Exhibit E

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PLAINTIFF'S
EXHIBIT
DUP-1014

Discussion of the Technological Feasibility of Attaining a 0.5 Fiber/Cubic Centimeter Time-Weighted Average Airborne Concentration of Asbestos Fiber in the Workplace as Proposed by OSHA in the Federal Register of Thursday, October 9, 1975

by

Johns-Manville Corporation

April, 1976

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PROCESS DESCRIPTION FLOW CHARTS

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SUMMARY AND CONCLUSIONS

Johns-Manville has for many years installed mechanical exhaust ventilation systems, modified process equipment, and introduced new work practices in its plants manufacturing asbestos-containing products in an effort to reduce the airborne concentrations of asbestos fiber and other materials to which its employees are exposed. These procedures have been continuously upgraded and improved as the "state of the art" of dust control advanced.

Until December 1971, the Threshold Limit Value or exposure limit for asbestos dust was 5 million particles per cubic foot. Dust control mechanisms which were installed prior to December 1971 were not designed solely to achieve 5 mppcf, but were designed to attain the lowest possible airborne concentration of asbestos dust in the workplace - with the goal wherever feasible, of reducing exposures below 5 mppcf in our asbestos-using operations. We employed what we believed, at the time of installation, to be the best available technology.

Surveys performed by our industrial hygiene laboratories - using the impinger technique - revealed that by 1970, we were close to achieving our goal; approximately 90% of our monitored asbestos-using work stations were under the then existing TLV. This accomplishment required a concerted effort by plant personnel and by our General Plant Engineering and Environmental Control Departments. In addition to the design and installation of the best available dust control equipment, these efforts included the development of improved processes and techniques and utilized the expenditure of about $12,000,000 during the period 1950 to 1970. Efforts to control airborne concentrations of asbestos fiber actually were instituted well before 1950. Installation of dust control equipment dates at least as far back as the mid 1930's. No records presently exist as to the specific airborne concentrations of asbestos fiber present or the total expenditure for dust control made during this period.

In December 1971, OSHA promulgated its emergency standard for exposure to asbestos dust. This standard specified an 8-hour time-weighted average exposure limit of 5 fibers per cubic centimeter, as determined by the membrane filter/personal air sampler technique. Johns-Manville, on the recommendation of the Bureau of Occupational Safety and Health, had initiated this type of monitoring technique in our plants during 1969. At the time the emergency standard went into effect, we had completed the monitoring of our asbestos-using work stations

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with this new fiber counting method. An analysis of our industrial hygiene data in early 1972 showed that only 60% of our work stations complied with the then new OSHA exposure limit; contrasted to over 90% compliance with the previous TLV of 5 million particles per cubic foot.

Following the promulgation of the December 1971 OSHA emergency standard, Johns-Manville immediately initiated programs to comply. These programs were further intensified after promulgation of the permanent standard, with its requirement of an exposure limit of 2 f/cc by July 1, 1976. As in the past, our programs were not primarily designed to achieve 5 f/cc or 2 f/cc, but rather, were targeted towards achieving the lowest feasible level, with the minimum goal of all work stations being below 2 f/cc by July 1, 1976. We again employed what we considered to be the best available dust control technology and instituted work practices and process modifications that were developed for those situations where we believed available dust control technology would not be adequate. These intensive efforts were guided by our Environmental Engineering Department.

Three case histories are included in this report detailing our efforts over the years to reduce airborne concentrations of asbestos at three different manufacturing facilities. These histories define specific problem areas and possible steps that can be taken to further reduce asbestos fiber concentrations.

By mid 1975, it appeared that our environmental control efforts which had required giving up the manufacture of some products and an expenditure of $8,500,000 from 1971-1975, would be successful. Industrial hygiene surveys showed approximately 90% compliance with the July 1, 1976 limit of 2 f/cc.

When OSHA published its October 1975 Notice of Proposed Rulemaking-Occupational Exposure to Asbestos - with a proposed 8-hour TWA exposure limit of 0.5 f/cc, we examined our industrial hygiene data to determine our compliance status. This examination indicated that as a result of our intensive past endeavors, 45% of our monitored work stations were already in compliance with the proposed Permissible Exposure Limits.

It must be clearly understood that the attainment of 45% of our monitored work stations below the proposed Permissible Exposure Limits of 0.5 f/cc in no way implies, let alone assumes that the application of best available technology can similarly reduce airborne concentrations of asbestos fibers at all of the remaining work stations. To the contrary, best available technology has already been applied to most of these work stations. It is fair to conclude that 45% of our monitored work stations do comply with the proposed permissible exposure limits

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only because best available technology was successful at these stations and was not successful to the same extent in other process steps in our facilities where the same control efforts were made.

A review of our industrial hygiene data for all of our asbestos industry segments indicates that, in general, the process steps with major problems, that is, process steps with TWA fiber counts above 0.5 f/cc, are concentrated in two areas:

1. Fiber introduction
   a. Bag opening, emptying and disposal
   b. Fiber handling
2. Finishing
   a. Machining
   b. Surface sanding

These are not the only problem areas that will need study and development effort in order to reduce exposure levels. These two process steps are major operations, common to many asbestos-product manufacturing facilities and will require the greatest attention from Johns-Manville.

Our study of these major problem areas has convinced us that entirely new processes, methods, and equipment must be developed by trial and error, with no guarantees that the proposed Permissible Exposure Limits can, in fact, be met. It is impossible to predict now the cost and implementation time for these developments. We don't know what will be needed to achieve compliance.

CONCLUSIONS:

1. DESPITE THE MAXIMUM FEASIBLE EFFORTS OF MANY YEARS EMPLOYING BEST AVAILABLE TECHNOLOGY, WE HAVE NOT BEEN SUCCESSFUL IN REDUCING EMPLOYEE EXPOSURES TO AIRBORNE CONCENTRATIONS OF ASBESTOS TO BELOW 2 F/CC AT ALL WORK STATIONS.

2. BEST AVAILABLE TECHNOLOGY CAN NOT ACHIEVE COMPLIANCE WITH THE PROPOSED TWA EXPOSURE LIMIT OF 0.5 F/CC. EQUIPMENT, PROCESSES AND WORK PRACTICES, UNAVAILABLE UNDER EXISTING TECHNOLOGY, WILL HAVE TO BE DEVELOPED THROUGH THE TRIAL AND ERROR METHOD - WITH NO ASSURANCE OF SUCCESS.

3. BECAUSE OF MANY UNKNOWN FACTORS, IT IS IMPOSSIBLE NOW TO PREDICT THE COST AND TIME REQUIRED FOR THESE DEVELOPMENTS - SUCCESSFUL OR OTHERWISE.

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JOHNS-MANVILLE'S INVOLVEMENT IN THE ASBESTOS INDUSTRY

Johns-Manville is the largest manufacturer of asbestos-containing products in the United States. In 1974, we used 197,000 tons of asbestos fiber in producing 620,000 tons of goods that sold for approximately $185,000,000.

Canadian Johns-Manville Company, Ltd. (C-JM) is the largest producer of asbestos fiber in the Western World. It is estimated that in 1976 C-JM will mine and sell 720,000 tons of asbestos; 421,000 tons in the United States, the remainder internationally. Of the amount sold in the U.S., Johns-Manville itself will consume 146,000 tons, plus 44,000 tons from other asbestos sources.

Johns-Manville operates 20 plants manufacturing asbestos-containing products in the U.S., employing over 3800 people. Table A on page 5-6 sets forth specific details on these plants, including employment and financial data.

Our product lines can be categorized into 6 major asbestos industry segments.

1. Pipe -Asbestos-cement pressure and sewer pipe, conduit and vents for the construction industry.

2. Boards - Plain and pigmented asbestos-cement boards for the electrical, laboratory furniture and construction industries.

   Asbestos reinforced calcium silicate boards for fire retardant partitions, oven construction and for the aluminum industry.

3. Roofing - Asphalt saturated asbestos roofing felts, roof coatings and cements, putties and sealants for residential, commercial and industrial building construction.

4. Sealing Components - Molded packings, sheet gaskets, and asbestos textile based mechanical packings for original equipment installation and maintenance of mechanical equipment.

5. Building Systems - Extruded asbestos-cement wall panels and shapes, formed flat asbestos-cement sheets and laminated A/C sheet panels for commercial and industrial building construction.

6. Paper - Commercial asbestos paper and high purity specialty asbestos paper for the electrical industry. Pipeline felt for underground pipe protection.

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TABLE A

PLANT DATA

Location	Product Line	Date Built	Replace. Value Million $	1974 Employees	1974 Sales Millions $
BOARDS			16.0	200	10.4
Nashua, NH	Plain and pigmented asbestos cement boards for the electrical, furniture & construction industries.	1930			
Billerica, MA	Asbestos/calcium silicate boards for shipboard fire retardant partitions, oven construction and for the aluminum industry.	1944			
PIPE			135.2	1600	100.0
Denison, TX	Asbestos-cement pressure & sewer pipe, conduit and vents for the construction industry.	1958			
Green Cove Springs, FL		1966			
Long Beach, CA		1939			
Manville, NJ		1936			
Stockton, CA		1957			
Waukegan, Il		1929			
ROOFING			54.4	1400	44.4
Los Angeles, CA	Asphalt saturated asbestos roofing felts, commercial asbestos paper, roof coatings and cements, putties and sealants for residential, commercial and industrial building construction.	1929			
Manville, NJ		1914			
Marrero, LA		1936			
Pittsburg, CA		1928			
Savannah, GA		1956			
Waukegan, IL		1922			
SEALING COMPONENTS			35.6	300	7.0
Manville, NJ	Molded packings, sheet and other gaskets, and asbestos textile based packings for mechanical equipment.	1914			
Waukegan, IL		1927			

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Location	Product Line	Date Built	Replace. Value Million $	1974 Employees	1974 Sales Million $
BUILDING SYSTEMS			16.0	100	9.1
Manville, NJ Waukegan, IL	Extruded asbestos-cement wall panels and formed flat A/C sheets for commercial and industrial building construction	1969 1927			
PAPER			8.0	75	2.9
Tilton, NH	High purity specialty asbestos papers for the electrical industry.	1947			
OTHER			2.0	150	11.0
	TOTALS		267.2	3825	184.8

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MAJOR PROBLEM AREAS

As noted in the "Summary and Conclusions" section of this report, there are two process steps, common to most asbestos industry segments, where control of airborne fiber generation is of major concern, because past efforts have been unsuccessful in reducing employee exposures consistently to less than 2 f/cc, to say nothing of reaching 0.5 f/cc as an 8-hour TWA.

