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Technological Feasibility and Economic Impact of OSHA Proposed Revision to the Asbestos Standard

Prepared for:

Asbestos Information Association/North America
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Technological Feasibility
and Economic Impact
of OSHA Proposed Revision
to the Asbestos Standard
(Construction Exclude)

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SECTION 1

EXECUTIVE SUMMARY

Background

The Asbestos Information Association/North America (AIA/NA) formed an industry task force and engaged Roy F. Weston to perform a feasibility and impact study. The study concluded with a report of the technological feasibility and economic impact of the Department of Labor's proposed revision to the existing asbestos standard, which was published in the Federal Register Thursday, 9 October 1975. The Department has granted two separate 60-day extensions for interested parties to comment. The second comment period ends Friday, 9 April 1976.

To determine the feasibility and impact of the proposed revision to the asbestos standard, Weston investigated how asbestos fibers are processed and incorporated into other products as they move through the industrial sectors (Construction Excluded) on their way to a final resting place or product. The asbestos products industry can be classified into three sectors: primary, secondary, and consumer industries. (See Figure 2-1, page 2-3, for a graphic display of the Asbestos Products Industry.)

Each industry group (primary, secondary, and consumer) was investigated to collect data and information for this study. The information was collected from firms in each of the three industry groups, as well as trade associations, governmental agencies, colleges and universities, and other sources. For the most part, "hard" data (rather than opinions) were requested. The Weston project team collected the data in three ways:

- Plant visits and inspections
- Questionnaires
- Telephone interviews

Once the raw data were assembled, the technical, engineering and economic information was compiled on each industry group (primary, secondary, and consumer). The primary industries were further broken down into ten segments, since these are where asbestos is introduced into the manufacturing process. Technological feasibility and economic impact were developed for each industry group. In addition, foreign trade impact was developed for the consumer industries.

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Weston's study resulted in specific conclusions for the three industry groups. These conclusions are specific to the particular industry group and can be found at the end of each industry section: primary (Section 4), secondary (Section 5), and consumer (Section 6). Each primary-industry segment also has a set of conclusions. Weston summarized these specific conclusions into two broad areas: Technological and Economic.

Conclusions -- Technological

- Primary industries have expeditiously worked toward reducing employee exposure in the work environment, even before the 1972 standard was promulgated. Most of the secondary industries, because of the nature of their operations, were then meeting the ceiling and 8-hour time-weighted average (TWA) standard (10 fibers/cc and 5 fibers/cc). The consumer industries are meeting the proposed ceiling and 8-hour TWA standard.

- Best Available Technology ("BAT") WILL NOT ACHIEVE 0.5 fibers/cc TWA in the primary industries. Sixty-five percent of the primary industry processing steps will be above 0.5 fibers/cc TWA after BAT is installed.

- Several processing steps in the secondary industries will be ABOVE 0.5 fibers/cc TWA after implementation of BAT. Typical process steps are similiar to those in the primary industries, e.g., where the secondary industry performs sanding, drilling, grinding, cutting, etc.

- Based on industry estimates, implementation of BAT will take three to five years in the primary industries. The implementation period for the secondary industries, because of their limited technical and capital base, can be even longer.

- Implementation of BAT will achieve 2.0 fibers/cc TWA at all processing steps in the primary and secondary industries.

Conclusions -- Economic

The economic conclusions for each industry segment have been summarized in Table 1-1. This table summarizes those factors, developed by industry group, which affect the asbestos

Table 1-1

Summary of Economic Impact

Costs	Primary	Secondary	Consumer	Total
Capital Cost to achieve BAT	$93,950,000	$1,020,000,000	Not Required	$1,113,950,000
Total Annual Costs to achieve BAT (Annualized Capital + Operating + Industrial Hygiene and Medical Costs)	$66,440,000	$2,251,960,000	$1,652,000,000	$3,970,400,000
Industrial Hygiene and Medical Program vs Total Annual Costs (Percent)	51	85	100	89
Estimated Total Number of employees	37,500	2,270,000	11,800,000(2)	14,107,500
Estimated number of plant locations	190	258,000	140,000	398,190
Estimated increase in selling price for implementing BAT (percent).(1)	5.1	4.7	0.3	

(1) The values shown for secondary and consumer industry groups do not include the pass-through increases required to achieve BAT by the previous industry group.

(2) The total employment for this industry group may include employees from the primary and secondary industry groups.

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products industry. The results represented are considered as the MINIMUM since hard data were limited concerning employment levels and fiber counts in the secondary and consumer industries. The most significant variable in developing total annual costs is the number of employees continuously or frequently in the work environment. Any increase in the number of employees will have a corresponding increase in the total annual costs.

- The capital costs to achieve BAT (in 1975 dollars, exclusive of current capital dollars) is estimated at $1,113,950,000. These costs are in the primary and secondary industry groups since the consumer industries are assumed not to have ceiling or 8-hour TWA exposure above the proposed standard.

- Total annual costs to achieve BAT (in 1975 dollars exclusive of current annual costs) are estimated at 3,970,400,000 for the primary, secondary, and consumer industries. The largest costs are the industrial hygiene and medical program costs, which represent, when compared to total annual costs: 51 percent for the primary, 85 percent for the secondary, and 100 percent for the consumer industries. The average is 89 percent.

- The minimum estimated number of employees continuously or frequently in the work environment is 14,107,500 for the three industry groups.

- The estimated number of work establishments continuously subject to the proposed standard is 398,190 for primary, secondary, and consumer industries.

- Each industry group will be required to increase its selling prices to recover the total annual costs to achieve BAT. The increase for primaries is 5.1 percent, for secondaries is 4.7 pe:cent and for consumers is 0.3 percent. These cost increases do not include the pass-through costs required by the previous group to implement BAT.

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SECTION 2
INTRODUCTION

The Asbestos Information Association/North America (AIA/NA) is an incorporated, non-profit organization representing industries involved in the mining, milling, processing, and sales of asbestos in the United States and Canada. AIA/NA has these objectives:

- To provide industry-wide information on asbestos and health and on industry efforts to eliminate existing hazards.
- To cooperate with governmental agencies in developing and implementing industry-wide standards for worker protection and for the control of asbestos dust emissions into community air and water.
- To exchange information on methods and techniques of asbestos dust control.
- To correct misleading and uninformed reporting on asbestos health problems.
- To publicize the unique benefits and importance of asbestos products, and otherwise represent the asbestos industry.

The Board of Directors of AIA/NA, upon review of the revision of the existing standard for Occupational Exposure to Asbestos proposed by the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor, determined that the proposed revision may not be technologically feasible and could have a severely adverse economic impact on the industry. Consequently, the Board of Directors set up an AIA/NA industry-regulation task force and directed it to:

- Develop an industry response to the proposed OSHA revision of the asbestos standard.
- Secure the participation of non-AIA-member companies in the development of the industry response.
- Select a qualified consultant to prepare a Technological Feasibility and Economic Impact report.
- Solicit industry's comments and recommendations on all phases of the proposed (revised) asbestos standard.
- Summarize industry's comments and recommendations, and submit the recommendations to OSHA.

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Purpose of the Present Project

AIA/NA retained Roy F. Weston to gather data and opinions from participating companies and to prepare the Technological Feasibility and Economic Impact report. The purpose of this project is an objective evaluation of the effect of OSHA's proposed revision to the asbestos standard on the entire asbestos industry. OSHA's proposed standard excludes the construction industry; thus, Weston's study only encompasses the industries covered by the proposed standard (reference 29 CFR Part 1910).

Industry Structure

Asbestos is a widely used inorganic fiber whose properties make it particularly well suited to many applications requiring strength, chemical inertness, mold and mildew resistance, and non-flammability.

Many asbestos products pass through several manufacturing and fabrication steps before they reach the consumer. It is logical to expect different exposure levels and control technologies at different steps in the manufacture of any particular product; Weston, therefore, classified the asbestos products industry into three groups:

- Primary Industries: those industries that start the manufacturing process with raw asbestos fiber and modify the fiber to produce an intermediate product (to be further processed or fabricated) or a finished product.

- Secondary Industries: those industries that continue the manufacturing process with an intermediate asbestos product (one in which the fiber has previously been modified in a primary industry), and further process, modify, or fabricate it to produce either another intermediate product (to be further processed or fabricated) or a finished product.

- Consumer Industries: those industries that purchase a finished asbestos-containing product (from a primary or secondary industry), and apply, install, erect, or consume the asbestos-containing product without further physical modification of the product.

This classification is depicted in Figure 2-1.

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The following example provides further illustration of these three industry groups:

- Company A purchases raw asbestos fiber, combines it with cement and other materials, and forms it into an asbestos cement sheet. Company A sells this material to Fabricator B.

- Fabricator B cuts the asbestos cement sheet, and sands it to a smooth finish. Fabricator B sells this material to Laboratory Furniture Manufacturer C.

- Laboratory Furniture Manufacturer C then sells the finished asbestos cement sheet as a laboratory tabletop.

- Company A represents a Primary Industry.
  Fabricator B represents a Secondary Industry.
  Laboratory Furniture Manufacturer C represents a Consumer Industry.

Primary industries will always experience some worker exposure to asbestos fiber, because it is virtually impossible to handle raw fiber without the release of some fiber to the atmosphere. Primary industries are a well-defined industry group and can be readily identified as those which purchase asbestos fiber. This industry group can be further sub-divided by the type of products produced:

Asbestos Paper.
Asbestos Cement Pipe.
Floor Tile.
Friction Products.
Paints, Coatings, and Sealants.
Asbestos Cement Sheet.
Gaskets and Packings.
Asbestos-Reinforced Plastics.
Asbestos Textiles.
Miscellaneous.

Employees in secondary industries will generally experience exposure to asbestos fiber from the release of fiber through further modification of an asbestos-containing product. However, it is conceivable that a particular secondary industry could operate with no employee exposure to asbestos fiber. The secondary industries are a much more diversified group than the primary industries, and are also more difficult to define and enumerate than the primary industries. They

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are generally smaller in size, employment, and sales. Many secondary industries also handle, process, or fabricate other materials not containing asbestos; their use of asbestos products may range from occasional to full-time.

Consumer industries may experience some employee exposure to asbestos fiber. However, based upon this study, Weston determined the exposure to employees to be below the proposed standard. This group is even more diversified than the secondary industries. Identification is difficult, since its members may be several steps removed from the original asbestos product.

Scope of Investigation

Weston's services covered both the technological feasibility and the economic impact of OSHA's proposed revision of the asbestos standard.

Primary Industries

The principal investigations and activities performed by Weston were:

- Development of a questionnaire requesting data specific to: General Product/Process Information; Control Technology/Cost Information; Industrial Hygiene and Health Information; Economic Impact Information; and Information regarding Manufacturers/Fabricators of asbestos-containing products. Follow-up activities to the questionnaire consisted of on-site collection of industry-provided data and information, as well as data and information collection by telephone discussions and receipt of questionnaires by mail (Appendix A).

- Definition of primary asbestos industries by segment and by the major steps in the processing or formulation of products containing asbestos.

- Data compilation and assessment, developed in the preceding steps, for the purpose of characterizing the industry segments for major steps in the processing or formulation of products containing asbestos, to determine:

  - The present status of industry compliance with the current standard.

  - The best available technology ("BAT").

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- Preparation of a Technological Feasibility and Economic Impact report on the proposed revision to the asbestos standard, including an assessment of the technological effect on industry segments, as well as the micro-economic effect on these industry segments.

Secondary and Consumer Industries

On 11 February 1976, Weston submitted an addendum to its original proposal, to cover extension of the scope of the technological feasibility and economic impact of the proposed OSHA asbestos regulations to include the secondary and consumer industries in the overall survey. The purposes of this extension were to assess the full impact of the proposed regulations (excluding the construction industry) on the asbestos-consuming industry, and to define the effects throughout the industry chain (primary, secondary, and consumer industries). Thereby Weston would be able to estimate the end-market effects of the proposed regulations on each of the major industry segments.

The amended proposal by Weston included the following activities:

- Characterization of secondary and consumer industries to include: a general description, number of facilities and employees exposed, sales dollars, production, and degree of asbestos usage.

- Development of a technology base for secondary and consumer industries by: type of process, typical fiber counts, control equipment and work practices, BAT, and costs for BAT.

- Determination of: the economic impact on secondary and consumer industry, including the effect of foreign trade.

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This report represents the results of Weston's data collection, compilation, and analysis activities, and provides information received from the asbestos industry. Conclusions drawn on the basis of these activities represent Weston's objective assessment of the data and information collected.

Standards

Background

OSHA initially promulgated a standard for occupational exposure to asbestos on 29 May 1971. However, on 4 November 1971 the Industrial Union Department of the AFL-CIO petitioned OSHA for an emergency standard to control concentrations of asbestos dust. As a result, on 7 December 1971 OSHA promulgated an emergency temporary standard concerning exposure to asbestos fibers. A notice of proposed rule-making regarding a permanent standard was published in the Federal Register on 12 January 1972. Arguments both orally and in writing concerning data and opinions were made on the proposed permanent standard. Resulting from this rule-making procedure, OSHA promulgated, on 7 June 1972, a permanent standard for exposure to asbestos fibers. This standard prescribed permissible exposures to be effective 7 July 1972 and 1 July 1976.

The 7 July 1972 standard stated that the permissible exposure to airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed 5 fibers (longer than 5 micrometers) per cubic centimeter of air for an 8-hour time-weighted average concentration. The permissible exposure to airborne concentrations of asbestos fibers which any employee may be exposed as of 1 July 1976 would be: not to exceed 2 fibers (longer than 5 micrometers) per cubic centimeter of air for an 8-hour time-weighted average concentration.

In addition to permissible exposure to airborne concentrations of asbestos fibers, the standard described:

- Methods of Compliance.
  1) Engineering Methods.
  2) Work Practices.
- Personal Protective Equipment.
- Methods of Measurement.
- Monitoring.
- Caution Signs and Labels.
- Housekeeping.
- Record Keeping.
- Medical Examinations.

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In 1974, as a result of a decision in the case of Industrial Union Department, AFL-CIO vs. Hodgson, the United States Circuit Court for the District of Columbia directed the Secretary of Labor to:

1. Reconsider the effective date (1 July 1976) for the present standard, and determine whether such a date might be accelerated for all or some industries so affected.

2. Review the record-keeping provision requiring a 3-year retention period for exposure-monitoring records, to determine whether such a time period would be adequate to assure employee protection and prevention of asbestos-related diseases.

Proposed Standard

On 9 October 1975, OSHA published in the Federal Register a notice of proposed rule-making concerning the occupational exposure to asbestos. The proposed revision would reduce the permissible exposure limit to an eight-hour time-weighted average of 0.5 fibers per cubic centimeter for all segments of the asbestos industries except construction activities.

Permissible levels for the construction industry would continue under the present standard, which has a ceiling limitation of 10 fibers/cc. OSHA indicated that separate rule-making is planned for revising the construction asbestos standard.

The proposed standard broadens the content of the existing standard and utilizes the format developed by OSHA's standards-completion program. Sections included in the proposed standard are:

- Permissible exposure to airborne concentration of asbestos fibers.
- Regulated areas.
- Monitoring.

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- Methods of compliance.
- Respiratory protection.
- Personal protective clothing.
- Hygiene facilities and practices.
- Medical surveillance.
- Employee information and training.
- Danger signs and labels.
- Housekeeping.
- Record keeping.
- Observation of monitoring.

(For a more detailed discussion, see the Federal Register, 9 October 1975, pages 47660-47665, and FR 17 December 1975, pages 58457-58458.)

Information Sources and Overall Approach

The predominant data source for this study was the asbestos industry itself. For the types of information required (fiber counts, work practices, equipment costs, etc.), the industry was not only the best source, it was often the only source. There is an obvious hazard in such an approach, in that an industry may bias its data to support conclusions which it would like to see drawn. To avoid this problem, several steps were taken:

1. For the most part, "hard" data (rather than opinions) were requested. Where estimates or projections were involved, the report is so documented.

2. Data were collected from as many plants as possible within each industry segment. This allowed comparison of data from one plant to another, and lessened the effect of any one plant on the data summaries.

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3. The efforts to comply with the existing regulations and the historical impact provided a yardstick for gauging the predicted impact.

Data were collected in three ways:

1. Plant visits.
2. Questionnaires.
3. Telephone interviews.

The purposes of the plant visits were to obtain more detailed information than could be solicited by questionnaire, and to provide an opportunity for plant inspections.

Overall, 56 plants visits were made, including 48 at primary industries, 13 at secondary industries (some plants included both primary and secondary facilities), and one visit to a fiber-warehousing facility.

The questionnaire (Appendix A) provided a convenient means of obtaining broad coverage of the entire asbestos products industry, including both raw fiber and asbestos products. Names of those to be contacted by questionnaire were provided by AIA members. Of the 601 questionnaires mailed, 140 were completed and returned, a response of 23 percent. Of those returned, 81 (representing 108 plants) were from primary industries and 32 from secondary industries.

The total U.S. asbestos fiber usage for 1975 was estimated at 900,000 tons by one industry member; this value is slightly higher than the 817,000 tons consumed in 1974. Table 2-1 indicates asbestos utilization by primary industry segment (data provided by industry members), and the industry coverage in tons of asbestos consumed and number of companies represented by the survey (plant visits and questionnaires).

