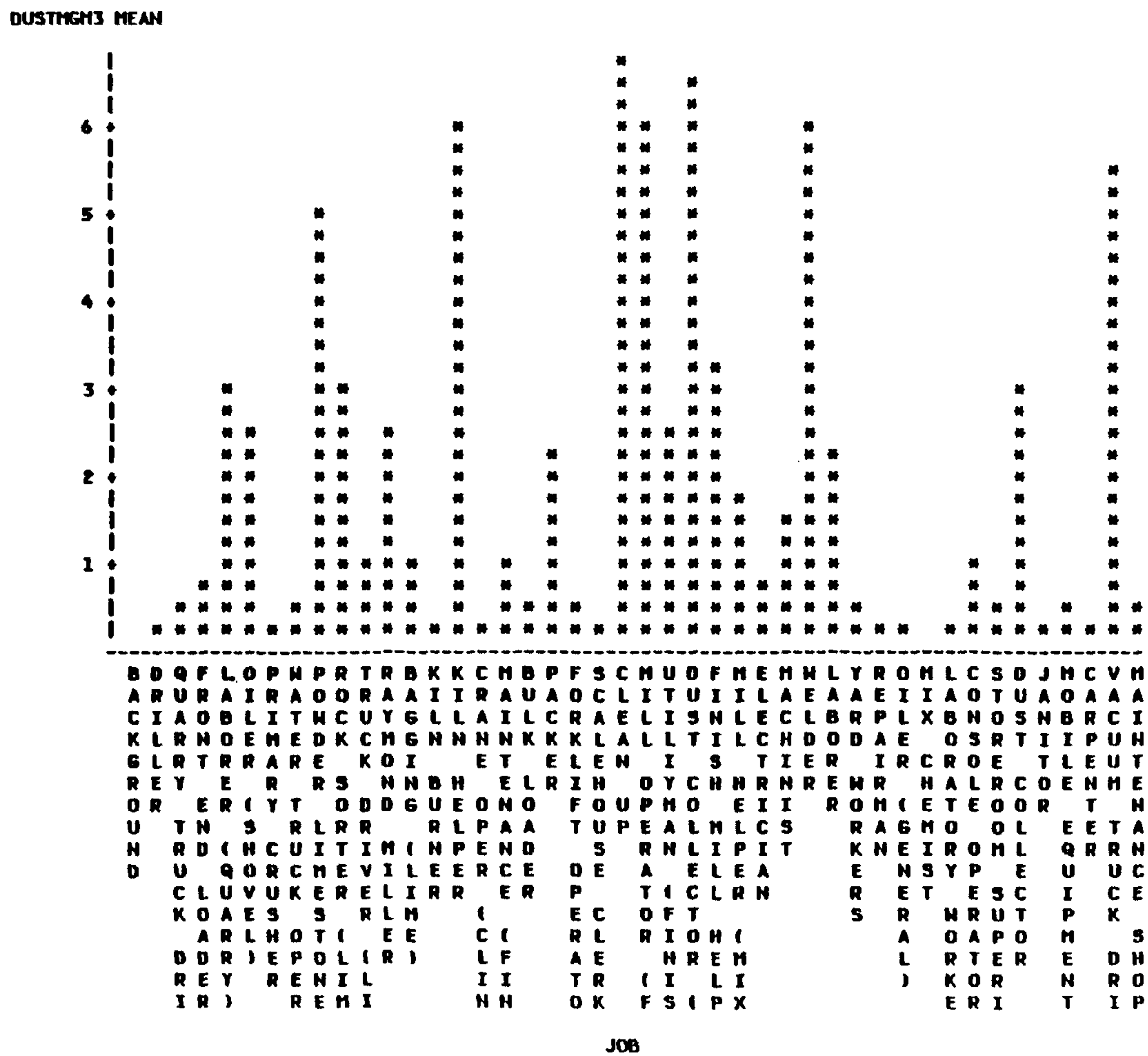

Table 4

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

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
POWDER LIMESTONE OPER	07DEC81	2	N	N	RAW
~~RAYMOND MILLER~~	~~08DEC81~~	~~1~~	~~N~~	~~N~~	~~RAW~~
TRUCK DRIVER (LIME PLANT)	08DEC81	1	N	N	RAW
LABORER (QUARRY)	08DEC81	1	8.7	262.30	RAW
POWDER LIMESTONE OPER	09DEC81	1	N	N	RAW
BAGGING (LIME)	09DEC81	1	N	N	RAW
OILER (SHOVEL)	10DEC81	1	2.4	58.29	RAW
FRONT END LOADER	10DEC81	1	5.1	86.02	RAW
ROCK SORTER (LIME PLANT)	10DEC81	1	1.5	44.83	RAW
KILN HELPER	07DEC81	2	3.3	79.08	CLINKER
KILN HELPER	08DEC81	1	7.3	1380.4	CLINKER
UTILIYMAN (FINISH)	07DEC81	2	N	N	FINISH
MILL OPERATOR (FINISH)	07DEC81	2	N	N	FINISH
DUST COLLECTOR (FINISH)	07DEC81	2	0.7	46.90	FINISH
PACKER	07DEC81	2	1.0	65.72	FINISH
UTILIYMAN (FINISH)	07DEC81	2	N	N	FINISH
CLEAN UP	07DEC81	2	N	N	FINISH
UTILIYMAN (FINISH)	08DEC81	1	N	N	FINISH
FINISH MILL HELPER	08DEC81	1	N	N	FINISH
MACHINIST	07DEC81	2	N	N	MIX
MILL HELPER (MIX)	07DEC81	2	4.9	86.48	MIX
FRONT END LOADER (YARD)	07DEC81	2	N	N	MIX
VACUUM TRUCK DRIVER	08DEC81	1	N	N	MIX
VACUUM TRUCK DRIVER	09DEC81	1	N	N	MIX
LABORER	09DEC81	1	N	N	MIX
DUST COLLECTOR	09DEC81	1	5.0	133.58	MIX
DUST COLLECTOR	10DEC81	1	4.2	146.94	MIX
WELDER	10DEC81	1	N	N	MIX
LABORER	10DEC81	1	N	N	MIX
LABORER	10DEC81	1	N	N	MIX

