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 77-57-460
JOHNS-MANVILLE PRODUCTS CORPORATION
VERNON, CALIFORNIA

FEBRUARY 1978

I. TOXICITY DETERMINATION

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

1) Employees working in and around the shingle manufacturing line are not exposed to excessive levels of fibrous glass. This determination is based on the fact that fibrous glass fiber counts were below detectable limits and dust levels were low in the samples collected on April 18, 1977.

2) The slateman is exposed to potentially toxic levels of dust containing crystalline silica. This determination is based on the dust levels measured and the work practices reviewed on April 18, 1977.

3) Employees entering the saturator and working near where petroleum asphalt is heated and fumes are generated are exposed to potentially high levels of benz(a)pyrene. This determination is made as a result of the measurements made on April 18 and August 24, 1977. No conclusion as to what constitutes a high level of benz(a)pyrene or other polynuclear aromatic hydrocarbons has been made by any official governmental agency.

4) Employees' exposure to asphalt fumes could not be adequately characterized to make a definite conclusion concerning toxicity with the currently available sampling and analytical techniques.

5) Employees' exposures to formaldehyde, toluene, and total aliphatic hydrocarbons are not toxic. This determination is based on the results of samples collected on April 18, 1977.

6) The backtender on the rolled line is exposed to asbestos fiber levels in excess of the NIOSH recommended limit but well below Federal or California State standards. This determination is based on asbestos levels measured on April 18, 1977.

The above determinations and conclusions were made concerning the major processes and air contaminants that employees were exposed to at the Johns-Manville Products Corporation plant. More detailed information concerning

these determinations is contained in the body of the report. Recommendations are included in Section V of this report. The final report has taken longer than usual to complete because of problems with some of the laboratory analyses.

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 the NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

(a) Johns-Manville Products, Inc., Vernon, California

(b) U.S. Department of Labor, Region IX

(c) CAL/OSHA

(d) NIOSH, Region IX

(e) Authorized Representative of Employees - International Union of the United Paperworkers

For the purpose of informing the approximate 25 affected employees, the employer will post the report in a prominent place(s) 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 an 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 Local #307 of the United Paperworkers International Union, Vernon, California, to determine whether fibrous glass and crystalline silica used in the production of asphalt shingles are toxic in the concentrations used or found at the Johns-Manville Products Corporation

plant, Vernon, California. In response to previous Health Hazard Evaluation requests (RHE #76-54-436 and #76-55-443) submitted by the International Union of the United Paperworkers, evaluations of other asphalt shingle manufacturing plants were made by NIOSH. At that time, fibrous glass matte was also of concern, but used only sporadically and NIOSH was unable to evaluate the effects of employee exposure to fibrous glass fibers in this type of industry. Therefore, an effort was made by the International Union to find companies where fibrous glass was processed more frequently and which had local representatives in the Union. This effort resulted in an official request being submitted for the Johns-Manville Products Corporation in Vernon, California. Although the request only cited the substances fibrous glass and crystalline silica, for purposes of completeness an attempt was made to evaluate worker exposure to some of the other materials used in the workplace such as asbestos, formaldehyde, and asphalt (petroleum).

IV. HEALTH HAZARD EVALUATION

A. Description of Plant Process

The main roofing line at the Johns-Manville (J-M) plant produces asphalt shingles which have cores made of either paper felt or fibrous glass. The core is usually referred to as the "matte." At J-M, some of the paper matte contains a small percentage of asbestos. When the matte is paper, it is fed from large rolls through a series of accumulation loops before entering the asphalt "saturator." The large rolls are continuous since they are attached together via an operation called "splicing." In the saturator, hot petroleum liquid asphalt which ahs been heated to approximately 400°F is applied to the matte as it passes through another series of loops. When it leaves the saturator, the matte has been completely saturated with asphalt. The saturated matte then passes through a baffle of liquid asphalt which has been thickened. This bath and baffle system is known as the "coater." When fibrous glass matte is run on the production line, the saturator is not used, and the matte goes directly through the coater. As either type of matte leaves the coater, granules of the desired color are dropped on the top side of the matte and pressed into the still hot asphalt with a roller ("pressroll area"). Additionally, a mixture of sand and talc is placed on the backside of the matte to prevent sticking and three thin strips of polyester film are applied. The material then passes through a water spray and another series of cooling and accumulation loops ("cooling section"). An intermittent strip of liquid asphalt is applied to the shingle at the "sealamatic resin strips applicator" as it leaves the cooling loops and proceeds to the final steps (cutting, stacking, wrapping, and storage).

