U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT 77 - 2- 404
JOHNS-MANVILLE SALES CORPORATION
LOMPOC, CALIFORNIA

JULY, 1977

I. TOXICITY DETERMINATION

It has been determined that at the Johns-Manville Plant, Lompoc, California:

1) Employees working in and around diatomaceous earth packing stations where calcined and flux-calcined diatomaceous earth products were processed were exposed to potentially toxic concentrations of dust containing cristobalite. This determination is based on the fact that dust concentrations measured at these packing stations during NIOSH's investigation (December 21-22, 1976) were high in terms of the criteria used for this study. The use of NIOSH certified respirators in these areas does not automatically constitute an obviation of the potential dust hazards since strict and proper use of respirators was not observed at all times.

2) Employees working in and around the conveying mechanisms and catwalks that constitute the "dry end" process of the systems handling calcined or flux-calcined diatomaceous earth products were also exposed to potentially toxic concentrations of dust containing cristobalite. This determination is based on dust measurements. Again, the use of NIOSH certified respirators does not automatically obviate the dust hazard.

3) Employees working in the train tunnel are not exposed to toxic dust concentrations as determined by the environmental measurements taken.

4) Employees who work at the "crushing station" may be exposed to excessive dust levels, but this fact was not conclusive. Quartz and cristobalite were present in the environmental sample in quantities much higher than expected.

5) Employees who work in the Mortar Plant were not exposed to toxic concentrations of dust or asbestos fibers. Dust levels were well below calculated limits. Asbestos fiber counts were well below current OSHA standards and NIOSH's recommended limits.

6) The medical surveillance program at Johns-Manville prior to 1973 was not adequate to insure the protection of the health of its workers.

7) The current medical surveillance program (since 1973) is acceptable by today's standards, but will need periodic review in order to insure worker health in the future.

8) The mortality data, presently available to NIOSH, seems to show a pattern of mortality excesses among the Johns-Manville population consistent with those previously documented for diatomaceous earth workers. Diseases of the respiratory system and lung cancer were the causes of death that were higher than expected. However, the current data is not adequate to make any definite conclusions.

The above determinations and conclusions were made concerning the major diatomaceous earth processes at the Johns-Manville facility. Detailed information concerning the above medical and environmental results of this determination are contained in the body of the report. Recommendations are included in Section V of this report. An addendum containing any conclusions derived from a further study of the mortality data will be completed in the future and will be sent to the principals involved in this hazard evaluation.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio, 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

(a) Johns-Manville Sales Corporation
(b) U.S. Department of Labor, Region IX
(c) Cal/OSHA
(d) NIOSH, Region IX
(e) Authorized Representative of Employees - International Chemical Workers Union, Local 146, Lompoc, California

For the purpose of informing the approximately 500 employees, copies of the report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized respresentative of the International Chemical Workers Union, Local 146, Lompoc, California, concerning the health hazards of diatomaceous earth dust exposure at the Johns-Manville production facility.

IV. HEALTH HAZARD EVALUATION

A. Plant Process

The Johns-Manville (JM) Sales Corporation facility in Lompoc is engaged in the production of diatomaceous earth (DE) products. The plant has been owned by JM for about fifty years and currently has about 500 employees. The raw DE is extracted from quarries located on JM's property and is moved to large shafts or storage bins called "glory holes." The raw DE is moved from the "glory holes" by train through a tunnel to the Crushing Plant. Raw DE, which was formed by the deposition of diatom skeletons during past geological periods, is silicon dioxide (SiO_2) and water in chemical combination. The SiO_2 molecules are found in a random, nonperiodic arrangement defined as amorphous silica. Raw DE can also contain trace amounts of impurities and small quantities of "crystalline" silica (free silica) which refers to a fixed pattern structure of the SiO_2 molecules. The three most common forms of free silica in industry are quartz, tridymite, and cristobalite.

The usable form of diatomaceous earth is a powder which has been sieved and dessicated. At JM, three powders are processed: (1) natural, (2) calcined, and (3) flux-calcined. The natural powder is processed by drying, milling and air-classifying the raw DE. The calcined product is made by passing the natural powder through rotary kilns at a temperature between 1800-2100^{o} F. The flux-calcined product is made by the same process except that the natural powder is mixed with a flux (sodium carbonate) prior to heating in the kiln. During the calcination process, a portion of the amorphous silica undergoes a structural change to cristobalite. Flux-calcination increases the amount of cristobalite and can result in the occurrence of a small amount of tridymite in the final product.