Telephone contacts provided information from sources other than the industry itself. Some of these sources included: insurance companies, trade organizations, retail organizations, and medical and industrial hygiene organizations. This information was then utilized throughout all phases of the asbestos regulation study, including definition of Best Available Technology (BAT) and economic impact analysis.

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Table 2-1

Asbestos Fiber Usage and Percent of Coverage
of Each Industry Segment

	Industry Segment	% of U.S. Asbestos Usage	Tons Consumed	Tons Represented by Survey	% of Coverage	Companies Responding to Survey	Plants Covered by Survey
1	Asbestos Paper	38.0	342,000	182,000	53	12	17
2	Asbestos Cement Pipe	16.0	144,000	144,000	100	4	13
3	Floor Tile	12.5	112,500	43,400	39	5	9
4	Friction Products	6.5	58,500	35,100	60	12	13
5	Paints, Coatings and Sealants	7.5	67,500	20,500	30	16	26
6	Asbestos Cement Sheet	6.0	54,000	48,000	89	[illegible]	8
7	Gaskets and Packing	3.0	27,000	11,000	41	7	7
8	Asbestos-Reinforced Plastics	2.0	18,000	9,900	55	5	5
9	Asbestos Textiles	1.5	13,500	12,900	96	3	5
10	Miscellaneous	7.0	63,000	20,000	32	4	5
	Total	100.0	900,000	526,800	58		108

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SECTION 3
METHODOLOGY AND DATA PRESENTATION FOR THE PRIMARY INDUSTRIES

Nine of the ten segments of Primary Industries (see Industry Structure in Section 2) have been analyzed on the basis of technological feasibility and of economic impact. The tenth segment (Miscellaneous) has not been analyzed for economic impact, because the diverse responses from that segment were not amenable to further analysis.

Technological Feasibility

Method of Analysis

Once the raw data were assembled, the technical and engineering information was compiled on a segment-by-segment basis. Each of the ten segments comprising the asbestos primary industries is described in detail in Section 4, as is Receiving and Storage, which is a common first step in all of these segments. The order of discussion is as follows:

Process Description
Work Practices/Controls
Existing Fiber Counts
Best Available Technology (BAT)
Projected Fiber Counts (with BAT)
Advanced Technology

The process descriptions for the industry segments emphasize fiber-emission aspects of the process, rather than product movement or unit operations. One of the primary functions of this survey was to identify similar process steps within the industry that might be adaptable to the same control technology. An example of such a common step is the fiber receiving and storage. Within most segments, similar process technology was found at most plants.

Existing engineering controls and work practices employed at each step in the process flow diagrams were defined. By collection of this information, the full range of control equipment currently used could be determined.

Time-weighted average (TWA) fiber count data were obtained for every work station or significant operation in the process. Note that all fiber count data included in this

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section have been reported as TWA exposure. In many instances, an 8-hour TWA exposure was calculated and reported, even though the worker typically spent less than a full shift at one location. The objective of calculating a TWA on the basis of the employee's being at the work station for 8 hours was to insure adequate control in the event that process or production rate changes would require an operator to stay at one work station for a full shift.

Fiber Count Distribution

The distribution of fiber count data received by Weston appears in Figure 3-1. The 270 data points reported from the present survey should not be assumed to be singular measurements of fiber count data (TWA). Rather, the 270 data points are based on numerous tests by the industries, and therefore represent a larger data base. The broad distribution of data may be the result of: 1) variations in extent of fiber control from one segment to another; 2) variations from one plant to another; 3) variations from one process step to another; or 4) day-to-day variations in fiber count at the same work station. An objective of this study is the determination of the cause or causes of the data spread. Explanations and qualifications of reported data for given process steps are included in the appropriate discussions of the primary industry segments in Section 4 of this report.

Employee Exposure

Employment and exposure levels are presented in Table 3-1. The numbers of employees surveyed were taken directly from the questionnaires, and projected employment levels were based on the segment coverage figures in Table 2-1. Total projected employment in the primary asbestos industries is estimated to be 37,500, which is approximately 0.2 percent of the overall manufacturing work force. Very likely, this estimate is low, because in this survey a higher proportional response was received from larger plants. Small plants tend to be more labor-intensive; larger plants are likely to be more capital-intensive and more efficient. Projected figures, therefore, were based on large facilities and may tend to underestimate total industry employment.

Also, 37,500 represents employment at the plant level, and does generally include corporate staff such as management, administrative, research, engineering, and sales personnel.

The Miscellaneous segment was omitted, because it tended to misrepresent true exposure levels in those plants handling the bulk of asbestos tonnage. Employees in the Miscellaneous

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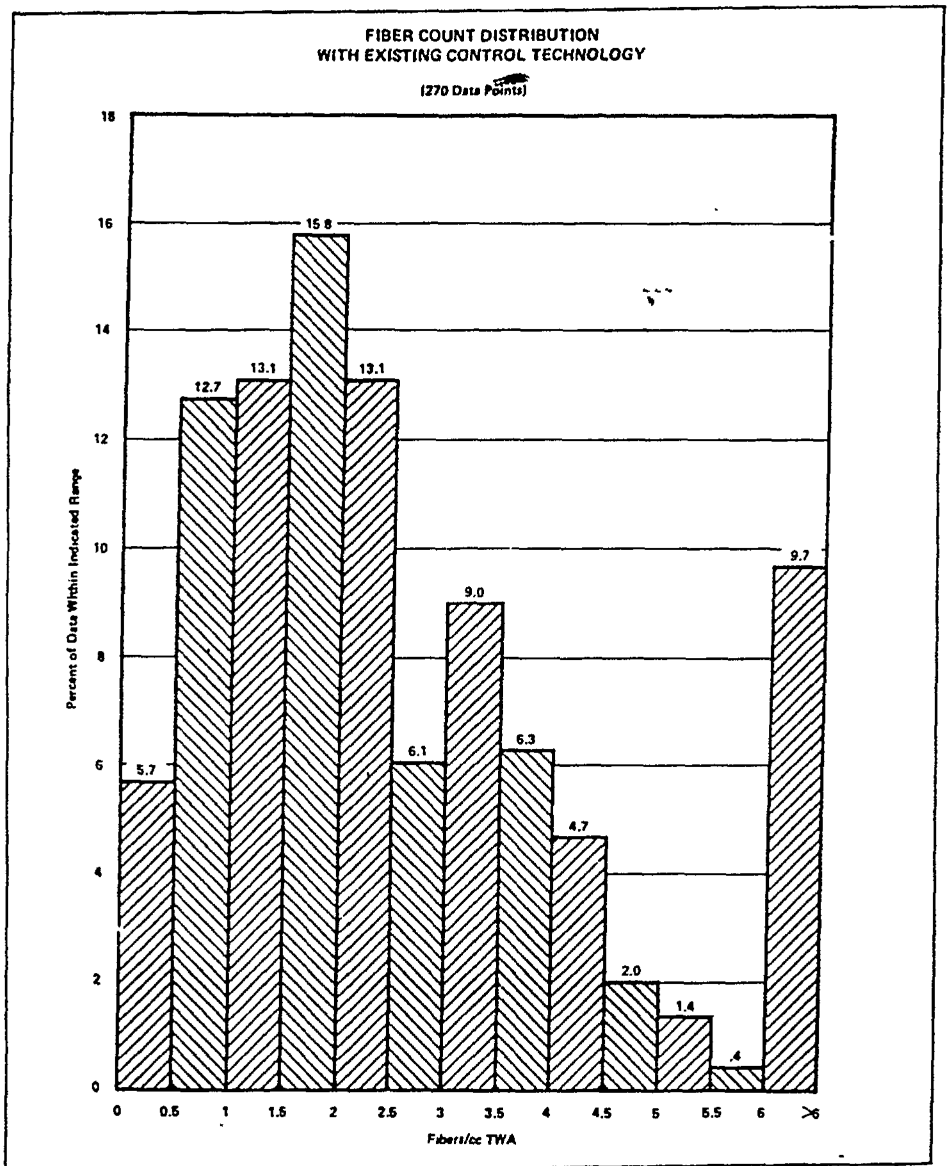

FIGURE 3-1 FIBER COUNT DISTRIBUTION WITH EXISTING CONTROL TECHNOLOGY

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Table 3-1

Number of Employees at Various Exposure Levels
Primary Asbestos Industries

Industry Segment	Continually in the Work Environment		Frequently in the Work Environment		Occasionally in the Work Environment		Never or Only Very Infrequently in the Work Environment		Total	
	Surveyed	Total in Segment	Surveyed	Total in Segment	Surveyed	Total in Segment	Surveyed	Total in Segment	Surveyed	Total in Segment
1. Asbestos Paper	608	1,147	285	538	124	234	1,344	2,536	2,361	4,455
2. Asbestos Cement Pipe	1,643	1,643	350	350	123	123	253	253	2,369	2,369
3. Floor Tile	1,137	2,915	269	759	368	944	796	2,041	2,570	6,659
4. Friction Products	2,937	4,895	607	1,012	412	687	426	710	4,382	7,304
5. Paints, Coatings and Sealants	106	353	130	433	107	357	566	1,887	909	3,030
6. Asbestos Cement Sheet	550	618	117	131	40	45	406	456	1,113	1,250
7. Gaskets & Packings	259	632	120	293	141	344	2,006	4,893	2,526	6,162
8. Asbestos-Reinforced Plastics	467	849	112	204	51	93	783	1,424	1,413	2,570
9. Asbestos Textiles	2,296	2,392	329	343	323	336	642	669	3,590	3,740
TOTALS	10,003	15,444	2,319	4,063	1,689	3,163	7,222	14,869	21,233	37,539
Percent By Exposed Category	47.1		10.9		8.0		34.0		100.0	

segment do not make asbestos products similar to other Primary Industry segments; but, generally use small quantities of asbestos fiber to make an end-product more typical of secondary industries. In most of these plants, a relatively small number of employees handle asbestos; for example, in one plant only 5 of 1,140 employees handle asbestos. Including such a plant in Table 3-1 would tend to indicate a generally lower level of exposure than actually occurs.

The categories of exposure are defined as follows:

1. Continually in Work Environment: those whose normal work station is at a location involving asbestos exposure (production employees).

2. Frequently in Work Environment: those who enter an area of asbestos exposure on a daily basis, but who are not continuously assigned to such a location (maintenance personnel, foremen, supervisors).

3. Occasionally in Work Environment: those exposed to asbestos fiber, but who enter the work area on a less than daily basis (engineers, plant management, specialty maintenance personnel).

4. Never or Very Infrequently in the Work Environment: those employed at the plant, but not in a production area (secretaries, clerks, guards).

Data provided by industry indicated 66.0 percent of plant personnel exposed on a regular basis (Categories 1, 2, 3), or 24,750 employees. It is our opinion that this estimate is low; it is unlikely that 34.0 percent of employees at the plant level do not enter the work area on a regular basis. We believe that many responding to the questionnaire equated the four categories of exposure with levels of exposure (i.e., TWA fiber count), and, indeed several respondents indicated such. The proposed standard affects all those who are exposed to any levels, even if on an intermittent or non-routine basis. For instance, a clerk may spend virtually all his time in an office, except for fifteen minutes on Friday afternoons, when he delivers the payroll. This employee falls into Category 3, and is affected by certain parts of the proposed standard.

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Ranges and Typical Data Value Statements

The data reported to Weston on the industry questionnaires, as well as the data from plant visits and telephone contacts, were in the form of ranges of exposure levels or in the form of a single value that represented multiple data points. All data were assumed to be representative of employee exposures under normal production conditions for the processing steps involved. In several instances, however, the data range was extremely broad, indicating questionable sampling or counting procedures, or the inclusion of data collected during the non-routine operations. When such data anomalies were evident, Weston discarded those few anomalous data which appeared questionable. The resultant values are indicated for the segment and for each process step as: "range of fiber count with existing control technology, fibers/cc".

The range of fiber count with existing control technology is further simplified by condensing the range into a single or "typical" value for each processing step. Where sufficient data exist, the typical value is approximated by the average of data points. In some instances, available data were insufficient for calculation of a meaningful average; in such a case, Weston selected a value which, in our judgement, would represent the "typical" value. The resultant values are indicated for the segment and for each process step as: "typical fiber count with existing control technology, fibers/cc".

Best Available Technology (BAT)

Best Available Technology (BAT) is defined as control equipment, process modifications, work practices, or combinations thereof which have been demonstrated to provide the most effective control or reduction of contaminant (asbestos fiber) emission. Specification of BAT at each process step will set the standard by which the feasibility of attaining any specified TWA exposure will be determined.

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While each manufacturer was asked to report his equipment and capital requirements for BAT, the BAT defined in this section was based on the engineering analysis and judgment of the Weston staff. In some instances, BAT and existing controls and procedures were identical. BAT for one processing step may set the standard for other steps in the same industry segment, or for processes in other segments.

Industry was also asked to project the TWA fiber count based on implementation of controls. While this input was considered in formulating the projected fiber count reported in this section, the fiber count reported is based on the engineering judgment of the Weston staff, and on the reported data for existing fiber counts and existing control equipment. It is notable that, in most cases, the projected BAT falls near the low end of the reported existing fiber count range. Such a result should be expected on the basis of the definition of BAT, and its occurrence adds validity to the data. The projected fiber counts after implementing BAT are designated as average values. Variations in these projections must be expected depending upon individual plant situations which may affect the projected values.

Where Best Available Technology was not expected to achieve a TWA of 0.5 fiber/cc, an advanced technology was suggested. Advanced technologies are those controls, work practices, or process modification which might be expected to reduce fiber count to levels lower than those achievable via BAT, but which have not yet been developed, commercially operated, or proven effective.

Economic Impact

Method of Analysis

To determine the economic impacts for the segments of the primary asbestos industry, the data obtained from the questionnaires were extrapolated on the basis of raw-fiber tonnage utilized in that segment.

Although each segment was surveyed, some responses were not used for the economic analysis because they did not contain sufficient information. The extent of the segment's response to the questionnaire is given, and the percent usable data for generation of cost information is present in each segment, to make clear the data base for this study.

A sample questionnaire appears in Appendix A. From the questionnaires received, Weston summarized pertinent information on an Economic Impact Approach Worksheet (Table 3-2). The asbestos utilization (tons/year), asbestos content in the product, and 1975 asbestos-product sales volume were taken directly from each questionnaire. The capital costs and the related operating costs to achieve BAT were taken from Question 17 of the questionnaire. These costs were assumed to be direct costs related to installing and operating BAT equipment, and for accomplishing any changes in work practices as defined by Weston's selection of BAT.

Typical total annual capital expenditures, shown as Item E on the worksheet (Table 3-2), were averages of each company's response to Question 5. These individual company averages were combined to calculate an average for the industry segment, and this, together with the production information (in tons), was used to extrapolate the value to the entire segment. These costs were assumed to be the normal capital expenditures for existing control equipment, process modifications, technology upgrading, capacity increases, and work practices.

The annualized capital cost to achieve BAT was amortized over a 5-year period at 8 percent interest.

Industrial Hygiene and Medical Program Costs

The industrial hygiene and medical program costs include the incremental costs involved in complying with the following paragraphs of the proposed standard:

- Monitoring
- Respiratory Protection
- Personal Protective Clothing
- Hygiene Facilities and Practices
- Medical Surveillance
- Employee Information and Training
- Recordkeeping

To determine what the methods industry would use to comply with the proposed standard, Weston developed Section III of the questionnaire, Industrial Hygiene and Health Information (Appendix A, pages A-7 to A-9). Additionally, Weston discussed and collected data from physicians, industrial hygienists, nurses, technicians, health care professionals, professional and technical organizations, as well as governmental agencies concerning availability of equipment, facilities, and manpower. From these sources, Weston developed industrial hygiene and medical program costs per employee per year, as shown in Table 3-3.

The total annual cost to achieve BAT includes a summation of annualized capital and operating costs, and industrial hygiene and medical program costs.

Table 3-2

Work Sheet
Economic Impact Approach

A.	Tons of Asbestos/Year		________
B.	Tons/Units of Product Containing Asbestos		________
C.	1975 Sales Volume		$________
D.	Capital Cost to Achieve BAT		$________
E.	Typical Total Annual Capital Expenditures		$________
F.	Number of Employees		________
G.	Costs:		
	1. Annualized Capital to Achieve BAT[1]	$________	
	2. Operating Costs to Achieve BAT	$________	
	3. Industrial Hygiene and Medical Program (Medical + Lost time + Physicals)[2]	$________	
H.	Total Annual Costs		$________
I.	Unit Cost of Product (C ÷ B)		$________/Ton
J.	Incremental Unit Cost (H ÷ B)		$________/Ton
K.	Total Annual Costs/Average Annual Sales (H÷C)		________%
L.	Capital Cost to Achieve BAT/Typical Total Annual Capital Expenditure (D÷E)		________%

[1]Five-years at 8 percent interest

[2]$900 per exposed employee incremental cost for primary segments

BAT = Best Available Technology

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The percent coverage factor was used to relate the economic impact estimates from each company to the entire industry segment. The total annual cost was then divided by the average annual sales to determine the percent increase in company operating costs brought about by the additional expenditures required for compliance with the proposed OSHA standard, and is expressed as a percentage of the current selling price of the product.