Two shifts were in operation during NIOSH's two visits to the plant (April 18 and August 24, 1977). Approximately 12 employees can handle the entire main shingle line. A "splicer" and "splicer helper" are responsible for feeding and splicing the rolls of paper or fibrous glass matte. One worker ("coaterman") handles the coater and one employee tends the pressroll and cooling section areas of the shingle line. One employee handles the slate granules and other minerals used in the shingles. This "slateman" is responsible for monitoring the flow of granules and/or loading the minerals into ventilated hoppers in the slateroom which is located above the coater.

At Vernon, rolled roofing products are processed on a smaller line ("rolled line") which is parallel to the main shingle line. A "backtender" feeds the matte which passes through a saturator, continues through a series of cooling loops, and is rolled and cut into the final product. One worker ("machine tender") watches the entire line, and two employees handle the rolling, cutting, and stacking of the final product.

On April 18, 1977, fibrous glass matte was being processed and samples for fibrous glass and crystalline silica were taken. Additionally, since workers at J-M were being exposed to essentially the same air contaminants as those employees in other asphalt shingle manufacturing plants, spot sampling for asphalt fumes, volatile hydrocarbons, polynuclear aromatics (especially benz(a)pyrene), formaldehyde, and asbestos was conducted.

Exposure to fibrous glass fibers is greatest among employees working near the uncoated matte and it diminishes as the material reaches the end of the process. Any exposure to asbestos will follow the same pattern as for fibrous glass.

At Vernon, the saturators and the coater have mechanical ventilation systems designed by Johns-Manville and are known as "HEAF" units (High Efficiency Air Filters). The saturators are enclosed and under negative pressure. Employees only enter the saturator during breakdowns and spot checks and the greatest exposures to asphalt fumes plus any substances contained in the fumes occur at this time. No respiratory protection is used when employees enter the saturators. The coater has partial enclosure and this HEAF unit captured most of the fumes and smoke. However, during the NIOSH visits, some of the contaminants were escaping into the general work area. Thus, the potential for the greatest asphalt fume exposure is at the coater and in the saturators, but it seems that low-level exposures can occur throughout the shingle manufacturing line.

Exposures to workers from crystalline silica can occur in the slateroom and near the cooling section and coater. The sources of silica are colored granules and sand which are applied to asphalt shingles. The potential for a health hazard from silica is generally confined to these areas of the shingle manufacturing line.

B. Evaluation Methods (Environmental)

The methods for the evaluation of the work environment varied depending upon the substance being sampled and are described below:

Fibrous Glass Fibers - Two measurements were made using the same method but different collecting filters.

a) Fiber Count - For fiber counts, an open-face filter cassette containing a membrane filter with 0.8 micrometer (um) pore size was attached to a worker near the breathing zone. Air was drawn through the filter with a MSA Model G battery-operated personal sampling pump at a rate of 1.7 liters per minute (lpm). The fiber counts were done using phase contrast microscopy. Since fibrous glass does not polarize under phase contrast microscopy, it is not difficult to differentiate between asbestos and fibrous glass fibers.

b) Total Weight - The same sampling apparatus and procedure as described for the fiber counts was used for gravimetric analysis except that a tared (pre-weighed) vinyl metricel filter was substituted for the membrane filter. Reweighing was done upon receipt of samples by the NIOSH laboratory.

Asbestos Fibers - Asbestos samples were collected using an open-face membrane filter cassette containing a membrane filter with 0.8 um pore size which was attached to a worker near the breathing zone. Air was drawn through the filter with a MSA Model G battery-operated sampling pump at a rate of 1.5 lpm. The fiber counts were done using phase contrast microscopy.

Crystalline Silica - Silica samples were collected on polyvinyl chloride (FWS-B) filters and the same MSA pumps. Silica samples were for both respirable and total dust. The sampling filter cassette was attached to the worker near the breathing zone. Respirable samples required the additional use of a 10 millimeter cyclone. The sampling rate was 1.7 lpm. Silica analysis was accomplished by X-ray diffraction.

Asphalt (Petroleum) Fume - Asphalt fume samples were collected with the same MSA Model G battery-operated personal sampling pumps. The sampling cassettes were attached to workers near the breathing zones or in general work areas and contained tared silver membrane and glass fiber filters. The flow rates were 1.0 or 1.7 lpm. The lower flow rate occurred when charcoal tubes were used in combination with the filters. In the laboratory, the particulates (which included fume and dust) were extracted with cyclohexane and the soluble fraction was determined. It was assumed that the soluble fraction represented the amount of asphalt collected on the filters, however, there were major difficulties with this analysis which are explained in later sections of this report. The cyclohexane soluble fraction was in turn analyzed for benz(a)pyrene (BAP) and other polynuclear aromatics (PNA's) such as chrysene, benz(a)anthracene, pyrene, and fluoranthene.

