Industrial Hygiene Survey of Dundee Cement Co.

Dundee, Michigan

Cement Workers Morbidity Study

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Executive Summary

The Dundee Cement Plant in Dundee, Michigan was surveyed by a NIOSH team of industrial hygienists, on March 23 through March 26, 1981. Samples were collected and analyzed for respirable and total dust, free crystalline silica, aluminum, cobalt, magnesium, manganese, nickel, other trace elements, asbestos, and oxides of sulfur.

The respirable and total dust levels for most jobs are below recommended exposure levels. Six respirable and three total dust samples exceeded the ACGIH recommended level for nuisance particulate. Seven respirable dust samples exceeded the MSHA-PEL for respirable quartz. Of the dust contaminants measured only quartz was present in excessive concentrations. Low level exposure to hydrogen sulfide gas was found in areas associated with the limestone quarry water.

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. Dundee Cement in Dundee, Michigan was the seventh 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 Dundee Cement plant began cement production in 1959. It is located just north of the village of Dundee, in southeastern Michigan. The Dundee plant was surveyed on Monday, March 23 through Thursday, March 26, 1981, by Frank Hearl, Thomas Wood, and Wayne Sanderson. Limestone and clay are obtained from a quarry adjacent to the plant. The limestone and clay are crushed and milled into a slurry and then pumped into the rotary kilns, where clinkers are produced in two of the largest cement kilns in the country. Both kilns are fueled by pulverized coal, with petroleum coke serving as an auxilliary fuel. Four types of cement are produced by this plant.

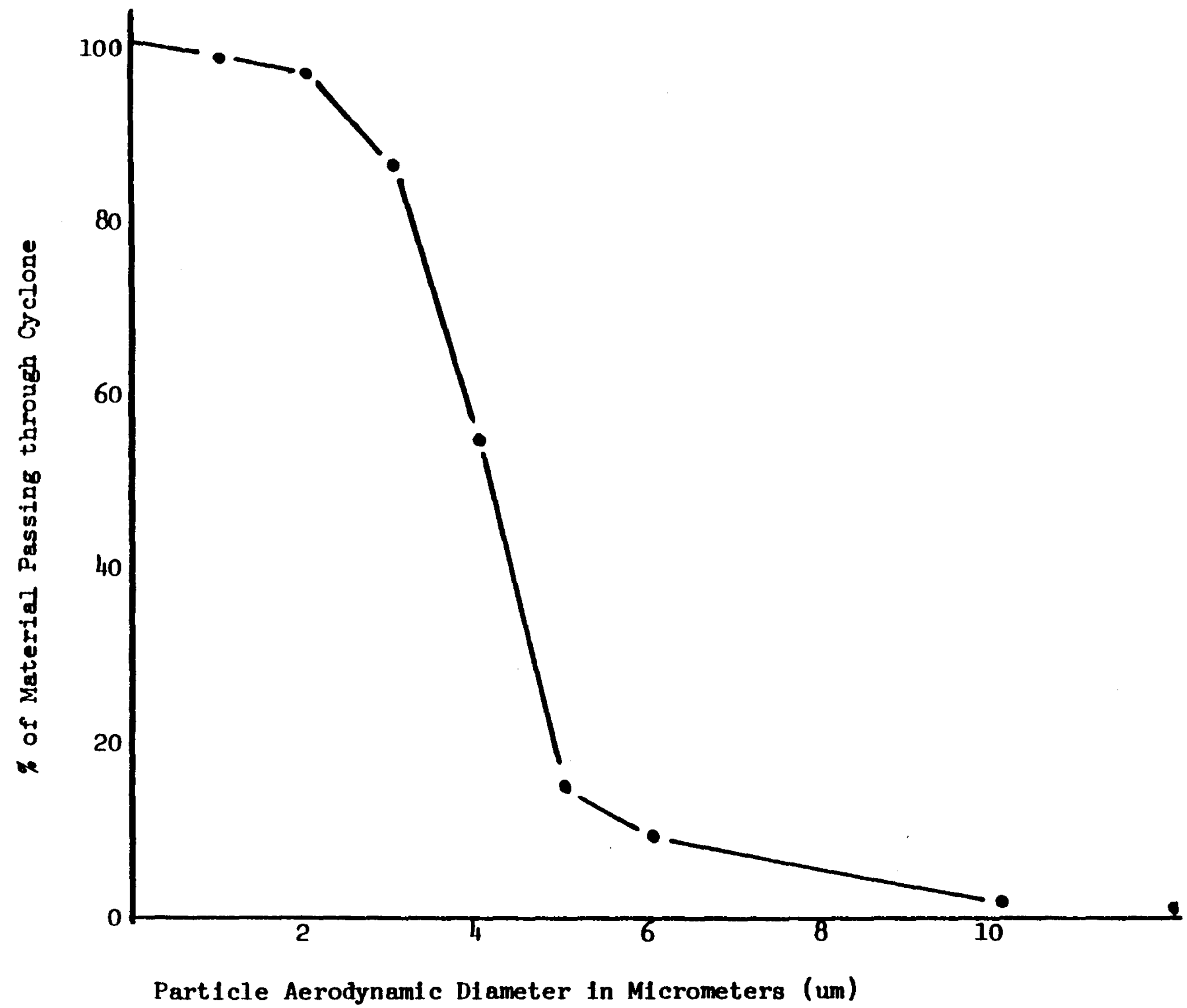
Methods and Results

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 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 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 "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

Figure 1 COLLECTION EFFICIENCY OF THE PERSONAL RESPIRABLE DUST CYCLONE



than the limit of detection. Note that these samples were not used in calculating the means, standard deviations, geometric means, and geometric standard deviations. Hence those values represent average concentrations for samples with detectable quantities. "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 free silica (PCT_SIO2). A value of "N" indicates that the measured quantity was below the analytical limit of detection. Limits of detection for each method are given in Table 1. Samples with detectable quartz concentrations are also shown on Table 5 with their calculated MSHA-PEL. This will be discussed in detail in the Discussion Section.

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

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

Area Total Dust Samples

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

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

One area sample from each exposure category was analyzed for content of 31 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)

In this survey 16 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 which exposure category the samples were taken; that is, 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 oxides of sulfur analyses are listed in Table 14. The JOB column tells where the sample was collected. The SO4_UGM3 and SO3_UGM3 columns give the sulfate and sulfite concentrations in micrograms per cubic meter; the SO2_PPM column gives the sulfur dioxide levels in parts per million. The lower limits of detection for these analyses are listed in Table 1.

Direct Reading Indicator Tubes for Toxic Gases

Drager direct reading indicator tubes were used to sample for sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), hydrocarbons, and hydrogen sulfide (H_2S). Air was 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% at 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 15.