Table 5

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
California Cement, Colton, California

Detectable Quartz Compared to MSHA Permissible Exposure Levels

Job	Levels of Dust Conc. Mg/m3	Quartz Conc. % Quartz	ug/m3	MSHA PEL mg/m3
Laborer (quarry)	3.02*	8.7	262.3	0.93
Oiler (shovel)	2.40*	2.4	58.29	2.27
Front end loader	1.68*	5.1	86.02	1.41
Rocksorter	3.08*	1.5	44.83	2.86
Kiln helper	2.39*	3.3	79.08	1.89
Kiln helper	18.85*	7.3	1380.4	1.08
Dust collector (finish)	6.6*	0.7	46.09	3.7
Packer	3.6*	1.8	65.72	2.63
Mill helper	1.77*	4.9	86.48	1.45
Dust collector	2.67*	5.0	133.58	1.43
Dust collector	3.51*	4.2	146.94	1.61

*Indicates measured concentration exceeds the MSHA Permissible Exposure Limit.

Table 6

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3
GROUPED BY EXPOSURE AREA

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	08DEC81	1	0.00
BACKGROUND	09DEC81	1	0.19
BACKGROUND	10DEC81	1	0.21

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
LABORER (RAW)	08DEC81	1	1.60
ROCK SORTER (LIME PLANT)	08DEC81	1	13.90
BLASTER	10DEC81	1	4.28
QUARRY TRUCK DRIVER	10DEC81	1	1.49

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
KILN HELPER	09DEC81	1	27.03

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
MILL OPERATOR (FINISH)	08DEC81	1	13.50
PACKER	09DEC81	1	26.56