Asphalt (Petroleum) Volatiles - Asphalt volatiles were collected with the same procedure as described for asphalt fume samples only silver and glass fiber filters were followed in series with a charcoal tube. The flow rate was 1.0 lpm with the charcoal tubes being used for the asphalt volatiles analysis. This analysis was performed using gas chromatographic techniques.

Formaldehyde - General area samples for formaldehyde near the splicing and coating areas were collected over a time period using the same MSA pumps and midget impingers containing 1% sodium bisulfite as the absorbing reagent. The flow rate was 1.0 lpm. The samples for formaldehyde were analyzed with colorimetric techniques. Additionally, grab samples for formaldehyde were taken with Draeger length-of-stain indicator tubes.

C. Evaluation Criteria

1. Environmental Standards or Criteria

The three primary sources of environmental evaluation criteria were NIOSH Criteria Documents, if available, for recommended occupational exposures to particular substances, the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's) for Chemical Substances and Physical Agents in the Workroom Environment for 1977, and applicable CAL/OSHA standards. These criteria are discussed below:

Fibrous Glass[1]- The NIOSH recommended limit for fibrous glass fibers based on a time-weighted average (TWA) over a work shift is 3.0 fibers per cubic centimeter (cc) with diameters equal to or less than 3.5 micrometers (um) and a length equal to or greater than 10 um. Additionally, NIOSH recommends that airborne concentrations determined as total fibrous glass be limited to a TWA concentration of 5.0 milligrams per cubic meter (mg/m^3) of air. There is no U.S. Department of Labor Standard for fibrous glass and the ACGIH lists it under their nuisance dust category.

Asbestos[2]- The NIOSH revised recommended limit for asbestos fibers is 0.1 fibers greater than 5 um in length/cc based on an eight-hour TWA with peak concentrations not to exceed 0.5 fibers greater than 5 um in length/cc based on a 15-minute sample period. The U.S. Department of Labor and the CAL/OSHA Standards are identical: 2.0 fibers greater than 5 um in length/cc based on a TWA sample and a peak concentration of 10.0 fibers greater than 5 um in length/cc.

Crystalline Silica[3]- The NIOSH recommended limit for crystalline silica (SiO_2) in respirable samples based on a TWA over a work shift is 0.050 mg/m^3 for all forms of crystalline SiO_2. The ACGIH recommended TLV's (which are

also the CAL/OSHA Standards) for respirable and total dust samples are calculated from the following formulas:

$$\text{respirable samples in mg/m}^3 = \frac{10 \text{ mg/m}^3}{\% \text{ SiO}_2 + 2}$$

$$\text{total dust samples in mg/m}^3 = \frac{30 \text{ mg/m}^3}{\% \text{ SiO}_2 + 3}$$

Asphalt (Petroleum) Fume[5]- The ACGIH recommended TLV for asphalt fume is 5.0 mg/m^3 based on a TWA over a workshift (which is also the CAL/OSHA Standard). There is no U.S. Department of Labor Standard for asphalt fumes. NIOSH recommends a maximum exposure of 5.0 mg/m^3 for asphalt fume based on any 15-minute sampling period.

Formaldehyde[4]- The NIOSH recommendation for formaldehyde exposure is a ceiling concentration of 1.0 parts per million (ppm) based on a 30-minute sampling period. The ACGIH TLV for formaldehyde is a ceiling concentration of 2.0 ppm.

Criteria for other substances with no current limits or found only in trace amounts during this investigation will be discussed in the results section of this report.

2. Medical Standards or Criteria

The adverse effects from exposures to substances evaluated in this investigation depend upon the degree and length of exposure and vary with the agent. No medical investigation was made by NIOSH at Vernon, but the effects of exposure to some of the substances are described below:

Fibrous Glass - The recommended standard has been designed to protect workers against the development of acute and chronic effects of exposure to fibrous glass. The acute effects include skin, eye, and respiratory tract irritation. The standard is also based on preventing chronic effects such as bronchiolar impairment and fibrosis. The term fibrous glass describes a set of materials that can have different dimensions and consequently different biological effects. Even though observed adverse effects of fibrous glass on humans have been confined primarily to skin irritation due to mechanical action, concern over possible long-term injury arising from inhaled fibers was present from the earliest use of fibrous glass. Despite limited evidence of chronic effects from inhalation of fibrous glass, this concern continues to prevail, particularly with respect to possible long-term adverse effects in humans from exposure to fibers less than 3.5 um in diameter. However, an evaluation of the available information has resulted in the NIOSH conclusion that occupational exposure to fibrous glass has not resulted in the development of cancer. No cases of human cancer that can be directly linked to exposure to fibrous glass exposure have been found. Many gaps are present in the literature on the effects of fibrous glass on humans and animals.