At Johns-Manville, diatomaceous earth products are mainly processed in a facility called the Powder Mill. The raw DE is brought by conveyor belts to crude bins from the Crushing Plant. At this point, the DE undergoes what JM calls the "wet-end" process. It is conveyed to weighing belts and into a furnace. Next, the DE passes through a series of blowers, cyclones, and classifiers prior to being fed into the kilns. At this stage, the product is termed "natural." Once the DE enters the kilns, it undergoes the "dry-end"process which is again a series of blowers, cyclones, screens, and classifiers. At this point, the DE enters the packer bins and is ready for bagging and stacking in a press-well. The Powder Mill is a huge complex, of equipment and catwalks. The entire process is designed to be air-tight, but leaks can occur. Maintenance men and cleaners are exposed to ambient DE throughout the mill. Packers and press-well operators are exposed to airborne DE which escapes from the packing machines. The packing machines are equipped with mechanical local exhaust ventilation. Also, the press-wells have slot ventilation. NIOSH certified respirators are mandatory throughout most of the Powder Mill.

Two smaller plants are located on the Johns-Manville grounds. The Mortar Plant is a special facility where one of the diatomaceous earth powders can be mixed with other ingredients such as cellulose or asbestos. The entire process is performed in a series of hoppers and two packing stations. The packing stations and hoppers have excellent mechanical ventilation and NIOSH certified respirators are mandatory in the Mortar Plant.

The Silicate Plant is involved in the production of a "synthetic" DE product. Raw DE undergoes a digestion process and is dried in furnaces prior to bagging. The DE is not calcined in kilns. This plant was not in operation during NIOSH's visit.

B. Evaluation Methods

1. Environmental

During the initial visit to the Johns-Manville plant on November 11, 1976, bulk samples of diatomaceous earth products were obtained and sent to a NIOSH laboratory. The samples were analyzed for per cent quartz, cristobalite, and tridymite. These results were used as background information for a follow-up environmental study of the Powder Mill and the Mortar Plant where DE dust samples in air were collected. Several airborne asbestos samples were also collected at the Mortar Plant. The follow-up environmental samples were combined with data from a NIOSH medical evaluation in this full report.

The majority of dust samples were collected with MSA Model G battery powered personal sampling pumps. The sampling cassettes held 37 millimeter (mm) polyvinyl chloride filters in combination with 10 mm nylon cyclones. The pumps were set at a rate of 1.7 liters of air per minute (lpm). After completion of the sampling, the filters were sealed and sent to a NIOSH laboratory in Salt Lake City, Utah, for analysis. The free silica content of each filter was determined by x-ray diffraction and the filter weights were measured on an electrobalance. Asbestos samples were collected with the same MSA Model G pumps. Air was drawn at a rate of 2.0 lpm through

Millipore 37 mm AA filters. It was also agreed upon during the initial visit that NIOSH would take some impinger samples in order to make dust counts. Impingers and collecting solution were provided by JM's industrial hygiene staff. Ten-minute samples were collected by holding the impingers in the worker's breathing zone and following him while he performed his job. Bendix C115 pumps were used to draw air through the impingers at a rate of 2.8 lpm. Each impinger sample was brought to the JM industrial hygiene office where Dunn Cells were prepared for counting. Dust counts were done on the same samples by both a NIOSH and JM industrial hygienist. Five fields per cell were counted. Particles greater than 10 micrometers in diameter were excluded. If the counts by the two hygienists differed by more than 20%, they were repeated. The follow-up environmental survey was conducted on December 21 and 22, 1976.

2. Medical

During the initial visit to the Lompoc facility, it was requested of NIOSH by the Union to review current medical information at the plant to determine whether there were excessive deaths among workers from various kinds of cancer and to evaluate the adequacy of the current medical surveillance program. The questions posed by the union necessitated two separate approaches from a medical standpoint. First, the past and present medical monitoring programs at JM were evaluated. Second, an epidemiological study was begun to assess the incidence of all types of cancer in this population of workers. Of particular concern were cancers of the respiratory tract because of the occurrence of a documented mesothelioma and a number of lung cancer cases among past employees.

During January 17-21, 1977, the NIOSH medical officer and epidemiologist visited the plant in an effort to resolve the questions posed by the union. The NIOSH medical officer reviewed the medical records of 29 current employees. Chest x-rays of about 35 present and past employees were reviewed and personal interviews with approximately 25 current workers were conducted. This information was used by the NIOSH medical officer to assess the adequacy of the past and current medical surveillance programs. The NIOSH epidemiologist collected available death certificates, discussed further data collection with union and company officials, and examined company personnel records in an effort to accumulate as much information as possible.

C. Evaluation Criteria

1. Environmental Standards or Criteria

The two primary sources of environmental evaluation criteria used for this report were the NIOSH Criteria Document for crystalline silica and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's) for dusts containing free silica.

The TLV for each sample was calculated on the assumption that the dust was a mixture of natural diatomaceous earth, quartz, and cristobalite. No tridymite was found in the bulk samples. The sum of these agents were assumed to total 100%. Thus, the TLV was calculated according to the following formula for a respirable dust sample:

$$TLV(mg/m^3) = \frac{1}{\frac{f(Q)}{TLV(Q)} + \frac{f(CRIS)}{TLV(CRIS)} + \frac{f(N)}{TLV(N)}}$$

f(Q) = fraction of quartz in sample
TLV(Q) = TLV of 100% quartz - 0.098 mg/m^3 (respirable)
f(CRIS) = fraction of cristobalite in sample
TLV(CRIS) = TLV of 100% cristobalite - 0.049 mg/m^3 (respirable)
f(N) = fraction of natural diatomaceous earth in sample
TLV(N) = TLV of 100% natural diatomaceous earth - 1.5 mg/m^3 (respirable)

NIOSH recommends in its Criteria Document for crystalline silica that occupational levels of free silica be controlled so that no worker is exposed to airborne concentrations exceeding 50 micrograms of respirable free silica per cubic meter of air (50 ug/m^3 of 0.050 mg/m^3) based on a time-weighted average (TWA) for a full work shift. This 50 microgram limit takes into account all forms of free silica.