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
ELECTRICIAN	08DEC81	1	10.12
YARD WORKERS	08DEC81	1	20.36
WELDER	08DEC81	1	3.83
FRONT END LOADER (YARD)	09DEC81	1	5.01
LABORER	09DEC81	1	4.32
OILER (GENERAL)	09DEC81	1	2.87
WELDER	10DEC81	1	0.02
LABORER	10DEC81	1	8.72

Table 7

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	3	0.13	0.12	0.07	5.64	0	0.00	0.21
RAW	4	5.32	5.87	3.45	2.85	0	1.49	13.90
CLINKER	1	27.03	.	27.03	.	0	27.03	27.03
FINISH	2	20.03	9.23	18.93	1.61	0	13.50	26.56
MIX	8	6.91	6.30	3.02	9.07	0	0.02	20.36
PLANTWIDE	15	9.57	8.94	4.62	6.18	0	0.02	27.03

Figure 4

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

BAR CHART OF MEANS

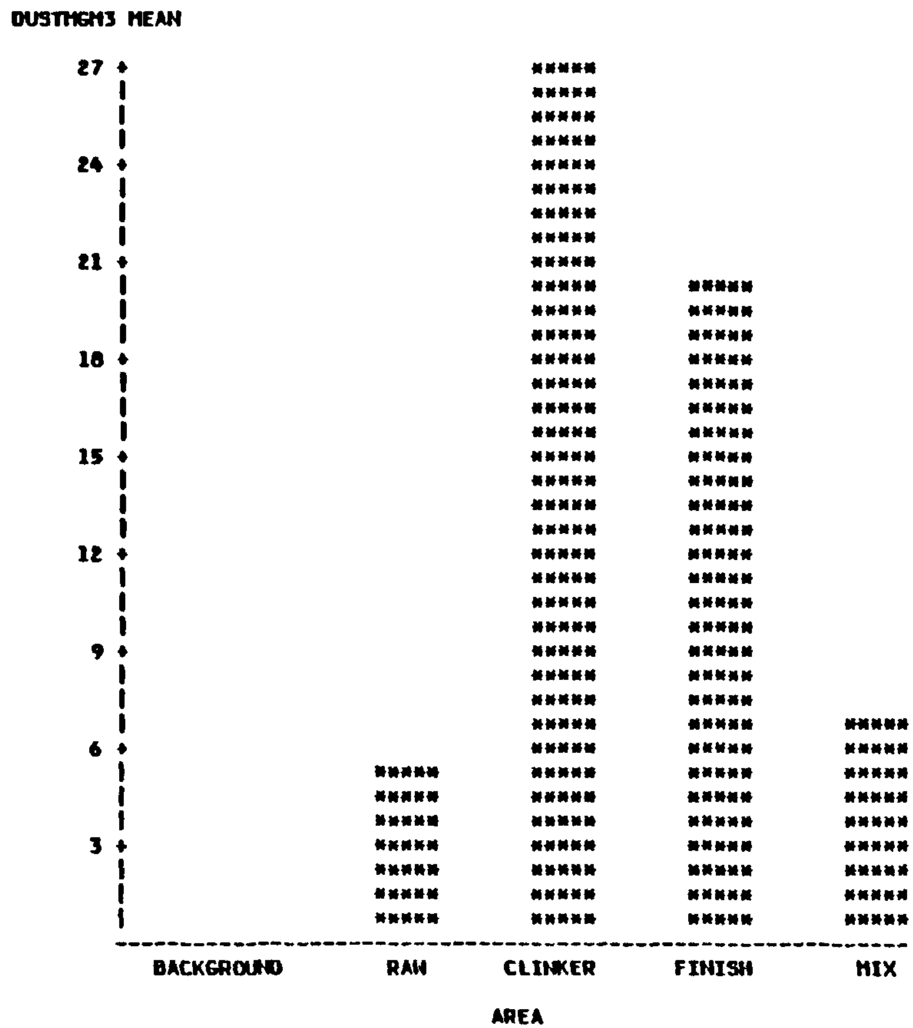

Figure 5

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

BAR CHART OF MEANS

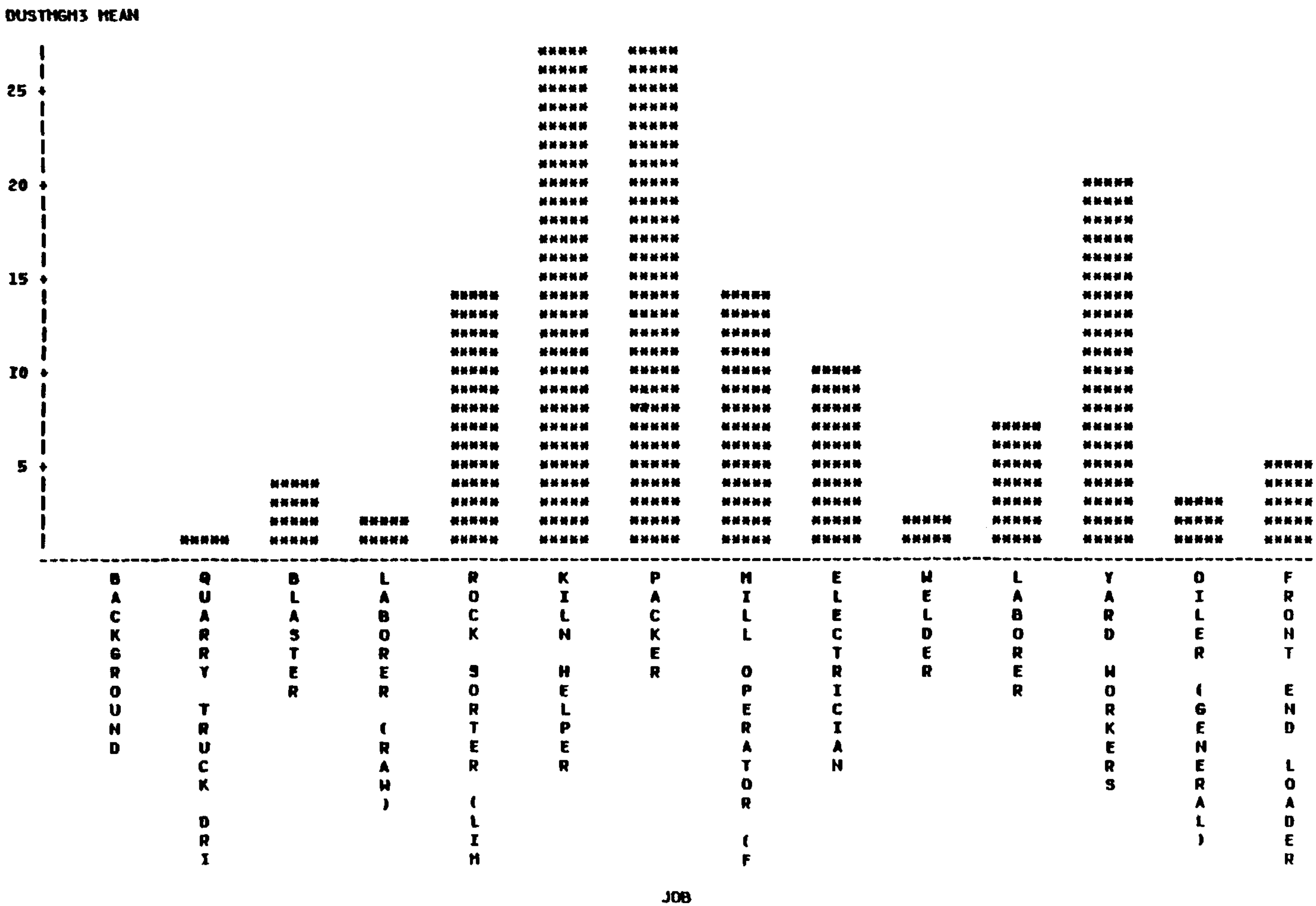

Table 8

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
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	08DEC81	1	LABORER (RAW)	15	N	N	8	N	N
~~RAW~~	~~08DEC81~~	~~1~~	~~ROCK SORTER (LIME PLANT)~~	26	N	N	90	N	N
RAW	10DEC81	1	QUARRY TRUCK DRIVER	14	N	N	10	N	N