Asbestos - Inhalation of asbestos fibers can result in a chronic lung disease known as asbestosis which is characterized by diffuse interstitial fibrosis with pleural thickening or calcification. These pulmonary fibrotic changes develop slowly, often progressing after cessation of exposure to asbestos. In some cases, pulmonary function impairment is present without equivalent X-ray changes. The previous NIOSH recommendations were designed primarily to prevent asbestosis among exposed workers. However, review of recent information by NIOSH seems to indicate that the present standard of 2.0 fibers/cc (TWA) does not necessarily halt the development of X-ray changes among exposed workers. Additionally, there is greater evidence of the carcinogenic activity of asbestos. Currently it is impossible to establish a safe exposure level for the carcinogenic activity of asbestos, and the new NIOSH recommended airborne limit of 0.1 fibers/cc (TWA) is the lowest level that can be monitored reliably using phase contrast microscopy.

Crystalline Silica - Finely divided silica in the free state can cause silicosis, a fibrotic lung disease. This form of pneumoconiosis usually occurs after a number of years of exposure, although it can occur in a short time with severe exposures. The acute form may be recognized after eight to 18 months of exposure. Patients may note severe shortness of breath and rapid breathing. Chest X-rays may show fibrosis. However, an uncomplicated case may progress to an advanced stage without showing much functional impairment in the individual. Chronic silicosis is the type often observed in industry and usually occurs after years of exposure to silica dust. Silicosis often progresses in spite of termination of the exposure and incapacitates the affected person. Prevention is extremely important since treatment is not effective.

Asphalt (Petroleum) Fume - Asphalt fume contains a large number of organic chemicals. Many of the chemicals are present only in trace amounts and may even be undetectable by standard methods of analyses. Asphalt fume contains condensed particles composed of long chain, complex, high-boiling hydrocarbons. It also contains hydrocarbons that are vapors at room temperature. These vapors may include the aliphatic hydrocarbons C-8 through C-16 and certain aromatic hydrocarbons such as toluene or benzene. Toluene can cause irritation of the eyes, respiratory tract, and skin. Acute exposure to toluene results in central nervous system depression. Heating of asphalt may generate into the atmosphere such polynuclear aromatic (PNA) compounds as anthracene, chrysene, pyrene, fluoranthene, and benz(a)pyrene (BAP). Benz(a)pyrene is considered as a carcinogen, although it is not currently a regulated carcinogen. The other PNA's are on the NIOSH suspected carcinogen list. In any given batch of asphalt, there may or may not be BAP present in trace amounts. Even though BAP is not a regulated carcinogen and does not have an established environmental limit, it can be a potential health hazard in asphalt shingle manufacturing plants since the amount of BAP (if any) in each batch of asphalt is so variable. In general, the components of asphalt fume present in high enough quantities may produce narcotic symptoms and eye, nose, and throat irritation.

Formaldehyde - The major effect of exposure to formaldehyde in air is localized irritation of the eyes, nose, and throat. The perception of formaldehyde by odor has been shown to become less sensitive with time as adaptation occurs. Some persons, if not acclimitized, will experience unpleasant eye, nose, and throat irritation at concentrations below 5 ppm. Additionally, exposure to formaldehyde may cause sensitization in exposed individuals resulting in irritation complaints, disturbing odor, and disturbed sleep at 1 to 2 ppm.

D. Evaluation Results and Discussion

1. Fibrous Glass

Twelve fibrous glass samples were taken at Johns-Manville at Vernon on April 11, 1977. Three samples each were taken in the breathing zones of the splicer, splicer helper, and coaterman. Three general area samples were taken in the coater area. The results are contained in Table I. The personal samples covered at least seven hours of a working shift. In terms of the NIOSH criteria for fibrous glass fibers (less than or equal to 3.5 um in diameter and greater than or equal to 10 um in length), there were so few fibers that the laboratory reported the results as not detected. The lower limit of detection is 0.01 fibers/cc.