Indicator tube samples suggested that workers could be exposed to excessive levels of sulfur dioxide. The results of these samples were not included in Table 15, because these tubes do not react specifically with sulfur dioxide, but will react with any sulfur compound. Since these excessive levels of sulfur dioxide were not confirmed by sulfur dioxide filter analyses, the tubes were probably reacting to the sulfur compound, hydrogen sulfide, and not sulfur dioxide. Hydrogen sulfide was found in concentrations ranging from 0.0 to 4.0 ppm.

General Comments and Schedule

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

The environmental investigations team began sampling Monday, March 23, 1981. The sampling schedule was as follows:

Monday, March 23 - 2nd shift
Tuesday, March 24 - 1st shift
Wednesday, March 25 - 1st shift
Thursday, March 26 - 1st shift
Thursday, March 26 - 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:

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

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

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

Examining the personal respirable samples collected from various jobs, Table 2, six samples exceeded 5.0 mg/m^3. One sample was collected from the primary crusher operator/conveyor tender. Two samples were from laborers cleaning up spills in finish mill elevator pits, and two from maintenance workers repairing the clinker coolers. Since no crystalline silica was detected on any of these samples, they are considered samples of nuisance particulate. One sample was collected from a kiln burner during a shift frought with problems maintaining one of the kilns. During this shift he was exposed to clinker, coal, and precipitator dusts. Since this sample contained 5.2% quartz it is a mineral dust sample. For all workers the geometric mean respirable dust level was 1.41 mg/m^3.

Three personal total dust levels, Table 6, exceeded 10 mg/m^3. Two were collected from shift utility workers and one from a yard worker. Both of these jobs involved clean up of spills and equipment after breakdowns. The geometric mean total dust level was 5.82 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, laboratory workers, packhouse workers, mill operators, kiln oilers, 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.

<u>Crystalline Silica</u>

A coal sample and three raw material bulk samples contained quartz. Quartz is a common constituent of limestone, clay, and sand, and frequently is found as a contaminant in coal dust. The highest percentage of quartz (15.7%) was found in a clay sample. Two samples of waste precipitator dust contained approximatley 3% quartz, and the coal sample 4.4%. No quartz was found in any clinker or finished cement samples. Generally, after quartz passes through the high kiln temperatures it is transformed from its free crystalline form into silicates.

Twelve personal respirable dust samples contained detectable levels of quartz. All twelve samples were collected from workers observed to have spent either the entire shift or part of it exposed to raw material, coal, or waste precipitator dusts. Five of the samples were from quarry workers and one from a shift utility worker assigned to the quarry during the shift sampled. The mobile equipment operator was hauling precipitator dust to the quarry for dumping. Four samples were collected on the third shift of March 26, when there were problems maintaining one of the kilns. These workers were exposed to precipitator and coal dusts.

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 3) have a range of 4.8 - 12.3%.

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. Seven of the twelve samples exceed the permissible exposure limit. Six of the twelve samples with detectable levels of quartz contained concentrations greater than 100 ug/m^3. Exposures below this level have been suggested in past research as safe levels of exposure. (9,10,11)

Trace Metals

The personal total dust samples were analyzed for the six trace metals: aluminum, chromium, cobalt, magnesium, manganese, and nickel. From the personal samples, none of the metals were found in concentrations greater than the MSHA permissible exposure levels or the ACGIH recommended TLV's. Area total dust samples were collected throughout the plant and analyzed for the same six trace metals. Although we attempted to place the area samples in locations representative of work areas, these stationary samples should not be considered estimates of personal exposure. Their purpose is to document the presence of these metals in airborne particulates and their relative concentrations. Aluminum and magnesium are commonly found in the dust particles. Manganese is occasionally found. None of the samples 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 potassium.

Asbestos

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

Oxides of Sulfur

A sulfur dioxide concentration of 0.12 ppm was found at the front end of the kiln. This level is below the ACGIH TLV of 2 ppm, and MSHA PEL of 5 ppm. This measurement shows however that exposure to sulfur dioxide does occur. Exposures to greater concentrations may occur because of breakdowns or breaches in the kiln exhaust system. Also, if the sulfur content of the kiln fuel increases, more sulfur dioxide may be produced. Sulfate and sulfite 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, sulfites, or sulfates at levels detected at Dundee. (1, 12, 13)

Toxic Gases

No carbon monoxide, nitrogen dioxide, or hydrocarbons were detected in levels known to cause toxic effects. Carbon monoxide, oxides of nitrogen, and sulfur dioxide are common contaminants in exhaust gases from the burning of fossil fuels. Portland cement plants have several areas which may be contaminated with these exhaust gases. At this facility the kilns are fired with pulverized coal. When the coal and materials such as sulfur 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 exhaust. It is our judgement, barring unforeseen mechanical or maintenance problems, that the workers are exposed to very low or insignificant levels of these gases.

It is well known that acute exposures of hydrogen sulfide in high concentrations can lead to death. Low levels of hydrogen sulfide (< 20 ppm) for a few hours can lead to headache, sleep disturbances, nausea, weight loss, and eye, nose, and throat irritation. These irritative effects are due to the formation of an alkali sulfide when the gas comes in contact with moist tissues. The toxic action of hydrogen sulfide on body systems is thought to be due to inhibition of cytochrome oxidase by binding to iron which is essential for cellular respiration. In other words, the H_2S prevents body tissues form receiving oxygen and excreting carbon dioxide. (8)

Therefore, workers may periodically experience headaches, nausea, dizziness, staggering gait, etc. Also, it is possible that high concentrations might accumulate in still water and enclosed or confined spaces. Before any worker must enter a confined space associated with quarry water or an area where stagnant quarry water will be disturbed, the area should be checked out for concentrations of hydrogen sulfide.

This is the first time that we have encountered hydrogen sulfide in any concentration at a Portland Cement facility. Hydrogen sulfide is a common contaminant of natural water springs. Hydrogen sulfide will only be detected in areas associated with quarry water. The odor threshold for hydrogen sulfide is below one part per million. However, caution should be stressed since at high levels olfactory sensations are overcome, and hydrogen sulfide cannot be smelled

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 Dundee Cement Plant in Dundee, Michigan are below recommended exposure levels. Six respirable and three total dust samples exceeded the ACGIH recommended level for nuisance particulates. Twelve samples from workers associated with raw material, coal, or precipitator dusts contained detectable levels of quartz. Seven 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 hydrogen sufide gas also occurs at this plant, but detected concentrations did not exceed federal standards or recommended levels.

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.