CLINKER	09DEC81	1	KILN HELPER	367	N	N	353	11	N
FINISH	08DEC81	1	MILL OPERATOR (FINISH)	150	N	N	115	4	N
FINISH	09DEC81	1	PACKER	346	N	N	314	9	N
MIX	08DEC81	1	ELECTRICIAN	108	N	N	84	3	N
MIX	08DEC81	1	WELDER	149	N	N	16	34	N
MIX	08DEC81	1	YARD WORKERS	175	N	N	148	4	N
MIX	09DEC81	1	LABORER	49	N	N	41	2	N
MIX	09DEC81	1	OILER (GENERAL)	N	N	N	19	N	N
MIX	09DEC81	1	FRONT END LOADER (YARD)	35	N	6	25	1	4
MIX	10DEC81	1	WELDER	32	5	N	21	32	N
MIX	10DEC81	1	LABORER	37	N	N	30	N	N

Table 9

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
California Cement, Colton, California

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

Metal	N	Means	Std.dev.	Minimum	Maximum
Aluminum	13	116	120.59	14	367
Chromium	1	5	—	5	5
Cobalt	1	6	—	6	6
Magnesium	14	91	111.66	8	353
Manganese	9	11	12.87	1	34
Nickel	1	4	—	4	4

Table 10

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
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	08DEC81	1	BACKGROUND	N	N	N	N	N	N
BACKGROUND	09DEC81	1	BACKGROUND	N	N	N	3	N	N
BACKGROUND	10DEC81	1	BACKGROUND	N	N	N	2	N	N
RAW	07DEC81	2	RAW MILLS	227	N	N	240	11	N