As a further measure of economic impact, the capital cost to achieve BAT was divided by the industry segment's typical total annual capital expenditure. This percentage indicates the relative portion of an industry's total annual capital outlay required to implement BAT. For a fixed yearly capital improvement program, the higher the portion for BAT, the less remains for productivity improvements and expansions.

The economic impact was developed for all the industry segments, except Miscellaneous, which was excluded because the diverse responses from that segment were not amenable to further analysis.

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Table 3-3

Incremental Costs for
Industrial Hygiene and Medical Program

Primary Asbestos Industries

1.	Monitoring	$ 80
2.	Respiratory Protection	205
3.	Personal Protective Clothing	290
4.	Hygiene Facilities and Practices	260
5.	Medical Surveillance	10
6.	Employee Information and Training	50
7.	Record Keeping	5
	Total/Employee/Year	$900

Note: Labor costs per hour were estimated at $5.00/hr direct + 20% overhead, or $6.00/hr.

The bases for the figures in Table 3-3 are as follows:

1. Monitoring: The proposed standard permits "An employee in one shift may be deemed a representative of all employees in other shifts...." Weston estimated that monitoring 25 percent of the employees will provide data representative of employee exposure in the work environment. The existing standard requires samples taken at least twice per year for personal monitoring and twice per year for environmental monitoring (4 samples per year). The proposed standard requires monthly monitoring (12 samples/year), when monitoring shows an employees' exposure above the 8-hour TWA or the ceiling concentration. At an estimated cost of $40/sample for counting (Question 20, h & i), the cost per employee is:

   (.25) (8 samples/year additional requirement) ($40/sample) = $80

2. Respiratory Protection: In the development of process flow diagrams for this study, 86 process steps were documented. 56 of these would have exposure levels higher than 0.5 fiber/cc after implementation of BAT; therefore 56/86, or 65 percent,

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of the process steps would require respiratory protection. Table 3-1 (Employee Exposure) indicated that 58 percent of the employees are continuously or frequently in the work environment. The cost is based on use of reusable respirators, with replacement filters ($2.80/filter replaced weekly) and an estimated 0.1 hour required for cleaning, sanitizing, stocking, and fitting of the respirator.

(.65) (.58) ($2.80/filter) (50 wks/yr)
+ (0.1 hr) ($6.00/hr) (250 days/yr) = $205

3. Personal Protective Clothing: This part of the cost was based on 58 percent of the employees being continuously or frequently in the work environment (from 2 above) and requiring daily uniform changes. Estimated at $2.00/uniform for the disposable type.

   (.58) ($2.00/uniform) (250 days/year)
   = $290

4. Hygiene Facilities and Practices: It was assumed that all primary industries had change room/shower/lavatory facilities (information collected during study). The cost is based on 58 percent of the employees being continuously or frequently in the work environment (from 2 above) and required to shower daily, and on 0.3 hr of non-productive time required to shower and clean up.

   (.58) (0.3 hr) ($6.00/hr) (250 days/year) = $260

5. Medical Surveillance: The proposed standard adds sputum cytology as an additional requirement. Laboratory costs of $7.00 and 0.5 hr/examination were estimated.

   ($7.00) + (0.5) ($6.00/hr) = $10

6. Employee Information and Training: Estimated at 8.0 hrs/year to provide training and information.

   (8.0 hrs/year) ($6.00/hr) = $50

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7. Recordkeeping: Costs provided by industry for Question 20, d & e, averaged $5/employee additional costs for medical and exposure records. No data were available for mechanical ventilation measurement or employee training records.

Receiving and Storage[1]

The manufacturing process for all asbestos products starts with fiber receiving, warehousing, and storage. Since this step is common to all, it is described in detail, once, before the segment-by-segment discussion. The descriptions, technologies, and fiber counts included in this discussion are generally applicable to all segments of the primary industries, although some small asbestos fiber consumers will probably not be able to implement advanced technologies, if and when they are developed, because of economic limitations.

Technological Feasibility

Process Description

Dry asbestos fiber is normally transported in rail cars, bagged as palletized cargo. It is unloaded by fork lift truck or manually, depending on the quantity and frequency of delivery. The fiber is then stored in a warehouse for use in the manufacturing operation. When needed, it is trucked to the fiber introduction area.

Work Practices/Controls

Protecting the integrity of the asbestos bag during transportation is an important step in minimizing asbestos exposure during the unloading operations. The following practices are in use to minimize damage to the asbestos bag: inflatable dunnage, lined rail cars, palletized loading, wide cargo doors, shrink-wrapped pallets, and double-sealed bags. In addition, housekeeping practices such as taping broken bags and vacuuming the cars prior to unloading are also effective.

Careful unloading of the pallets of asbestos bags from the rail cars is one of the most important responsibilities of the fork lift truck operator. If the operator, by careful unloading, transporting, and stacking, can prevent damage to the bags, asbestos exposure in the receiving and storage

[1]Step 1 in all segments of the primary asbestos industries.

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areas is low. However, if bags are damaged and not immediately repaired, and the spill is not cleaned up promptly, there could be high dust exposure in both the receiving and warehouse areas; this exposure would also occur in the fiber introduction step when the damaged bags are trucked to this area.

Bulk shipment of compressed asbestos pellets and blocks is available from selected suppliers. However, this form of asbestos, although less dust-producing in receiving and warehousing, necessitates added equipment in the fiber introduction step to break up the pellet or block, because conventional beaters and hydropulpers are not designed for this. This added equipment is a potential dust source. Since this form of fiber shipment is in a development stage with respect to the equipment needed to open the fibers and the effects of using this fiber on product quality, it is defined as advanced technology.

Existing Fiber Counts

From a survey of all primary asbestos industry segments, the range of asbestos exposure in receiving and storage is 0.25 to 2.5 fibers/cc TWA; a typical exposure level is 1.0 fibers/cc TWA. The upper portion of the exposure range is characteristic of damaged shipment, careless unloading procedures, and ineffective housekeeping practices. The most important single factor influencing high asbestos exposure is the condition of the bags in which the asbestos is shipped. Generally, loading and shipping procedures are not controllable by the customer. Therefore, cleaning in the car before unloading and repairing broken bags serves only to lessen the exposure and is not a totally effective control.

Best Available Technology (BAT)

Best available technology for receiving and warehousing asbestos fiber includes all of the practices discussed under Work Practices/Controls plus: improved packaging; stronger pallets; standardized minimum number of sizes for bags, and improved transportation practices. Control of the BAT involved in transportation and packaging may lie with the shipping and supplying companies, rather than with the purchaser of asbestos fiber. Therefore, the BAT is not applicable to these plants and the purchasers are limited in their ability to reduce asbestos exposure to in-plant control measures.

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Projected Fiber Counts (with BAT)

Employing the best available technology exclusive of controlling transportation and packaging practices, will reduce asbestos exposure in the receiving and storage steps to 1.0 fibers/cc TWA. If BAT includes improvements in shipping and packaging, exposure to asbestos dust will be 0.5 fibers/cc TWA.

Advanced Technology

This category includes shipments of fiber in compressed pellets and blocks. This form of asbestos is available to a limited degree. However, equipment designed to break open the pellets or blocks is under development; additionally, effects on product quality are being investigated.

Specially-designed rail cars which maximize fork lift truck access must be made available. Such cars will minimize damage to asbestos bags by lessening the probability of bumping into the sides of the car with the truck. Fully containerized shipment of fiber may be an alternative to bags. The container is a sealed metal canister which is transported as a unit to the user, warehoused, and placed on a receiver in the fiber introduction step. The canister is then opened automatically and the fiber dumped into the process under negative pressure, to prevent release of the fiber. When empty, the canister is returned to the asbestos supplier to be refilled.

Bulk shipment of dry fiber via rail or truck hopper cars has been investigated. However, the fibers tend to bridge in the cars and silos, and cause problems in unloading, conveying, and storing. Further developmental work in this area is needed to overcome the operational shortcomings.

Conclusions

- With implementation of Best Available Technology (exclusive of packaging and transportation procedures), the exposure level in the fiber receiving and storage step can be reduced to 1.0 fiber/cc TWA.
- With implementation of BAT that includes packaging and transportation improvements, the exposure level in the fiber receiving and storage step can be reduced to 0.5 fiber/cc TWA.

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- Most of the companies involved in the primary asbestos industry segments will be able to meet the standard of 2.0 fibers/cc TWA for fiber receiving and storage, by improving present operations.

- The use of a BAT that includes packaging and transportation improvements is impossible for many plants, because they do not have effective control over the supply and transportation procedures.

Asbestos Paper

Technological Feasibility

The production of asbestos-containing paper products involves a series of processing steps similar to those in the manufacture of pure cellulosic materials. The asbestos content of the finished material may vary from five percent to essentially 100 percent, depending on the ultimate use of the product. Asbestos papers are used in the electrical industry for paper tubes and tapes. The asbestos content imparts the excellent thermal and electrical resistance necessary for its effectiveness as insulation and fire protection for electrical conductors. These papers may also be impregnated with a variety of specialized laminates for use as switchboards. Other specialized uses in the electrical field include electrofine paper and diaphragms for brine electrolysis cells. Asbestos papers, combined with other "sandwich-type" materials, are used in making head gaskets for internal combustion engines.

Coarse grades of asbestos paper are impregnated with bitumen and used for roofing felts and pipe wrapping. Here, the asbestos fibers impart a high degree of dimensional stability and rot-proofing to the felt. In spite of the dimensional stability, the fibers allow slight movement of the felt to accommodate expansion/contraction movements of the underlaying structure without cracking. Roofing felts may be used for the entire roof or as damp-proof courses (underlayments) in conjunction with other roofing materials. Pipe wraps are used to provide corrosion-resistant barriers for pipelines and piping. Latex-bound asbestos papers are extensively used in the floorings industry as underlayments for sheet vinyl. Again, these papers impart characteristics of dimensional stability, durability, resistance to alkali chemical attack, and thermal insulation.

Process Description

As shown in Figure 4-1, the production of asbestos paper products begins with introduction of dry asbestos fiber (Step 2). Here, the individual asbestos bag is opened (manually or semiautomatically), and the contents are dumped into a storage hopper and conveyed to the stock preparation area (Step 3). Many process combinations are practiced in the industry with respect to Steps 2 and 3. For instance, both steps may be combined by introducing the asbestos fiber directly into the stock preparation without the intermediate storage and

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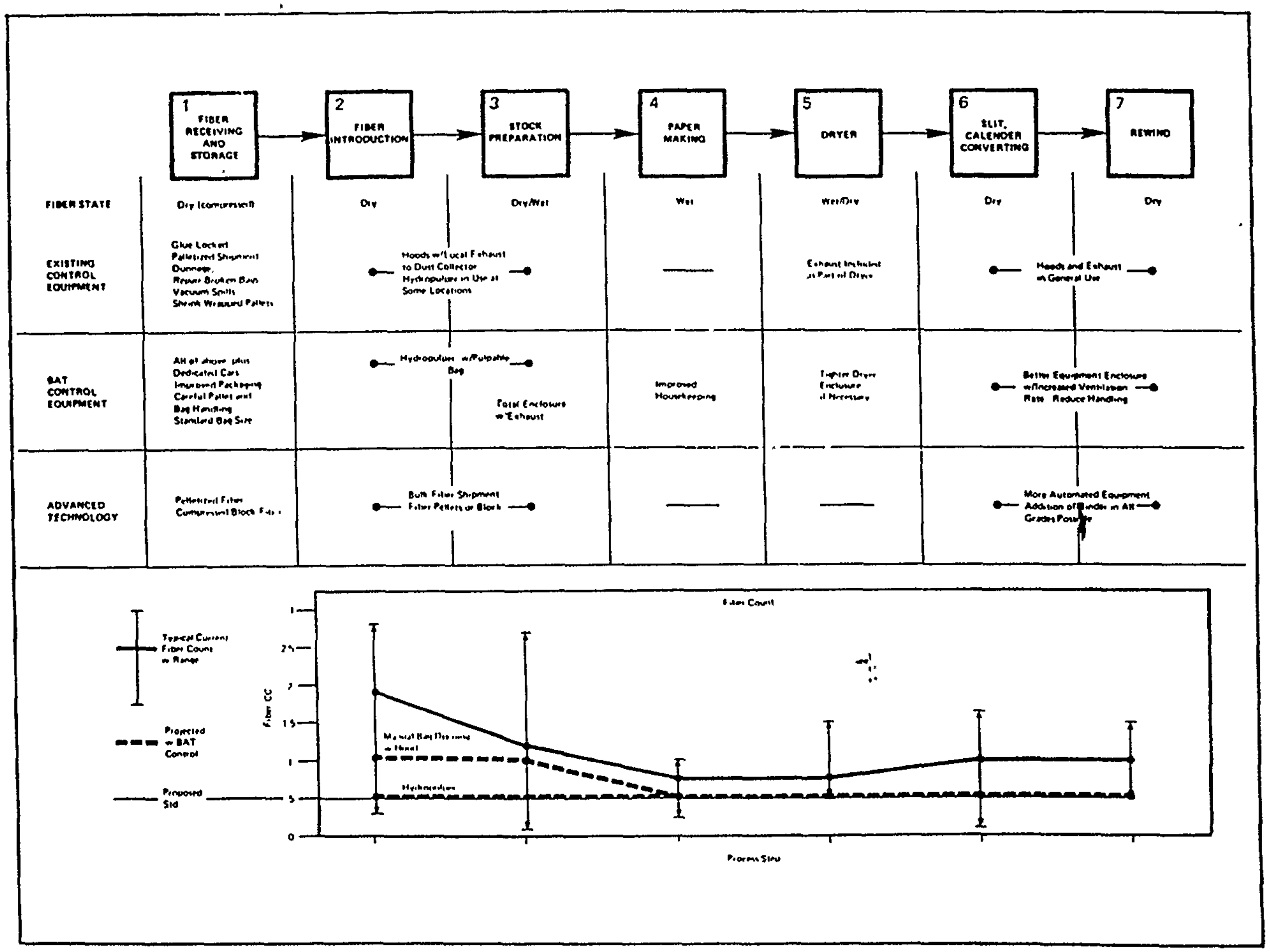

FIGURE 4-1 DIAGRAM OF PROCESS FLOW AND FIBER COUNT — ASBESTOS PAPER

CAPCO JEN 0003532

conveying previously described. Another variation is the use of "pulpable" kraft paper bags to contain the asbestos fibers. Pulpable bags are used in conjunction with a hydro-pulper and allow the bags to be introduced directly into the stock preparation without a separate bag-opening operation.

The stock preparation step is a wet-blending operation where dry asbestos fiber, paper stock (cellulose), liquids (water, latex, etc.) and additives are mixed to specific concentrations and consistencies. In some product applications, this wet-blending step is preceded by a dry-blending operation to achieve a more homogeneous mix of the ingredients. The stock is then introduced into the papermaking machine (Step 4). Basic machines include multi-cylinder and Fourdrinier-types; the operation is essentially identical to non-asbestos paper-making activities.

The wet paper is then routed to a dryer (Step 5) to reduce the moisture content of the paper to the desired product specifications. After the paper is dried, it is sent to a cutting/slitting area (Step 6) to be cut into sheets or small rolls. From this step, the paper may be packaged and shipped, or it may be sent to Step 7, rewinding. In rewinding, the finished product is placed on a large spool, packaged, and wrapped for bulk shipment.

Although there are considerable variations to the asbestos paper products manufacturing operation, the process description is common to nearly all asbestos paper products. Specific processing steps, requiring greater explanations to fully describe asbestos dust exposures, will be included in the following paragraphs which deal with Work Practices/Controls.

Work Practices/Controls

The fiber introduction area is characterized by manual or semi-automatic bag opening and release of the contents into a storage/conveyor system or directly into stock preparation. The difference between the manual and the semi-automatic bag opening procedure is in the way the bag is moved, positioned, and opened. The semi-automatic station may use a conveyor system (to move the bag into position) and a mechanical system of knives (to open the bag), while in the manual procedure, the operator positions the bag and opens it with a knife. In both the semi-automatic and the manual station, operators are required to dispose of the empty bag.

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All bag-opening stations have hoods which direct the asbestos dust to a central collection system for ultimate capture in a baghouse. Bag-opening stations handling large amounts of fiber normally have some conveyor and elevated platform area which is partially enclosed. Air flow is directed from behind the operator, across the asbestos bag, and to the central collection ductwork. Thus, the operator's exposure is considerably less at a semi-automatic station, because the operator is remote from the actual bag opening.

Empty bag disposal is a source of considerable dust, especially if the operator is required to remove the empty bag from the enclosure and dispose of it in a separate receptacle. Some stations have empty-bag receptacles below or alongside the enclosure. In these cases, the operator does not remove the empty bag from the enclosure but simply directs it to the disposal chute. Since the exhaust air flow is from the operator's back, the exposure from this step is minimal.