Most of the heavy dust exposures were to workers involved in maintenance or clean-up operations. It is difficult to implement controls to protect workers involved in these types of operations since their duties may take them into non-routine work stations. In these cases, workers may be provided with personal protective devices.

It is possible that extremely high concentrations of hydrogen sulfide might accumulate in still water and enclosed or confined spaces. Before any worker may enter a confined space associated with quarry water or an area where stagnant quarry water will be disturbed, the area should be checked for concentrations of hydrogen sulfide. If workers experience headaches, nausea, dizziness, or complaints believed to be caused by low level hydrogen sulfide exposure, then they may be provided with acid gas respirators. These respirators should not be used to enter acutely hazardous concentrations of hydrogen sulfide since breakthrough may occur with the purifying media. To enter areas with concentrations greater than 300 ppm of H_2S, only supplied-air or self-contained breathing apparati can be used. Areas of the plant, such as the quarry pump house and the leach plant, may be monitored on a periodic basis to make sure hydrogen sulfide concentrations remain below recommended limits.

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. The disposable respirators will, however, provide some protection to workers exposed to nuisance particulates. Whenever workers are potentially exposed to excessive quartz concentrations, quarter or half mask dust-fume-mist respirators should be used. If workers complain of eye irritation, full-face piece respirators may be used instead of half or quarter mask respirators to alleviate the problems. It is suggested that workers be involved in the selection of a comfortable NIOSH/MSHA approved dust-fume-mist respirator and be fit-tested to ensure that they are adequately protected.

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

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Table 1

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Dundee Cement, Dundee, Michigan

Number of Samples With Detectable Levels of Contaminants

Contaminant	# Samples Collected	# Samples with Detectable Conc.	Limit of Detection
Respirable dust	75	75	0.01 mg
Total dust	18	18	0.01 mg
Quartz	77	12	0.03 mg
Cristobalite	77	0	0.03 mg
Aluminum	37	21	0.20 mg
Chromium	37	0	0.004 mg
Cobalt	37	0	0.005 mg
Magnesium	37	31	0.002 mg
Manganese	37	10	0.002 mg
Nickel	37	0	0.004 mg
Asbestos	16	0	4500 fibers
Sulfate	12	10	0.005 mg
Sulfite	12	3	0.01 mg
Sulfur dioxide	12	1	0.01 mg

Table 2

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

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	23MAR81	2	0.00
BACKGROUND	24MAR81	1	0.03
BACKGROUND	26MAR81	1	0.14

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
CONVEYOR OPERATOR	23MAR81	2	0.41
DOZER OPERATOR	23MAR81	2	2.69
QUARRY SUPERVISOR	23MAR81	2	0.69
FRONT END LOADER	23MAR81	2	0.45
FRONT END LOADER	23MAR81	2	4.77
QUARRY TRUCK DRIVER	23MAR81	2	0.68
PRIMARY CRUSHER OPERATOR	23MAR81	2	7.68
CONVEYOR OPERATOR	23MAR81	2	0.59
LABORER (QUARRY)	24MAR81	1	0.69
FRONT END LOADER	24MAR81	1	0.32
QUARRY TRUCK DRIVER	24MAR81	1	0.69
CONVEYOR OPERATOR	24MAR81	1	0.97
QUARRY TRUCK DRIVER	25MAR81	1	0.50
DOZER OPERATOR	25MAR81	1	1.08
DRILLER	25MAR81	1	1.06
BLASTER	25MAR81	1	0.87
CONVEYOR OPERATOR	25MAR81	1	1.56
DOZER OPERATOR	25MAR81	1	0.44
PRIMARY CRUSHER OPERATOR	26MAR81	1	2.42
DRILLER	26MAR81	1	1.65
FRONT END LOADER	26MAR81	1	0.54
LABORER (QUARRY)	26MAR81	1	1.19

AREA=CLINKER

JOB	DATE	SHIFT	DUSTMGM3
CRANE OPER (CLINKER)	23MAR81	2	0.74
CRANE OPER (CLINKER)	24MAR81	1	0.61
CRANE OPER (CLINKER)	26MAR81	3	0.92

Table 2

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

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
BULK LOADER	24MAR81	1	0.59
BULK LOADER	24MAR81	1	0.67
BULK LOADER	25MAR81	1	1.50
BULK LOADER	25MAR81	1	0.79
LOCOMOTIVE OPERATOR	25MAR81	1	1.32
BULK LOADER	26MAR81	1	0.66

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
MILL OPERATOR	23MAR81	2	0.85
REPAIRMAN	23MAR81	2	2.89
KILN BURNER	23MAR81	2	0.94
YARD WORKERS	23MAR81	2	0.72
STOREROOM SUPERINTENDENT	23MAR81	2	0.27
MILL HELPER (MIX)	23MAR81	2	0.80
KILN BURNER	23MAR81	2	0.14
REPAIRMAN	23MAR81	2	1.85
UTILITY (SHIFT)	23MAR81	2	1.13
REPAIRMAN	23MAR81	2	0.43
MILL OPERATOR	24MAR81	1	1.94
STOREROOM SUPERINTENDENT	24MAR81	1	0.72
SHIFT FOREMAN	24MAR81	1	0.73
ELECTRICIAN	24MAR81	1	0.54
MILL HELPER (MIX)	24MAR81	1	2.19
KILN BURNER	24MAR81	1	0.23
KILN BURNER	24MAR81	1	0.68
UTILITY (SHIFT)	24MAR81	1	4.84
LABORATORY WORKER	24MAR81	1	0.19
YARD WORKERS	25MAR81	1	5.08
MILL OPERATOR	25MAR81	1	0.30
REPAIRMAN	25MAR81	1	1.17
KILN BURNER	25MAR81	1	1.37
MOBILE EQUIPMENT OPER (PLANT)	25MAR81	1	0.96
OFFICE WORKER	26MAR81	1	0.26
YARD WORKERS	26MAR81	1	5.41
REPAIRMAN	26MAR81	1	6.77
LABORER	26MAR81	1	1.31
STOREROOM SUPERINTENDENT	26MAR81	1	0.81
REPAIRMAN	26MAR81	1	0.79
KILN BURNER	26MAR81	1	0.89
KILN BURNER	26MAR81	1	0.69
REPAIRMAN	26MAR81	3	0.27
KILN BURNER	26MAR81	3	0.25
REPAIRMAN	26MAR81	3	1.91
REPAIRMAN	26MAR81	3	1.67
REPAIRMAN	26MAR81	3	0.58
REPAIRMAN	26MAR81	3	5.93

Table 2

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

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
REPAIRMAN	26MAR81	3	1.07
SHIFT FOREMAN	26MAR81	3	1.07
ELECTRICIAN	26MAR81	3	0.27
MILL OPERATOR	26MAR81	3	0.19
UTILITY (SHIFT)	26MAR81	3	1.68
KILN BURNER	26MAR81	3	8.01