RAW	08DEC81	1	LIME PLANT	397	12	40	2477	27	45
RAW	08DEC81	1	PRIMARY CRUSHER	N	N	N	39	N	N
RAW	09DEC81	1	SHAKERS/BELT TRANSFER	41	N	N	213	N	N
RAW	10DEC81	1	ROCK SORTING	N	N	N	18	N	N
RAW	10DEC81	1	RAW STORAGE	367	N	N	1364	16	N
RAW	10DEC81	1	SECONDARY CRUSHER	608	N	7	1787	23	7
CLINKER	07DEC81	2	CRANE (OVER SILOS)	339	N	N	231	9	N
CLINKER	07DEC81	2	CLINKER COOLER	592	5	N	473	17	N
CLINKER	09DEC81	1	CLINKER COOLER	338	N	N	277	9	N
FINISH	07DEC81	2	BAGGING	93	N	N	81	N	N
FINISH	08DEC81	1	FINISH BALL MILLS	303	N	N	212	6	N
FINISH	09DEC81	1	FINISH BALL MILLS	1562	16	13	1562	108	14
FINISH	09DEC81	1	BULK LOADING SILOS	N	N	N	10	N	N
FINISH	10DEC81	1	FINISH BALL MILLS	1242	N	N	874	30	N
MIX	08DEC81	1	MAINTENANCE SHOP	N	N	N	5	N	N

Table 11

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
California Cement, Colton, California

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

Metal	N	Means	Std. Dev.	Minimum	Maximum
Aluminum	12	509	454.01	41	1562
Chromium	3	11	5.31	5	16
Cobalt	3	20	17.44	7	40
Magnesium	18	548	747.36	2	2477
Manganese	10	26	30.01	6	108
Nickel	3	22	19.94	7	45