Dust counts were also performed on selected samples at the plant to compare with the gravimetric samples. It is felt, however, that no direct comparison can be made between the two methods since the dust count samples were collected for 10 minutes while the gravimetric samples were run for most of the work shift. The TLV for dust counts where free silica is present is calculated from the following formula:

$$\text{TLV in mppcf (million particles per cubic foot of air)} = \frac{300}{\%\text{quartz} + 10}$$

A dust count TLV for a mixture can also be calculated, but not TLV in mppcf for natural diatomaceous earth is listed. Since no direct comparison between gravimetric and dust count samples are made in this report, TLV's for mixtures will not be calculated. However, as a reference point, if the airborne dust contained 50% and 100% quartz, the calculated TLV's would be 5 mppcf and 2.73 mppcf respectively. If these percentages represented the amount of cristobalite in the sample instead of quartz, the limits would be halved to 2.5 and 1.36 mppcf.

The current Cal/OSHA and Federal standards for occupational exposure to asbestos is 2.0 fibers longer than 5.0 micrometers in length per cubic centimeter (cc) of air based on a time-weighted average. The proposed change in the Federal Standard, which has not been adopted, calls for a lowering of the limit to 0.50 fibers/cc. In December of 1976, NIOSH submitted new criteria to OSHA recommending a standard of 0.1 fibers/cc.

2. Medical Standards or Criteria

a) Diatomaceous Earth (1,3,5)

In its natural state, diatomite is an opaline or amorphous form of silica with no crystalline pattern detectable by conventional x-ray diffraction. Upon calcination, a portion of the amorphous silica can convert to a crystalline form, cristobalite, that may exceed 50% in some flux-calcinated products. Experimental studies in animals and epidemiological studies in man indicate that the cristobalite is much more likely to produce fibrosis than other forms of free silic .

In a study done by the U.S. Public Health Service[3] it was found that with excessive diatomaceous earth exposure a significant number (25%) of workers will have radiographic evidence of pneumoconiosis after five years of exposure. X-ray changes will often precede pulmonary function abnormalities, but they may appear concomitantly. In some cases, x-ray abnormalities may progress after termination of exposure, and there may be progressive reduction in the pulmonary function studies that can eventually lead to incapacitation and even death. Workers who incur these changes appear to be more susceptible to infections and the effects of tobacco use.

b) Asbestos (4)

Asbestos refers to a number of fibrous mineral silicates that differ in chemical composition. Hydrated magnesium silicate (chrysotile, sodium iron silicate (crocidolite), and iron magnesium silicate (amosite) are the types of greatest commerical importance.

Exposure to asbestos is associated with the development of a potentially disabling pneumoconiosis. The respiratory impairment usually occurs after prolonged exposure (20-30 years), and commonly presents itself with dyspnea and a non-productive cough. Physical examination may reveal dry, crackling rales at the lung bases as an early sign of disease. Pulmonary function studies may show small airway disease, and diffusion capacity may be reduces. However, vital capacity measurement may be the first parameter to change in the pumonary function studies. X-ray changes are variable and usually have no relationship to physiologic function.

All other forms of lung cancer, in addition to mesothelioma, are also increased in those workers exposed to asbestos.

D. Evaluation Results and Discussion

1. Environmental Results

a) Free Silica

Respirable dust samples were collected in the workers breathing zones over a two-day period on December 21 and 22, 1976. The results are contained in Tables I, III, and IV.

Time-weighted average (TWA) samples were run between 288 - 411 minutes. One sample was collected on the "crusherman" in the Crushing Plant. His respirable dust exposure concentration was 0.60 mg/m^3 (milligrams of dust per cubic meter of air). The calculated TLV for this samples was 0.24 mg/m^3 based upon the per cent of free silica in the sample. Thus, the dust level taken on the "crusherman" exceeded the calculated limit. This worker was required to wear a NIOSH certified respirator. Two samples were collected in the train tunnel. These TWA samples showed dust concentrations of 0.35 mg/m^3 each as opposed to a calculated TLV of 1.5 mg/m^3.