Table 3

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
DUNDEE CEMENT   DUNDEE,MICHIGAN
PERSONAL RESPIRABLE DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	3	0.06	0.07	0.04	3.72	0	0.00	0.14
RAW	22	1.45	1.72	0.98	2.26	0	0.32	7.68
CLINKER	3	0.76	0.15	0.75	1.22	0	0.61	0.92
FINISH	6	0.92	0.39	0.86	1.48	0	0.59	1.50
MIX	44	1.61	1.91	0.94	2.84	0	0.14	8.01
PLANTWIDE	75	1.47	1.74	0.93	2.49	0	0.14	8.01

Figure 2

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

BAR CHART OF MEANS

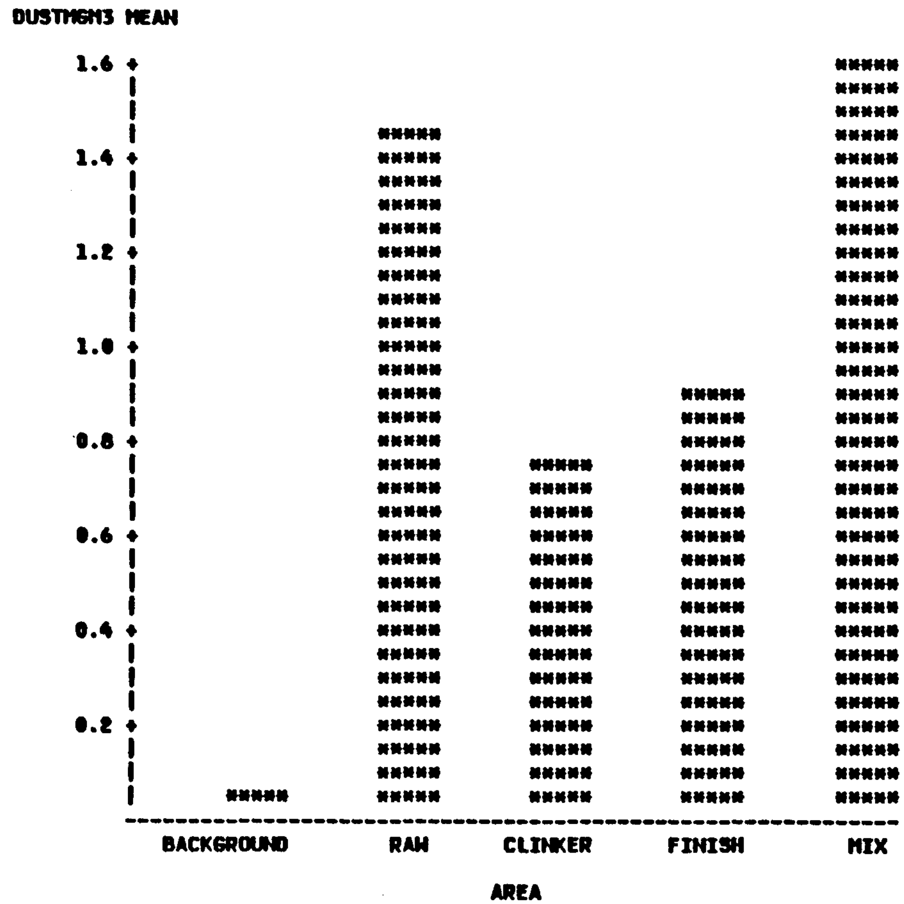

Figure 3

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

BAR CHART OF MEANS

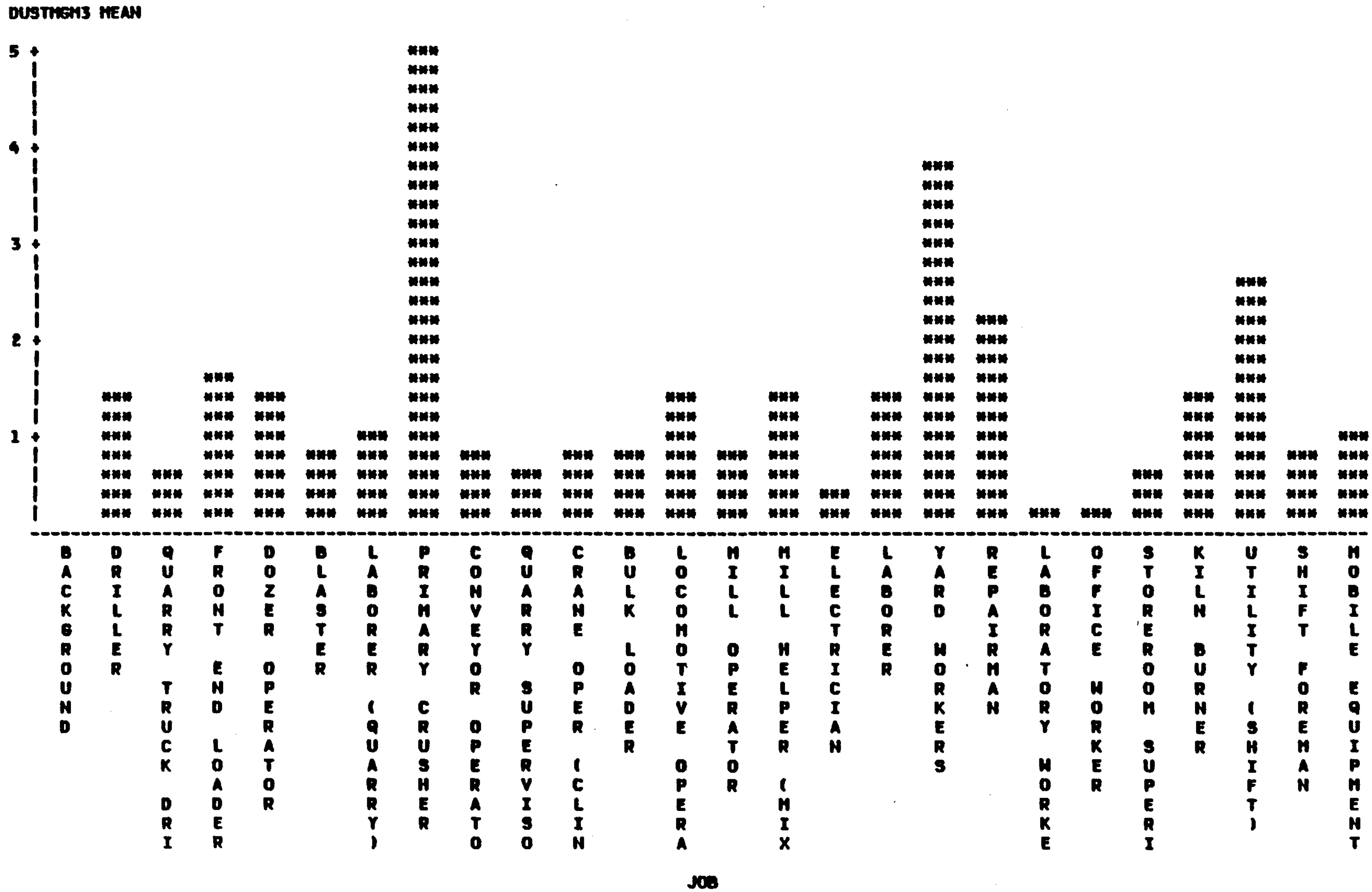

Table 4

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

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
FRONT END LOADER	23MAR81	2	N	N	RAW
PRIMARY CRUSHER OPERATOR	23MAR81	2	N	N	RAW
DOZER OPERATOR	23MAR81	2	5.3	143.84	RAW
CONVEYOR OPERATOR	23MAR81	2	N	N	RAW
CONVEYOR OPERATOR	23MAR81	2	N	N	RAW
FRONT END LOADER	23MAR81	2	N	N	RAW
QUARRY SUPERVISOR	23MAR81	2	N	N	RAW
QUARRY TRUCK DRIVER	23MAR81	2	N	N	RAW
CONVEYOR OPERATOR	24MAR81	1	N	N	RAW
FRONT END LOADER	24MAR81	1	N	N	RAW
QUARRY TRUCK DRIVER	24MAR81	1	N	N	RAW
LABORER (QUARRY)	24MAR81	1	N	N	RAW
FRONT END LOADER	25MAR81	1	N	N	RAW
BLASTER	25MAR81	1	6.4	55.23	RAW
DOZER OPERATOR	25MAR81	1	N	N	RAW
DOZER OPERATOR	25MAR81	1	12.3	132.10	RAW
CONVEYOR OPERATOR	25MAR81	1	8.2	128.35	RAW
DRILLER	25MAR81	1	N	N	RAW
QUARRY TRUCK DRIVER	25MAR81	1	N	N	RAW
LABORER (QUARRY)	26MAR81	1	4.9	58.61	RAW
DRILLER	26MAR81	1	N	N	RAW
PRIMARY CRUSHER OPERATOR	26MAR81	1	N	N	RAW
FRONT END LOADER	26MAR81	1	N	N	RAW
CRANE OPER (CLINKER)	23MAR81	2	N	N	CLINKER
CRANE OPER (CLINKER)	24MAR81	1	N	N	CLINKER
CRANE OPER (CLINKER)	26MAR81	1	N	N	CLINKER
CRANE OPER (CLINKER)	26MAR81	3	N	N	CLINKER
BULK LOADER	24MAR81	1	N	N	FINISH
BULK LOADER	24MAR81	1	N	N	FINISH
BULK LOADER	25MAR81	1	N	N	FINISH
LOCOMOTIVE OPERATOR	25MAR81	1	N	N	FINISH
BULK LOADER	25MAR81	1	N	N	FINISH
BULK LOADER	26MAR81	1	N	N	FINISH
REPAIRMAN	23MAR81	2	N	N	MIX
STOREROOM SUPERINTENDENT	23MAR81	2	N	N	MIX
YARD WORKERS	23MAR81	2	N	N	MIX
MILL HELPER (MIX)	23MAR81	2	N	N	MIX