Housekeeping practices are very important in minimizing asbestos dust exposure in this step. The use of central vacuum cleaning systems and mechanical floor sweepers is preferred to manual sweeping and cleaning of floors and equipment. The physical condition of the individual asbestos bags and the handling of palletized loads from warehouse or storage areas affect the background exposure by introducing a source not initiated by the bag-opening step and which is likely not to be adequately controlled by ventilating the bag-opening area.

The Stock Preparation step involves mixing and blending of asbestos fibers, cellulose materials, liquids (such as water or latex), and additives according to a defined specification to achieve a desired consistency and concentration dependent upon the product being manufactured. The process vessel in which this mixing usually takes place is called a beater.

Asbestos fiber from fiber introduction (Step 2) is added to the beater along with other materials. The beater usually has a hood and exhaust system connected with the central dust collection system, to minimize the release of asbestos dust into the work environment. In some applications, a hydropulper is used in place of the conventional beater. This equipment allows the use of a pulpable bag (kraft paper), which is introduced directly into the stock preparation without necessitating a separate bag-opening/empty bag disposal operation. The exposure to airborne asbestos is lessened by use of this technology in conjunction with more conventional exhaust hoods.

CAPCO JEN 0003534

Housekeeping in the stock preparation area is an important factor in minimizing operator exposure to asbestos. Use of central vacuum-cleaning systems and mechanical floor sweepers/vacuums, and proper handling of "broke" (recycled material) are effective in controlling potential dust exposures.

The papermaking step involves the formation of the asbestos paper on a conventional paper machine (Fourdrinier or cylinder) from the slurry provided in the stock preparation step. Throughout the entire process step, the asbestos paper is wet; hence, minimal airborne asbestos is generated.

The stock slurry is introduced into the paper machine from the stock chest and is formed into a "sheet" which is approximately 98-99 percent water. By a series of moisture-removal operations involving gravity draining, vacuum suction, and felt absorption, the sheet is gradually reduced to about 75 percent water. This high moisture content precludes the release of airborne asbestos to a great extent. Some manufacturers use a low-exhaust-volume hood over this process; however, most installations provide no direct control of asbestos dust. Housekeeping operations are the same as those in use for stock preparation (Step 3): central vacuum cleaning systems, mechanical floor sweepers/vacuums, and proper handling of recycle and waste material.

The dryer step involves drying the asbestos paper sheet from about 75 percent moisture to the desired product specification. This is normally accomplished by passing the sheet over steam-heated rollers, which gradually remove the moisture. Again, the sheet has a high moisture content except at the end of the drying operation, when the moisture may be about 5 percent.

Virtually all manufacturers use hoods to collect the removed water vapor and to transport it away from the drying paper. This low-pressure, high-exhaust-volume hood also serves to remove any asbestos dust that may be released during the drying operation.

The slitting and calendering step involves cutting, slitting, winding, and spooling the dried paper to meet customer specifications or to make it suitable for subsequent processing. These operations are basically similar, in that they all involve cutting/slitting a roll or sheet of paper to size. All processes are carried out with the product paper dry.

CAPCO JEN 0003535

Local exhausts, area hoods, and exhausts connected to a central collection system are the normal control measures to minimize asbestos dust generation. Housekeeping operations in use for this process step are identical to those for the stock preparation and papermaking steps.

The rewinding step involves bulk packaging of paper products on spools, reels, or beams from larger rolls. The operation is completely dry, with area hoods and exhausts being the normal asbestos dust-control practices.

Housekeeping operations in use for this process step are identical to those for stock preparation and papermaking steps.

Existing Fiber Counts

Fiber counts are greatly affected by the asbestos content of the products. There is a wide range of asbestos content available (from a few percent to nearly 100 percent), and the higher the asbestos content of the product, the higher the potential exposure. Therefore, if a plant makes a product of essentially 100 percent asbestos, the exposure potential is much greater than in a plant making a product of 20 percent asbestos where both plants use the same process/control technologies.

A summary of time-weighted average fiber counts is presented in Table 4-1 to cover all the process steps of asbestos paper production.

The fiber introduction step is similar in asbestos dust exposure levels to the fiber introduction step in other industry segments. In examining data collected from the industry survey (Figure 4-1), a range of 0.3 to 2.8 fibers/cc TWA was observed. A typical exposure would be 1.9 fibers/cc TWA.

In manufacturing operations with separate stock preparation and fiber introduction steps (i.e. no pulpable kraft paper bags), fiber counts ranged from 0.1 to 2.7 fibers/cc TWA for stock preparation, with a typical count of 1.2 fibers/cc TWA exposure.

It is important to note that there is a distinct range of differential processing control technologies represented in this stock preparation step. Since this is the case, the range of asbestos exposure from 0.1 to 2.7 fibers/cc TWA requires additional explanation. The data fall basically into three areas of processing/control technology, as follows:

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Table 4-1

Time-Weighted Average Fiber Counts
Asbestos Paper

Process Step	Fiber Counts with Existing Control Technology		Projected Fiber Count with Best Available Technology (1)
	Typical Fibers/cc	Range Fibers/cc	Fibers/cc
1 Receiving & Storage	1.0	0.25 - 2.5	0.5 or 1.0
2 Fiber Introduction	1.9	0.3 - 2.8	0.5 or 1.0
3 Stock Preparation	1.2	0.1 - 2.7	0.5 or 1.0
4 Papermaking	0.75	0.25 - 1.0	0.5
5 Dryer	0.75	0.5 - 1.5	0.5
6 Slit and Calendering	1.0	0.1 - 1.6	0.5
7 Rewind	1.0	0.5 - 1.5	0.5

Data Base: Data collected from plants consuming 182,000 tons of asbestos annually, or 53 percent of the Asbestos Paper Segment.

(1) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

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- Fiber range of 0.1 to 1.5 fibers/cc TWA is the result of using a hydropulper with pulpable bags, in addition to high-exhaust-volume hoods and enclosures. With this equipment, Steps 2 and 3 are combined, because there is no separate bag-opening or empty bag disposal. The range of data is broad, with the upper end being characteristic of asbestos dust present on the bags and released in the area when transported from storage or warehouse.

- Fiber range of 1.0 to 2.5 fibers/cc TWA is the result of a conventional beater (no pulpable bags), a separate fiber introduction step, and high-exhaust-volume hoods and enclosures. Since Steps 2 and 3 are separate and there is a bag-opening and empty bag disposal operation, a higher fiber count is expected in spite of adequate ventilation.

- Fiber range of 2.0 to 2.7 fibers/cc TWA is the result of a conventional beater, a separate fiber introduction step, and only moderate- to low-exhaust-volume hoods with virtually no enclosures. Bag-opening and empty bag disposal operations are not adequately ventilated, enclosed, or controlled.

The water content of the asbestos paper sheet varies from 99 percent to 75 percent in the paper machine. The high moisture content minimizes asbestos dust generation; therefore, installations do not normally require hoods and exhaust systems. The range of asbestos exposure is 0.25 to 1.0 fibers/cc TWA; a typical step will be 0.75 fibers/cc TWA. The use of an exhaust hood does not seem to affect the data significantly at those plants which use no control in this step.

A more important influence on exposure is the housekeeping and clean-up procedures. By preventing spilled material from drying and thus creating a potential dust source, exposure in this step is minimized.

The high-moisture end of the drying operation inhibits the release of asbestos dust. At the dry end, however, the moisture content is about 5 percent and there is potential dust exposure from the handling of a dry asbestos-containing material. The range of asbestos dust varies from 0.5 to 1.5 fibers/cc TWA, with a typical exposure of 0.75 fibers/cc TWA at the dry end of the paper machine.

The dried asbestos paper sheet is handled in a variety of ways to prepare it for customer specifications, mostly by cutting or slitting or rolling. Asbestos dust exposure in this step ranges from 0.1 to 1.6 fibers/cc TWA; a typical value of exposure is 1.0 fiber/cc TWA.

The mechanical energy used to prepare the product for shipment releases asbestos dust, which is collected by exhaust hoods and local machine exhausts. Wet processing is not possible because it is not compatible with the product's physical properties. Fiber exposure is influenced by proper housekeeping and handling of "broke" or recycled materials.

The rewind step involves a rewinding of the paper sheet onto a large roll for shipment of a bulk product. Normally, only a minor amount of cutting is involved; however, the physical process of winding the paper onto a spool or beam generates a range of asbestos dust exposures from 0.5 to 1.5 fibers/cc TWA. A typical rewinding step will have 1.0 fibers/cc TWA.

Exhaust hoods are provided as in Step 6, with similar housekeeping procedures followed. Again, the very nature of the product (e.g. percent of asbestos) greatly influences the dust exposures encountered.

Best Available Technology (BAT)

In general, BAT for fiber introduction involves the use of: hydropulpers with pulpable bags where applicable; increased ventilation rates; more restrictive bag-opening and empty-bag disposal facilities; minimizing manual bag handling; central vacuum systems for cleanup; and general good housekeeping practices.

The BAT involved in stock preparation is identical to that described in Step 2. There are, however, some instances where hydropulpers are not directly interchangeable with beaters in the production of a specific item. The use of a pulpable bag with a beater is not generally practiced in the industry, because of the differences in process equipment and product specifications. Therefore, the use of hoods and exhausts and enclosures is more applicable as BAT if hydropulpers with pulpable bags are not being used. Similarly, pulpable bags are not available from all suppliers and may not be used in applications where the bag (kraft paper) would impart unacceptable product qualities.

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Since the papermaking operation is wet processing, little asbestos dust exposure is realized. Housekeeping and maintenance procedures are presented as BAT, because the improvement in these practices is sufficient to reduce the potential dust exposure.

The drying operation already has an exhaust system designed to remove both airborne asbestos and evaporated water vapor. By improving the exhaust systems (increasing air flow), more fully enclosing this operation, and instituting improved housekeeping and maintenance programs, asbestos exposure will be minimized.

The manual handling and mechanical modifications involved in slitting, calendering and converting generate asbestos dust. BAT for this step will be: decreased manual handling of products; improved hood and exhaust systems and tighter enclosure where the slitting, cutting, etc. is done; more automated equipment; and better housekeeping and handling of "broke" material.

The BAT for rewinding is identical to the paper slitting operation.

Projected Fiber Counts (with BAT)

Use of the best available technology in fiber introduction consistent with product specifications and production equipment will yield an asbestos exposure range of 0.5 to 1.0 fiber/cc TWA. Operations which allow the use of hydropulpers and pulpable bags in conjunction with efficient exhaust systems and maximum practical enclosure represent the lower end of the exposure range. If beaters and non-pulpable bags are used (necessitating bag-opening and empty bag disposal), the ventilation and enclosure systems will have asbestos exposure towards the upper end of the range.

Housekeeping and maintenance operations to minimize dust exposures must be improved. However, the extent of exposure is affected by asbestos dust clinging to the bags from the preceeding fiber receiving/storage step and by the amount of handling necessary to get the fiber from the bags into the processing operation.

The stock preparation step is generally job-connected with fiber introduction; therefore, the use of BAT is assumed to control the asbestos dust exposure to the same range, i.e. 0.5 to 1.0 fibers/cc TWA.

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The use of BAT will reduce asbestos exposure in the Papermaking, Dryer, Slitting, and Rewinding steps to 0.5 fibers/cc TWA.

Advanced Technology

The use of bulk fiber shipments in the form of pellets or compressed blocks may reduce asbestos exposure levels in the Receiving and Storage step by supplying the fiber in a less dust-producing form. However, in most operations, the fiber cannot be used in this form in stock preparation, and thus requires a fiber-opening step. A hammer mill or some similar device is needed to open the pellet or block. This equipment, although a potential source of dust, is more easily controlled by appropriate exhaust systems than is a loose fiber introduction, which requires more manual handling and less area enclosure.

Bulk shipment of asbestos fiber in this form is available in limited amounts; however, the practical aspects of the fiber-opening step and the effects on product quality are still in the development/experimental stage.

The use of a fully-automated, completely-enclosed bag opener for conventional compressed-packed bags has not been demonstrated to have the reliability of operation necessary to prevent product contamination and operational upsets. This equipment, although commercially available in one form or another, is still basically developmental due to the inconsistency of operations.

The use of more highly automated equipment which can be enclosed and ventilated and in which the operator need not be present is being developed. Research is also under way to determine if additional or different binders in the product will affect the fiber release upon mechanical modification and if those binders will affect product specifications.

Economic Impact

Data and information supplied to Weston represent 53 percent of the segment (Table 2-1); however, only 29 percent of this segment supplied data usable for generation of meaningful cost analysis. The size of the companies which supplied usable data ranged from 350 to 36,000 tons of asbestos use annually.

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The capital costs required to achieve BAT for this segment are $5,100,000, and operating costs are projected to be $200,000/year. In this segment, 43 percent of the employees are exposed. The industrial hygiene and medical program costs will be $4,010,000; this is almost 3/4 of the total annual costs ($5,510,000). The total annual costs to comply with the proposed standard represent 1.7 percent of this segment's average annual sales, with a range of 0.1 to 4.5 percent. The capital costs estimated by industry as necessary for its compliance with the proposed standard represent 172 percent of this segment's typical total annual capital expenditures.

Summary of Impact
Asbestos Paper Segment

Asbestos Usage			342,000 tons/year
Increased Cost of BAT to Industry Segment:			
Capital Cost to Achieve BAT		$5,100,000	
Annual Costs:			
Capital	$1,300,000		
Operating Costs	200,000		
Industrial Hygiene and Medical Program	4,010,000		
Total Annual Costs		$5,510,000	
Total Annual Costs versus Average Annual Sales			1.7 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures			172 percent

Conclusions

- In the production steps involving papermaking, drying, slitting and calendering, and rewinding, it will be possible to reduce asbestos exposure levels to 0.5 fiber/cc TWA after employing BAT.

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- In the steps involving fiber introduction and stock preparation, it may be possible to reduce asbestos exposure levels to 0.5 fiber/cc TWA, if production equipment and product specifications allow the use of hydropulpers and pulpable bags as process modifications involving implementation of BAT.

- In production steps involving hydropulping in the fiber introduction and stock preparation steps, it may be possible to reduce asbestos exposure levels to 1.0 fiber/cc TWA by employing improved ventilation and enclosure techniques as control technologies involving implementation of the best available technology where extensive process modifications are prohibited by product constraints.

- Significant development is needed for equipment (control and process) capable of reducing asbestos exposure levels below 1.0 fiber/cc TWA. Development time estimates range from 3 to 7 years for situations where hydropulpers cannot be used and a separate bag-opening step is needed.

- At present, it is not possible to state with certainty that development of advanced technologies will be capable of reducing asbestos exposures to 0.5 fiber/cc TWA in all process operations.

- Companies with a small capital and sales base may find it difficult to fund the capital required to install BAT, because this segment's relationship of expected capital costs to typical capital expenditures is 172 percent.

CAPCO JEN 0003543

Asbestos Cement Pipe

Technological Feasibility

Asbestos cement (A/C) pipe is a durable, inexpensive pipe material used extensively in underground applications. The material is resistant to erosion and corrosion from internal and external factors. Ease of installation and the integrity of joints are valuable properties of pipes made from this material.

The two major uses for A/C pipe are sewer service and water supply systems. The water supply pipe, a pressure pipe, must withstand line pressure; much of this pipe is pressure-tested before shipment. Pipe is produced in sizes ranging from 4" to 32" in diameter.

The basic raw materials used in the production of A/C pipe include asbestos fiber, portland cement, silica sand, and water. Asbestos is generally shipped into the plant by rail, packaged in 100-pound, compressed bags. The palletized bags or bales are warehoused until required. Figure 4-2 illustrates the production flow for pipe production.

Process Description

At the introduction to the process, the bags of asbestos are manually opened and dumped. Conveying equipment carries the fiber to a dry mixing step. Agitation in this step serves two purposes: opening or fluffing the fiber and mixing the concrete components. As the bags or bales of fiber are dumped, they usually break apart; however, large chunks of compressed fiber still remain intact. Mixing action breaks the lumps into individual fibers, thus increasing their effectiveness as reinforcing and filling materials. Sand and portland cement are added at this point.

From the dry mix step, the mix is conveyed to the wet mixing operation, just ahead of the pipe-forming machine. A separate dry and wet mix are necessary because of the concrete's limited setting time and variations in machine speed. Water is added at this step, forming the cement mortar.