Two samples over both days were collected on a "cleaner" who worked in the "dry end" of the # 3&4 systems. The TWA results were 0.13 and 0.15 mg/m^3. The calculated TLV's were respectively 0.07 and 0.06 mg/m^3. This cleaner's dust exposure was in excess of the calculated TLV on both days. The cleaner on the #6 system (dry end) was also monitored on both days. The TWA results were 0.24 and 0.16 mg/m^3 versus the calculated TLV's were 0.11 and 0.07 mg/m^3 respectively. The exposures were in excess of the TLV's. One sample was collected on the "wet end" cleaner at the #3&4 system and the TWA result was 0.37 mg/m^3 as opposed to a calculated TLV of 1.5 mg/m^3. If no quartz or cristobalite was present in the dust sample, it was assumed that the sample contained natural diatomaceous earth which has a respirable TLV of 1.5 mg/m^3. All cleaners are required to wear NIOSH certified respirators.

Four samples were collected at the #11 system packing station. Each packing station has a packer and a press-well operator who alternate jobs every two hours. On December 21, one packer's dust sample had 11.1% quartz and a TWA dust concentration of 0.82 mg/m^3. The calculated TLV was 0.58 mg/m^3. The other three samples had no free silica present and the TWA concentrations were 0.11, 0.40, and 0.84 mg/m^3. The TLV was assumed to be 1.5 mg/m^3. Usually, only natural DE is packed on this system, but on December 21, a different product was run for a period of two hours. This fact may explain the presence of quartz in one out of the four samples taken over a two-day period at the #11 system. NIOSH certified respirators were required at this packing station.

Four samples were taken over two days at the #5 packing station. The TWA concentrations were 0.84, 0.07, 0.13, and 0.23 mg/m^3. The respective calculated TLV's were 0.17, 0.05, 0.09, 0.08 mg/m^3. Thus, all four samples showed dust concentrations in excess of the TLV's. NIOSH certified respirators were required at this packing station.

Two samples were taken at the #6 packing station. The TWA concentrations were 1.86 and 0.19 mg/m^3. The calculated TLV's were respectively 0.72 and 0.10 mg/m^3. Both samples were in excess of the TLV's. No explanation could be found for the big difference in the respirable dust concentrations between the two workers during a single day's exposure. NIOSH certified respirators were required at this packing station.

Two samples on a single day were collected at the #6SC baghouse packing station. The TWA concentrations were 0.18 and 0.37 mg/m^3. The respective calculated TLV's were 0.10 and 0.12 mg/m^3. Both samples showed dust levels in excess of the TLV's. NIOSH certified respirators were required.

Two samples were collected at the #3 packing station. The TWA dust concentrations were 0.49 and 1.38 mg/m^3 and the calculated TLV's were both 0.05 mg/m^3. The dust levels were well in excess of the calculated TLV. Again, NIOSH certified respirators were required.

Two maintenance men were sampled. The "whistleman's" dust exposure was 0.08 mg/m^3 and the calculated TLV was 1.5 mg/m^3. The other maintenance man was in an area where 26.3% of his sample was cristobalite. The calculated TLV was 0.17 mg/m^3 and his dust exposure was 0.19 mg/m^3. His dust exposure was slightly above the TLV. Maintenance men are required to wear NIOSH certified respirators in mandatory respirator areas of the Powder Mill.

Samples on the forklift driver and the Tennant Sweeper operator showed TWA dust levels that were low (0.13 and 0.06 mg/m^3). The TLV was assumed to be 1.5 mg/m^3 since no free silica was present in either sample.

Two samples for DE were taken at the Mortar Plant packing station. One sample was incomplete because the employee was injured after two hours and could not continue working. The other sample showed a TWA dust concentration of 0.06 mg/m^3 versus a TLV of 1.5 mg/m^3.

b) Dust Counts

Dust count results are contained in Table II. The majority of samples were taken at various packing stations in the Powder Mill and the counts ranged from 0.16 to 2.25 mppcf. No direct comparisons were made between the dust counts and the gravimetric samples since sampling times for the dust counts were so short. Also, the sampling medium could only be held in the worker's breathing zone versus placing the filter on an employee's lapel for the whole work shift. TLV's were not calculated for the dust counts since the per cent free silica was not obtained at the same time. At Johns-Manville past data from long-term sampling is used to estimate the per cent free silica in the workers' breathing zones and is the basis for any dust count TLV calculation.

c) Asbestos

On December 22, several asbestos samples were taken at the packing station of the Mortar Plant. Two samples were taken in the morning when a cellulose-containing product was being processed. No asbestos was in this product although cellulose fibers can become airborne. The fiber counts were 0.02 and 0.18 fibers/cc and were assumed to be cellulose fibers. Three samples were taken in the afternoon while a 10% asbestos product was being packed. The fiber counts were 0.03, 0.03, and less than 0.01 fibers/cc. These asbestos counts were well below the current CAL/OSHA and Federal standards of 2.0 fibers/cc and NIOSH's recommended limit of 0.1 fibers/cc for asbestos.