REPAIRMAN	23MAR81	2	N	N	MIX
KILN BURNER	23MAR81	2	N	N	MIX
REPAIRMAN	23MAR81	2	N	N	MIX
KILN BURNER	23MAR81	2	N	N	MIX
MILL OPERATOR	23MAR81	2	N	N	MIX
UTILITY (SHIFT)	23MAR81	2	N	N	MIX
KILN BURNER	24MAR81	1	N	N	MIX
UTILITY (SHIFT)	24MAR81	1	4.8	231.68	MIX
MILL OPERATOR	24MAR81	1	N	N	MIX
KILN BURNER	24MAR81	1	N	N	MIX
SHIFT FOREMAN	24MAR81	1	N	N	MIX
ELECTRICIAN	24MAR81	1	N	N	MIX
LABORATORY WORKER	24MAR81	1	N	N	MIX
STOREROOM SUPERINTENDENT	24MAR81	1	N	N	MIX
MILL HELPER (MIX)	24MAR81	1	N	N	MIX

Table 4

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

JOB	DATE	SHIFT	PCT_SIO2	QUARTZ	AREA
YARD WORKERS	25MAR81	1	N	N	MIX
KILN BURNER	25MAR81	1	5.9	80.71	MIX
MOBILE EQUIPMENT OPER (PLANT)	25MAR81	1	7.8	75.17	MIX
REPAIRMAN	25MAR81	1	N	N	MIX
MILL OPERATOR	25MAR81	1	N	N	MIX
YARD WORKERS	26MAR81	1	N	N	MIX
LABORER	26MAR81	1	N	N	MIX
OFFICE WORKER	26MAR81	1	N	N	MIX
REPAIRMAN	26MAR81	3	N	N	MIX
REPAIRMAN	26MAR81	3	N	N	MIX
KILN BURNER	26MAR81	3	5.2	413.00	MIX
REPAIRMAN	26MAR81	3	N	N	MIX
REPAIRMAN	26MAR81	3	N	N	MIX
MILL OPERATOR	26MAR81	3	N	N	MIX
KILN BURNER	26MAR81	3	N	N	MIX
REPAIRMAN	26MAR81	1	N	N	MIX
SHIFT FOREMAN	26MAR81	3	7.0	74.45	MIX
UTILITY (SHIFT)	26MAR81	3	7.5	125.53	MIX
KILN BURNER	26MAR81	1	N	N	MIX
REPAIRMAN	26MAR81	3	N	N	MIX
STOREROOM SUPERINTENDENT	26MAR81	1	N	N	MIX
ELECTRICIAN	26MAR81	3	N	N	MIX
REPAIRMAN	26MAR81	1	N	N	MIX
REPAIRMAN	26MAR81	3	7.0	74.45	MIX
KILN BURNER	26MAR81	1	N	N	MIX

Table 5

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Dundee Cement, Dundee, Michigan

Detectable Quartz Compared to MSHA Permissible Exposure Levels

Job	Levels of Dust Conc. Mg/m^3	Quartz Conc. % Quartz	ug/m^3	MSHA-PEL
Dozer operator	2.69*	5.3	143.84	1.37
Blaster	0.87	6.4	55.23	1.19
Dozer operator	1.08*	12.3	132.10	0.70
Conveyor operator	1.56*	8.2	128.35	0.98
Laborer (Quarry)	1.19	4.9	58.61	1.45
Shift Utility	4.84*	4.8	231.68	1.47
Kiln Burner	1.37*	5.9	80.71	1.27
Mobile Equipment Operator (Plant)	0.96	7.8	75.17	1.02
Kiln Burner	8.01*	5.2	413.00	1.39
Shift Forman	1.07	7.0	74.45	1.11
Shift Utility	1.68*	7.5	125.53	1.05
Repairman	0.58	7.0	74.45	1.11

*Indicates measured concentration exceeds the MSHA Permissible Exposure Limit.