Table 12

Environmental Investigations Branch
Industrial Hygiene Survey of Cement Workers
California Cement, Colton, California

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

Exposure Categories

Metals	Mill Rm. Grey Plant	Clinker-Cooler Grey	Bagging White Plant	Finish & Clinker Cooler White Plant
Aluminum	125.4	714.3	264.5	115.5
Calcium	3207.9	15473.2	5932.1	7011.1
Iron	157.9	822.7	311.0	291.9
Magnesium	108.6	527.3	203.7	187.8
Manganese	N	16.8	6.3	7.3
Sodium	21.8	68.4	33.4	4.73
Phosphorus	N	6.0	N	0.6
Titanium	10.0	34.1	13.2	6.2
Zinc	N	N	5.26	3.0

The following elements were analyzed for, but were less than 0.5 ug/filter in all samples: silver, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, lithium, molybdenum, nickel, platinum, selenium, tellurium, thallium, tin, vanadium, yttrium, zirconium.

Table 13

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
ANALYSIS OF BULK MATERIAL PRESENTED AS PERCENT BY WEIGHT

AREA	JOB	QUARTZ	CRISTB	AL	CR	CO	MG	MN	NI	ASBEST
RAW	RAW MATERIAL	12.5	N	0.52	N	N	0.96	0.04	N	0.0
RAW	RAW MATERIAL	N	N	0.87	N	N	0.94	0.03	N	0.0
RAW	RAW MATERIAL	8.1	N	1.20	N	N	0.93	0.04	N	0.0
RAW	RAW MATERIAL	N	N	0.76	N	N	0.90	0.02	N	0.0
RAW	RAW MATERIAL	6.3	N	1.40	N	N	0.79	0.04	N	0.0
RAW	RAW MATERIAL	5.2	N	0.50	N	N	1.10	0.03	N	0.0
RAW	RAW MATERIAL	N	N	0.10	N	N	0.93	0.01	N	0.0
RAW	RAW MATERIAL	N	N	0.97	N	N	1.20	0.04	N	0.0
RAW	RAW MATERIAL	N	N	N	N	N	0.97	0.01	N	0.0
RAW	RAW MATERIAL	N	N	0.19	N	N	0.37	0.02	N	0.0
CLINKER	CLINKER	N	N	1.80	N	N	1.50	0.05	N	0.0
CLINKER	CLINKER	N	N	1.60	N	N	1.60	0.05	N	0.0
CLINKER	CLINKER	N	N	2.10	N	N	1.60	0.05	N	0.0
FINISH	FINISH	N	N	2.00	N	N	1.80	0.04	N	0.0
FINISH	FINISH	N	N	2.00	N	N	1.70	0.06	N	0.0
FINISH	FINISH	N	N	2.10	N	0.03	1.50	0.06	N	0.0
FINISH	FINISH	N	N	2.00	N	N	1.60	0.07	N	0.0
FINISH	FINISH	N	N	1.90	N	N	1.70	0.06	N	0.0
MIX	CLINKER FINISH	N	N	2.00	N	N	1.70	0.07	N	0.0
MIX	CLINKER FINISH	N	N	2.00	N	N	1.60	0.06	N	0.0
MIX	CLINKER FINISH	N	N	1.80	N	N	1.60	0.06	N	0.0
MIX	CLINKER FINISH	N	N	2.10	N	N	1.70	0.05	N	0.0
MIX	CLINKER FINISH	N	N	1.90	N	N	1.70	0.07	N	0.0

Table 14

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
SOX CONCENTRATIONS

JOB	DATE	SHIFT	AREA	SO4_UGM3	SO3_UGM3	SO2_PPM
BACK END OF KILN	07DEC81	2	RAW	N	N	N
BACK END OF KILN	07DEC81	2	RAW	N	N	0.01
BACK END OF KILN	10DEC81	1	RAW	12.29	N	0.01