CAPCO JEN 0003544

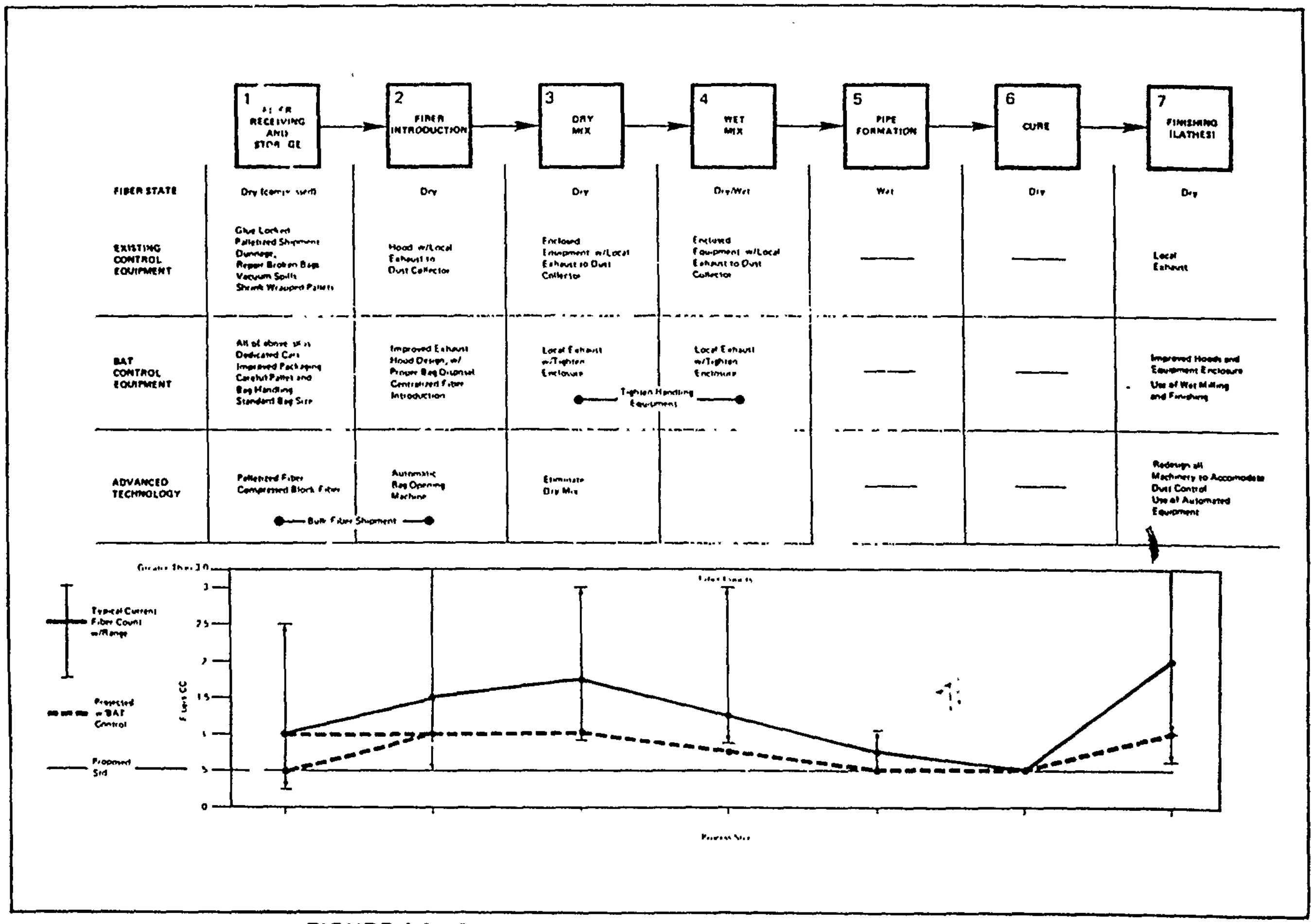

FIGURE 4-2 DIAGRAM OF PROCESS FLOW AND FIBER COUNT — ASBESTOS CEMENT PIPE

CAPCO JEN 0003545

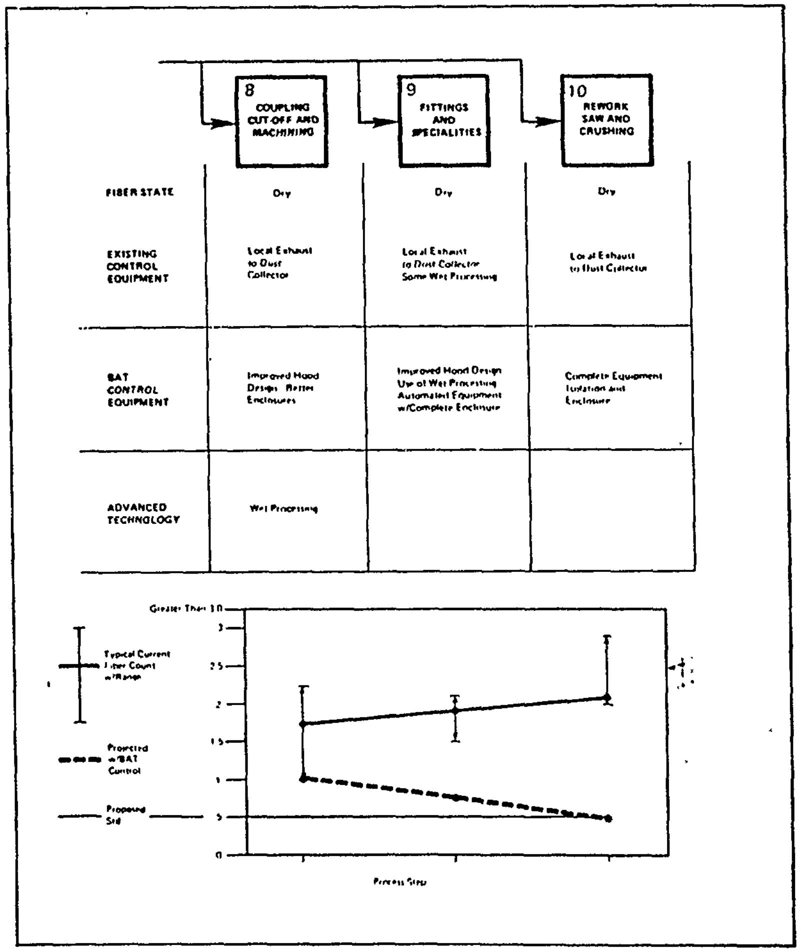

FIGURE 4-2 DIAGRAM OF PROCESS FLOW AND FIBER COUNT
(Continued)

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The mortar is immediately deposited in the pipe-forming machine. The mixture of asbestos and cement is picked up on the rotating pipe form, or mandrel. Deposition is continued until the proper thickness has been applied. Pipe sections are generally cast in 10- to 15-foot lengths. After the pipe has set, it is stripped from the mandrel. The pipe section is then air-dried and "steam-cured" in an autoclave.

The cured pipe sections then pass to the finishing step. Here the pipe is cut to uniform lengths. A number of pipes are then cut into half and quarter sections. Single- or multiple-point scoring tools are used, rather than diamond or carborundum abrasion wheels. To insure a tighly fitting pipe joint, the ends of the sections are machined smooth. Machining is carried out on a lathe.

The finished pipe is inspected, and pressure pipe is tested. Stock generally awaits shipment in outdoor storage areas.

In addition to full and partial lengths, pipe plants also produce a variety of standard and special fittings. Pipe coupling is the most widely used fitting. To mate with the machined pipe ends, the inside surface of the couplings must be machined and grooved to hold a rubber seal. Production of pipe couplings is a full-time operation.

Other fittings (tees, elbows, reducers, etc.) are produced on a less frequent schedule. Most plants will also produce specialty fittings and pieces, on an individual basis. Operations required for fitting production include sawing, drilling, machining, boring, and gluing. Some specialty applications require pipe lengths which are machined over their entire length. This operation is carried out on a special lathe.

Defective sections and scrap are crushed and reused as a filler in non-pressure pipe. The operation includes a rework saw to cut material into smaller lengths, permitting some salvage and easier crushing of waste.

Work Practices/Controls

As one of the larger asbestos consumers, the A/C pipe segment has been a leader in the development of equipment and work practices to reduce worker exposure to airborne asbestos.

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Control equipment currently in use at the fiber introduction step is essentially hood and local exhaust. Pallets of fiber bags are moved from the warehouse by fork lift truck. The bags are manually moved from the pallet to a hooded area. The bag is slit and the fiber drops to a bucket elevator and conveying system. The A/C pipe industry generally uses asbestos in paper bags. The empty bag is disposed of outside of the process. Fiber introduction and subsequent mixing is a batch operation. Actual opening, slitting, and emptying of the bags requires about four hours per shift.

Fiber loss at the dry mixing step is controlled by maintaining slight negative pressure inside the mixer. The mixer is generally a totally enclosed unit, with raw material introduction and removal by screw conveyor. By maintaining negative pressure inside the mixer and restricting leaks from seals and loose-fitting equipment, fiber material is not permitted to escape into the environment.

Local exhaust is also employed at the wet mixing operation. Introduction of the dry mortar into the mixer and initial agitation until the solids become wet produce the dust at this step. Once the mortar becomes wet, little additional fiber becomes airborne.

A significant portion of the fiber emitted between fiber introduction and wet mixing may result from material-handling equipment (screw conveyors and bucket elevators). Dust control in conveying equipment is obtained through exhaust of hoods and mixing equipment.

No control equipment is in use during pipe formation, air curing, and steam curing. Good housekeeping is essential at these steps, since spills of mortar or fragments of pipe will dry, ultimately resulting in fiber release due to traffic movement in the area.

Pipe finishing and machining represents a significant source of airborne fibers. Local exhaust and partial hooding is used at the tool head to capture and control fiber emission. The use of single-point cutting and/or chipping tools, rather than saws or cutting and machining equipment using abrasion, substantially reduces fiber levels at the finishing step.

CAPCO JEN 0003548

Control equipment for coupling and fittings production is essentially the same as that described for pipe finishing. Local exhaust near the working point of the tool is used to capture and remove dust and fiber. Variability in production techniques and in the size and shape of the pipe make tight-fitting hoods and an exhaust system impractical. A small amount of wet sawing is also used.

Dust control for the rework saw and scrap crusher is brought about by the use of local exhaust. This is an infrequent operation, and actual worker exposure to fiber from this step will be small.

Existing Fiber Counts

Typical TWA fiber counts in the A/C pipe segment vary from 0.5 to 4.5 fiber/cc through all processing steps. The fiber count at the fiber receiving and warehousing operations will vary widely depending on the condition and the handling of the car in transit. Asbestos cement pipe plants are large consumers of asbestos, and can therefore exert pressure on the fiber supplier to improve his packaging and shipping techniques. TWA exposure during the fiber-handling step is consistantly at 1.0 fiber/cc, with occasionally higher levels when a car with damaged bags is unloaded. Table 4-2 illustrates existing and projected fiber counts.

Fiber introduction into the process currently results in typical TWA exposure of 1.5 fiber/cc. In addition to actual bag slitting and dumping, fiber-handling equipment (bucket elevators, conveyors) taking fiber from the bag-dumping station may contribute to worker exposure in this area.

By the nature of the operation, the mixing step results in significant fiber exposure -- typically 1.8 fiber/cc. Often the same operator is responsible for both fiber introduction and dry mix operation.

The wet.mix operation would normally be expected to result in little fiber loss; however, some agitation occurs before the solids are completely wetted and results in a TWA fiber count of about 1.2 fiber/cc.

At the pipe formation step, little if any fiber is released. The fiber count of 0.75 fiber/cc typically encountered at this point is most likely a background level from adjacent mixing operations.

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Table 4-2

Time-Weighted Average Fiber Counts
Asbestos Cement Pipe

Process Step		Fiber Count with Existing Control Technology		Projected Fiber Count with Best Available Technology[1]
		Typical Fibers/cc	Range Fibers/cc	Fibers/cc
1	Fiber Receiving & Storage	1.0	0.25 - 2.5	0.5 or 1.0
2	Fiber Introduction	1.5	0.5 - 3.5	1.0
3	Dry Mix	1.8	0.8 - 3.0	1.0
4	Wet Mix	1.2	0.8 - 3.0	0.75
5	Pipe Formation	0.75	0.5 - 1.1	0.5
6	Cure	0.5	-	0.5
7	Finishing (Lathes)	2.0	0.6 - 4.5	1.0
8	Coupling Cutoff & Machining	1.75	1.0 - 2.25	1.0
9	Fittings & Specialties	1.9	1.5 - 2.1	0.75
10	Rework Saw & Crushing	2.2	2.0 - 2.9	0.5

Data Base: Data collected from plants consuming 144,000 tons of asbestos annually, or 100 percent of the Asbestos Cement Pipe Segment

(1) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

CAPCO JEN 0003550

Air curing and steam curing require no physical modification to the pipe section and therefore generate minimal airborne fiber. Some handling of pipe is involved; broken sections which are not immediately removed can result in some fiber release.

The most significant source of fiber in an A/C pipe plant is from the finish and fittings production area. Typical TWA counts in this area ranged from 1.75 to 2.2 fiber/cc, depending on the particular piece of equipment. The very nature of the operation tends to generate dust and fiber. In general, the more mechanical energy imparted to a system, the more dust and fiber produced. Cutting and machining of concrete obviously require high energy input and therefore produce high dust and fiber levels.

In addition, A/C pipe does not produce a clear cut. The fibrous nature of the asbestos tends to hold small fiber and dust particles in the surface of the pipe. Fiber produced during cutting and machining is also deposited inside the pipe. These fibers become airborne as the pipe is handled, thus producing another "background" fiber level.

Best Available Technology (BAT)

BAT for the fiber introduction step in an A/C pipe plant includes: proper bag handling; a well designed hood or enclosure; adequate ventilation and exhaust velocity; and proper bag disposal. Proper bag handling includes careful handling and removal from the pallet and avoidance of actions which would prematurely break the bag. Proper hood design should include as tight an enclosure as possible, with adequate exhaust velocity (at least 300 ft/min) directed away from the operator. Provision should be made for a slot or opening at the rear of the area, which allows the empty bag to drop into an enclosed container, eliminating much of the exposure encountered in forward bag removal and handling by the operator.

In some segments of the asbestos products industry, hydropulpers are used with pulpable bags consisting of Kraft paper, eliminating the bag slitting and dumping step. With A/C pipe, even a small percentage of cellulose cannot be tolerated in the product without producing a weakened or defective product.

One additional step can be taken to reduce the cost of control equipment and worker exposure. Where plants have several operating lines, a central bag opening and dumping station will reduce the area where loose asbestos is handled and will reduce the overall level of asbestos in the work area.

Existing control technology is essentially BAT at the dry mixing step. Some improvement can be expected if equipment is more tightly sealed and well maintained. Rotating equipment such as that used results in vibration which continually loosens seals and connections.

Equipment exhaust, as currently installed, represents BAT in the wet mixing operation. Some improvement can be expected if equipment is well sealed and regularly maintained.

Significant improvement will likely result from a general tightening of all materials-handling equipment between the fiber introduction and wet mixing steps. Screw conveyor covers, in particular, are prone to loosening from vibration and require routine maintenance and periodic replacement of seals. Exhaust from conveying equipment will also reduce fiber and dust emission from materials-handling equipment.

BAT for the finishing area must be considered as local exhaust equipment, combined with the use of single-point cutting tools. This type tool is not without its disadvantages: dust is generated around the entire circumferance of the pipe, rather than at a single point, thus making dust capture and collection more difficult. Some improvement in hood or enclosure design is expected to reduce fiber emission to the atmosphere.

Existing control equipment represents BAT in the coupling and finishing areas. Some improvement can be made in the design of hoods and enclosures, particularly for small tools. Wet machining should also be used more extensively.

Complete enclosure and isolation of scrap reworking equipment will significantly reduce employee exposure.

Some sawing will still be necessary, and wet dust supression should be used. Operation of the crusher in an isolated area with minimum employee entrance (maintenance, equipment inspection, etc.) will eliminate much of the exposure at this operation.

Projected Fiber Counts (with BAT)

Projected TWA fiber count for receiving and storage appears in Table 4-2.

If BAT is applied to the fiber introduction step, the projected TWA exposure is estimated to be 1.0 fiber/cc. The reduction in exposure is obtained primarily as a result of proper empty bag disposal. Centralized fiber introduction will not reduce the TWA exposure for the operator at that step; rather, it reduces the background concentration in the plant, by isolating one of the higher-fiber-emission operations.

Reduction of exposure at the dry mixing step will result in a TWA fiber count of 1.0 fiber/cc. Tightening of the materials-handling equipment between fiber introduction, dry mix and wet mix processes will further reduce the "background" fiber concentration in this area of the plant.

Improvements in other plant areas and tightened enclosure of wet mix equipment should reduce exposure at this step to about 0.75 fiber/cc. Likewise, reduction in background fiber levels should reduce exposure at the pipe formation and curing steps to 0.5 fiber/cc or less.

Implementation of BAT equipment will result in significant reduction in TWA fiber count in the finishing area. Exposure should be controllable to within the 0.75 to 1.0 fiber/cc range through dust control systems designed specifically for each individual unit. Development of methods to remove loose fiber from inside the pipe sections should reduce the general "background" fiber levels.

Complete enclosure of the scrap crusher should eliminate fiber exposure from the actual crushing operation, except for periodic maintenance and equipment inspection. Some fiber is likely to become airborne as a result of conveying equipment, and adequate precautions must be taken.

Advanced Technology

Advanced technology in the fiber introduction step takes the form of two options: automatic bag opener and bulk fiber shipment. Automatic bag opening will reduce both the fiber released to the atmosphere and worker time spent at this process step. Although automatic bag opening can be considered

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BAT in some industry segment, the problem of contamination of the product with pieces of bag material has yet to be overcome. Considerable work has been done, but no machine yet available will consistently slit and empty bags without allowing some bag material into the fiber, resulting in possible imperfections in the pipe section.

The second level of advanced technology, bulk fiber shipment, will take longer to develop and implement, but should eliminate virtually all worker exposure at this process step.