d) Discussion of Environmental Results

During the days of NIOSH's environmental survey, dust levels at several packing stations in the Powder Mill were high. These packing stations were the ones where calcined and flux-calcined diatomaceous earth products were being processed. All 10 samples taken at these packing stations showed dust concentrations in excess of the calculated TLV's. Clean-up jobs on catwalks in the "dry-end" sections of the Powder Mill where calcined and flux-calcined products were being processed were also in areas where dust levels were high. Maintenance men can also work in areas of the plant where dust levels were too high. Dust levels in the train tunnel, Mortar Plant, and in areas where the forklift driver and Tennant Sweeper entered were low. The sample result at the "crusherman's" work station seemed to be unusual because it contained 11.8% quartz and 11.8% cristobalite. This work station is a check point where slate is separated from raw DE. Ordinarily, quartz or cristobalite is not expected in such quantities. The dust concentration in the only sample taken in the area exceeded the calculated TLV because of the presence of the free silica in the sample. Further study is needed in order to make a definite conclusion about this work station.

Table III contains a variation in the calculations listed in Table I. The NIOSH Criteria Document for crystalline silica recommends a time-weighted average limit of 50 ug/m^3 (0.050 mg/m^3) for airborne respirable concentrations of free silica in any form. The per cent free silica in each sample was multiplied by the measured respirable dust concentrations to determine the respirable SiO_2 concentrations. These values were compared to the 50 ug/m^3 limit recommended by NIOSH. In Table I, 17 samples exhibited dust concentrations which exceeded their respective calculated TLV's. In Table III, all 17 samples had respirable SiO_2 concentrations above 50 ug/m^3. Thus, using two different criteria, these samples were an indication of high dust levels.

The industrial hygiene staff at JM has, in the past, performed high volume respirable dust sampling in all areas of the plant in order to develop a quartz and cristobalite standard for use in their environmental monitoring program. The JM staff has never found more than 50% cristobalite in any of these samples. Table IV contains re-calculations of six samples where the per cent cristobalite ranged from 66.6-100.0%. The per cent cristobalite was hypothetically reduced to 50% and the new TLV's and respirable SiO_2 were calculated. Five out of six samples were still in excess of the new TLV's and the 50 ug/m^3 limit. Thus, in areas of the Powder Mill where there is a potential for exposure to dust containing cristobalite, it is felt that dust levels are too high. It is noted, however, that in these areas, NIOSH certified respirators are mandatory.

The asbestos samples collected during the survey substantiated the fact that the generation of asbestos fibers into the work atmosphere in the Mortar Plant seemed to be well controlled. Strict Cal/OSHA regulations governing asbestos use in California are being followed and address the asbestos question at this time.

e) Discussion of Medical Results

The epidemiological evaluation of deaths among the employee population at Johns-Manville has been only partially completed. Death certificate data acquired before the site visit by the NIOSH medical team represents an inadequate sample of total deaths at JM. Further data is being collected from the company, union, and insurance carriers. The results of a crude analysis of the original data seem to show a pattern of mortality excesses among the JM population consistent with those previously documented for diatomaceous earth workers. Deaths due to diseases of the respiratory system and lung cancer were among those causes which showed significant excesses. Although the crude analysis of the original data has indicated a possibility of increased mortality among company employees from these causes, a final evaluation will only be made after an adequate death certificate sample is reviewed, if that is possible. The results of any subsequent evaluation of death certificate data will be included in an addendum to this report and it will be made available to the principals of this official health hazard evaluation request.

The assessment of the medical surveillance program was more easily done. Upon completion of the review of current medical records, chest x-rays, and personnel records, several observations could be made:

1) The medical surveillance program at Johns-Manville prior to 1973 was less than acceptable. During review of medical records prior to 1973, it was noted that there were inconsistencies in yearly x-ray performance, as well as small numbers of workers with any pulmonary function studies done at anytime. There were also occasional workers who had abnormalities detected that were not properly followed-up.

2) The current method of keeping medical records both active and inactive was found to be cumbersome and incomplete, as well as difficult to use.

3) The current medical surveillance program since 1973 is acceptable by today's standards, but it will need periodic review in order to insure worker health in the future.

V. RECOMMENDATIONS

In view of the findings by NIOSH at the Johns-Manville Sales Corporation Plant, Lompoc, California, the following recommendations are made to supplement those measures already in force to insure that potential health hazards are being fully addressed and to provide a better work environment for the employees covered by this determination:

1) Employees should be examined medically once a year.

2) In addition to the current pulmonary function studies, a maximal mid-expiratory flow rate ($MMEF_{25-75}$) measurement or a pulmonary flow loop measurement should be performed.

3) Johns-Manville should arrange for the services of a pulmonary function specialist to evaluate those workers who show clinical abnormalities or whose chest x-rays or pulmonary functions change from the previous year.

4) Both union and management should combine energies to discourage smoking of tobacco by all employees.

5) A tuberculosis screening program should be instituted.

6) Routine physical examinations should be expanded to include measurement and recording of blood pressure. Blood pressure should be checked every month if it is found to be greater than 140/90. It is remains elevated for three successive measurements, the worker should be encouraged to see their physician for evaluation.