In two of the samples (AA13 and AA3), a single fiber was found. In AA13 (coaterman), the fiber size was 19 um in length by 2 um in diameter. In AA3 (coater general area), the fiber size was 11 um in length by 3 um in diameter. Two fibers were found in sample AA16 (splicer). The sizes of the two fibers were 15 um x 1 um and 10 um x 1 um. Thus, it was found that fibrous glass fiber levels in terms of fiber count were well below the NIOSH recommended limit of 3.0 fibers/cc based on a TWA over a work shift. Additionally, so few fibers were found that representative sizing of fibers could not be done.

Table II contains the TWA gravimetric dust sample results for the splicer, splicer helper, and in the general area of the coater. The respective gravimetric dust levels were 0.46, 0.33, and 2.87 mg/m^3. NIOSH recommends that airborne concentrations determined as total fibrous glass be limited to 5.0 mg/m^3 based on a TWA. The levels were well below 5.0 mg/m^3 and most of the dust was evidently not fibrous glass.

2. Asbestos

As a check for asbestos, three samples covering over seven hours of a work shift were taken in the breathing zone of the backtender of the rolled line. The rolled line uses a paper matte which contains a small amount of asbestos. The results are also contained in Table I. The asbestos counts were 0.25, 0.18, and 0.13 fibers/cc. The TWA based on these three samples was 0.19 fibers/cc. This level of asbestos is well below the current enforceable standard of 2.0 fibers/cc but is in excess of NIOSH's recommended limit of 0.1 fibers/cc.

3. Crystalline Silica

Table III contains the results of the samples taken for crystalline silica. Two samples were taken over a work shift on the slateman. His dust exposure levels for respirable and total dust taken in the breathing zone were respectively 1.25 mg/m^3 and 6.11 mg/m^3. The calculated limits based on the percent of SiO_2 in the samples were respectively 0.86 mg/m^3 and 0.95 mg/m^3. Thus, the slateman was exposed to potentially toxic levels of crystalline silica. Dust respirators were mandatory in most areas where the slateman worked, but this policy was not enforced adequately. One respirable sample was collected in the breathing zone of the cooling section operator. His exposure was well below the calculated limit. Two general area samples (respirable and total dust) were taken in the pressroll area over a work shift. The respirable dust level was below the calculated limit but the total dust level was slightly high. No one works in the pressroll area, but the cooling section operator will occasionally rotate through there.

4. Asphalt Fume

Asphalt fume samples were taken on both visits to the J-M plant. The NIOSH sampling and analytical technique failed in each case to adequately quantitate the true exposure to asphalt fume based on total particulate. These results are contained in Table IV. On each visit, a breathing zone sample was collected on the coaterman, cooling section operator, and machine tender. The coaterman's total particulate exposure was 4.2 and 5.1 mg/m^3 and the corresponding cyclohexane soluble fraction (which is assumed to be the asphalt fume portion) was 3.3 and 3.9 mg/m^3 respectively. These results are reasonable with the cyclohexane soluble fraction being roughly 70% of the total weight concentration. If the cyclohexane soluble fractions are correct, both results are below the current NIOSH and ACGIH criteria for asphalt fume of 5.0 mg/m^3. The two total weight levels found in the samples for the cooling section operator were 0.3 and 1.0 mg/m^3. However, the cyclohexane soluble fractions were 0.7 and 1.6 mg/m^3 which is higher than the respective total weights and makes the accuracy of the results suspect. One of the two samples for the machine tender followed this pattern, as did both bulk samples in the saturator. If the highest figure found is used as a basis for a conclusion, the exposures of the cooling section operator and the machine tender are still well below the criterion of 5.0 mg/m^3. Also, if the two cyclohexane soluble fraction results found in the saturator are considered as reasonable (8.6 and 9.9 mg/m^3), it would indicate that the asphalt fume concentration was roughly 10 mg/m^3. However, workers enter the saturator only occasionally. Because of the analytical difficulties encountered with the accepted NIOSH sampling and analytical method, no definite conclusion concerning asphalt fume exposure can be made at this time.

In Table IV, the results from three charcoal tube samples for volatile hydrocarbons are listed. For aromatic hydrocarbons, only a trace of toluene was found in the samples taken on the coaterman, cooling section operator, and the machine tender. The respective levels of 0.6, 0.4, and

0.4 mg/m^3 are well below the current CAL/OSHA standard of 375 mg/m^3 (TWA) for toluene. In the same samples, total aliphatic hydrocarbon levels were found to be respectively 8.1, 6.0, and 17.5 mg/m^3. The results represented mixtures of long-chain hydrocarbons (C-7 to C-12). No criteria exist for long-chain hydrocarbons C-10 and above. The TLV's for C-7, C-8, and C-9 are respectively 1600, 1450, and 1050 mg/m^3. NIOSH recommends a limit for the alkanes (C-5 to C-8) of 350 mg/m^3. In any case, the levels found in these samples were extremely low.