There is no apparent advanced technology for the dry mix step. It has been suggested that this step could be eliminated or significantly reduced through the early addition of water to the raw materials. Such a process change will require extensive development before its feasibility can be established.

Advanced technology in the finishing operation takes two forms: use of wet dust suppression and complete re-design of machinery. Wet machining has been used at some areas in the A/C pipe finishing and fitting production, falling somewhere between BAT and Advanced Technology. Some development work will be necessary to determine if wet suppression can be adapted to the pipe lathes and if it in fact reduces the fiber release at the process step.

Commercial milling equipment and machinery with minor modification has been used in pipe finishing. Significant reduction in worker exposure could be achieved if the machinery were redesigned with the express intent of improving dust control. Considerable automation could also be incorporated in machinery redesign, thereby reducing employee exposure.

There appears to be no advanced technology on the horizon in the control of dust and fiber from fittings production equipment.

Economic Impact

Data and information supplied to Weston represent 100 percent of this segment (Table 2-1). All of the companies supplied usable data for generating cost information. The sizes of the firms supplying usable data range from 10,000 to 88,500 tons of raw asbestos used annually.

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The capital costs to achieve BAT for this segment are $12,000,000. Insufficient information was provided for operating costs. The operating cost was estimated to be 25 percent of the annualized capital cost to achieve BAT recovery (average of other segments). This segment has 89 percent of its employees exposed. The industrial hygiene and medical program costs will be $2,150,000 for this segment. This represents 36 percent of the total annual costs ($5,900,000). The total annual costs to comply with the proposed standard represent 3.2 percent of this segment's average annual sales. The total annual costs vs. average annual sales range from 0.7 percent to 5.8 percent.

The expected capital costs estimated by industry to comply with the proposed standard represent 162 percent of this segment's typical total capital expenditures.

Summary of Impact
Asbestos Cement Pipe Segment

Asbestos Usage		144,000 tons/year
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		$12,000,000
Annual Costs:		
Capital	$3,000,000	
Operating Costs	750,000(1)	
Industrial Hygiene Medical Program	2,150,000	
Total Annual Costs		$5,900,000
Total Annual Costs vs. Average Annual Sales		3.2 percent
Expected Capital Costs vs. Typical Total Annual Capital Expenditures		162 percent

(1) Average of other segments.

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Conclusions

- The A/C Pipe Industry segment is, for the most part, in compliance with the 1 July 1976 exposure standard. Only one work station is above 2.0 fiber/cc (Step 10).
- Although typical values are generally below 2 fibers/cc, occasionally high fiber levels are experienced because of reasons yet unknown or circumstances beyond the manufacturer's control.
- Reduction of TWA exposure to 0.5 fiber/cc or less at all work stations in the plant is not feasible, using the Best Available Technology. Only 3 of 10 work stations will have TWA's at or less than 0.5 fiber/cc. All others are projected to be between 0.5 and 1.0 fiber/cc.
- Implementation of BAT control equipment will require about three years, based on industry estimates.
- Competition with firms using alternative materials of construction for pipe (e.g. cast iron or clay) may require asbestos cement pipe manufacturers to absorb the additional production costs rather than to pass them on to customers and risk a reduction in the market. It can be expected that profit margins will be significantly affected.

CAPCO JEN 0003556

Floor Tile

Technological Feasibility

Floor tile is manufactured in the U.S. by six producers, most having more than one manufacturing site. A few small companies produce floor tile, but their impact on the market is insignificant. Floor tile manufacturing involves proprietary production line processes highly developed by the individual manufacturers. Equipment layout, process description and compound formulations are held very confidential because the industry is highly competitive. Floor tile generally contains from 0 to 0.13 pounds of asbestos per square foot. Non-asbestos-containing floor tile is generally a premium-priced, specialized product; considerations of cost and product quality mean that the predominant amount of floor tile produced contains asbestos. The asbestos imparts strength, dimensional stability, and resistance to cold.

Process Description

Figure 4-3 illustrates a production flow sheet used to manufacture floor tile. The same general production steps are believed to be employed by most manufacturers. Fiber receiving and storage handling problems in the floor tile industry are the same as the problems of the industry in general.

Based upon companies responding to the questionnaire and Weston's field surveys, fiber introduction steps are also similar to those of the overall industry. Opened bags of asbestos are manually dumped into a ribbon blender along with other dry ingredients (Step 3). The raw asbestos fiber is received in polyethylene plastic bags. The bags are collected and added to the Banbury mixer, where they are incorporated into the product. Trial runs are being conducted where pelletized asbestos is used rather than semi-compressed loose fiber.

The Banbury mixer works the dry material into an agglomerated plastic mass. As the material is sheared in the Banbury, the asbestos, fillers, and pigments are dispersed throughout the vinyl plastic mass. The mechanical working of the material generates heat. At a predetermined temperature, the Banbury mixing is terminated, and the mass is dumped onto a conveyor. At this point, the asbestos is fully bound in the warm plastic.

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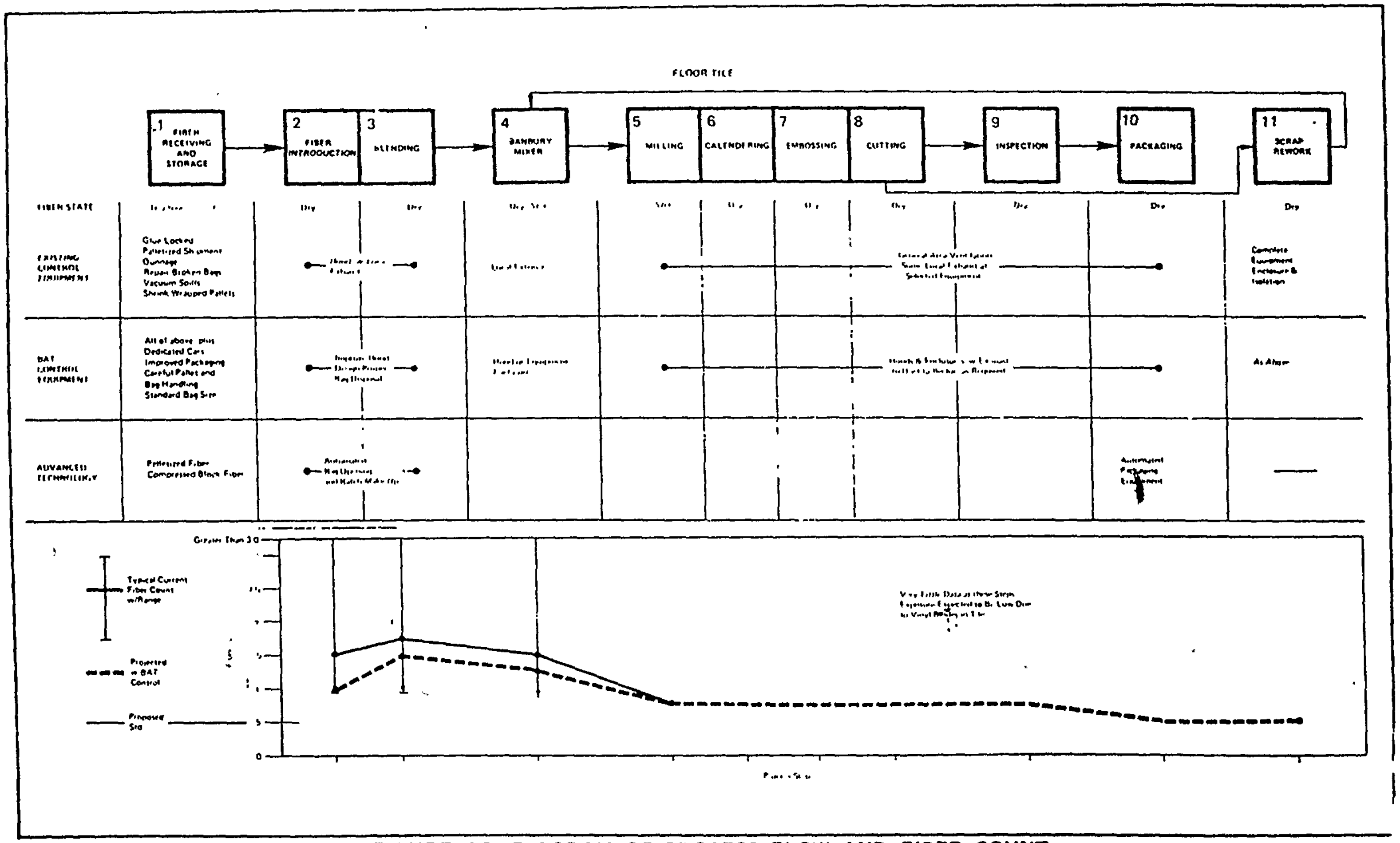

FIGURE 4-3 DIAGRAM OF PROCESS FLOW AND FIBER COUNT — FLOOR TILE

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The mass undergoes final mixing and conversion to a continuous sheet form during milling. From this point of production, the operation is essentially continuous until manufacture of the variety of floor tile in production is terminated. The sheet is conveyed to calendering, where the synchronous speed rollers impart final thickness and smoothness to the sheet.

The sheet remains warm and pliable as it is conveyed through embossing, which imparts design and texture to the surface. The sheet is cut into squares by a cutting press, and the tiles are separated from the scrap "window framing" of the sheet. The finished tiles pass through inspection and are packaged. The scrap "window framing" and rejected tile are reworked and returned to the Banbury mixer for recovery. The scrap material is chopped into small chips before charging into the Banbury.

Work Practices/Controls

Floor tile manufacturers appear to have a high level of dust control technology and have implemented good house cleaning procedures to minimize asbestos dust exposure. Additionally, many of the production steps do not evolve high asbestos dust levels. Thus, the airborne fiber sources have been generally restricted and controlled; sources of low amounts of fiber are not influenced by high background levels from any of the major sources of fiber.

Hoods, dust collectors and air bag-filters are employed in the fiber introduction area, where dry materials are conveyed. Enclosed conveyors with dust exhausts, cyclones, and bag-filters are installed for handling loose fiber. The Banbury mixing area is hooded, with exhaust air directed to the dust removal system.

Scrap material is conveyed to an isolated (enclosed)area. Automatic machines are used to chop the scrap into chips. The chips are conveyed from the isolation room to the Banbury area for recovery. Air is evacuated from the scrap recovery room for dust control. Since the area is unmanned, no worker exposure is incurred during normal operations.

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Existing Fiber Counts

A summary of time-weighted average fiber counts is presented in Table 4-3. It covers all processing steps of Floor Tile production.

Fiber introduction data ranges from less than 1.0 to in excess of 4 fibers/cc TWA. It is not known to what extent the use of pelletized asbestos rather than raw fiber influences the range of results. Pelletized asbestos has been available to primary industries for approximately 5 years; however, information collected by Weston indicated that the use of pelletized asbestos appears to be in the developmental or trial stage rather than the general rule. The extent existing processes and products permit the use of pelletized asbestos is not fully known. Indications are that using pelletized asbestos in fiber introduction yields low worker exposure TWA levels (in the 0.5 to 1.0 range), while the use of bagged raw asbestos for fiber introduction can exceed 4.0 fibers/cc TWA.

Dry blending of the asbestos fibers generates worker exposures of approximately 1.8 fibers/cc TWA. This process is enclosed and does not require sustained worker attendance near the equipment. Banbury mixing data indicates worker exposure levels of approximately 1.5 fibers/cc TWA. These levels have been recently achieved through the installation of hooded exhausts and better housekeeping. Data from milling of the plastic mass shows exposure levels ranging from less than 0.5 to approximately 0.75 fibers/cc. The extent to which these data are influenced by the proximity of the mills to the dry fiber operations, by general background levels, and by emissions directly from the mill are not known.

The calendering operation yields low exposure levels (less than 0.75 fibers/cc TWA). The interpretation of these data is unclear, since the operation is largely automatic and unattended. These readings should be minimally influenced by background counts, since the equipment is sufficiently removed from the dry fiber operations. Sufficient data for the other operations such as embossing, cutting, inspection, and packaging are not available, although worker exposure levels for these areas are expected to be low.

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Table 4-3

Time-Weighted Average Fiber Counts
Floor Tile

Process Step	Fiber Count with Existing Control Technology: Typical Fibers/cc	Fiber Count with Existing Control Technology: Range Fibers/cc	Projected Fiber Count with Best Available Technology(1) Fibers/cc
1 Receiving & Storage	1.0	0.25 - 2.5	0.5 or 1.0
2 Fiber Introduction	1.5	0.9 - 4.3	1.0
3 Blending	1.75	0.9 - 4.3	1.5
4 Banbury Mixer	1.5	0.8 - 4.3	1.25
5 Milling	0.75	-	0.75
6 Calendering	0.75	-	0.75
7 Embossing	0.75	-	0.75
8 Cutting	0.75	-	0.75
9 Inspection	0.75	-	0.75
10 Packing	0.5	-	0.5
11 Scrap & Rework	0.5	-	0.5

Data Base: Data collected from plants consuming 43,400 tons of asbestos annually, or 39 percent of the Floor Tile Segment.

(1) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

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Best Available Technology (BAT)

This industry has already installed the elements of best available technology (hoods, dust evacuators, air bags, etc.) in anticipation of meeting the 2.0 fibers/cc standard to be effective in July 1976. More extensive use of dust control equipment already employed will likely result in only a small incremental decrease in asbestos exposure.

Further partitioning of the work areas relating to raw fiber handling and changes in plant layout may be possible to reduce worker exposure. Since much of the production line is automated, some controls and adjustments may be further removed from the immediate areas of fiber dust to reduce worker contact. Any work practices that result in moving the worker farther from the dust sources would be beneficial in reducing the eight-hour TWA exposures. Further reductions in exposure levels would require advanced technology: to automate fiber introduction, to isolate the worker from the sources of handling fiber, and to effect a general reduction in the background of fiber dust.

Advanced Technology

Because the Floor Tile segment handles large quantities of raw bagged asbestos, improved packaging techniques and automatic bag-opening machines would represent a major advance towards worker safety. If the industry could shift to using 100% pelletized asbestos (already in trial operation), fiber exposure would be further reduced.

It is estimated that application of advanced technology to floor tile manufacturing could reduce and maintain worker exposure to 1.0 fibers/cc TWA or less in nearly all areas.

Economic Impact

Data and information supplied to Weston represent 39 percent of this segment (Table 2-1); however only 15 percent of this segment supplied usable data to generate cost information. The size of firms supplying usable data range from 3,900 to 9,000 tons of asbestos used annually. Unfortunately, these data do not include the large companies or the very small ones. The capital costs to achieve BAT for this segment are $2,720,000. Operating costs are projected to be $1,380,000/year. This segment has 69 percent of its employees exposed.

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The industrial hygiene and medical costs will be $6,000,000 for this segment. This represents 74 percent of the total annual costs ($8,060,000). The total annual costs to comply with the proposed standard represent 3.0 percent of this segment's Average Annual Sales. The total annual costs vs. Average Annual Sales range from 2.5 to 8.4 percent. The expected capital costs estimated by industry to comply with the proposed standard represent 33 percent of this segment's typical total annual capital expenditures. This low percentage indicates that a large amount of capital has been spent previously to achieve BAT.

Summary of Impact
Floor Tile Segment

Asbestos Usage		112,500 tons/year
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		$ 2,720,000
Annual Costs:		
Capital	$ 680,000	
Operating Costs	1,380,000	
Industrial Hygiene and Medical Program	6,000,000	
Total Annual Costs		$ 8,060,000
Total Annual Costs versus Average Annual Sales		3.0 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures		33 percent

Conclusions

- Although further data are required, it is indicated that the Floor Tile segment is currently close to BAT control conditions, having mostly complied to a 2.0 fiber/cc TWA standard.

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- Advanced technology would be required to achieve any significant reductions in current exposure levels. It is not known if the proposed 0.5 fiber/cc TWA can be attained in the foreseeable future.

Friction Products

Technological Feasibility

Friction materials are used in practically all industries as a key component in clutches for transmitting torque, brakes for slowing down or stopping motion or as torque limiters. These friction applications are not limited to brakes and clutches in automobiles, trucks, busses, construction equipment and railroad cars. Rather, these applications are found wherever motion must be controlled. The following examples show the diversification of friction material usage: farm tractors, presses, hoists, tensioning devices in production of wire and plastic rope and cable, lift trucks, machine tools, shuttlecars, specialized mining equipment, chainsaws, drilling equipment, spinning and knitting equipment, x-ray machines, wheel brakes, tape recorders, typewriters, bicycle brakes, snowblowers, and washing machines. This industry segment is composed primarily of five major companies; foreign competition, some from Korea, has started to penetrate the market.

The industry employs asbestos typically bound in cured resin compounds to form hardened friction materials. These pads may be bonded, riveted, or otherwise attached to machined metal pieces (as in the production of brake shoes). Asbestos is an essential ingredient in these products because it imparts strength, good friction properties, can withstand high temperatures, and is a good insulator.

Process Description

Figure 4-4 illustrates a typical manufacturing scheme that is employed in manufacturing friction products.