Table 6

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

AREA=BACKGROUND

JOB	DATE	SHIFT	DUSTMGM3
BACKGROUND	23MAR81	2	0.09
BACKGROUND	24MAR81	1	0.19
BACKGROUND	26MAR81	1	0.09

AREA=RAW

JOB	DATE	SHIFT	DUSTMGM3
FRONT END LOADER	24MAR81	1	1.72
QUARRY TRUCK DRIVER	25MAR81	1	0.73
PRIMARY CRUSHER OPERATOR	25MAR81	1	3.03
QUARRY SUPERVISOR	25MAR81	1	0.80
FRONT END LOADER	26MAR81	1	1.10
BLASTER	26MAR81	1	3.58

AREA=FINISH

JOB	DATE	SHIFT	DUSTMGM3
PACKHOUSE FOREMAN	24MAR81	1	0.84
BULK LOADER	26MAR81	1	0.81
LOCOMOTIVE OPERATOR	26MAR81	1	2.36

AREA=MIX

JOB	DATE	SHIFT	DUSTMGM3
REPAIRMAN	24MAR81	1	4.33
UTILITY (SHIFT)	24MAR81	1	29.47
YARD WORKERS	24MAR81	1	16.97
REPAIRMAN	25MAR81	1	3.89
REPAIRMAN	25MAR81	1	6.83
YARD WORKERS	25MAR81	1	5.51
UTILITY (SHIFT)	26MAR81	1	18.02
MILL HELPER (MIX)	26MAR81	1	4.47
OFFICE WORKER	26MAR81	1	0.28

Table 7

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
DUNDEE CEMENT DUNDEE,MICHIGAN
PERSONAL TOTAL DUST CONCENTRATIONS, MG/M3

AREA	SAMPLES	MEAN	STD	GM	GSD	NLOD	MIN	MAX
BACKGROUND	3	0.12	0.06	0.11	1.56	0	0.09	0.19
RAW	6	1.83	1.21	1.51	1.96	0	0.73	3.58
FINISH	3	1.34	0.89	1.17	1.83	0	0.81	2.36
MIX	9	9.97	9.46	5.77	3.87	0	0.28	29.47
PLANTWIDE	18	5.82	7.81	2.83	3.52	0	0.28	29.47