Table 15

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
CALIFORNIA CEMENT COLTON, CALIFORNIA
NO2 CONCENTRATIONS IN PPM

JOB	DATE	SHIFT	AREA	CONC
BACKGROUND	08DEC81	1	BACKGROUND	0.06
BACKGROUND	09DEC81	1	BACKGROUND	0.08
BACKGROUND	10DEC81	1	BACKGROUND	0.10
LABORER (QUARRY)	08DEC81	1	RAW	0.02
TRUCK DRIVER (LIME PLANT)	08DEC81	1	RAW	0.02
DRILLER	08DEC81	1	RAW	0.03
PRIMARY CRUSHER OPERATOR	08DEC81	1	RAW	0.03
FRONT END LOADER	08DEC81	1	RAW	0.02
QUARRY TRUCK DRIVER	08DEC81	1	RAW	0.02
WATER TRUCK OPERATOR	09DEC81	1	RAW	0.04
BAGGING (LIME)	09DEC81	1	RAW	0.07
POWDER LIMESTONE OPER	09DEC81	1	RAW	0.06
QUARRY TRUCK DRIVER	10DEC81	1	RAW	0.06
DRILLER	10DEC81	1	RAW	0.07
FRONT END LOADER	10DEC81	1	RAW	0.07
FRONT END LOADER	10DEC81	1	RAW	0.08
OILER (SHOVEL)	10DEC81	1	RAW	0.03
KILN HELPER	08DEC81	1	CLINKER	0.06
KILN HELPER	09DEC81	1	CLINKER	0.19
UTILIYMAN (FINISH)	08DEC81	1	FINISH	0.04
CLEAN UP	08DEC81	1	FINISH	0.03
BULK LOADER	09DEC81	1	FINISH	0.04
PACKER	09DEC81	1	FINISH	0.13
FORKLIFT OPERATOR (FINISH)	09DEC81	1	FINISH	0.12
FORKLIFT OPERATOR (FINISH)	10DEC81	1	FINISH	0.12
REPAIRMAN	08DEC81	1	MIX	0.01
OILER (GENERAL)	08DEC81	1	MIX	0.05
VACUUM TRUCK DRIVER	08DEC81	1	MIX	0.07
YARD WORKERS	09DEC81	1	MIX	0.11
VACUUM TRUCK DRIVER	09DEC81	1	MIX	0.09
DUST COLLECTOR	09DEC81	1	MIX	0.04
DUST COLLECTOR	10DEC81	1	MIX	0.05
OILER (GENERAL)	10DEC81	1	MIX	0.08
WELDER	10DEC81	1	MIX	0.06
BULK LOADING SILOS	08DEC81	1	FINISH	0.07
BULK LOAD SCALEHOUSE	08DEC81	1	FINISH	N
MAINTENANCE SHOP	10DEC81	1	MIX	0.02

Table 16

Environmental Investigations Branch
Industrial Hygiene Survey of Cement Workers
California Cement, Colton, California

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

Date	Area	CO	NOx	NO2
Dec. 8	Bulk load platform for	ND	ND	ND
	transport trucks	ND	0.5	ND
		ND	ND	ND
	Parking area -forklifts	ND	ND	ND
	are operating	5.0	4.0	2.0
		ND	2.0	0.5
	Around raw mill dryers	ND	ND	ND
		ND	ND	ND
	Primary crusher	ND	ND	ND
	trucks dumping	ND	ND	ND
	Lime bagging area	ND	0.5	ND
	forklifts operating	ND	ND	ND
Dec. 9	Bulk load platform for transport trucks (3 trucks being laoded)	6.0	2.0	0.2
Dec. 10	Raw mill dryers	Trace		
	Inside quarry truck	2.5	0.25	0.25
	during loading and	0.5		0.25
	dumping cycle	5.0	0.25	0.25
		2.5		0.25
		<u>HCl</u>	<u>NH3</u>	
Dec. 10	In lab when			
	chemist doing wet	1.0	5-15	
	chemical analysis	2.0	20-25	
		ND	ND	

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.