7) It is suggested that routine physical examinations include fasting blood sugar, cholesterol, and triglycerides evaluations every other year. This is to provide early detection of diabetes and lipid disorders in the work force.

8) The ventilation systems at the packing stations in the Powder Mill should be studied and be upgraded if necessary to lower the dust levels. A better maintenance program may be sufficient.

9) All enclosed conveying systems which handle powders containing cristobalite should be repaired immediately if leaks occur.

10) The respirator program should be reviewed to see if it conforms to all Cal/OSHA regulations. The wearing of NIOSH certified respirators in mandatory areas should be strictly enforced since there were visual observations of respirators being improperly worn or not worn at all.

11) Maintenance men and cleaners who work on catwalks in the Powder Mill should always be required to wear NIOSH certified respirators.

12) The NIOSH certified respirators should also be worn inside the specially designed clothes cleaning booths.

13) Applicable recommendations contained in NIOSH's Criteria Document for occupational exposure to crystalline silica should be followed.

VI. REFERENCES

1. Zenz: Occupational Medicine, pp. 121-124.

2. Documentation of Threshold Limit Values, American Conference of Governmental Industrial Hygienists, 1976.

3. U.S.P.H.S., HEW, "Pneumoconiosis in Diatomite Mining and Processing," pp. 62-89.

4) Hamilton and Hardy: Industrial Toxicology, 3rd edition, pp. 339-340.

5) "Criteria for a recommended standard...occupational exposure to Crystalline Silica," U.S. Department of Health, Education, and Welfare, PHS, NIOSH, 1975.

VII. ACKNOWLEDGMENTS AND AUTHORSHIP

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TABLE I. LEVELS OF RESPIRABLE DUST AND PERCENTAGES OF RESPIRABLE QUARTZ AND CRISTOBALITE BY JOB OR OPERATION IN BREATHING ZONE SAMPLES COLLECTED AT THE JOHNS-MANVILLE LOMPOC DIATOMACEOUS EARTH PLANT ON DECEMBER 21 AND 22, 1976.

Sample #	Date	Samp. Time	Air Vol.	Wt. Samp.	Conc.	Wt. Q[1]	%	Wt. Cris[2]	%	Calc. TLV[3]	Area or Operation (R,N,C,F)[4]
PV 461	12/21/76	333 mins.	566 lit.	0.34 mg.	0.60 mg/m^3	0.04 mg.	11.8	0.04 mg.	11.8	0.24 mg/m^3	Crusherman (R)
PV 508	12/21/76	335 mins.	570 lit.	0.20 mg.	0.35 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	Trainman (R)
PV 507	12/21/76	286 mins.	486 lit.	0.17 mg.	0.35 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	Trainman-Loader (R)
PV 353	12/21/76	352 mins.	598 lit.	0.09 mg.	0.15 mg/m^3	<0.04 mg.	0	0.06 mg.	66.6	0.07 mg/m^3	Dry-End Clean-Up #3,4 (C,F)
PV 479	12/22/76	368 mins.	626 lit.	0.08 mg.	0.13 mg/m^3	<0.04 mg.	0	0.06 mg.	75.0	0.06 mg/m^3	Dry-End Clean-Up #3,4 (C,F)
PV 649	12/21/76	362 mins.	615 lit.	0.15 mg.	0.24 mg/m^3	<0.04 mg.	0	0.10 mg.	41.6	0.11 mg/m^3	Dry-End Clean-Up #6 (C)
PV 559	12/22/76	371 mins.	631 lit.	0.10 mg.	0.16 mg/m^3	<0.04 mg.	0	0.07 mg.	70.0	0.07 mg/m^3	Dry-End Clean-Up #6 (C)
PV 634	12/22/76	361 mins.	614 lit.	0.23 mg.	0.37 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	#3,4 Wet-end Clean-Up (N,F)
PV 393	12/21/76	322 mins.	547 lit.	0.45 mg.	0.82 mg/m^3	0.05 mg.	11.1	<0.04 mg.	0	0.58 mg/m^3	#11 Packer (N)*
PV 646	12/21/76	319 mins.	542 lit.	0.05 mg.	0.09 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	#11 Packer (N)*
PV 450	12/22/76	389 mins.	661 lit.	0.07 mg.	0.11 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	#11 Packer (N)
PV 524	12/22/76	387 mins.	658 lit.	0.26 mg.	0.40 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	#11 Packer (N)
PV 650	12/21/76	343 mins.	583 lit.	0.49 mg.	0.84 mg/m^3	<0.04 mg.	0	0.13 mg.	26.5	0.17 mg/m^3	#5 Packer (C)
PV 474	12/21/76	346 mins.	588 lit.	0.04 mg.	0.07 mg/m^3	<0.04 mg.	0	0.04 mg.	100.0	0.05 mg/m^3	#5 Packer (C)
PV 741	12/22/76	411 mins.	699 lit.	0.09 mg.	0.13 mg/m^3	<0.04 mg.	0	0.05 mg.	55.5	0.09 mg/m^3	#5 Packer (C)
PV 636	12/22/76	404 mins.	687 lit.	0.16 mg.	0.23 mg/m^3	<0.04 mg.	0	0.09 mg.	56.2	0.08 mg/m^3	#5 Packer (C)
PV 385	12/21/76	341 mins.	580 lit.	1.08 mg.	1.86 mg/m^3	<0.04 mg.	0	0.04 mg.	3.7	0.72 mg/m^3	#6 Packer (F)*
PV 642	12/21/76	336 mins.	571 lit.	0.11 mg.	0.19 mg/m^3	<0.04 mg.	0	0.05 mg.	45.4	0.10 mg/m^3	#6 Packer (F)*
PV 569	12/21/76	333 mins.	566 lit.	0.10 mg.	0.18 mg/m^3	<0.04 mg.	0	0.05 mg.	50.0	0.10 mg/m^3	#6 SC Baghouse Packer (N,F)
PV 394	12/22/76	369 mins.	627 lit.	0.23 mg.	0.37 mg/m^3	<0.04 mg.	0	0.09 mg.	39.0	0.12 mg/m^3	#6 SC Baghouse Packer (N,F)
PV 419	12/22/76	404 mins.	687 lit.	0.34 mg.	0.49 mg/m^3	<0.04 mg.	0	0.31 mg.	91.2	0.05 mg/m^3	#3 Packer (F)
PV 510	12/22/76	401 mins.	682 lit.	0.94 mg.	1.38 mg/m^3	<0.04 mg.	0	0.94 mg.	100.0	0.05 mg/m^3	#3 Packer (F)
PV 517	12/21/76	300 mins.	510 lit.	0.04 mg.	0.08 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	Maintainer-Whistleman (Varied)
PV 629	12/21/76	332 mins.	564 lit.	0.19 mg.	0.34 mg/m^3	<0.04 mg.	0	0.05 mg.	26.3	0.17 mg/m^3	Maintainer (Varied)
PV 531	12/22/76	387 mins.	658 lit.	0.04 mg.	0.06 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	Tennant Sweeper (Varied)
PV 483	12/22/76	368 mins.	626 lit.	0.08 mg.	0.13 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	Forklift Driver (Varied)
PV 400	12/22/76	288 mins.	490 lit.	0.03 mg.	0.06 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	Packer, Mortar Plant (F)
PV 523	12/22/76	113 mins.	192 lit.	0.0 mg.	0.0 mg/m^3	<0.04 mg.	0	<0.04 mg.	0	1.5 mg/m^3	Packer, Mortar Plant (F)