The manufacturing plants for friction products are large, centralized facilities. The plant layouts include machinery such as drilling presses, grinders, mills, lathes, metal stampers, curing ovens, molds and presses, paper machines, conveyors, mixing vats, and chemical operations.

The manufacturing of friction products is highly labor-intensive and involves many processing operations before the finished product is obtained. Some manufacturers provide incentive pay to the employees to maintain high output. Millions of disc brake pads and tens of millions of automatic transmission plates are manufactured yearly at a given site.

The products flow directly to the original equipment manufacturers (automotive and industrial) or to hundreds of thousands of marketing outlets.

CAPCO JEN 0003565

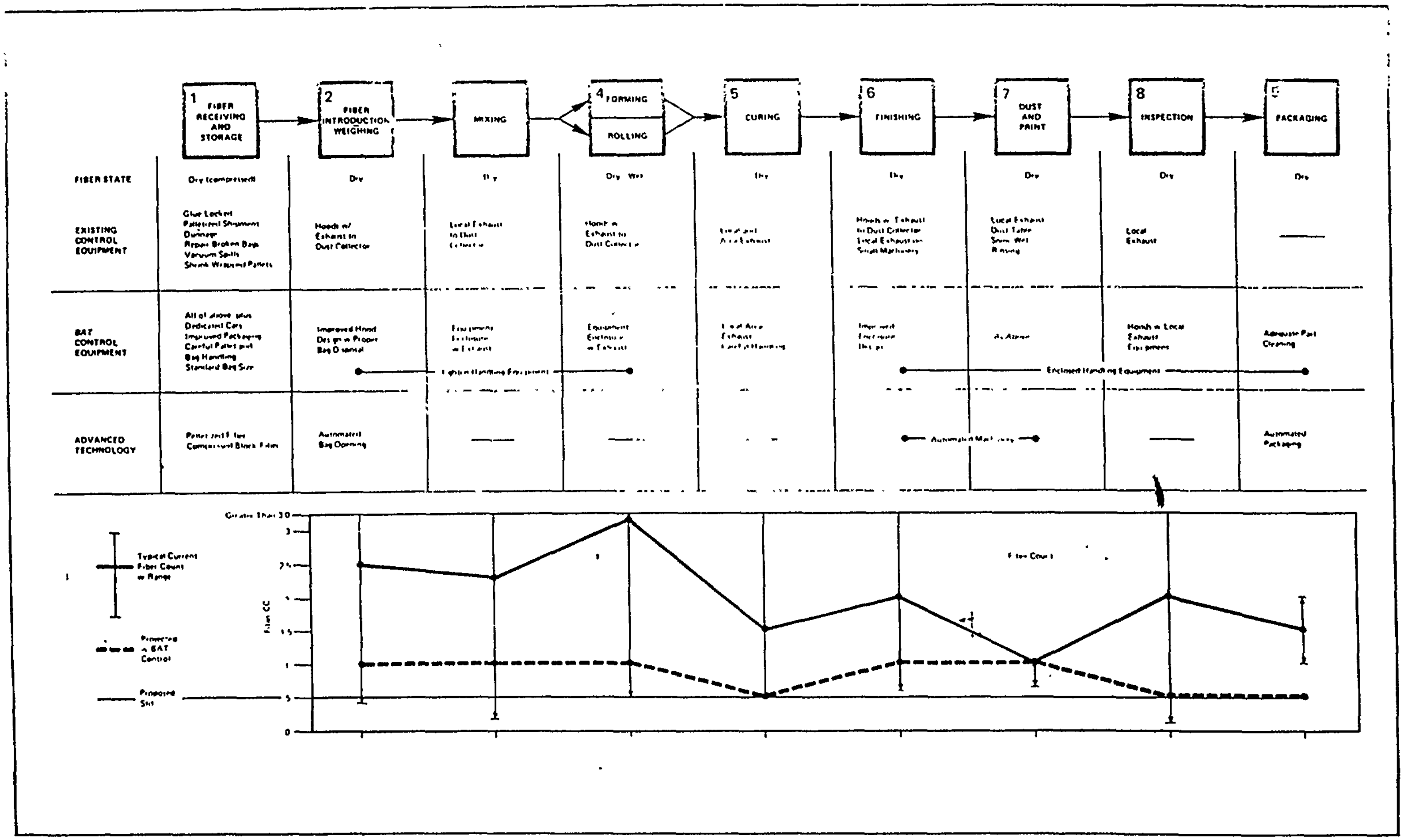

FIGURE 4-4 DIAGRAM OF PROCESS FLOW AND FIBER COUNT
— FRICTION PRODUCTS

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The asbestos bags are weighed, manually opened, and placed in movable hoppers for in-plant transportation. The hoppers are dumped into mixers. The formulations may be mixed either wet or dry depending on the product specification. The mixers blend the asbestos, fillers, and liquid resin.

The mix is fed through a compression molder or an extruder, depending on the required product. Formed strips are cut and bent into various widths and lengths. A parting compound is added to prevent parts from sticking.

Dry-mixed formulations are transferred to pressing molds where slabs are formed. Some formulas require a preheating step. The slabs are then hot pressed, which causes the resin to flow and bind the mixture. The formed slabs are sawed into specific parts and sent to a curing oven.

Following curing, the parts undergo a number of finishing steps to produce the final block. These machine-assisted manual operations include grinding, sawing, drilling, blanking, tapping, and boring.

The brake pads may be packaged and sold to a secondary manufacturer or may be applied directly to brake shoes by bonding or riveting.

The asbestos formulations are processed wet where it is practical to meet product specifications. This reduces the potential for asbestos fiber elution. In some instances, automatic transmission plates are presoaked in transmission fluid to reduce dusting.

Work Practices/Controls

Extensive centralized vacuum exhaust systems are employed with trunk connections to evacuate dust from individual machine operations. Hoods and enclosures are extensively employed. Where raw fiber is handled, the plant layout is generally arranged to isolate this operation from other production areas. Many products undergo a brushing operation to remove latent dust. Manual inspection of parts is carried out on down-draft air exhausting tables to minimize worker exposure.

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Workers in the industry are generally highly trained and highly skilled. The employers provide extensive safety training and incentives to minimize hazards in the working environment. The workers are encouraged by incentive pay.

Constant houskeeping is conducted round-the-clock, as most plants operate three shifts per day and up to seven days per week at peak periods. Vacuuming is the general housekeeping practive; however, brooms are also used where the spilled material is difficult to vacuum.

Existing Fiber Counts

Because of the complexity of the manufacturing operations, the frequent handling and transporting of components throughout the plant, the high volume of production, and the extensive machine-assisted manual operations, the fiber count data reported for 8-hour TWA exposures varies over a wider range than any other primary segment.

Table 4-4 illustrates the ranges of 8-hour TWA fibers/cc data received for the Friction Products segment.

The Friction Products segment has collected extensive exposure data for all phases of its operations, but interpretation of the data is complex. The nature of the work place, the largely individual manual techniques, the multitude of operations, and the influence of many variables cause the monitoring techniques and calculation procedures for TWA exposures to be subject to considerable error and deviation. The following factors influence the data received:

- Worker practices: these practices may be identifiable (e.g., carelessness) or unidentifiable (e.g., individual skill and technique).

- Percent of asbestos in product being processed: formulations and operations characteristically have asbestos concentrations from 30 to 70%.

- Asbestos fiber breakdown: high mechanical forces subjected to the compounds at various operating phases break the asbestos fiber chain into many distributions of sub-fibers. Where fibers are broken to a length of less than 3 to 1, the asbestos is not counted by the

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Table 4-4

Time-Weighted Average Fiber Counts
Friction Products

	Process Step	Fiber Count With Existing Control Technology: Typical fibers/cc	Fiber Count With Existing Control Technology: Range fibers/cc	Fiber Count With Best Available Technology (1) fibers/cc
1	Receiving & Storage	1.0	0.25-2.5	0.5 or 1.0
2	Fiber Introduction & Storage	2.5	0.4 -4.6	1.0
3	Mixing	2.3	0.2 -8.0	1.0
4	Forming or Rolling	3.3	0.5 - 22.0	1.0
5	Curing	1.5	0.5 -3.5	0.5
6	Finishing	2.0	0.6 -7.4	1.0
7	Adjustment & Printing	1.0	0.7 -1.0	1.0
8	Inspection	2.0	0.1 -15.0	0.5
9	Packaging	1.5	1.0 -2.0	0.5

Data Base: Data collected from plants consuming 35,100 tons of asbestos, or 60 percent of the Friction Products Segment.

(1) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

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sampling technique, thus reducing the relative exposure data. However, a fiber may be broken into several components greater than 5 microns, thus increasing the relative exposure levels.

Best Available Technology (BAT)

The segment currently has a heavy investment in control equipment. This equipment includes vacuum exhaust dust collection, hoods, partitioning, and isolation. The best available technology for control equipment would be an extension of these devices where they are now not applied.

Further development of work practices, industrial engineering methods, and house-cleaning are in part BAT as well as control technology. Stricter control supervision can be employed to minimize worker carelessness or poor technique. A larger janitorial work force can be developed for continually maintaining cleaner work areas.

Projected Fiber Counts (with BAT)

Since extensive control equipment is already in use, additional engineering controls will have little influence on the average exposure levels already in existence. However, these controls may eliminate certain isolated high exposures experienced in today's friction products segment.

Advanced Technology

Far-reaching advances will be required by the friction products segment to effect a significant lowering of existing asbestos TWA exposures. New facilities and processes will be required. Automatic handling of the raw asbestos and intermediate products is required. Considerable industrial engineering work practices and worker techniques need to be developed and implemented.

Economic Impact

Data and information supplied to Weston represents 60 percent of the segment (Table 2-1); however, only 46 percent of this segment supplied usable data to generate cost information. The size of firms supplying usable data ranges from 500 to 9,500 tons of asbestos used annually.

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The capital costs to achieve BAT for this segment are $29,800,000. Operating costs are projected to be $3,360,000. This segment has 90 percent employees exposed. The industrial hygiene and medical costs will be $6,570,000 for this segment; this represents 38 percent of the total annual costs ($17,380,000). The total annual costs to comply with the proposed standard represent 7.8 percent of this segment's average annual sales. The total annual costs versus average annual sales range from 1.0 to 25 percent. The expected capital costs estimated by industry to comply with the proposed standard represent 316 percent of this segment's typical total annual capital expenditures.

Summary of Impact
Friction Products Segment

Asbestos Usage		58,500 tons/year
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		$29,800,000
Annual Costs:		
Capital	$7,450,000	
Operating Costs	3,360,000	
Industrial Hygiene and Medical Program	6,570,000	
Total Annual Costs		$17,380,000
Total Annual Costs versus Average Annual Sales		7.8 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures		316 percent

Conclusions

- Significantly improved work practices and major incorporation of advanced technology are required to significantly reduce worker exposure to airborne asbestos to less than 1.0 fiber/cc TWA.

- The industry cannot achieve the proposed 0.5 fibers/cc TWA in all process areas through engineering controls and work practices in the foreseeable future.

- No substitute has been proven for the asbestos in the friction product, nor can the country do without it; therefore, the friction product companies must pass the cost on to the customer. This could results in substantial loss of business to imported friction products.

CAPCO JEN 0003572

Paints, Coatings, and Sealants

Technological Feasibility

The production of roof coatings, caulks, sealants, paints, adhesives, and undercoatings generally involves mixing asbestos and other fillers into an asphalt base. Solvents may be added to reduce the viscosity and to allow spray application. Upon application, the solvents vaporize out of the coating, leaving a tough, semi-hardened consistency.

Several types of blends, with varying ingredients, are required for different product lines such as tennis court surfaces, roof coatings, automobile undercoatings, and foundation sealants. The products are compounded normally using proprietary blends to provide cost effectiveness, ease of application, color and texture, and resistance to weathering.

Small manufacturers, such as those producing 1.0 MM gallons per year, normally have one production line for all products produced. In general, their product mix is small and the equipment is scheduled to produce the desired product. Larger manufacturers, producing in excess of 3.0 MM gallons per year, may have a wide product mix and several production lines oriented to a specific product. Smaller manufacturers package and ship their coatings nearly exclusively in five-gallon metal pails. Large manufacturers may ship their coatings in five-gallon pails, barrels, and tank cars. Thus, batch sizes produced may vary from several hundred gallons to several thousand gallons, depending on the size of the company, type of product, method of containerizing, type of existing equipment, and size of order. Specialized products and techniques exist in the industry, such as oil-in-water emulsions for coatings, but are not covered in this report.

Figure 4-5 illustrates the basic manufacturing operations for coatings manufacturing. A small manufacturer may have all production steps in one or two areas. A larger manufacturer with several production lines has separate locations (partitioned work areas or separate buildings) for the different production stages.

CAPCO JEN 0003573

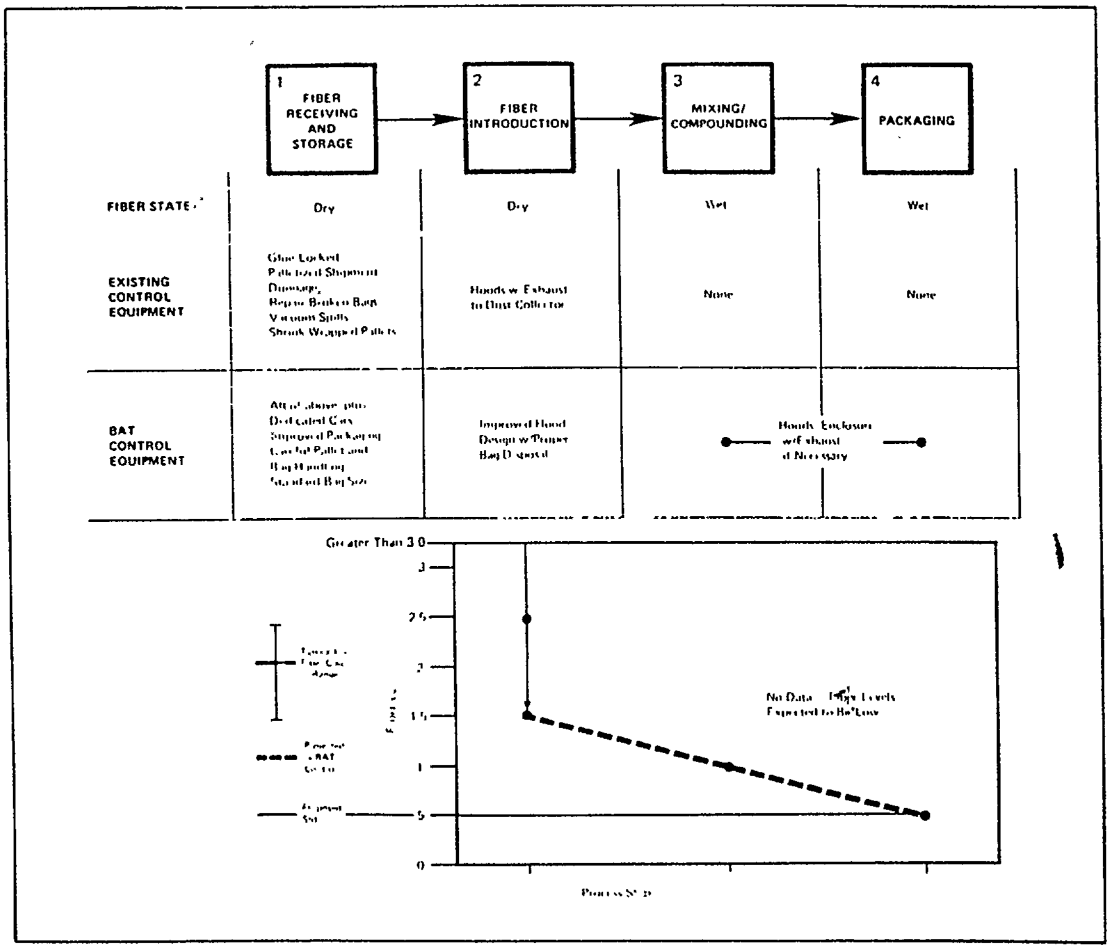

FIGURE 4-5 DIAGRAM OF PROCESS FLOW AND FIBER COUNT PAINTS, COATINGS, AND SEALANTS

Process Description

Fiber introduction is the key phase with regard to worker exposure. The pallets of asbestos are moved to a staging area and weighed. The bags are manually slit and dumped either into a hopper or directly into a fluffing machine. This machine breaks down the compressed fibers to an open, free condition to enable dispersion and encapsulation during asphalt mixing.

Cutting the bags and dumping the free asbestos subject the worker to localized asbestos exposure. Fiber can also become airborne or can fall to the floor, causing house-cleaning problems and contributing to an overall background level of asbestos exposure. Worker tidiness and care, equipment arrangement, and housekeeping procedures highly influence the amount of asbestos exposure resulting from this operation.

Empty bags containing residual asbestos create a disposal problem in this operation. As several bags may be emptied at once, a waste receiver is often made available for direct disposal. Where the bags are laid on the floor or otherwise remain loose until the fiber introduction is completed, free asbestos creats a housekeeping problem in the work area. Several thousand emptied asbestos bags are disposed of by a single coatings manufacturer in a year's time.