1. Fiber Introduction

   a) Bag opening, emptying and disposal, (common to all asbestos industry segments)

   Since 1954, we have designed and installed 18 different bag opening stations. None has been successful from the standpoint of maintaining exposure levels below 2 f/cc. Presently, the TWA airborne asbestos concentrations to which our employees are exposed at our best bag opening station, range from 0.8 to 2.2 f/cc, with an average of 1.1 f/cc. Fiber counts for all bag opening stations range from 0.8 to 8.6 f/cc.

   In addition to our own development efforts, we have tested three commercially available automated bag opening systems. None were suitable because at frequent intervals during their operations, portions of the kraft or plastic bag would enter the raw material mix. In many of our asbestos-containing products,particularly asbestos-cement products, these contaminants result in faulty units which must be rejected.

   In order briefly to illustrate the considerable investigation by Johns-Manville of possible alternatives, a history of our efforts to develop a bag opening system follows this section in the reports. It is titled: "CASE HISTORY 1 - ASBESTOS BAG OPENING STATIONS."

   As a result of our investigation of possible alternatives, we believe that a fully automated bag opening system, which includes a provision for bag disposal to meet EPA standards, represents our best chance for complying with the proposed permissible limit of 0.5 f/cc. A workable system is unavailable under existing technology. It will be necessary for the asbestos industry, in conjunction with an equipment manufacturer, to undertake a major program to develop a suitable system.

   b) Fiber Handling (common to many asbestos using operations)

   Presently, the TWA airborne asbestos concentrations to which our employees are exposed at various fiber handling opera-

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tions range from less than 0.5 to 1.4 f/cc, with an average of 1.0 f/cc.

Development of an improved version of the negative willow system presently used in our pipe plants must be undertaken. If this development is successful, complete systems must be installed in plants presently utilizing different procedures, and the improvements must be incorporated in the pipe plant systems.

Operations in the fiber handling "downstream" from the negative willow system must be carefully studied and improved methods of dust control developed.

If trial installation of a new negative willow system and improved "downstream" operations proves them inadequate and unable to reduce airborne concentrations of asbestos to within the proposed Exposure Limits, then a wet feeding system must be developed and utilized. This system would completely replace existing fiber handling equipment - from after the bag opening station to delivery into the forming machine. Johns-Manville presently is proposing a $545,000 project to develop and install such a system on one machine at one of our asbestos-cement pipe plants.

2. <u>Product Finishing</u> (common to many asbestos industry segments)

a) Sawing of asbestos-containing boards

TWA airborne asbestos concentrations to which our employees are exposed at sawing operations range from less than 0.5 to 4.5 f/cc, with an average of 1.5 f/cc.

Saws used in board trimming and fabricating operations presently are equipped with mechanical exhaust ventilation for dust control. The first step in an attempt to achieve compliance with the proposed permissible Exposure Limit would be the design and trial operation of refined dust control equipment and procedures.

b) Machining of pipe

Machining operations include:

(i) End trimming and shaping of pipe.
(ii) Cutting and forming of pipe couplings.

TWA airborne asbestos concentrations to which employees are exposed in our pipe machining operations presently range from less than 0.5 to 4.5 f/cc, with an average of 1.5 f/cc.

Pipe machining is performed on specially designed equipment

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with dust collection hoods at all points of dust generation. These hoods are part of elaborate mechanical ventilation systems that exhaust through fabric bag filters. Initial development efforts would concentrate on the trial installation of redesigned ventilation equipment on various types of existing finishing equipment.

If trial installations indicate that this procedure will not achieve compliance with the proposed permissible limits, then new, automated machinery with dust collection as an integral part, unavailable under existing technology, must be developed from the "ground up." Initial development efforts would concentrate on an automated pipe lathe--a lathe used to machine pipe ends. If trials of the new lathe are successful, then development work must be expanded to automate the other types of finishing equipment used in an asbestos-cement pipe plant.

c) Board and sheet surface sanding

Even though our existing sanding lines are relatively new (installed during the last five years) and equipped with manufacturer supplied sophisticated dust control systems, some operating steps are even difficult to maintain at/or below a TWA of 2 f/cc. Exposure levels range from less than 0.5 f/cc at the feed end to 3.5 f/cc at inspection and take-off stations.

The major source of airborne fiber is residual dust on the face of the sheet that is not removed by the existing surface cleaning equipment. Further reductions in the airborne concentration of asbestos fibers from this operation can only be achieved by a more effective cleaning procedure. Equipment to achieve this goal is unavailable under existing technology and would have to be developed through a trial and error process.

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CASE HISTORY 1

ASBESTOS FIBER BAG OPENING STATIONS

For approximately 25 years, numerous attempts have been made to reduce the exposure to asbestos fiber of workers in Johns-Manville plants who are required to open bags containing asbestos fiber. Up to this time, despite the efforts enumerated below, no mechanical bag opening machine or manual bag opening station, has been developed that consistently meets all of the following specifications:

1. Maintains asbestos fiber exposures below a TWA level of 2 fibers per cc.
2. Opens bags without contaminating the process with the bag material.
3. Provides means for removing the empty bag.
4. Does not interfere with the process.

Part of the problem is due to the diversity of packaging materials , size of the package, and differences between the pressure packed and loose pack bags. The problem was much more acute before the Canadian asbestos fiber industry made a major improvement in fiber packaging with the introduction in 1954 of the pressure packed kraft paper bag, replacing the loose packed jute bag. The jute bag leaked fiber and was difficult to handle during the bag opening process. The pressure packed paper bag was smaller, easier to handle, and unless accidentally broken, relatively dust free.

Asbestos fiber today may be shipped in loose packed or pressure packed lined jute bags, pressure packed paper, or pressure packed reinforced plastic. Package sizes may vary from grade to grade of asbestos fiber and from manufacturer to manufacturer. Johns-Manville, like many other users of asbestos fibers, purchases fiber from various suppliers, often located in different parts of the world. Therefore, it is difficult, if not impossible, to achieve standardization with respect to bag type or size.

The following is a history, that is by no means complete, of efforts made to solve the bag opening problem.

1. In 1954, a carefully designed bag opening station with a fiber breaker was installed at our Jeffrey Mine to refeed off grade or damaged pressure packed paper bags.
2. In 1954, we installed in our Nashua, N.H. plant a ventilated bag opening station with a screw conveyor on the bottom to feed amosite.

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3. In 1954, large hoods for opening and asiding empty bags were installed in the Thermobestos insulation operations in our Manville, N.J., Waukegan, Ill. and Long Beach, Calif. plants.

4. In 1957, at our Billerica, Mass. plant, a mechanical bag opener was installed to open and empty jute bags containing amosite.

5. In several of our asbestos-cement pipe plants, starting in 1958, ventilated belt conveyors were installed for opening, batching, and feeding dry mixers in the raw material preparation area.

6. In the late 1950's, ventilated bag opening stations were installed on belts feeding Moody openers.

7. In 1960, a ventilated hood with fiber breakers in the floor was installed for feeding the boot of an elevator in our Manville, N.J. asbestos-cement extrusion operation.

8. In 1966, in our shingle plant in Manville, considerable work was done to develop a prototype of a manual, ventilated, bag opening station. The effort was reasonably successful, but great difficulty has been experienced in using the prototype in other processing areas.

9. In 1969, a commercial mechanical bag opener, called a bag splitter, was tried out on a test basis but did not work.

10. In 1969, an attempt was made to design an improved ventilated bag opening station for the Thermobestos insulation operations in our Manville plant. It did not work.

11. In the textile plant at Manville, many months and over $10,000 was spent trying to permit the use of an enclosed glove box for opening asbestos fiber bags. Knives of various types, conveyors, and mechanical aids were installed in the system in an atempts to solve operating problems. Efforts were finally abandoned as unsuccessful.

12. A mechanical bag opening station, using a horseshoe knife cutter, was designed and tested in 1970 in our Waukegan plant. After many months of effort and many thousands of dollars of expenditures, it was abandoned as unsuccessful.

13. For several years commencing in about 1970, our Jeffrey asbestos mine purchased and tried to solve the operating problems of mechanically opening pressure packed fiber bags with various types of knife arrangements. It is not successful.

14. Since 1973, our Jeffrey Mine has worked almost constantly on a second mechanical opening station using a guillotine type of principle to open pressure packed bags of fiber. To date, this effort is not successful.

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15. In 1975, an improved manual ventilated bag opening station was installed in our Green Cove Springs, Fla. pipe plant.

16. In 1975, an improved manual bag opening station was installed in our Toronto, Canada pipe plant. Trouble was experienced in opening bags of blue and amosite fiber. This trouble was corrected, but the opened fiber cannot be carried away by the process elevators. This effort is continuing, but is not successful.

17. In 1976, our Jeffrey Mine purchased and installed an English bag opener that is reputed to work well with asbestos fiber. It is still too early to say whether this opener will be successful.

18. In 1976, our asbestos-cement Pipe Division started a new effort to develop a manual bag opening station in an effort to solve process and environmental problems.