1 - Q = weight of quartz in milligrams (mg); the limit of detection for quartz is 0.04 mg.

2 - CRIS = weight of cristobalite in mg; limit of detection of CRIS is 0.04 mg

3 - CALC TLV = Calculated TLV is based on percentages of quartz, cristobalite, and natural diatomaceous earth (DE) in each sample. Calculation is based on a TLV for a mixture:

$$TLV\ (mg/m^3) = \frac{1}{\frac{f(Q)}{TLV(Q)} + \frac{f(CRIS)}{TLV(CRIS)} + \frac{f(N)}{TLV(N)}}$$

where f(Q) = fraction of quartz in sample ; TLV(Q) = TLV of 100% quartz ;
f(CRIS) = fraction of crystobalite in sample ; TLV(CRIS) = TLV of 100% cristobalite ;
f(N) = fraction of natural D.E. in sample or 1.0- [f(Q) + f(CRIS)] ;
TLV(N) = TLV of 100% natural D.E.

4 - Most probable product worker exposed to: R = raw D.E.; N = natural D.E.; C = calcined D.E.; F = flux-calcined D.E.

* - Short-term switching of products occurred.

TABLE II. DUST COUNTS FOR SELECTED JOB OPERATIONS AT THE JOHNS-MANVILLE DIATOMACEOUS EARTH PLANT, LOMPOC, CALIFORNIA.

SAMPLE #	DATE	SAMPLE PERIOD	JOB OPERATION	DUST COUNT (R,N,C,F)[1]	
20	12/21/76	12:49-12:59	#5 Packer	0.97 mppcf[2]	(C)
28	12/21/76	14:43-14:53	#5 Press-well Op	0.95 mppcf	(C)
40	12/21/76	15:16-15:26	#5 Press-well Op	1.14 mppcf	(C)
23	12/21/76	13:08-13:14	#6A Packer	0.56 mppcf	(F)
		13:30-13:34			
25	12/21/76	14:28-14:38	#6A Press-well Op	0.53 mppcf	(F)
24	12/21/76	13:44-13:54	#6 SCBH Packer	0.40 mppcf	(N,F)
34	12/21/76	15:02-15:12	#6 SCBH Packer	1.10 mppcf	(N,F)
14	12/21/76	10:10-10:20	Crusherman	1.90 mppcf	(R)
12	12/21/76	9:47- 9:57	Trainman	2.20 mppcf	(R)
47	12/22/76	10:30-10:40	#3 Packer	2.25 mppcf	(F)
6	12/22/76	8:50- 9:00	#3 Press-well Op	0.97 mppcf	(F)
46	12/22/76	9:42- 9:52	#5 Packer	0.22 mppcf	(C)
30	12/22/76	9:25- 9:35	#11 Packer	2.15 mppcf	(N)
26	12/22/76	9:10- 9:20	#11 Press-well Op	1.07 mppcf	(N)
48	12/22/76	10:55-11:05	Mortar Plant Packer	0.68 mppcf	(F)
50	12/22/76	11:10-11:20	Mortar Plant Packer	0.16 mppcf	(F)

1. Most probable product worker exposed to:
   R = raw D. E.
   N = natural D. E.
   C = calcined D. E.
   F = flux-calcined D. E.