Table V contains results for polynuclear aromatic hydrocarbons (PNA's). The levels of PNA's in petroleum asphalt are highly variable and are usually found only in trace amounts. All the PNA's analyzed for in these samples were selected because of some evidence of carcinogenicity. However, no standards or recommended criteria exist for these compounds. Of primary interest is benz(a)pyrene (BAP) whose carcinogenic activity is the most documented. The U.S. Department of Labor, in its Report of the Standards Advisory Committee on Coke Oven Emissions (May 24, 1975), recommended that a maximum exposure to BAP be set at 0.2 ug/m^3 (TWA). In each sample taken inside the saturator during two different visits (April 18 and August 24, 1977), BAP was present and the levels were 1.6 and 2.4 ug/m^3. For personal samples, the coaterman, cooling section operator, and machine tender were exposed to BAP levels at roughly 0.2 ug/m^3 on some occasions. Thus, it is apparent that low levels of BAP can be measured on occasion in the work atmosphere at Johns-Manville and levels of some concern are found in the saturator.

5. Formaldehyde

Two general area samples for formaldehyde were taken on April 18, 1977, while fibrous glass was being processed. No problems were expressed by employees concerning irritation, but the samples were taken as confirmation of formaldehyde levels. One sample was taken near the splicer. The formaldehyde concentration was 0.03 parts per million over a work shift. One sample at the coater showed a level of 0.07 ppm. In terms of the CAL/OSHA standard of a peak concentration of 2.0 ppm, these levels seemed extremely low.

E. Conclusions

On the basis of the sample results, it does not appear that fibrous glass fibers are a hazard at Johns-Manville. All the samples showed fiber counts below detectable limits. Average fiber size could not be measured since so few fibers were collected on the filters.

On the basis of dust levels and the fact that wearing of respirators is not strictly enforced, the slateman is exposed to potentially toxic levels of silica-containing dust. The cooling section operator is not exposed to

potentially toxic levels of crystalline silica based on his personal sample. However, crystalline silica levels in that part of the shingle manufacturing line (i.e., coater, pressroll, cooling section) can at times approach or exceed some of the criteria used in this study and needs to be monitored periodically.

On the basis of sample results, asbestos exposure to the backtender on the rolled line may be potentially hazardous if the NIOSH-recommended limit is followed, although the asbestos levels are well below current enforceable standards.

Workers exposed to asphalt fumes may be exposed to potentially toxic levels of benz(a)pyrene based on the results of the personal samples and the general area samples taken in the saturator. No definite conclusions can be made concerning the other polynuclear aromatic compounds (benz(a)anthracene, pyrene, chrysene, and fluoranthene) since they did not show up in most samples. Asphalt fume itself could not be characterized because of analytical difficulties. Toluene and total aliphatic hydrocarbons were not hazardous since these compounds were measured in such low levels. The difficulties with the asphalt fume samples resulted in delaying the final report.

Formaldehyde did not seem to represent a health hazard since the measured levels were so low.

V. RECOMMENDATIONS

On the basis of NIOSH's investigation of the Johns-Manville plant, the following recommendations are made:

1. The slate transfer system should be looked at and any leaks should be repaired. The feasibility of adding local exhaust ventilation at the slate transfer points should also be studied.

2. The slateman should wear a NIOSH certified respirator whenever he works in the slate area.

3. Wearing of NIOSH certified respirators in mandatory respirator areas of the shingle line should be strictly enforced.

4. Whenever any worker enters a saturator, a NIOSH certified respirator efficient against polynuclear aromatic hydrocarbons and asphalt fume should be worn.

5. The HEAF units should be serviced since asphalt fumes and smoke were escaping from around the units over the coater and were entering the general work atmosphere.

6. The possibility of using some type of engineering controls at the feed ends of the shingle and rolled lines should be studied since asbestos fibers are still present in the work atmosphere in excess of NIOSH's recommended limit.

7. Periodic environmental monitoring for crystalline silica, asbestos, and polynuclear aromatic hydrocarbons where applicable is recommended.

8. NIOSH Criteria Documents have been published for Fibrous Glass, Crystalline Silica, Asbestos, and Asphalt Fumes. Workers who are exposed to any of these substances as defined in the documents should have medical surveillance as outlined in the documents.