As stated previously, despite all of the efforts enumerated above, we have not been able to develop or find a mechanical bag opening machine or manual bag opening station which will consistently meet the four specifications listed above. Some cannot meet any of these specifications.

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PROCESS DESCRIPTIONS

To provide a better understanding of the fiber control problems associated with each asbestos industry segment (product line), brief descriptions of the processes used to manufacture our line of asbestos-containing products are set forth on the following pages.

These descriptions include:

A. Flow charts which delineate the major process steps which result in fiber generation and report the range of fiber counts from our latest industrial hygiene surveys.

B. Comments on the major areas where new processes, methods and equipment must be developed.

ASBESTOS-CEMENT PIPE

Basic Description

Asbestos-cement pipe is presently manufactured at 6 separate Johns-Manville manufacturing facilities. It is a durable, inexpensive pipe material, used primarily in underground applications. It is resistant to erosion and corrosion from internal and external factors. Two of the major attributes of asbestos-cement pipe are ease of installation and the integrity of the pipe joint. The pipe is manufactured in sizes ranging from 4" to 32" in diameter. The two major uses for asbestos-cement pipe are in water supply systems and sewer service. Additional uses include air handling systems and vent lines.

The raw materials used in the production of asbestos-cement pipe are asbestos fiber, portland cement and silica sand.

Process Description

Bags of asbestos fiber are conveyed on pallets by fork trucks to the fiber bag opening station. At this location, the bags are manually opened, the fiber removed, and the bag disposed under a dust control hood. The fiber is mechanically conveyed to a totally enclosed willow for opening or fiberizing. It is then air conveyed under negative pressure to fiber storage bins. Dust in the conveying air is removed by fabric bag filters and returned to the fiber feed system. From the fiber bins, the fiber is conveyed to dry mixers, where it is mixed with the other dry ingredients, portland cement and sand. Points of potential dust emission have dust control hooding.

After dry mixing, these blended raw materials are mechanically conveyed to a wet mixer and then into the pipe forming machine. The asbestos-cement slurry is picked up from a felt and deposited

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on a rotating mandrel. Deposition on the mandrel is continued under pressure until proper thickness has been attained. After preliminary set the pipe is stripped from the mandrel, air cured and steam cured.

The cured pipe sections are conveyed by fork truck to the finishing operations. Here the pipe is cut to length and end machined for the coupling device. Other machining operations performed include the manufacture of finished couplings from pipe stock. Machining is done by single or multiple point lathe type tools. Elaborate dust collection pick-up hoods are provided at each point of dust generation.

All finished pipe is visually inspected and all finished pressure pipe is hydrostatically tested.

After inspection and testing the pipe is stacked into unit loads for shipment and conveyed by fork truck to an outside storage yard to await final shipment.

In addition to the standard pipe and couplings, pipe plants will produce special pipe lengths and a variety of special fittings including tees, elbows and reducers.

The current range of airborne concentrations of asbestos fibers to which our employees are exposed, without regard to the use of respirators in each process step in our asbestos-cement pipe manufacturing facilities, are set forth in Figure 1.

As discussed in the "Major Problem Areas" section of this report, the two process steps that will require extensive improvement in order to achieve the proposed exposure limits are:

1. Fiber Introduction

   a. Bag opening, emptying and disposal

   b. Fiber handling

2. Machining of Pipe

Presently, the TWA airborne asbestos fiber concentrations to which our employees are exposed at our bag opening stations range from 0.8 to 3.5 f/cc, with an average of 1.6 f/cc. A history of our concerted efforts in the past to reduce airborne concentrations of asbestos at out bag opening stations is set forth in "CASE HISTORY 1-ASBESTOS BAG OPENING STATIONS," in the "Major Problem Areas" section of this report.

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The TWA airborne asbestos concentrations to which our employees are exposed at different fiber handling steps range from less than 0.5 f/cc to 1.4 f/cc with an average of 1.0 f/cc.

TWA airborne concentrations of asbestos to which our employees are exposed at pipe machining stations presently range from less than 0.5 f/cc to 4.5 f/cc, with an average of 1.5 f/cc.

A history of our concerted efforts in the past to reduce airborne concentrations of asbestos at the fiber handling steps and pipe machining steps in our pipe plants is set forth in "CASE HISTORY 2 - REDUCTION OF ASBESTOS FIBER EXPOSURES IN ASBESTOS-CEMENT PIPE PLANTS - FIBER INTRODUCTION AND PRODUCT FINISHING," at the end of this industry segment section.

Following CASE HISTORY 2, is CASE HISTORY 3 - WAUKEGAN PIPE. CASE HISTORY 3 traces the history of the major efforts at our Waukegan, Illinois pipe plant in past years to reduce airborne concentrations of asbestos. This history is representative of similar efforts at our other 5 asbestos-cement pipe plants.

Steps which can be taken to further reduce airborne concentrations of asbestos fibers in these process steps are set forth under the "Problem Areas" section of this report.

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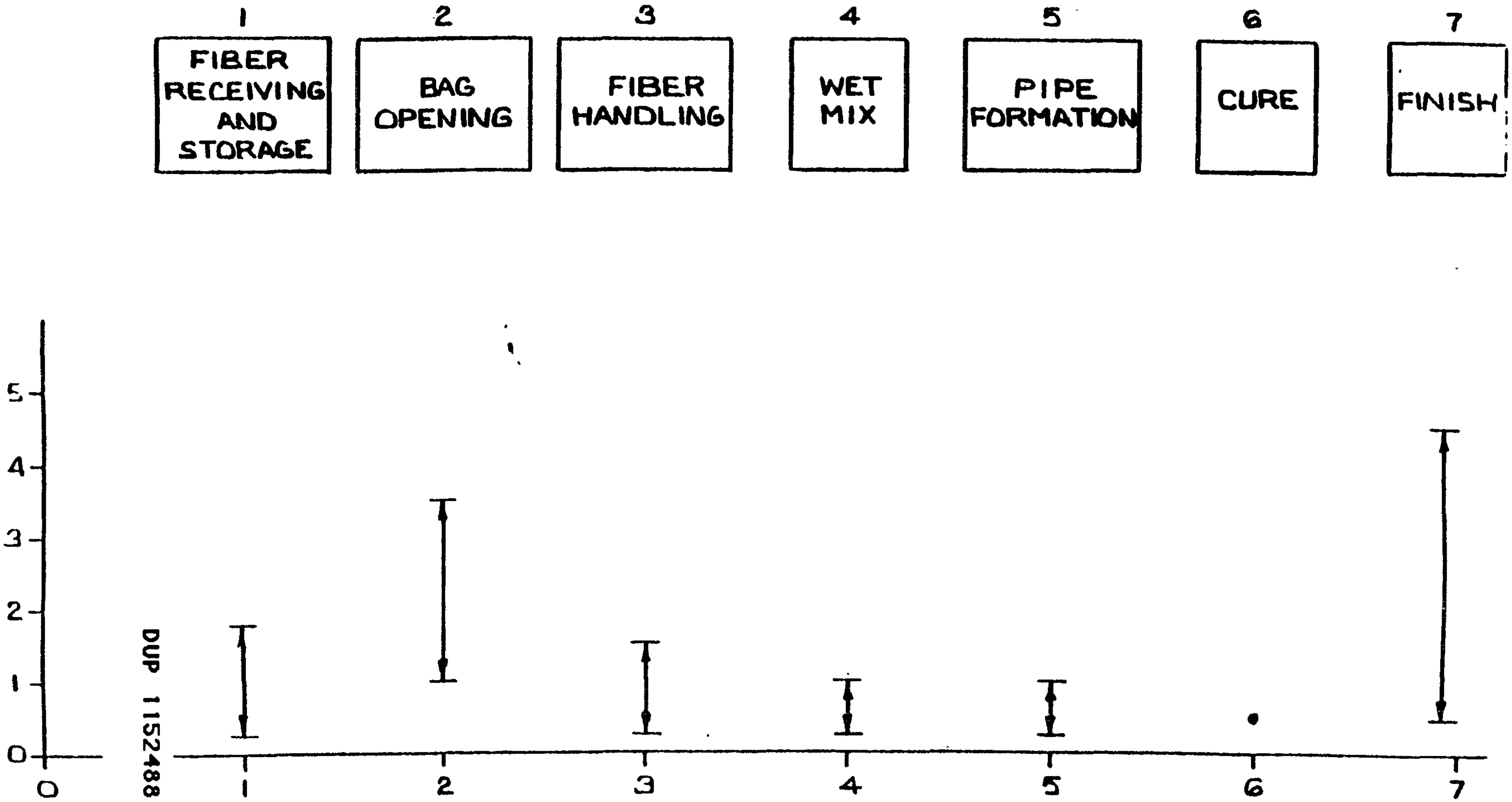
FIGURE 1

ASBESTOS - CEMENT PIPE



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PROCESS STEPS

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CASE HISTORY 2

REDUCTION OF ASBESTOS FIBER EXPOSURES IN ASBESTOS-CEMENT PIPE PLANTS FIBER INTRODUCTION AND PRODUCT FINISHING

Over past years, Johns-Manville has made tremendous efforts to reduce asbestos fiber exposures in our manufacturing plants. These efforts included modification of processing equipment, improvement of asbestos fiber packaging and continual updating of dust collection facilities. The work done in improving asbestos fiber packaging is discussed in the case history on bag opening stations. The following discussion reviews the highlights of the modifications to process equipment and improvements in dust collection facilities.

Fiber Introduction

Bag Opening Stations

Bag opening stations still remain a problem. This was discussed in CASE HISTORY 1.

Fiber Handling

Asbestos processing equipment, after the bag opening station, has changed from a completely manual operation to automated systems. The original systems utilized positive pressure pneumatic conveying systems, feeding to live bottom fiber bins, from which the fiber was mechanically conveyed to the dry and wet mixing operations. The early dust collection facilities associated with fiber handling were wet collectors, that were not completely reliable. These were replaced with an intermittent type of fabric filter, whose draw back was the requirement that the unit be shut down for cleaning.

