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 77-56-467
JOHNS-MANVILLE PRODUCTS CORPORATION
PITTSBURG, CALIFORNIA

FEBRUARY 1978

I. TOXICITY DETERMINATION

It has been determined at the Johns-Manville Plant, Pittsburg, 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 on April 29, 1977, the day of NIOSH's investigation.

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 29, 1977.

3) Employees entering the saturator are exposed to potentially high levels of benz(a)pyrene. This determination is made on the basis of measurements taken in the saturator on April 29 and August 4, 1977. No conclusions as to what constitutes a high level of benz(a)pyrene or other polynuclear aromatic hydrocarbons have been made by any official government agency.

4) Employees' exposures 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, aromatic hydrocarbons, and total aliphatic hydrocarbons are not toxic. This determination is based on the results of samples collected on April 29, 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 is contained in the body of the report. Recommendations are included in Section V. 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., Pittsburg, 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 30 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), authorized 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 Local #329 of the United Paperworkers International Union, Pittsburg, California, to determine whether fibrous glass used in the production of asphalt shingles is toxic in the concentrations used or found at the Johns-Manville Products Corporation plant, Pittsburg, 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 Pittsburg, California. Although a determination for only fibrous glass was requested, for purposes of completeness environmental evaluations of worker exposure to some of the other materials in the workplace such as asbestos, crystalline silica, formaldehyde, and asphalt (petroleum) were made by the NIOSH investigators.

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 has 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 28 and August 4, 1977). Approximately 12 employees can handle the entire main shingle line (designated as line #1). A "splicer" and "splicer helper" are responsible for feeding and splicing the rolls of paper or fibrous glass matte. One worker (the "coaterman") handles the coater and one employee

tends the pressroll and cooling section areas of the shingle line. One person handles the slate granules and other minerals used in the shingles. This "slateman" is responsible for monitoring the flow of granules and for loading the minerals into ventilated hoppers in the slateroom which is located above the coater.

At Pittsburg, rolled roofing products are processed on a smaller line (#4 rolled line) which is parallel to the main shingle line. A splicer 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 ("saturator operator") watches the entire operation of this line, and two employees handle the rolling, cutting, and stacking of the final product.

The Pittsburg plant also contains a papermill where the paper matte is made. The papermill is located in an area separated by a wall near the shingle manufacturing lines. Since some of the paper matte contains small percentages of asbestos, equipment for shredding and adding bags of asbestos to the paper fiber slurry is also located in the plant. The asbestos equipment is located in another room next to the papermill.

On April 28, 1977, fibrous glass matte was being processed and samples for fibrous glass were taken. Additionally, since workers at J-M were being exposed to many of the same air contaminants as those employees in other asphalt shingle manufacturing plants, spot sampling for crystalline silica, asbestos, asphalt fumes, volatile hydrocarbons, polynuclear aromatics (especially benz(a)pyrene), and formaldehyde 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 should follow the same pattern as for fibrous glass.

At Pittsburg, 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 spot checks or when the matte breaks. The greatest exposure to asphalt fumes and its byproducts occur at this time. No respiratory protection is used by employees entering the saturators. The coater has an exhaust hood which is part of the HEAF unit. The hood is above the coater and it captures most of the fume and smoke. However, during the NIOSH visits, some of the contaminants were escaping into the general work area. Thus, it seems that low-level exposures to asphalt fumes can occur throughout the shingle line, but the greatest exposures are inside the saturators and near the coater.

Exposures to workers from crystalline silica can occur in the slateroom and near the coater and cooling sections. 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 these 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:

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

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

Asphalt (Petroleum) Fume - 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.[5]

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 Pittsburg, 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 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 the J-M plant in Pittsburg on April 28, 1977. Two samples each were taken in the breathing zones of the splicer and splicer helper of the #1 line and the coaterman over two different shifts. The results are contained in Table I. No fibrous glass fibers of any size were found in the samples. The samples characterizing each worker's exposure covered at least seven hours of his eight-hour workshift. In terms of 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), the laboratory reported the results as below the limits of detection (0.01 fibers/cc). Sizing of the fibrous glass fibers could not be done since none were present in the filters.

Table II contains the TWA gravimetric dust sample results for the splicer, splicer helper, and coaterman. Three samples were taken on each worker (two samples covering one shift and a third covering the swingshift). The samples took into account at least 6-1/2 hours of a shift. The average dust exposure for the splicer, splicer helper, and coaterman were respectively 0.80, 0.88, and 0.62 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 found in the breathing zone samples were well below 5.0 mg/m^3 and no fibrous glass fibers were found in the fiber count samples. The general area dust levels for the splicing and coater sections of the shingle line were respectively 2.26 and 3.33 mg/m^3 (TWA). Again, the dust levels in terms of the fibrous glass dust criterion (5.0 mg/m^3) were low.