VI. REFERENCES

1. NIOSH: "Criteria for a Recommended Standard ... Occupational Exposure to Fibrous Glass," Department of Health, Education, and Welfare Publication No. (NIOSH) 77-152, 1977.

2. NIOSH: "Revised Recommended Asbestos Standard," Department of Health, Education, and Welfare Publication No. (NIOSH) 77-169, 1976.

3. NIOSH: "Criteria for a Recommended Standard ... Occupational Exposure to Crystalline Silica," Department of Health, Education, and Welfare Publication No. (NIOSH) 75-120, 1974.

4. NIOSH: "Criteria for a Recommended Standard ... Occupational Exposure to Formaldehyde," Department of Health, Education, and Welfare Publication No. (NIOSH) 77-126, 1976.

5. NIOSH: "Criteria for a Recommended Standard ... Occupational Exposure to Asphalt Fumes," Department of Health, Education, and Welfare Publication No. (NIOSH) 78-106, 1977.

VII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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TABLE I. FIBROUS GLASS AND ASBESTOS FIBER COUNTS IN FIBERS PER CUBIC CENTIMETER (CC) IN BREATHING ZONE AND GENERAL AREA SAMPLES COLLECTED ON APRIL 18, 1977, AT THE JOHNS-MANVILLE PLANT, VERNON, CALIFORNIA.

Sample#	Type*	Area or Operation	Sample Period	Fibrous Glass Count	Asbestos Count***
AA1	BZ	Coaterman	8:53 am - 11:15 am	ND**	--
AA10	BZ	Coaterman	11:15 am - 1:39 pm	ND	--
AA13	BZ	Coaterman	1:39 pm - 4:22 pm	ND	--
AA3	GA	Coater	8:46 am - 11:05 am	ND	--
AA8	GA	Coater	11:05 am - 1:41 pm	ND	--
AA12	GA	Coater	1:41 pm - 4:23 pm	ND	--
AA6	BZ	Splicer	9:07 am - 11:05 am	ND	--
AA11	BZ	Splicer	11:05 am - 1:45 pm	ND	--
AA16	BZ	Splicer	1:45 pm - 4:25 pm	ND	--
AA2	BZ	Splicer Helper	9:10 am - 11:10 am	ND	--
AA7	BZ	Splicer Helper	11:10 am - 1:46 pm	ND	--
AA14	BZ	Splicer Helper	1:46 pm - 4:39 pm	ND	--
AA4	BZ	Backtender Rolled Line	9:13 am - 11:13 am	--	0.25 fibers/cc
AA9	BZ	Backtender Rolled Line	11:13 am - 1:47 pm	--	0.18 fibers/cc
AA15	BZ	Backtender Rolled Line	1:47 pm - 4:36 pm	--	0.13 fibers/cc

*Type - samples were either breathing zone (BZ) or general area (GA).

**ND - not detected; limit of detection for fibrous glass is 0.01 fibers/cc.

***asbestos fibers greater than 5 micrometers in length; limit of detection is 0.01 fibers/cc.

TABLE II. TOTAL DUST CONCENTRATIONS IN MILLIGRAMS PER CUBIC METER (MG/M^3) IN BREATHING ZONE AND GENERAL AREA SAMPLES COLLECTED ON APRIL 18, 1977, AT THE JOHNS-MANVILLE PLANT, VERNON, CALIFORNIA.

Sample#	Area or Operation	Sample Period	Volume	Dust Concentration
V1621	Coater General Area	8:46 am - 4:23 pm	777 liters	2.87 mg/m^3
V1221	Splicer	9:07 am - 4:25 pm	745 liters	0.46 mg/m^3
V1224	Splicer Helper	9:10 am - 4:39 pm	729 liters	0.33 mg/m^3

TABLE III. CRYSTALLINE SILICA SAMPLES BY AREA OR OPERATION COLLECTED IN BREATHING ZONE AND GENERAL AREA SAMPLES ON APRIL 18, 1977, AT THE JOHNS-MANVILLE PLANT, VERNON, CALIFORNIA.

Sample#	Type*	Area or Operation	Sample Period	Sample Vol.	$\%SiO_2$	Dust Conc.	Calculated Limit**
PV1003	R	Slateman	8:40 am - 4:03 pm	753 liters	9.6	1.25 mg/m^3	0.86 mg/m^3
PV881	T	Slateman	8:40 am - 4:03 pm	753 liters	28.7	6.11 mg/m^3	0.95 mg/m^3
PV884	R	Cooling Section Operator	9:25 am - 4:33 pm	728 liters	0.0	0.38 mg/m^3	5.00 mg/m^3
PV952	R	Pressroll General Area	9:28 am - 4:55 pm	760 liters	0.0	0.67 mg/m^3	5.00 mg/m^3
PV996	T	Pressroll General Area	9:28 am - 4:55 pm	760 liters	25.0	1.95 mg/m^3	1.07 mg/m^3

*samples were both respirable (R) and total dust (T) samples.