In the mid 1950's, we constructed two new asbestos-cement pipe plants. These plants were built with the following successful innovations which substantially reduced airborne concentrations of asbestos fibers:

1. Negative pressure asbestos fiber conveying systems instead of the previous positive pressure. This process change resulted in a spectacular improvement in airborne fiber concentrations in this portion of the plant.

2. Continuous automatic fabric filters were installed instead of the intermittent type. This improved filter design eliminated the necessity for shutting down the collector for cleaning.

3. Automatic weighing and conveying of asbestos fiber from the live bottom bins to the dry mixers.

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4. Mechanical equipment for scrap grinding, replacing the previous manual operation. These automated systems incorporated dust control to reduce employee exposures.

5. Live bottom bins for the automatic weighing and introduction of scrap into the process were installed. This new equipment eliminated the previous completely manual process.

These process improvements were so effective in reducing employee exposures to asbestos fiber, that they were quickly incorporated into our other existing pipe plants.

Finishing Equipment

All of our pipe plants, when originally built, were equipped with dust collection systems on the finishing equipment. Beginning in the late 1930's and continuing to the present day, a constant effort has been made to reduce the emission of airborne concentrations of asbestos fibers from the finishing equipment, by the installation of more effective hoods and total rebuild of control systems, as our knowledge of dust control procedures advanced. Some of the specific improvements incorporated in our plants were:

1. Complete redesign of the Universal pipe lathes that are used to machine pipe ends. This redesign included improved dust control.

2. Redesign and replacement of complete dust collection systems including improved hoods, new ductwork to accomodate greater air flows and improved fabric bag filters.

3. Continuing efforts to improve the hood design on all finishing equipment.

4. Installation of mechanical equipment to remove the chips generated by the pipe finishing process.

5. Installation of central vacuum cleaning systems to improve plant housekeeping.

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CASE HISTORY 3

WAUKEGAN PIPE PLANT

We have chosen to review our dust control efforts at this location because it is our oldest asbestos-cement pipe operation; it was started in 1929.

When the Waukegan, Illinois pipe plant was built it was equipped with limited dust control facilities, mainly on the finishing equipment. Fiber handling was manual with shovels used to convey the fiber into weigh boxes where it was mixed with sand and cement. A limited number of evaluations of airborne asbestos dust concentrations were made by industrial hygienists from our insurance carriers in the period 1930 to 1950. Unfortunately, records of the survey results are no longer available.

In the early 1950's, the first major changes in process and mechanical exhaust ventilation equipment were made. These included:

1. Automatic weighing and mixing of the fiber, cement and sand.

2. Positive pressure air conveying systems for the dry raw materials.

3. Additional mechanical exhaust ventilation capacity on the fiber bag opening, fiber conveying and raw material mixing systems.

During this same period modifications were made on the dust control systems on the finishing equipment to improve effectiveness.

Dust counts taken for us during the mid-1950's by our insurance carrier showed that approximately 90% of our monitored work stations were under the ACGIH TLV of 5 mppcf.

In the late 1950's and early 1960's, the second group of major process and dust control modifications were installed. The most significant modification was the conversion of the positive pressure fiber conveying system in the wet end to a negative pressure system. This virtually eliminated fiber leakage from the system to the workplace.

In 1958, we established the basic industrial hygiene laboratory system we have in effect today, with laboratories then located at three points in the United States and one in Canada. Our hygienists performed surveys at this location to determine asbestos dust concentrations using the impinger technique.

In 1962 our surveys showed the situation as follows:

No. of Work Stations Monitored	No. over TLV of 5 mppcf	High mppcf	Low mppcf
69	3	9.3	0.4

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In 1968, the last year in which our asbestos dust surveys were made by the impinger technique, the situation was even better.

No. of Work Stations Monitored	No. over TLV of 5 mppcf	High (mppcf)	Low (mppcf)
62	0	4.5	0.4

In 1969, Johns-Manville began using the membrane filter/personal air sampler technique for evaluating employee exposure to asbestos dust. The initial survey at this location was done in April 1969. While the last series of impinger surveys had shown complete control, that is, no counts over TLV, this new monitoring procedure indicated a much different situation.

No. of Work Stations Monitored	No. over ACGIH Proposed TLV of 5 f/cc	High (mppcf)	Low (mppcf)
51	15	25.9	0.6

These survey results triggered a program to further reduce airborne concentrations of asbestos fibers. After the promulgation of the OSHA temporary and permanent standards for exposure to asbestos, our efforts were intensified to assure compliance with the 2 f/cc exposure limit effective July 1, 1976. Modifications and improvements accomplished during the period of 1971 to the present include:

1. Utilization of better methods for shipping and handling of asbestos fiber.
2. Installation of additional mechanical exhaust ventilation at the points of dust generation.

Our records show that during the period of 1930 to 1972 approximately $1,500,000 was spent for asbestos dust control improvements at our Waukegan, Ill. pipe plant. To these capital costs must be added $500,000 in engineering and plant development expense for a total of $2,000,000. This figure does not include added maintenance and operating costs estimated at $50,000 to $100,000 per year.

Despite these efforts, only 38% of the stations monitored in our latest survey were below the proposed TLV of 0.5 f/cc. The present situation is:

No. of Work Stations Monitored	Fiber Levels: Less than 0.5	0.5-2.0	2.0-5.0	Greater than 5.
73	28	38	4	2

In two critical areas - fiber introduction and product finishing-

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new techniques and methods must be developed to meet the proposed Permissible Exposure Limit of 0.5 fibers/cc. These two critical problem areas were discussed in detail in the "Major Problem Areas" and "Process Description" (Asbestos-cement pipe) sections of this report.

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ASBESTOS-CONTAINING BOARDS

Basic Description

Asbestos-Cement Boards - Asbestos-cement board is a durable non-combustible material used in numerous applications including building construction, electrical switch gear and laboratory furniture.

Asbestos-cement boards used in building construction are produced as flat or corrugated sheets, normally 4 feet wide with lengths up to 12 feet. They have excellent weathering resistance and are suitable for roofing and siding.

Electrical equipment frequently contains a variety of asbestos-cement boards fabricated to shape. It can be used as a structural mounting panel for electrical switch gear components.

Pigmented asbestos-cement boards are used extensively in the laboratory furniture industry as a durable, chemical resistant laboratory bench top.

The raw materials used in the production of asbestos-cement boards are asbestos fiber, portland cement and silica sand.

Asbestos/Calcium-Silicate Boards -Johns-Manville developed MARINITE (asbestos/calcium-silicate boards) for use as a structural fire resistive material in shipboard partitions. It has seen extensive use internationally in this application. Because the board has structural integrity, as well as fire resistance and insulating properties, it is widely used as a panel material in oven construction.

Heat treated MARINITE is used throughout the aluminum industry.

Raw materials used in the manufacture of asbestos/calcium-silicate boards are asbestos fiber, lime, natural diatomaceous earth and clay.

Process Description

Asbestos-Cement Boards

Bags of asbestos fiber are conveyed on pallets by fork trucks to the fiber bag opening station. At this location the bags are manually opened, the fiber is removed and bags disposed under a dust control hood. The fiber is mechanically conveyed to a willow for opening or fiberizing and then to dry mixers, where it is mixed with the other dry ingredients, portland cement and sand. After dry mixing, the materials are conveyed to a wet mixer.

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The asbestos-cement sand slurry is gravity dumped into a hydraulic press, where it is pressed to the specified thickness and density. The formed sheet is stripped from the press and stacked on racks for air curing. After air curing, the sheets are conveyed by fork truck to autoclaves for steam curing.

After steam curing, the sheets are conveyed by fork truck to the finishing department to be trimmed to size and for surface sanding to the required thickness and finish. The finishing department also will cut to order special sheet sizes and shapes.

As discussed under the "Major Problem Areas" section of this report, the two process steps where it has been difficult to control airborne concentrations of asbestos fiber are:

1. Fiber introduction

   a. Bag opening, emptying and disposal

   b. Fiber Handling

2. Product finishing

   a. Saw fabricating

   b. Surface sanding

Presently, the TWA airborne concentrations of asbestos to which our employees are exposed in the fiber introduction steps range from less than 0.5 to 3.5 f/cc, with an average of 1.3 f/cc. In order to further reduce asbestos exposures at these operations, two improvements are necessary.

1a. Installation of an automated bag opening system.

1b. Installation of a "negative willow system" and revised dust control procedures at other steps in fiber introduction,
or
Installation of the yet to be developed wet feed system.

Exposures in the product finishing operation range from less than 0.5 f/cc to 3.8 f/cc, with an average of 1.5 f/cc. Possible reductions in airborne concentrations of asbestos fibers will require two modifications:

2a. Install, after development, improved mechanical exhaust ventilation systems on the fabricating saws.

2b. Implementation of new, improved procedures for cleaning the surface of sanded sheets.

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These proposed improvements and modifications are discussed in detail in the "Major Problem Areas" section of this report.

Asbestos/Calcium-Silicate Boards

Bags of asbestos fiber are conveyed on pallets by fork trucks to the fiber introduction station. Bags are mechanically elevated to a mezzanine where the bags are manually opened, the fiber is removed and bags disposed under a dust control hood. The fiber is air conveyed through a fiber opening system, and then into a wet mixer. The other raw materials are introduced at this location. From the wet mixer, the slurry is conveyed to a gel tank where the initial chemical reaction takes place. From the gel tank, the slurry is conveyed to the press where the product is pressed to the specified thickness and density. The sheets are stripped from the press, placed in racks and conveyed by fork truck to the autoclaves for steam curing. From the autoclaves, the sheets are transported by fork truck to the racking and unracking station. Here the sheets are placed in special racks for transport through the drying ovens. After drying, they are unracked and transported to a temporary storage area. From temporary storage, the sheets are taken to the sanding line where they are top and bottom sanded to thickness and the edges are trimmed to size. After sanding, the sheets are conveyed through a brush roll section for surface cleaning, through the turnover inspection station and to the sanding line take-off station. They are then transported to the finished goods storage area where they remain until prepared for shipment.