2. Asbestos

As a check for asbestos, the type AA filters for the splicer line #4 were analyzed only for asbestos and not fibrous glass. These results are contained in Table I. The splicer was sampled over two different shifts. The average asbestos fiber count was 0.08 fibers/cc which is below the NIOSH recommended limit of 0.10 fibers/cc. At the same time, the samples for fibrous glass did not contain fibrous glass fibers but asbestos fibers. Therefore, asbestos fiber counts were done on these samples for the #1 line splicer, #1 line splicer helper, and coaterman (Table I). All the asbestos fiber counts were below 0.07 fibers/cc and, therefore, below NIOSH's recommended limit.

3. Crystalline Silica

Table III contains the results of the samples taken for crystalline silica. The slateman was sampled over two work shifts. Both a respirable and total dust sample were collected in the breathing zone. During each work shift, the respirable sample was below the calculated limit but the total dust sample was above it. In California, compliance activity for silica is based mainly on the total dust sample results. Only general area samples were taken over two shifts near the sealamatic resin strip applicator. The total dust samples alone exceeded calculated limits in this area. However, the employee rotates through the area and does not remain there. Respirators were not mandatory in any of these sections of the shingle manufacturing line. Thus, the slateman was exposed to potentially toxic levels of crystalline silica and the sealamatic area had high levels of dust containing crystalline silica.

4. Asphalt Fume

Asphalt fume samples were taken on two visits to the J-M plant. The NIOSH sampling and analytical technique failed in each case to adequately quantitate levels of asphalt fume based on total particulate. These results are contained in Table IV. On April 29, 1977, a breathing zone sample was collected on the saturator operator over two shifts. In both samples, the cyclohexane soluble fraction concentration exceeded the total weight concentration. Two general area samples over two shifts were taken at the coater. One cyclohexane soluble fraction was in excess of its corresponding total weight concentration. On August 4, 1977, breathing zone samples were taken on the slateman and coaterman. The respective total weight concentrations were 3.35 and 2.10 mg/m^3. These results were reasonable but the samples taken in the saturator on the same day showed inconsistencies. The results were too inconsistent to make any definite conclusions concerning asphalt fume exposures. However, in terms of material on the filters and regardless of which analysis is looked at, none of the samples in the normal working areas surveyed had particulate concentrations in excess of 5.0 mg/m^3. In the saturator, it seemed that asphalt fume concentrations were at least 10.0 mg/m^3.

Table IV also contains results from four charcoal tube samples collected on April 29, 1977. The charcoal tube samples were used to determine volatile hydrocarbon levels. No toluene or other aromatic hydrocarbons were detected. Two samples were taken on the saturator operator over two work shifts and two were collected in the coater general area. In the same samples, total aliphatic hydrocarbons (TAHC) were determined. In the coater area, the TAHC levels were 3.4 and 5.2 mg/m^3. On the saturator operator, the levels were 4.8 and 25.4 mg/m^3. These results represented mixtures of long chain hydrocarbons (C-7 to C-12). No criteria exist for 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 (but has not proposed) that a maximum exposure to BAP be set at 0.2 ug/m^3 (TWA).

One sample was taken in the saturator on April 29, 1977. The BAP level was found to be 1.80 ug/m^3. No other PNA's were detected. On August 4, 1977, two samples were taken in the saturator. The BAP levels were found to be 3.44 ug/m^3 and not detected in the samples. The benz(a)anthracene concentrations were 6.19 and 1.89 ug/m^3 in the same samples. No other PNA's were detected. Seven samples were taken in the main work area on April 29 and August 4, 1977. BAP was detected in only two samples: 0.35 ug/m^3 (saturator operator) and 0.10 ug/m^3 (coater general area). Only one other PNA was found in the seven samples - 0.14 ug/m^3 of pyrene on the slateman. Thus, it appears that BAP can be measured in low levels on occasion in the work atmosphere and levels of some concern can be found inside the saturator. Additionally, definite quantities of benz(a)anthracene were measured inside the saturator.

5. Formaldehyde

Two general area samples were taken in the splicer area and two in the coater area on April 29, 1977, while fibrous glass was being processed. No formaldehyde could be detected in any of the samples.

E. Conclusions

On the basis of the sample results, it does not appear that fibrous glass fibers are a hazard at Johns-Manville. Fiber counts were below detectable limits and fiber sizing could not be done.

On the basis of dust levels and the fact that wearing of respirators is not mandatory, the slateman is exposed to potentially toxic levels of silica containing dust. Silica levels near the sealamatic resin strip applicator were above limits even though workers do not remain there for long time periods. This entire section of the shingle line needs periodic monitoring for crystalline silica.