Figure 4

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

BAR CHART OF MEANS

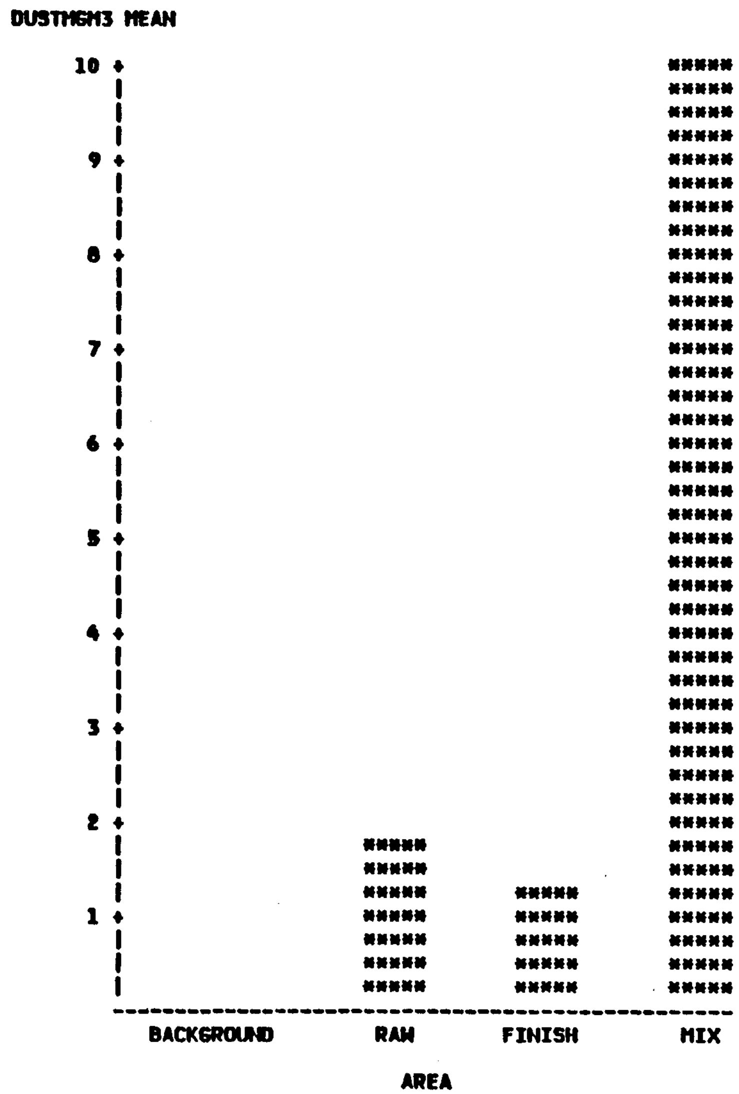

Figure 5

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

BAR CHART OF MEANS

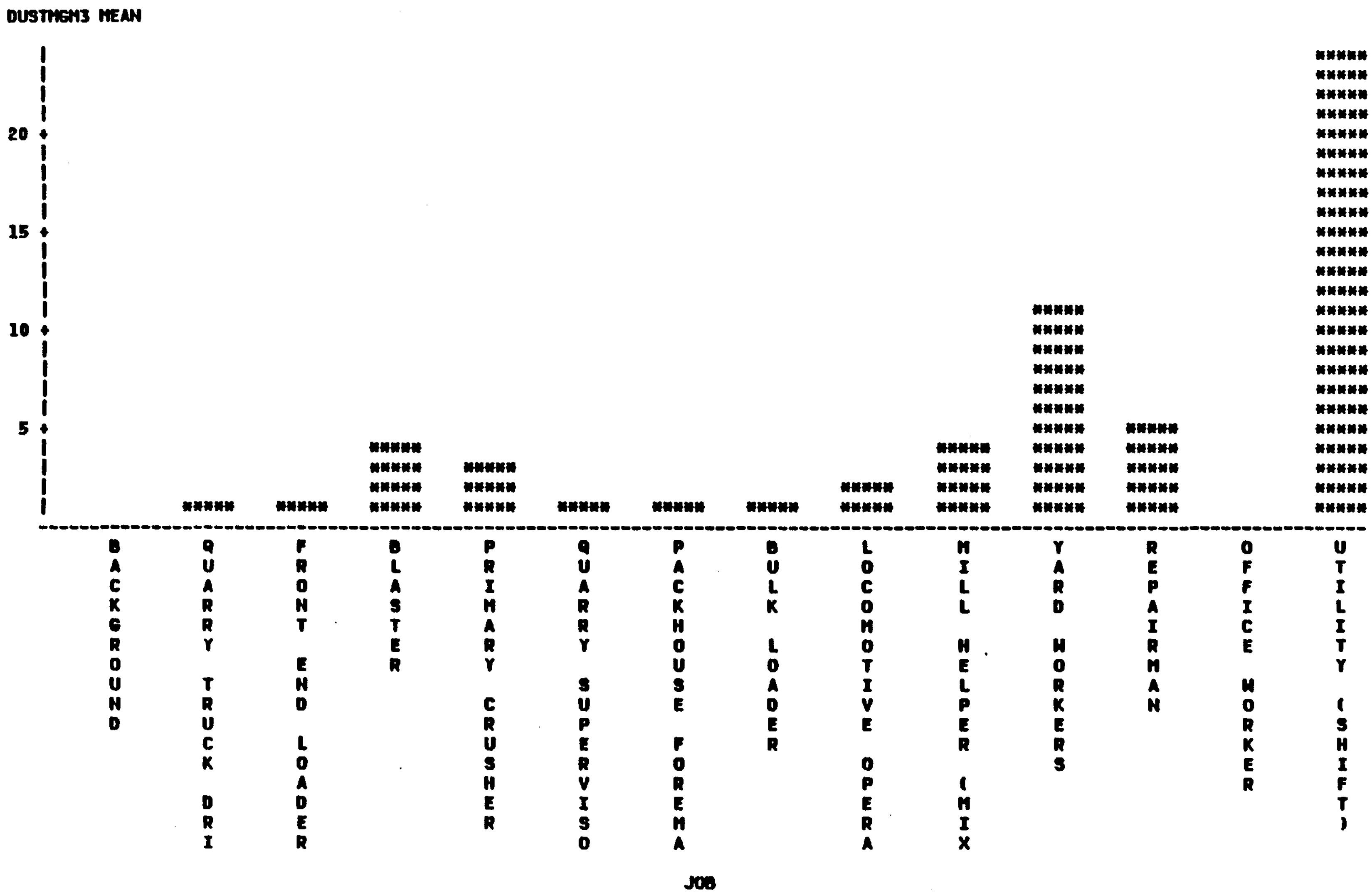

Table 8

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
DUNDEE CEMENT   DUNDEE,MICHIGAN
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	24MAR81	1	FRONT END LOADER	N	N	N	12	N	N
RAW	25MAR81	1	QUARRY TRUCK DRIVER	N	N	N	4	N	N
RAW	25MAR81	1	QUARRY SUPERVISOR	N	N	N	8	N	N
RAW	25MAR81	1	PRIMARY CRUSHER OPERATOR	54	N	N	24	N	N
RAW	26MAR81	1	BLASTER	N	N	N	26	N	N
RAW	26MAR81	1	FRONT END LOADER	N	N	N	10	N	N
FINISH	24MAR81	1	PACKHOUSE FOREMAN	N	N	N	N	N	N
FINISH	26MAR81	1	LOCOMOTIVE OPERATOR	34	N	N	23	N	N
FINISH	26MAR81	1	BULK LOADER	N	N	N	9	N	N
MIX	24MAR81	1	YARD WORKERS	282	N	N	171	6	N
MIX	24MAR81	1	REPAIRMAN	59	N	N	33	67	N
MIX	24MAR81	1	UTILITY (SHIFT)	669	N	N	392	12	N
MIX	25MAR81	1	REPAIRMAN	33	N	N	24	25	N
MIX	25MAR81	1	REPAIRMAN	86	N	N	54	15	N
MIX	25MAR81	1	YARD WORKERS	70	N	N	51	N	N
MIX	26MAR81	1	OFFICE WORKER	N	N	N	N	N	N
MIX	26MAR81	1	MILL HELPER (MIX)	31	N	N	22	N	N
MIX	26MAR81	1	UTILITY (SHIFT)	78	N	N	55	N	N

Table 9

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Dundee Cement, Dundee, Michigan

Summary for Personal Trace Metal Concentrations in
Micrograms per Cubic Meter

Metal	N	Means	Std.dev.	Minimum	Maximum
Aluminum	10	139	199.95	31	669
Magnesium	16	57	97.72	4	392
Manganeese	5	24	24.38	6	67

Table 10

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
DUNDEE CEMENT DUNDEE,MICHIGAN
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	23MAR81	2	BACKGROUND	N	N	N	N	N	N
BACKGROUND	24MAR81	1	BACKGROUND	N	N	N	N	N	N
BACKGROUND	26MAR81	1	BACKGROUND	N	N	N	N	N	N
RAW	24MAR81	1	SECONDARY CRUSHER	29	N	N	32	N	N
RAW	24MAR81	1	BACK END OF KILN	100	N	N	71	N	N
RAW	25MAR81	1	FEED END RAW MIILS	35	N	N	10	N	N
RAW	25MAR81	1	LEACH BUILDING	1287	N	N	630	19	N
RAW	25MAR81	1	PRIMARY CRUSHER	172	N	N	67	N	N
CLINKER	23MAR81	2	FRONT END OF KILN	32	N	N	15	N	N
CLINKER	23MAR81	2	CRANE (OVER SILOS)	62	N	N	48	N	N
CLINKER	26MAR81	1	CLINKER CONVEYOR	34	N	N	19	N	N
CLINKER	26MAR81	1	CRANE (OVER SILOS)	527	N	N	377	8	N
FINISH	23MAR81	2	BULK LOADING SILOS	N	N	N	8	N	N
FINISH	24MAR81	1	BULK LOADING SILOS	N	N	N	N	N	N
FINISH	26MAR81	1	FINISH BALL MILLS	N	N	N	15	N	N
MIX	23MAR81	2	MILL CONTROL AREA	45	N	N	30	N	N
MIX	24MAR81	1	MAINTENANCE SHOP	N	N	N	6	26	N
MIX	25MAR81	1	GENERAL WELDING OPERATION	104	N	N	22	164	N
MIX	26MAR81	1	WELDING SHOP	N	N	N	15	27	N