The current range of airborne concentrations of asbestos fibers to which our employees are exposed, without regard to the use of respirators, in each process step in our asbestos-containing board manufacturing facilities (including asbestos-cement boards and MARINITE), are set forth in Figure 2.

The major process steps where it has been difficult to control airborne concentrations of asbestos fiber are similar to the asbestos-cement board operation.

1. Fiber introduction

   a. Bag opening

   b. Fiber handling

The TWA airborne concentrations of asbestos to which our employees are exposed in fiber introduction range from less than 0.5 f/cc to 8.0 f/cc with an average of 1.3 f/cc.

2. Product finishing

   a. Surface sanding

Exposures at these operations range from less than 0.5 f/cc

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to 3.2 f/cc, with an average of 1.2 f/cc.

In order to further reduce airborne concentrations of asbestos in these process steps, improvements similar to those described for our asbestos-cement board operation must be made.

Immediately following this process description is CASE HISTORY 4 Billerica Plant, which reviews the dust control efforts at this plant, and demonstrates the difficulty of controlling asbestos fiber emissions generated by the finishing of low density asbestos-containing board products.

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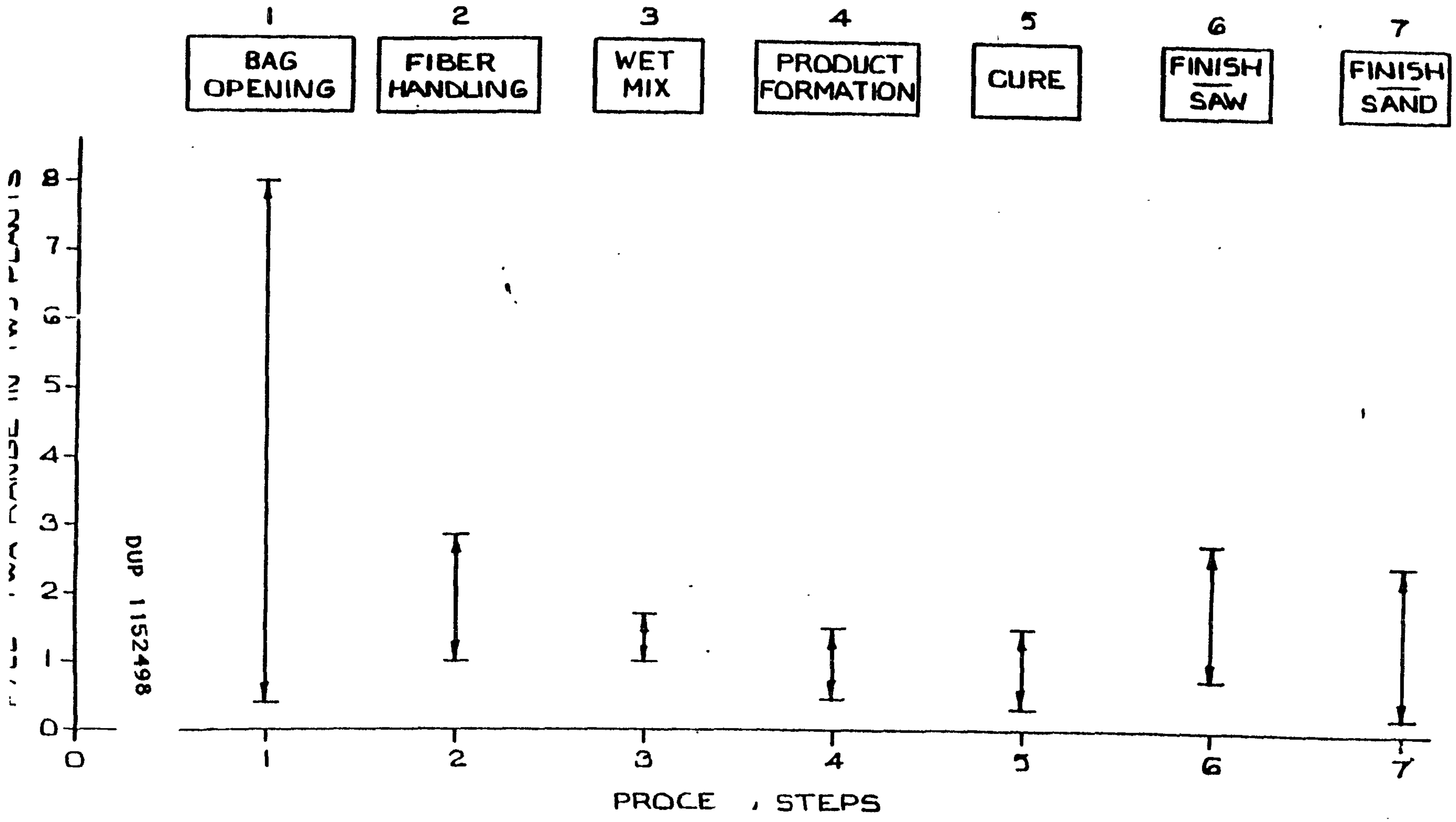
FIGURE 2

ASBESTOS CONTAINING BOARDS



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CASE HISTORY 4

BILLERICA PLANT

We have chosen to review our dust control efforts at this location in order to demonstrate the difficulty of controlling asbestos fiber emissions generated by the finishing of low density asbestos-containing sheet products.

Billerica was acquired in 1936 and production of MARINITE was begun in 1939. MARINITE is a calcium silicate, asbestos re-inforced sheet formed from natural diatomaceous earth, lime and asbestos fiber. The ingredients are introduced directly into a wet mixer, pumped to gel tanks, conveyed to a press and pressed to shape. After pressing, the sheet is autoclaved, oven dried and finished to the correct size by a sanding operation.

One of the major uses of MARINITE is in fire-safe wall partitions, primarily in marine construction. It is also used as a structural insulating panel in oven construction and a heat treated form is used extensively in the aluminum industry.

The MARINITE production facilities, as originally installed, included dust control systems in the raw material preparation and finishing operations. Surveys performed for us by our insurance carrier during the period 1940 to 1948 indicated satis-factory airborne dust levels as determined by the criteria of the period.

During the period 1949 to 1966, plant capacity was gradually increased and dust control systems were modified and enlarged to keep pace with this capacity increase.

In 1958, Johns-Manville organized its own industrial hygiene facilities. Our hygienists performed a dust level survey using the impinger technique at this location in 1962. Results of this survey were as follows:

No. of Work Stations Monitored	No. over TLV (5 mppcf)	High mppcf	Low mppcf
15	5	41.0	0.6

During the period 1962 to 1968, numerous improvements were made in the plant. The most significant change was the replace-ment of the individual finishing stations with a single pass finishing line. Simultaneously, adoption of a precision forming technique eliminated the need for saw trimming.

An industrial hygiene survey performed in 1968 showed marked reduction in airborne asbestos dust levels.

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No. of Work Stations Monitored	No. over TLV (5 mppcf)	High (mppcf)	Low (mppcf)
15	1	6.8	0.3

Funds expended during the period 1950 to 1968 at our Billerica plant to achieve these asbestos concentrations in the workplace totalled $135,000.

The first survey utilizing the membrane filter/personal air sampler technique was performed at Billerica in June, 1969. Results were as follows:

No. of Work Stations Monitored	No. over TLV (5f/cc)	High (f/cc)	Low (f/cc)
18	11	50	0.4

Here again, is the situation where exposure levels were below the TLV by one measurement system, and suddenly many work stations were above limits by a new measurement technique.

Numerous modifications were made in this plant from 1969 to the present, with the goal of reducing exposures below 2 f/cc. These modifications included total replacement of the sanding line and its dust control system. Improvements were made in fiber introduction. A total of approximately $550,000 was approved in capital funds to undertake these dust control improvements, plus $125,000 for engineering and design.

The latest industrial hygiene survey was performed at this plant in November 1975. The data are:

No. of Work Stations Monitored	Fiber Levels: Less than 0.5	0.5-2.0	2.0-5.0	Greater than 5.
22	6	11	4	1

Only 27% of our monitored stations are at or below the proposed exposure limit of 0.5 f/cc, despite past efforts.

The problem areas are similar to those in our other asbestos-using operations - fiber introduction and product finishing. Possible steps for improvements were discussed in the "Major Problem Areas" and "Process Description (Asbestos-Containing Boards) sections of this report.

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ROOFING

Basic Description

Roofing Felts - Roofing felts are asphalt saturated asbestos paper. This product is used extensively in "built-up" roofing systems for commercial and industrial buildings.

The asbestos fibers impart dimensional stability and rot-proofing to the felt. In addition to providing dimensional stability, the fibers permit slight movement of the felt to accommodate expansion/contraction movements of the building structure without cracking of the felt.

Roof Coatings -Roof coatings are manufactured from cut-back asphalt, inert fillers such as limestone, and 5-10% asbestos fiber. These coatings are used extensively in built-up roofing systems and foundation water-proofing. The asbestos again imparts dimensional stability, while permitting slight expansion and contraction of the coating without cracking.

Sealants - Sealants are manufactured from a variety of base materials such as castor oil, soybean oil and various resins reinforced with asbestos fiber.

These products are used extensively for caulking in building construction and for general purpose sealing compounds in industry.

Again the asbestos fiber imparts dimensional stability while still allowing a certain degree of flexibility.

The current range of airborne concentrations of asbestos fibers to which our employees are exposed, without regard to the use of respirators, in each process step in our roofing manufacturing facilities (only including roof coatings and sealants) are set forth in Figure 3.