On the basis of sample results, asbestos exposures to the splicer, splicer helper, and coaterman were not hazardous in terms of NIOSH's recommended limits. Samples were taken on a single day, and asbestos monitoring should be performed periodically.

Workers exposed to asphalt fumes may, at times, be exposed to potentially high quantities of benz(a)pyrene based on the samples taken inside the saturator. Other PNA's did show up in a few samples, but definite conclusions can not be made at this time. Exposure to asphalt fume itself could not be characterized because of analytical difficulties. Aromatic and total aliphatic hydrocarbons were not hazardous since they were measured in such low quantities. Also, formaldehyde was not a health hazard.

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 examined closely 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 for silica dust whenever he works in the slate area unless engineering control measures can lower dust levels.

3. The sealamatic area should be surveyed to determine how dust levels can be lowered. Workers who must remain in this area for any length of time should wear a NIOSH certified respirator for silica dust.

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

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

6. 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 SAMPLES COLLECTED ON APRIL 28, 1977, AT THE JOHNS-MANVILLE PLANT, PITTSBURG, CALIFORNIA.

Sample#	Area or Operation	Sample Period	Fibrous Glass Count	Asbestos Count
AA33	Splicer #1 Line	6:31 am - 10:58 am	ND*	0.05 fibers/cc**
AA20	Splicer #1 Line	10:58 am - 2:17 pm	ND	0.06 fibers/cc
AA47	Splicer #1 Line	4:12 pm - 7:18 pm	ND	0.07 fibers/cc
AA22	Splicer #1 Line	7:18 pm - 11:17 pm	ND	0.04 fibers/cc
AA19	Splicer Helper #1 Line	6:35 am - 10:56 am	ND	0.03 fibers/cc
AA41	Splicer Helper #1 Line	10:56 am - 2:14 pm	ND	0.07 fibers/cc
AA21	Splicer Helper #1 Line	4:09 pm - 7:16 pm	ND	0.06 fibers/cc
AA29	Splicer Helper #1 Line	7:16 pm - 9:55 pm	ND	0.04 fibers/cc
AA25	Splicer #4 Line	6:40 am - 11:08 am	--	0.07 fibers/cc
AA26	Splicer #4 Line	11:08 am - 2:22 pm	--	0.05 fibers/cc
AA18	Splicer #4 Line	4:18 pm - 7:32 pm	--	0.06 fibers/cc
AA43	Splicer #4 Line	7:32 pm - 10:52 pm	--	0.12 fibers/cc
AA17	Coaterman	6:50 am - 10:47 pm	ND	0.07 fibers/cc
AA34	Coaterman	10:53 am - 2:22 pm	ND	0.02 fibers/cc
AA42	Coaterman	4:00 pm - 7:29 pm	ND	0.03 fibers/cc
AA5	Coaterman	7:29 pm - 10:58 pm	ND	0.04 fibers/cc

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

**asbestos fibers larger than 5 micrometers; detection limit for chrystotile asbestos fibers 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 28, 1977, AT THE JOHNS-MANVILLE PLANT, PITTSBURG, CALIFORNIA.

Sample#	Type*	Area or Operation	Sample Period	Volume	Dust Concentration
V238	BZ	Coaterman	6:50 am - 10:47 am	403 liters	0.84 mg/m^3
V2880	BZ	Coaterman	10:53 am - 2:22 pm	330 liters	0.61 mg/m^3
V1228	BZ	Coaterman	4:00 pm - 10:58 pm	711 liters	0.52 mg/m^3
V296	GA	Coater	3:33 pm - 10:46 pm	433 liters	3.33 mg/m^3
V1820	BZ	Splicer	6:31 am - 10:59 am	455 liters	0.27 mg/m^3
V393	BZ	Splicer	10:59 am - 2:17 pm	311 liters	1.64 mg/m^3
V396	BZ	Splicer	4:12 pm - 11:17 pm	697 liters	0.75 mg/m^3
V1283	BZ	Splicer Helper	6:35 am - 10:55 am	416 liters	0.26 mg/m^3
V267	BZ	Splicer Helper	10:55 am - 2:14 pm	338 liters	0.99 mg/m^3
V159	BZ	Splicer Helper	4:09 pm - 9:55 pm	563 liters	1.17 mg/m^3
V219	GA	Splicer Area	3:46 pm - 10:48 pm	422 liters	2.26 mg/m^3

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

TABLE III. CRYSTALLINE SILICA SAMPLES BY AREA OR OPERATION COLLECTED IN BREATHING ZONE SAMPLES ON APRIL 28, 1977, AT THE JOHNS-MANVILLE PLANT, PITTSBURG, CALIFORNIA.