Table 11

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Dundee Cement, Dundee, Michigan

Summary for Area Trace Metal Concentrations in
Micrograms per Cubic Meter

Metal	N	Means	Std. Dev.	Minimum	Maximum
Aluminum	11	220	382.13	29	1287
Magnesium	15	91	175.27	6	630
Manganese	15	48	64.79	8	164

Table 12

Environmental Investigations Branch
Industrial Hygiene Survey of Cement Workers
Dundee Cement, Dundee, Michigan

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

	Exposure Categories			
Metals	Kiln Feed & Precip. Bldg.	Clinker Cooler	Coal Silos and Mill	Truck Load Silos
Aluminum	50.2	58.4	54.6	4.3
Calcium	1264.9	1056.9	1174.5	99.4
Iron	46.2	38.4	47.6	11.5
Magnesium	47.4	42.7	45.8	2.1
Potassium	64.0	77.1	82.7	2.2
Sodium	11.1	21.1	12.0	7.6
Tin	N	N	N	N
Titanium	2.3	N	N	N

All samples were analyzed for the following elements, but results were below the limits of detection: arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, lithium, manganeese, molybdenum, nickel, phosphorous, platinum, selenium, silver, tellurium, trhallium, tungsten, vanadium, yttrium, zinc, and zirconium.

Table 13

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

AREA	JOB	QUARTZ	CRISTB	AL	CR	CO	MG	MN	NI	ASBEST
RAW	RAW MATERIAL	N	N	0.20	N	N	1.54	0.02	0.05	0.0
RAW	RAW MATERIAL	15.7	N	3.81	N	N	1.65	0.05	0.05	0.0
RAW	RAW MATERIAL	N	N	0.20	N	N	1.25	0.02	0.05	0.0
RAW	RAW MATERIAL	2.9	N	1.32	N	N	1.24	0.03	0.04	0.0
RAW	RAW MATERIAL	3.2	N	1.41	N	N	1.40	0.02	0.04	0.0
RAW	RAW MATERIAL	N	N	0.20	N	N	1.07	0.02	0.04	0.0
CLINKER	CLINKER	N	N	2.10	N	0.02	1.35	0.03	0.06	0.0
CLINKER	CLINKER	N	N	2.26	N	N	1.68	0.03	0.05	0.0
CLINKER	CLINKER	N	N	2.06	N	N	1.42	0.03	0.05	0.0
CLINKER	CLINKER	N	N	2.58	N	N	1.45	0.03	0.05	0.0
FINISH	FINISH	N	N	2.14	N	N	1.75	0.03	0.06	0.0
FINISH	FINISH	N	N	2.85	N	N	1.53	0.03	0.05	0.0
FINISH	FINISH	N	N	2.64	N	N	1.35	0.03	0.05	0.0
FINISH	FINISH	N	N	2.50	N	N	1.55	0.03	0.05	0.0
FINISH	FINISH	N	N	2.17	N	N	1.58	0.03	0.04	0.0
FINISH	FINISH	N	N	2.46	N	N	1.55	0.04	0.04	0.0
FINISH	FINISH	N	N	2.72	N	N	1.34	0.03	0.13	0.0
FINISH	FINISH	N	N	2.39	N	N	1.39	0.03	0.05	0.0
MIX	RAW CLINKER	N	N	0.90	N	N	0.73	0.01	0.04	0.0
MIX	COKE OR COAL	4.4	N	1.80	N	N	0.09	0.01	0.04	0.0

Table 14

ENVIRONMENTAL INVESTIGATIONS BRANCH
CEMENT WORKERS MORBIDITY STUDY
DUNDEE CEMENT   DUNDEE, MICHIGAN
SOX CONCENTRATIONS

JOB	DATE	SHIFT	AREA	SO4_UGM3	SO3_UGM3	SO2_PPM
BACK END OF KILN	24MAR81	1	RAW	242.30	35.24	0.01
LEACH BUILDING	25MAR81	1	RAW	2207.5	220.97	0.03
PRECIPITATOR OF KILN (WASTE DUST)	26MAR81	1	RAW	124.81	N	N
QUARRY PUMP STATION	26MAR81	3	RAW	N	N	0.01
PRIMARY CRUSHER	26MAR81	3	RAW	N	N	N
RAW MILLS FEED END	26MAR81	3	RAW	122.42	N	0.01
SECONDARY CRUSHER	26MAR81	3	RAW	47.53	N	N
LEACH BUILDING	26MAR81	3	RAW	2142.5	40.75	0.01
LEACH BUILDING	26MAR81	3	RAW	1588.6	N	0.01
FRONT END OF KILN	24MAR81	1	CLINKER	55.94	N	0.01
FRONT END OF KILN	25MAR81	1	CLINKER	52.09	N	0.01
FRONT END OF KILN	26MAR81	1	CLINKER	157.86	N	0.12

Table 15

Environmental Investigations Branch

Industrial Hygiene Survey of Cement Workers
Dundee Cement, Dundee, Michigan

Short-Term Indicator Tube Sample Concentrations in
Parts Per Million (PPM)

Location	CO	NO_2	Hydrocarbons	H_2S
Kiln Precipitators (Back End)	0	0		0
Clinker coolers	0	0		
Mill Area	1	trace	.07%	
Front End of Kiln (East Kiln)	10	trace		
Secondary Crusher				0
Primary Crusher			.07%	0
Rock "Pecker"				0
Quarry Water Pump				0 3.0
Leach Plant				1.0 2.0 2.5

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.

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16. Abstract (Limit: 200 words) A walk through survey was conducted at the Dundee Cement Company, Dundee, Michigan to determine 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 six respirable dust samples and three total dust samples which exceeded the recommended ACGIH levels for respirable nuisance particulate. Detectable levels of quartz (14808607) were found in 12 respirable dust samples taken from workers associated with raw material, coal, or precipitator dusts. Seven total dust samples exceeded the Mine Safety and Health Administration limit of 10mg/m3. Exposure was also noted to hydrogen-sulfide (7783064). The authors recommend that engineering controls be used to reduce worker exposure to airborne dust. Workers who experience the greatest dust levels are usually those involved in maintenance and clean up operations; respirators should be provided for these workers. Before any worker enters a confined space associated with quarry water or an area where stagnant quarry water will be disturbed, the area should be checked for concentrations of hydrogen-sulfide. Substitution of a vacuum system for the currently used compressed air would greatly lessen the current exposure to dust during clean up operations. Disposable paper or cloth respirators should not be used to protect the worker from dust.

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