Process Description

Roofing Felts - The airborne asbestos problems associated with the manufacture of asbestos roofing felts are discussed under the asbestos paper process description section of this report.

Roof Coatings -Raw Material Introduction

Bags of asbestos fiber on pallets are conveyed by fork trucks to the fiber bag opening stations. At this location the bags are manually opened, the fiber is removed and the bags disposed under a dust control hood. The fiber is conveyed from the bag opening station, to a fiber fluffer, and then into a mixer.

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The other raw materials are introduced at the mixer. From the mixer, the finished product is conveyed to the filling station, where pails and cans of various sizes are filled and capped.

The only process step which generates significant concentrations of airborne asbestos fiber is bag opening in the fiber introduction segment.

Presently, the TWA airborne concentrations to which our employees are exposed at this operation range from 0.8 to 2.5 f/cc, with an average of 1.2 f/cc.

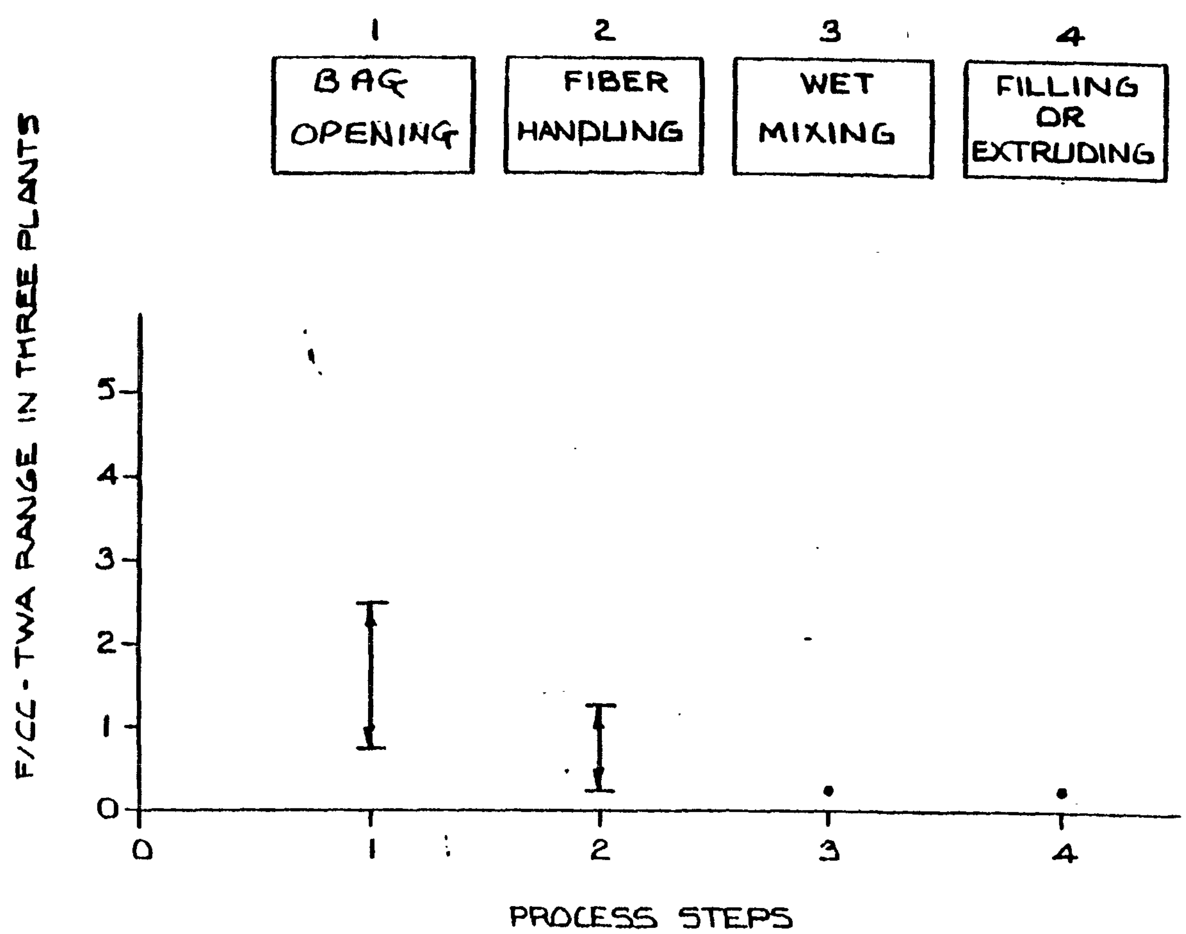
In order to further reduce airborne concentrations of asbestos at this process stepk the use of an automated bag opening system, as described under the "Major Problem Areas" section of this report will be required.

<u>Sealants</u> - The process for manufacturing sealants is very similar to that of coatings, except that a different mixer is used, and after mixing, the material is conveyed to an extruder for final processing to size and shape. The extruder is followed by a packing station where the sealants are prepared for shipment.

Again, the only process which generates significant concentrations of airborne asbestos fiber is bag opening in the fiber introduction segment. Exposure levels are similar to those at the roof coating operation. The steps which must be taken to further reduce airborne concentrations of asbestos are the same as described for roof coatings.

FIGURE 3

ROOFING
ROOF COATINGS AND SEALANTS



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SEALING COMPONENTS

Basic Description

Molded Packings -Precision dynamic sealing elements are made in a wide range of compounds, sizes and cross sections. They are used for sealing bearings, preventing oil seepage and excluding dirt in a large variety of mechanical equipment.

Molded packings are generally made from synthetic rubber, and are reinforced with canvas duck, asbestos textile, or asbestos-containing sheet gasket.

Sheet Gaskets - Sheets of varying compositions are used to seal two flat surfaces against leakage. Examples of applications are pipe flanges, cylinder heads, valve covers, and engine crank-cases.

Sheet gaskets contain 70% to 80% chrysotile asbestos fiber, bonded with rubber, or other compounds.

Mechanical Packings (Asbestos Textile Based)- Mechanical packings consist of a wide range of materials designed to control leakage between moving or stationary parts. Primary application is with pumps and valves. They are in a great variety of styles, shapes and cross sections.

These packings generally are made from asbestos textiles impregnated with rubber or graphite, reinforced with wire, and sometimes encased in wire mesh.

Process Description

Molded Packings - This product is precision die molded, single or multi-cavity, in a hydraulic press. Asbestos textiles or asbestos-rubber bonded sheet gaskets are used as heel reinforcement. There is virtually no asbestos exposure resulting from this process, since the asbestos is supplied to the process in bound form.

Sheet Gaskets - Bags of asbestos fiber are transported on pallets to the bag opening station. Here, bags are manually opened, the fiber removed, and bags disposed under a dust control hood. Fiber is mechanically conveyed to the fiberizing device, then air conveyed in a negative pressure system to the feed cyclone. From the cyclone, fiber is fed through a rotary air lock to the wet mixer, where it is combined with the other raw materials, mainly rubber and solvent. The conveying air is cleansed by a fabric bag filter

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and the captured fiber is returned to the system.

The blended raw materials,in paste form, are transported by box truck to the two roll sheeter. The sheeter rolls the paste into a sheet, which is stripped from the rolls and air cured.

The current range of airborne concentrations to which our employees are exposed, without regard to the use of respirators, in each process step in our sheet gasket manufacturing facilities are set forth in Figure 4.

The process step that presently generates fiber levels above 0.5 f/cc is bag opening. Exposure levels presently vary from 0.8 to 3.5 f/cc. In order to reduce airborne concentrations of asbestos at this process step, an automated bag opening system, as discussed in the "Major Problem Areas" section of this report, must be utilized.

Mechanical Packings - Mechanical packings are produced in two forms:

1. Braided from asbestos yarns.

2. Folded or formed from asbestos cloth.

Braided packings are square, round or oval in cross section. They are braided in solid form or around various core materials. After braiding, the product is impregnated with rubber, graphite, TFE, molydisulphide or petroleum wax. Lubricating surface coatings are frequently used.

Folded packings generally are square in cross section. They are folded to shape and bonded in their folded form with a neoprene base cement.

The current range of airborne concentrations of asbestos fibers to which our employees are exposed, without regard to the use of respirators, in each process step in our mechanical packings manufacturing facilities, are set forth in Figure 5.

The process step with major asbestos exposure is braiding. Even though the asbestos yarn and asbestos cloth has been treated with a latex emulsion during its manufacture, fiber exposure levels at the braiders range from less than 0.5 to 1.6 f/cc, with an average of 0.9 f/cc. It is our present belief that additional, presently unknown, changes in the yarn and textile manufacturing process will be required to further reduce airborne concentrations of asbestos fiber when handling asbestos textiles and yarns.

In order to fully comprehend the magnitude of the problem

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expressed above, it is essential that asbestos textile manufacturing be fully described, including industry attempts at dust control at the various process steps. In 1973, two scientists, Robert A. Curtis and Philip J. Bierbaum of the National Institute of Occupational Safety and Health made an in-depth study of the industry. Their report "Technological Feasibility of the 2 Fibers/cc Asbestos Standard in Asbestos Textile Facilities" includes an excellent description of the three basic manufacturing procedures.

1. Dry; or conventional

2. Damp; used by Johns-Manville

3. Wet (Liquid dispersion process)

During their study, Curtis and Bierbaum visited five "model" plants offered by the industry for their inspection. They concluded that only two plants; plant A (Johns-Manville using the damp process) and plant B (Using the wet process) had a possibility of achieving the 2 f/cc standard. They stated that both these plants had limited production facilities due to product restraints created by the new processes.

Curtis and Bierbaum conducted an asbestos dust sampling survey at these two plants. Results are given in their report. Their data for Plant A (Johns-Manville) and our most recent survey data are shown in the Table below.