**limits for dust exposures were calculated using the following formulas:

$$\text{respirable samples in } mg/m^3 = \frac{10\ mg/m^3}{\%SiO_2 + 2}$$

$$\text{total dust samples in } mg/m^3 = \frac{30\ mg/m^3}{\%SiO_2 + 3}$$

TABLE IV. ANALYSES FOR TOTAL WEIGHT, CYCLOHEXANE SOLUBLE FRACTION, AND VOLATILE HYDROCARBONS IN ASPHALT FUME SAMPLES COLLECTED ON APRIL 18, 1977, AND AUGUST 24, 1977, AT THE JOHNS-MANVILLE PLANT, VERNON, CALIFORNIA.

Sample#	Date	Area or Operation	Sample Period	Tot. Wt.[2]	Cyclo. Sol.[3]	Tol.[4]	TAHC[5]
AG39[1]	4/18/77	Coaterman	8:53 am - 4:22 pm	4.2 mg/m^3	3.3 mg/m^3	0.6 mg/m^3	8.1 mg/m^3
AG33	8/24/77	Coaterman	8:20 am - 2:45 pm	5.1 mg/m^3	3.9 mg/m^3	*	*
AG29[1]	4/18/77	Cooling Sect. Op.	9:25 am - 4:33 pm	0.3 mg/m^3	0.7 mg/m^3	0.4 mg/m^3	6.0 mg/m^3
AG35	8/24/77	Cooling Sect. Op.	8:30 am - 2:45 pm	1.0 mg/m^3	1.6 mg/m^3	*	*
AG35[1]	4/18/77	Machine Tender	9:49 am - 4:25 pm	0.4 mg/m^3	1.8 mg/m^3	0.4 mg/m^3	17.5 mg/m^3
AG36	8/24/77	Machine Tender	8:04 am - 2:50 pm	2.8 mg/m^3	0.6 mg/m^3	*	*
AG36	4/18/77	Bulk in Saturator	9:50 am - 4:30 pm	7.6 mg/m^3	8.6 mg/m^3	*	*
AG29	8/24/77	Bulk in Saturator	8:35 am - 2:48 pm	7.7 mg/m^3	9.9 mg/m^3	*	*

[1]Only three charcoal tube samples were taken for volatile hydrocarbons.
[2]Total weight concentration in mg/m^3 on silver membrane filters.
[3]Cyclohexane soluble fraction in mg/m^3.
[4]Toluene concentration in mg/m^3.
[5]Total aliphatic hydrocarbons in mg/m^3.
*Analysis not reported.

TABLE V. ANALYSES FOR POLYNUCLEAR AROMATIC HYDROCARBONS (PNA'S) INCLUDING BENZ(a)PYRENE (BAP) IN ASPHALT FUME SAMPLES COLLECTED ON APRIL 18, 1977, AND AUGUST 24, 1977, AT THE JOHNS-MANVILLE PLANT, VERNON, CALIFORNIA.

Sample#	Date	Area or Operation	BAP[1]	BAA[2]	F[3]	P[4]	C[5]
AG39	4/18/77	Coaterman	0.22	ND*	ND	ND	ND
AG33	8/24/77	Coaterman	ND	0.20	ND	ND	0.50
AG29	4/18/77	Cooling Sect. Op.	0.23	ND	ND	ND	ND
AG35	8/24/77	Cooling Sect. Op.	ND	ND	ND	ND	ND
AG35	4/18/77	Machine Tender	0.25	ND	ND	ND	ND
AG36	8/24/77	Machine Tender	0.03	ND	ND	ND	ND
AG36	4/18/77	Bulk in Saturator	1.60	ND	ND	ND	ND
AG29	8/24/77	Bulk in Saturator	2.40	6.3	ND	ND	ND

*Not detected (below limits of detection of the analytical method).
[1]Benz(a)pyrene concentration in micrograms per cubic meter (ug/m^3).
[2]Benz(a)anthracene concentration in micrograms per cubic meter (ug/m^3).
[3]Fluoranthene concentration in micrograms per cubic meter (ug/m^3).
[4]Pyrene concentration in micrograms per cubic meter (ug/m^3).
[5]Chrysene concentration in micrograms per cubic meter (ug/m^3).