Sample#	Type*	Area or Operation	Sample Period	Sample Vol.	% SiO_2	Dust Conc.	Calculated Limit**
PV367	R	Slateman	6:22 am - 2:00 pm	753 liters	33.3	0.20 mg/m^3	0.28 mg/m^3
PV370	T	Slateman	6:22 am - 2:00 pm	753 liters	44.8	0.89 mg/m^3	0.62 mg/m^3
PV432	R	Sealamatic	7:00 am - 2:36 pm	736 liters	26.7	0.20 mg/m^3	0.35 mg/m^3
PV537	T	Sealamatic	7:00 am - 2:36 pm	736 liters	46.1	1.21 mg/m^3	0.64 mg/m^3
PV487	R	Sealamatic	3:55 pm - 11:11 pm	714 liters	0.0	0.13 mg/m^3	5.00 mg/m^3
PV970	T	Sealamatic	3:55 pm - 11:11 pm	714 liters	46.2	3.10 mg/m^3	0.61 mg/m^3
PV497	R	Slateman	3:57 pm - 10:24 pm	513 liters	0.0	0.18 mg/m^3	5.00 mg/m^3
PV462	T	Slateman	3:57 pm - 11:09 pm	709 liters	55.5	1.52 mg/m^3	0.51 mg/m^3

*samples were in breathing zone and were both respirable (R) and total (T).

**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 29, 1977, AND AUGUST 4, 1977, AT THE JOHNS-MANVILLE-PLANT, PITTSBURG, CALIFORNIA.

Sample#	Date	Area or Operation	Sample Period	Tot. Wt.[1]	Cyclo. Sol.[2]	Tol.[3]	TAHC[4]
AG31	4/29/77	Saturator Op.	6:38 am - 2:12 pm	0.0	0.37	ND*	4.8
AG38	4/29/77	Saturator Op.	4:16 pm - 10:50 pm	1.0	2.10	ND	25.4
AG41	4/29/77	Coater Area	6:52 am - 2:22 pm	0.23	0.69	ND	3.4
AG30	4/29/77	Coater Area	3:33 pm - 11:10 pm	3.20	0.53	ND	5.2
AG21	8/4/77	Coaterman	7:59 am - 2:21 pm	2.10	0.22	--**	--
AG26	4/29/77	Slate Area	3:42 pm - 11:14 pm	0.55	0.35	ND	ND
AG22	8/4/77	Slateman	8:03 am - 2:24 pm	3.35	0.21	--	--
AG33	4/29/77	Inside Saturator	3:40 pm - 11:15 pm	9.8	10.0	ND	ND
AG23	8/4/77	Inside Saturator	8:06 am - 11:20 am	25.3	6.9	--	--
AG26	8/4/77	Inside Saturator	11:29 am - 12:40 pm	17.4	21.0	--	--

*Not detected (below limits of detection for the analytical method).
**Analysis not reported.
[1]Total weight concentration in milligrams per cubic meter (mg/m^3).
[2]Cyclohexane soluble fraction in milligrams per cubic meter (mg/m^3).
[3]Toluene concentration in milligrams per cubic meter (mg/m^3).
[4]Total aliphatic hydrocarbons in milligrams per cubic meter (mg/m^3).

TABLE V. ANALYSES FOR POLYNUCLEAR AROMATIC HYDROCARBONS (PNA'S) INCLUDING BENZ(a)PYRENE (BAP) IN ASPHALT FUME SAMPLES COLLECTED ON APRIL 29, 1977, AND AUGUST 4, 1977, AT THE JOHNS-MANVILLE PLANT, PITTSBURG, CALIFORNIA.

Sample#	Date	Area or Operation	BAP[1]	BAA[2]	F[3]	P[4]	C[5]
AG31	4/29/77	Saturator Op.	ND*	ND	ND	ND	ND
AG38	4/29/77	Saturator Op.	0.35	ND	ND	ND	ND
AG41	4/29/77	Coater Area	0.10	ND	ND	ND	ND
AG30	4/29/77	Coater Area	ND	ND	ND	ND	ND
AG21	8/4/77	Coaterman	ND	ND	ND	ND	ND
AG26	4/29/77	Slate Area	ND	ND	ND	ND	ND
AG22	8/4/77	Slateman	ND	ND	ND	0.14	ND
AG33	4/29/77	Inside Saturator	1.80	ND	ND	ND	ND
AG23	8/4/77	Inside Saturator	3.44	6.19	ND	ND	ND
AG26	8/4/77	Inside Saturator	ND	1.89	ND	ND	ND

*Not detected (below limits of detection for 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).