	NIOSH		J-M	
Operation	Range	Mean	Range	Mean
Carding	0.2-2.6	0.8	0.1-1.4	0.9
Twisting	0.1-1.5	0.5	0.3-1.5	0.8
Weaving	0.1-0.7	0.6	0.1-0.8	0.8
Braiding	0.0-0.7	0.2	0.3-1.6	0.9

The only serious discrepancy in data occurs in the braiding operation. Numerous repeat samples recently taken have convinced us that our data is correct. Many variables - such as product mix - influence airborne fiber levels, and their effect can be determined only over a period of time.

To effectively supplement this portion of the report we enclose two items :

1. A copy of "Technological Feasibility of the 2 Fiber/cc Asbestos Standard in Asbestos Textile Facilities" by Robert A. Curtis and Philip J. Bierbaum of NIOSH. This report is enclosed because of its excellent description of the asbestos textile manufacturing process and its conclusion concerning control of airborne concentrations of asbestos fiber.

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2. CASE HISTORY 5 - which describes the control efforts at our Manville Textile operations. This report includes our conclusions on the feasibility of attaining a 0.5 f/cc Permissible Exposure Limit.

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FIGURE 4

SEALING COMPONENTS
SHEET GASKETS

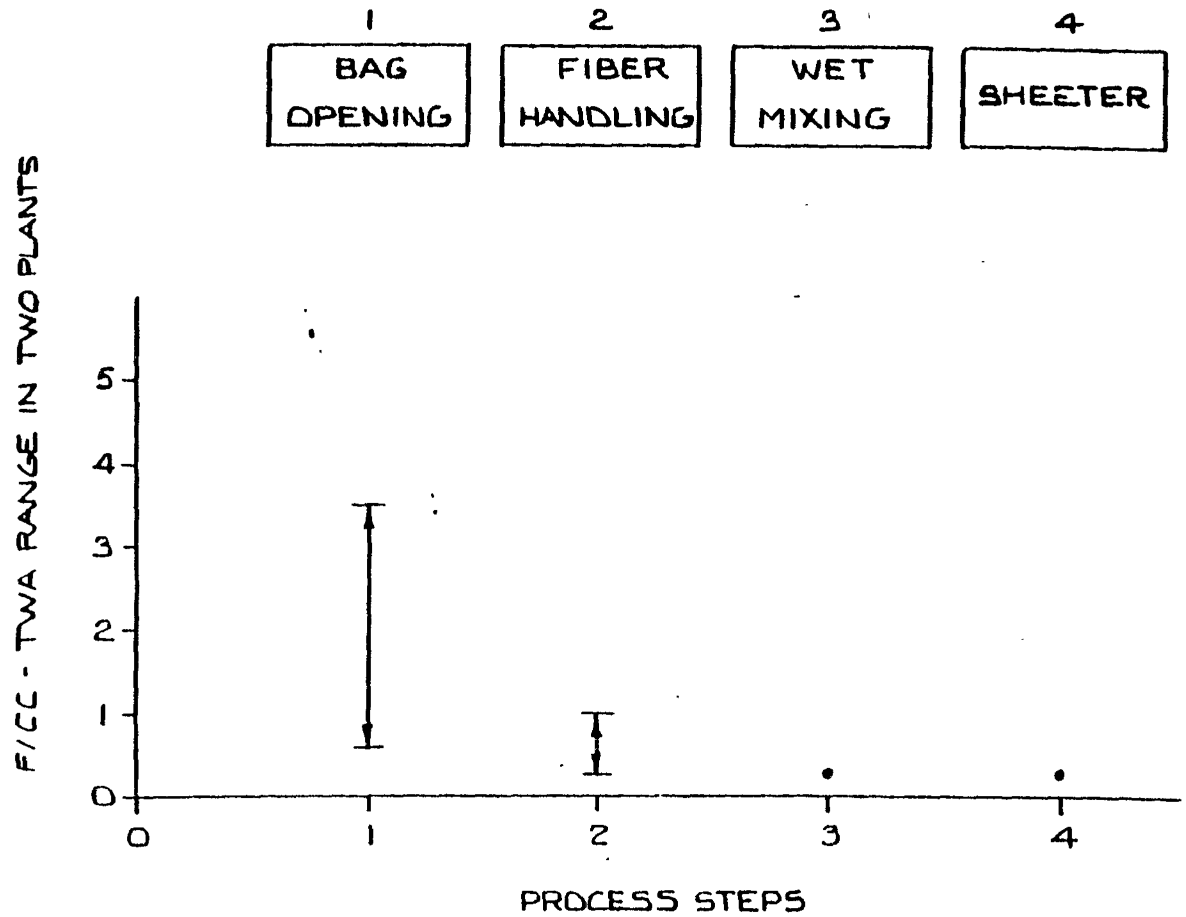

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TABLE 12: Sample Averages, Standard Deviations, Coefficient of Variation, Median, Low count and High Count For Samples given in Tables 2-11.

Sample No.	Average	Std. Dev.	Coef. of var.	Median	Low	Hig
1	.22	.09	.42	.19	.09	.5
2	1.5	1.5	1.00	1.1	.5	6.1
3	5.1	1.6	.31	4.7	2.5	8.0
4	.13	.05	.40	.13	.06	.24
5	1.8	.9	.50	1.5	1.0	4.4
6	1.0	.7	.70	.7	0.4	2.6
7	4.8	1.1	.23	4.8	2.1	6.7
8	.4	.09	.22	.4	.3	.6
9	.3	.17	.55	.2	.2	.7
10	.3	.13	.37	.3	.2	.6

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Table 10. Sample 9

Filter /Reader	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	TWAF/ML
A / EJB	100	7	.2	100	9	.2	100	4	.1	100	9	.2	100	12	.3	.2
A / J B	100	8	.2	100	5	.1	100	12	.2	100	7	.2	100	16	.4	.2
A / JRG	100	10	.2	100	15	.3	100	6	.1	100	5	.1	100	9	.2	.2
A / LJG	100	5	.1	100	6	.1	100	15	.2	100	16	.4	100	18	.4	.2
A / WCB	100	6	.1	100	4	.1	100	12	.2	100	7	.2	100	15	.3	.2
B / RVB	100	11	.2	100	9	.2	100	16	.2	100	21	.4	100	22	.4	.3
B / TFA	100	22	.4	100	27	.5	100	39	.6	100	12	.2	100	42	.8	.5
C / DAA	100	11	.2	100	13	.2	100	18	.2	100	7	.1	100	19	.4	.2
C / DKC	100	11	.2	100	10	.2	100	11	.2	100	5	.1	100	11	.2	.2
C / KJW	100	7	.1	100	7	.1	100	10	.2	100	10	.3	100	10	.2	.2
C / S G	100	6	.1	100	13	.2	100	18	.1	100	14	.3	100	21	.4	.2
D / C P	100	9	.2	100	9	.2	100	16	.3	100	4	.1	100	17	.4	.2
D / MVD	100	10	.2	100	40	.9	100	72	1.2	100	4	.1	100	12	.3	.6
E / RLG	100	10	.2	100	27	.5	100	24	.3	100	22	.4	100	44	.9	.4
E / YLA	100	20	.4	100	24	.5	100	42	.6	100	25	.6	100	65	1.5	.7

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Table 11. Sample 10

Filter /Reader	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	TWAF/ML
A / EJB	100	11	.3	100	16	.4	100	13	.2	100	9	.2	100	13	.3	.3
A / J B	100	7	.2	100	18	.4	100	16	.2	100	16	.4	100	9	.2	.3
A / JRG	100	5	.1	100	7	.2	100	8	.1	100	10	.2	100	8	.2	.2
A / LJG	100	11	.3	100	24	.5	100	17	.3	100	14	.3	100	22	.5	.4
A / WCB	100	13	.3	100	12	.3	100	10	.3	100	14	.3	100	5	.1	.3
B / RVB	100	14	.3	100	14	.3	100	23	.3	100	19	.4	100	10	.2	.3
B / TFA	100	33	.7	100	41	.8	100	36	.5	100	8	.2	100	25	.5	.5
C / DAA	100	27	.5	100	32	.6	100	24	.3	100	21	.4	100	19	.4	.4
C / DRC	100	11	.2	100	14	.3	100	11	.1	100	9	.2	100	7	.1	.2
C / KJW	100	19	.4	100	19	.4	100	27	.4	100	13	.3	100	25	.5	.4
C / S G	100	7	.1	100	19	.4	100	12	.2	100	5	.1	100	21	.4	.2
D / C P	100	13	.3	100	13	.3	100	15	.2	100	14	.3	100	14	.3	.3
D / MVD	100	13	.3	100	21	.5	100	12	.2	100	25	.6	100	17	.4	.4
E / RLG	100	12	.2	100	46	.9	100	42	.6	100	39	.8	100	30	.6	.6
E / YLA	100	6	.1	100	17	.4	100	57	.9	100	10	.2	100	22	.5	.5