2. mppcf = million particles per cubic feet of sampled air.

TABLE III. RESPIRABLE FREE SILICA (SiO_2) DUST CONCENTRATIONS IN MILLIGRAMS PER CUBIC METER OF AIR (mg/m^3) BY AREA OR OPERATION IN BREATHING ZONE SAMPLES COLLECTED AT THE JOHNS-MANVILLE LOMPOC PLANT ON DECEMBER 21 - 22, 1976.

Sample#	Date	%SiO_2[1]	Dust Conc.(mg/m^3)	SiO_2 Conc.(mg/m^3)[2]	Area or Operation
PV461	12/21	23.6	0.60	0.140	Crusherman
PV508	"	0.0	0.35	0.0	Trainman
PV507	"	0.0	0.35	0.0	Trainman-loader
PV353	"	66.6	0.15	0.099	Dry end clean-up (3&4)
PV479	12/22	75.0	0.13	0.098	" " "
PV649	12/21	41.6	0.24	0.099	Dry end clean-up (6)
PV559	12/22	70.0	0.16	0.112	" " "
PV634	"	0.0	0.37	0.0	Wet end clean-up (3&4)
PV393	12/21	11.1	0.82	0.091	#11 Packer*
PV646	"	0.0	0.09	0.0	" " *
PV450	12/22	0.0	0.11	0.0	" "
PV524	"	0.0	0.40	0.0	" "
PV650	12/21	26.5	0.84	0.223	#5 Packer
PV474	"	100.0	0.07	0.070	" "
PV741	12/22	55.5	0.13	0.072	" "
PV636	"	56.2	0.23	0.129	" "
PV385	12/21	3.7	1.86	0.069	#6 Packer*
PV642	"	45.4	0.19	0.086	" " *
PV569	"	50.0	0.18	0.090	#6SC Baghouse Packer
PV394	12/22	39.0	0.37	0.144	" " "
PV419	"	91.2	0.49	0.447	#3 Packer
PV510	"	100.0	1.38	1.380	" "
PV517	12/21	0.0	0.08	0.0	Maintainer-whistleman
PV629	"	26.3	0.34	0.089	Maintainer
PV531	12/22	0.0	0.06	0.0	Tennant Sweeper
PV483	"	0.0	0.13	0.0	Forklift Driver
PV400	"	0.0	0.06	0.0	Packer, Mortar Plant
PV523	"	0.0	0.0	0.0	" "¢

1 - %SiO_2 = total per cent of free silica (quartz and cristobalite) in sample

2 - SiO_2 Conc. = total free silica concentration (quartz and cristobalite) in respirable dust samples obtained by the multiplication of %SiO_2 times the respirable dust concentration

* - short-term switching of products occurred during total days run

¢ - worker unable to continue because of injury

TABLE IV. RESPIRABLE DUST CONCENTRATIONS IN MILLIGRAMS PER CUBIC METER OF AIR FOR SELECTED SAMPLES TAKEN AT THE JOHNS-MANVILLE PLANT ON DECEMBER 21 - 22, 1976 WITH RE-CALCULATIONS OF TLV's AND RESPIRABLE SiO_2 DUST CONCENTRATIONS IN MILLIGRAMS PER CUBIC METER BASED UPON A HYPOTHETICAL CRISTOBALITE LEVEL OF 50% BY OPERATION.

Sample#	Dust Conc.[1]	%Quartz	%Cristobalite	New TLV[2]	New SiO_2 Conc.[3]	Operation
PV353	0.15 mg/m^3	0.0	50.0	0.095 mg/m^3	0.075 mg/m^3	Dry end clean.(3&4)
PV479	0.13 "	0.0	50.0	0.095 "	0.065 "	" " "
PV559	0.16 "	0.0	50.0	0.095 "	0.080 "	" " (#6)
PV474	0.07 "	0.0	50.0	0.095 "	0.035 "	#5 Packer
PV510	1.38 "	0.0	50.0	0.095 "	0.690 "	#3 Packer
PV419	0.49 "	0.0	50.0	0.095 "	0.245 "	#3 Packer

1 - dust concentration as measured on original sample

2 - new TLV based on 0% quartz and a hypothetical 50% cristobalite

3 - new SiO_2 respirable dust concentration based on 0% quartz and hypothetical 50% cristobalite