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Table 8. Sample 7 C-14'2

Filter /Reader	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML.	TWA/ML
A / EJB	41	100	5.9	48	101	4.9	38	104	5.3	75	110	3.0	50	104	4.3	4.6
A / J B	45	102	5.5	53	101	3.7	33	102	6.0	90	103	2.3	47	100	4.4	4.4
A / JRG	31	103	8.0	29	100	6.7	27	101	7.2	50	104	4.2	41	102	5.1	6.2
A / LJG	40	101	6.1	60	138	4.5	40	116	5.6	80	107	2.7	40	107	5.5	4.8
A / WCB	25	104	10.1	36	107	5.0	25	108	8.4	70	105	3.0	56	101	3.7	6.1
B / KVB	85	100	2.5	96	100	1.8	72	101	2.4	100	39	1.6	86	103	2.2	2.1
B / TFA	25	103	8.7	23	100	7.5	22	100	7.7	43	100	4.1	31	101	5.9	6.7
C / DAA	26	103	8.2	26	102	6.6	30	116	6.4	60	97	2.8	39	96	4.3	5.6
C / DRC	29	103	7.6	37	125	5.7	35	101	4.8	76	102	2.3	42	103	4.3	4.9
C / KJW	26	104	8.3	27	102	6.4	39	103	4.4	70	100	2.2	55	101	3.2	4.8
C / S G	29	103	7.4	31	105	5.7	31	101	5.4	58	101	3.0	39	101	4.6	5.2
D / C P	56	107	4.6	46	102	4.3	32	101	6.1	81	100	2.5	57	101	3.6	4.3
D / RVD	50	103	5.0	51	101	3.9	31	102	6.4	100	69	1.4	75	102	2.8	3.9
E / RLG	60	101	3.5	27	101	6.2	56	100	2.9	72	100	2.4	35	100	5.0	4.0
E / YLA	50	109	4.5	50	236	7.9	50	116	3.8	72	111	2.7	50	111	3.9	4.6

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Table 9. wple 8

Filter /Reader	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	TWAF/ML
A / EJB	100	25	.6	100	31	.6	100	24	.4	100	22	.5	100	14	.3	.5
A / J B	100	13	.3	100	15	.3	100	18	.3	100	17	.4	100	12	.2	.3
A / JHG	100	18	.4	100	15	.3	100	10	.2	100	21	.5	100	19	.4	.3
A / LJG	100	30	.7	100	21	.4	100	22	.4	100	28	.6	100	23	.5	.5
A / MCB	100	18	.4	100	27	.5	100	32	.6	100	21	.5	100	11	.2	.5
B / RVB	100	21	.4	100	31	.6	100	25	.4	100	25	.5	100	23	.4	.5
B / TFA	100	37	.8	100	43	.8	100	29	.5	100	29	.6	100	21	.4	.6
C / DAA	100	25	.5	100	17	.3	100	21	.3	100	18	.2	100	34	.6	.4
C / DRC	100	30	.6	100	29	.5	100	29	.5	100	5	.1	100	27	.5	.4
C / KJW	100	16	.3	100	15	.3	100	22	.3	100	2	.0	100	27	.5	.3
C / S G	100	28	.6	100	25	.4	100	27	.4	100	6	.1	100	26	.4	.4
D / C P							100	8	.1	100	17	.4	100	27	.5	.3
D / MVD	100	15	.4	100	12	.2	100	8	.1	100	11	.2	100	16	.3	.3
E / RLG	100	30	.6	100	14	.2	100	25	.4	100	6	.1	100	25	.4	.4
E / YLA	100	33	.8	100	27	.5	100	26	.5	100	6	.1	100	29	.6	.5

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Table 4. Sample 3

Filter /Reader	FLDS	FIBERS	F/ML
A / EJB	20	106	4.0
A / J B	20	97	4.4
A / LJG	20	84	3.0
A / WCB	20	97	4.4
B / RVB	10	100	7.9
B / TFA	32	102	2.5
C / DAA	20	120	4.6
C / DRC	20	119	4.6
C / KJW	20	100	3.9
C / S G	20	143	5.5
D / C P	13	104	7.2
D / MVD	20	107	4.0
E / RLG	20	153	5.0
E / YLA	25	262	8.0

Table 5. Sample 4

Filter /Reader	FLDS	FIBERS	F/ML
A / EJB	100	9	.1
A / J B	100	4	.1
A / LJG	100	9	.1
A / WCB	100	11	.2
B / RVB	100	19	.2
B / TFA	100	6	.1
C / DAA	100	12	.1
C / DRC	100	10	.1
C / KJW	100	5	.1
C / S G	100	7	.1
D / C P	100	7	.1
D / MVD	100	12	.2
E / RLG	100	15	.2
E / YLA	100	10	.1

Table 6. Sample 5

Filter /Reader	FLDS	FIBERS	F/ML
A / EJB	100	101	1.4
A / J B	100	86	1.2
A / JRG	100	76	1.0
A / LJG	100	86	1.2
A / WCB	100	105	1.4
B / RVB	43	104	2.9
B / TFA	51	101	2.4
C / DRC	57	106	2.2
C / KJW	59	102	2.1
C / S G	100	105	1.2
D / MVD	100	77	1.0
E / RLG	55	101	2.1
E / YLA	50	109	4.4

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Table 7. S le 6

Filter /Reader	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	FLDS	FIBERS	F/ML	TWAF/ML
A / EJB	100	20	.8	100	35	.7	100	25	.5	100	18	.4	100	9	.3	.5
A / J B	100	34	.9	100	30	.6	100	14	.3	100	13	.3	100	10	.3	.5
A / JRG	100	26	.7	100	26	.5	100	15	.3	100	12	.3	100	4	.1	.4
A / LJG	100	29	.8	100	33	.7	100	20	.4	100	17	.4	100	13	.4	.5
A / WCB	100	29	.8	100	35	.7	100	18	.4	100	23	.6	100	10	.3	.5
B / RVB	84	101	2.9	71	100	2.5	76	107	2.5	95	100	2.3	100	73	1.8	2.4
B / TFA	100	34	.8	100	40	.7	100	23	.4	100	29	.6	100	31	.8	.7
C / DAA	100	38	.9	100	62	1.1	100	33	.6	100	30	.6	100	19	.5	.7
C / DRC	100	27	.6	100	61	1.1	100	30	.5	100	12	.3	100	8	.2	.6
C / KJW	100	43	1.0	100	65	1.1	100	26	.5	100	23	.5	100	11	.3	.7
C / S G	100	38	.9	100	75	1.3	100	20	.4	100	35	.7	100	16	.4	.8
D / C P	100	62	1.7	100	40	.8	100	31	.6	100	15	.4	100	9	.3	.8
D / MVD	70	100	3.6	75	103	2.8	52	100	4.0	100	76	1.9	100	17	.5	2.6
E / RLG	95	100	2.5	79	100	2.2	100	71	1.2	100	46	1.0	100	23	.5	1.5
E / YLA	103	115	2.7	100	74	1.5	100	42	.8	100	29	.7	100	20	.5	1.2

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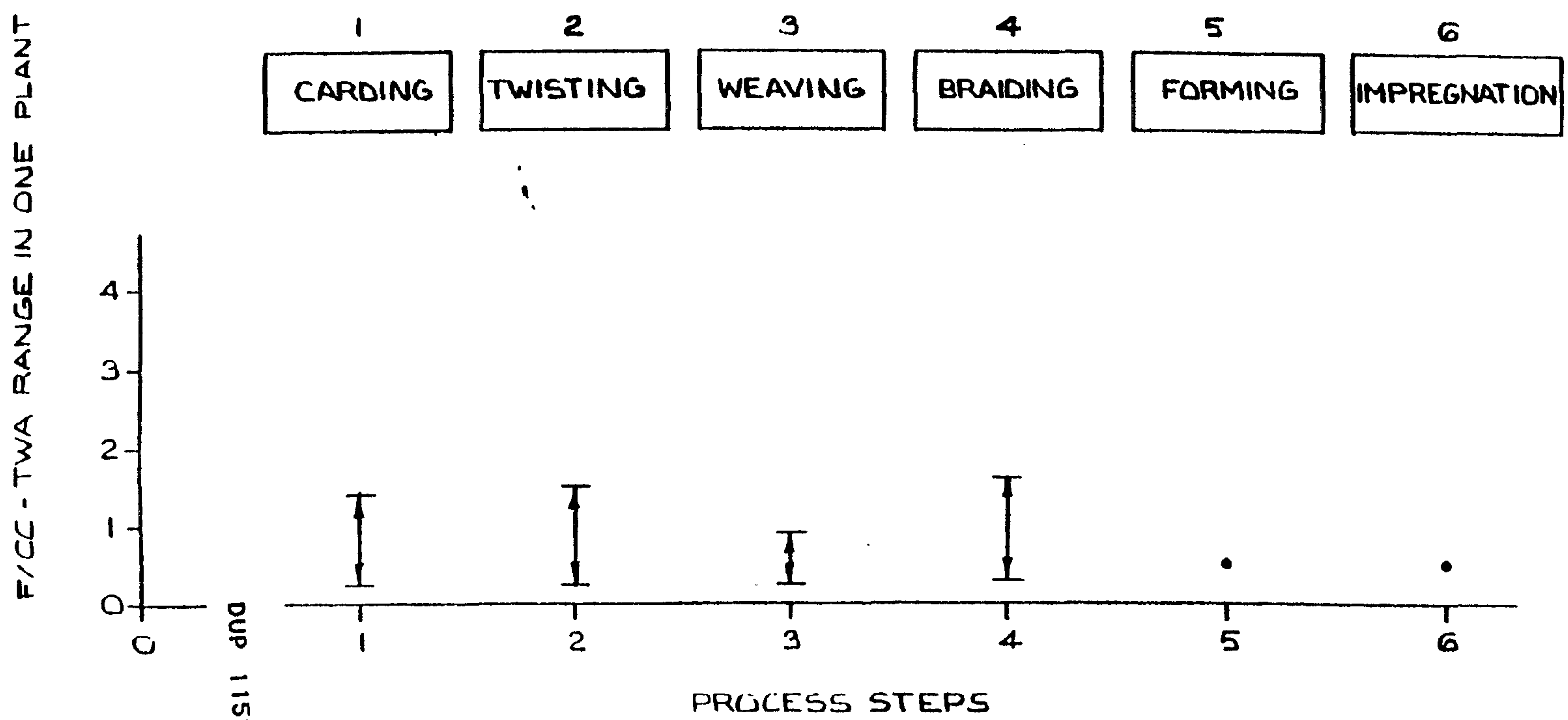
FIGURE 5

SEALING COMPONENTS
MECHANICAL PACKINGS AND TEXTILES



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