Typically, fluffed asbestos fiber is transferred to hoppers or directly to a batch mixing tank. Fiber transfer may be pneumatic, mechanical (conveyors), or manual. Pneumatic transfer systems are enclosed and use bag filters for the exhaust air. Conveyors are generally enclosed. Manual transfer may be employed for small operations or for specialized, low-volume requirements.

The fluffed fiber and other dry materials are brought into contact with asphalt (and solvents as required) in a batch tank. The material is mixed until an even dispersion is achieved. The batch mixing tanks are normally enclosed to prevent fiber dispersion. After a short mixing time, the asbestos fiber is bound in the asphalt. Upon completion of mixing, the asbestos is considered completely encapsulated in the asphalt with little chance for fiber dust exposure. When the batch is finished, the material is pumped to the packaging (containerizing) operation.

CAPCO JEN 0003575

The predominant packaging for coatings is five-gallon pails with sealed lids. Special orders are sometimes filled using drum containers. Bulk shipments such as in tank cars are infrequent.

Work Practices/Controls

Hoods, dust evacuators, and air bag-filters are employed in the fiber introduction areas in new and large plants. Some smaller plants do not have this equipment. The plants employing the higher technology also have enclosed conveyors, for handling loose fiber, equipped with dust exhausts and bag-filters are installed. No control equipment is installed or believed required from the mixing area through to the end of manufacturing.

It is standard practice to tape ripped or torn bags to prevent asbestos problems in house cleaning. Vacuum cleaners are used to pick up loose asbestos throughout the manufacturing plant. Respirators are used where loose asbestos is handled.

Larger plants employ equipment layout such that the fiber introduction operation is partitioned or isolated from areas producing little asbestos emissions. Smaller plants or older facilitities may not have restricted areas of higher asbestos source contamination.

Varying degrees of housekeeping are employed. Those that employ advanced housekeeping immediately vacuum accidential asbestos spills and routinely clean the building. Inspection of others, however, shows asbestos dust on most horizontal surfaces such as light shades, window frames, and rafters. In this condition, normal air currents can dislodge the asbestos fiber dust and contribute to a higher background reading.

Existing Fiber Counts

Fiber count data have been received from several manufacturers for the fiber introduction areas. Table 4-5 presents these data. Extensive fiber count data for other manufacturing areas have not been collected by the indusry. The survey data show the 8-hour time-weighted averages to range from 1.5 to 8.0 fibers/cc TWA, with a typical exposure level of 2.5 fibers/cc TWA for fiber introduction. On the basis of the data, four of the 12 locations will meet the 2 fiber/cc TWA

CAPCO JEN 0003576

Table 4-5

Time-Weighted Average Fiber Counts
Paints, Coatings, and Sealants

Process Step	Fiber Count with Existing Control Technology		Fiber Count with Best Available Technology (1)
	Typical Fibers/cc	Range Fibers/cc	Fibers/cc
1 Receiving & Storage	1.0	0.25 - 2.5	0.5 or 1.0
2 Fiber Introduction	2.5	1.5 - 8.0	1.5
3 Mixing Compounding	-	-	1.0
4 Packaging	-	-	0.5

Data Base: Data collected from plants consuming 20,500 tons of asbestos, or 30 percent of the Paints, Coatings, and Sealants Segment.

(1) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

CAPCO JEN 0003577

standard. One exceeds the 5 fiber/cc standard. Interviews with small, privately owned coatings manufacturers that do not have control equipment or fiber counts have disclosed that enforcement of a 2 fiber/cc standard might force them out of business because of dwindling profits and high capital requirements for compliance. None of the reporting manufacturers meet the 0.5 fiber/cc 8-hour TWA proposed standard.

Best Available Technology (BAT)

Where the bags are manually slit and dumped, hooded exhausts are employed with dust collectors. A central vacuum system (as well as portable) is used to clean up any spillage. Local containers for used bags are placed in the work area for immediate discard of the bags. Conveyors are enclosed when handling loose fiber with an exhaust system to a dust collector. Batch tanks, fluffers, and mixers are enclosed to prevent fiber loss.

Point sources of fiber dust, such as bag opening, are located in a remote or partitioned area to minimize carryover into other manufacturing areas.

Project Fiber Counts (with BAT)

With regard to fiber introduction, the data from the coatings industry show that BAT will likely meet the 2.0 fibers/cc TWA but will not achieve the proposed 0.5 fibers/cc TWA. The proposed peak 5.0 fiber/cc standard is expected to be exceeded regularly because of variations in manufacturing operations, human factors, equipment adjustment, and maintenance.

No data are available to assess the fiber levels achievable by BAT in other areas in the coatings segment, because these areas were considered by industry to be historically very low and no data were taken. However, the proposed 0.5 fiber/cc TWA may be exceeded by existing background levels in these areas. This would be particularly troublesome where these areas lie close to the fiber introduction operation because of plant layout.

Advanced Technology

Response by the industry indicates a need for development of improved packaging techniques for the raw asbestos and for automatic bag-opening machines. Improved packaging may include recyclable bulk containers, enclosed pallets to shield the bags from physical damage, and reinforced bags.

CAPCO JEN 0003578

Automatic bag-opening machines would eliminate the manual operation and remove the worker from a major point source of asbestos. Bag opening could be accomplished in a completely enclosed area with the fiber dust evacuated and collected.

Economic Impact

Data and information supplied to Weston represents 30 percent of the segment (Table 2-1); however, only 12 percent of this segment supplied usable data to generate cost information. The sizes of firms supplying usable data, range from 200 to 2,000 tons of asbestos used annually.

The capital costs to achieve BAT for this segment are $4,230,000. Operating costs are projected to be $550,000. This segment has 38 percent of its employees exposed, the lowest of all primary segments. The industrial hygiene and medical costs will be $2,730,000 for this segment; this represents 63 percent of the total annual costs ($4,340,000). The total annual costs to comply with the proposed standard represent 1.6 percent of this segment's average annual sales. The total annual costs versus average annual sales range from 0.2 to 3.7 percent. The expected capital costs estimated by industry to comply with the proposed standard represent 143 percent of this segment's typical total annual capital expenditures.

Summary of Impact
Paints, Coatings and Sealants

Asbestos Usage		67,500 tons/year
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		$4,230,000
Annual Costs:		
Capital	$1,060,000	
Operating Costs	550,000	
Industrial Hygiene and Medical Program	2,730,000	
Total Annual Costs		$4,340,000
Total Annual Costs versus Average Annual Sales		1.6 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures		143 percent

CAPCO JEN 0003579

Conclusions

- With many small companies in the coatings manufacturing industry, the level of control equipment for asbestos fiber varies greatly from company to company. Privately owned small companies generally have a lesser degree of control than larger companies and corporations, which have installed control approaching BAT.

- The fiber introduction process, bag handling, and raw asbestos fiber handling are the phases in coatings manufacturing which result in the major sources of fiber exposure.

- Reported 8-hour TWA fiber count data vary widely from plant to plant (ranging from 1.5 to 8.0). Most data are below the current 5 fibers/cc TWA. One-third of those reporting are near the 2 fibers/cc standard. None report data or indicate that the 0.5 fibers/cc TWA can be achieved with BAT.

- BAT is an extension of existing control equipment already in use at most locations. Full application of BAT may enable compliance with the 2.0 fiber/cc TWA, but attainment of the 0.5 fiber/cc TWA is not indicated.

- Development of advanced technology is indicated in asbestos packaging, shipping, and handling. An automatic bag opening machine would be a major breakthrough. No data are available to indicate the fiber exposure levels achievable with this advanced technology.

CAPCO JEN 0003580

Asbestos Cement Sheet

Technological Feasibility

Asbestos cement sheet is a flat or corrugated cement product using asbestos fiber as a reinforcing agent. The material is durable, strong, fireproof, and has excellent weathering resistance. It is widely used in construction applications such as roofing and siding for both industrial and residential buildings. It is also used in the manufacture of heaters, boilers, vaults and safes, electrical equipment mounting panels, welding shields, and many other applications requiring a non-combustible or heat-resistant sheet.

This industry segment also includes other asbestos-containing products, bound with cementatious materials other than portland cement. These sheet materials are generally thicker than the sheets described above, ranging from ½" to 4" in thickness. The products are used in specialty applications such as laboratory furniture and firedoor construction.

Process Description

The raw materials and manufacturing processes used to make asbestos cement sheet are similar to those used for asbestos cement pipe. Asbestos fiber is combined with cement, sand and water; the sheet is formed, cured, and finished.

Bags of fiber are manually opened and dumped at the fiber introduction step. The fiber is either dumped directly into the dry mixer or conveyed to the mixer by bucket elevator and screw conveyor. The first mixer breaks the compressed fiber lumps, thereby opening the fiber structure and obtaining maximum use of its reinforcing properties. Sand and cement are added at this point, and the solids are mixed until uniform.

The dry raw materials are conveyed to a second mixer, where water is added. After water is added, the mortar must be used within a short time, before the cement starts to set; therefore, the two mixing steps are required. Once the water is added, the sheet is formed in large presses. After the sheet has obtained preliminary set, it is removed from the press, allowed to cure further in the air, and is then cured with steam.

CAPCO JEN 0003581

Although sheet-forming casts a nearly uniform size, some trimming of the edges and ends is generally necessary after curing. Cut-off saws using diamond or carborundum wheels are used to trim the sheet to standard size. Even more important than edge trim is uniform sheet thickness. In the final manufacturing step, the cured and trimmed sheet is sanded to a uniform thickness.

In applications such as residential siding, the formation press is grooved to form the siding pattern. Several applications of paint are applied to the sheet between the curing and finishing steps, and the final product is oven-dried to cure the thermal-setting paint. No sanding is used in this application, but sheets are stamped to size before packaging. Corrugated roofing and siding are also produced without the final sanding step.

The thicker specialty products generally start by dry-mixing asbestos with lime and fine silica. The sheet is formed by pressing at high temperature and high pressure. While in the press, the lime and sand react to form a calcium silicate binder reinforced with asbestos. These products do not require the extensive curing of the portland cement sheets, but still require edge and end trim and surface sanding.

In addition to sheet formation, some large consumers have forced the sheet producer to do some initial fabrication, to reduce fiber exposure at the consumer's plant. Initial fabrication takes the form of cutting or punching standard sizes or shapes and drilling or punching holes.

Work Practices/Controls

Figure 4-6 illustrates the processes involved in sheet production. At the fiber introduction step, hoods and local exhaust are the control equipment in general use. Exhausted air is vented to the atmosphere through dust collectors. Bags are manually placed in the hooded area. The bags are slit and dumped; the empty bag is removed and placed in a large plastic bag for disposal. The A/C sheet segment uses paper bags. Raw material make-up is a batch operation. The batch make-up rate depends on sheet thickness; fiber introduction occurs for 2 to 6 hours per shift.

CAPCO JEN 0003582

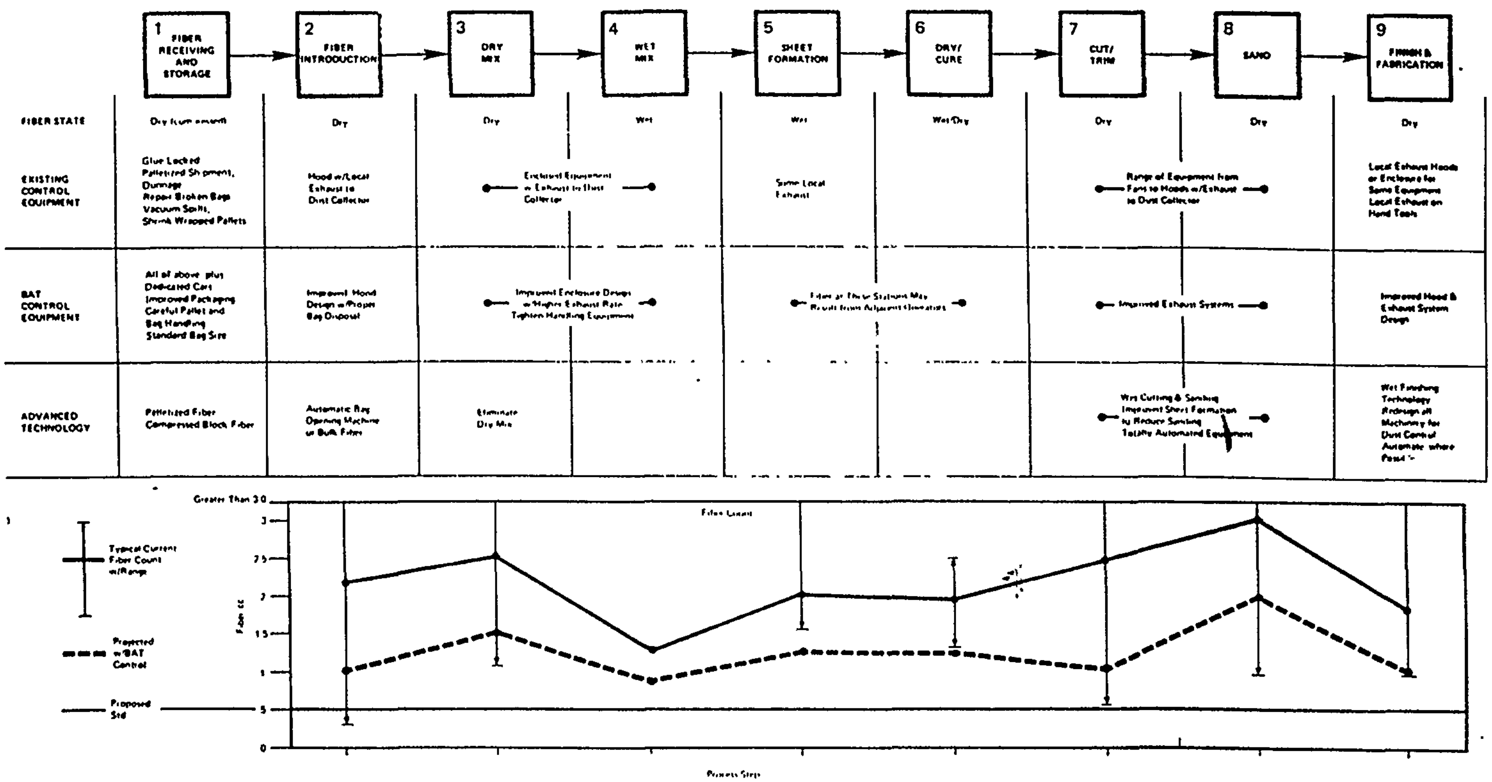

FIGURE 4-6 DIAGRAM OF PROCESS FLOW AND FIBER COUNT
— ASBESTOS CEMENT SHEET

CAPCO JEN 0003583

Local exhaust of enclosed mixing equipment is the control technology used at both the dry and wet mix processing steps. Exhausted air is vented to the atmosphere through fabric fiber (bag) dust collectors. Dry mortar conveying equipment between the fiber introduction step, dry mixing, and wet mixing steps also results in an area dust source. Some exhaust of the materials-handling equipment is obtained through exhaust of the mixing equipment.

Although the wet mortar is not expected to be a significant fiber source, some exhaust equipment is in use at the sheet formation press. Good housekeeping controls are also necessary when handling the wet mortar. While the wet material does not release fiber, abrasion from local traffic will result in significant airborne fiber concenrrations if a spill is allowed to dry.

No control equipment is used at the drying or curing steps. Good housekeeping is again required to minimize fiber release.

A broad range of dust control equipment and work practices were reported for the cutting, trimming, and sanding operations. The level of control technology ranged from area ventilation using exhaust fans to extensive equipment enclosures, exhausted to a dust collector. Some wet sanding was reported by an asbestos cement sheet manufacturer to be in use at one of his customers' plants; however, no wet sanding is currently practiced at any asbestos cement sheet manufacturer responding to our survey.

Local exhaust with hoods or enclosures is generally used for major pieces of finishing or fabricating equipment. Local exhaust is generally used on hand and small tools.

Existing Fiber Counts

Typical TWA fiber counts in the A/C sheet segment vary from 1.0 to 3.0 fibers/cc through all processing steps. (See Table 4-6).

Fiber introduction into the process results in a range of counts from 0.3 to greater than 3 fibers/cc, with a typical value of 2.3. The adjacent dry mixing operation has a TWA fiber count range of 1.1 to greater than 3, with a typical value of 2.5 fibers/cc. The TWA fiber counts at the fiber

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Table 4-6

Time-Weighted Average Fiber Counts
Asbestos Cement Sheet

Process Step		Fiber Count with Existing Control Technology: Typical Fibers/cc	Fiber Count with Existing Control Technology: Range Fibers/cc	Fiber Count with Best Available Technology(1) Fibers/cc
1	Receiving & Storage	1.0	0.25 - 2.5	0.5 or 1.0
2	Fiber Introduction	2.3	0.3 - 8.7	1.0
3	Dry Mix	2.5	1.1 - 8.4	1.5
4	Wet Mix	1.25	-	0.9
5	Sheet Formation	2.0	1.6 - 3.5	1.25
6	Dry/Cure	1.9	1.3 - 2.5	1.25
7	Cut/Trim	2.5	0.6 - 6.7	1.0
8	Sand	3.0	0.9 - 8.0	2.0
9	Finishing & Fabrication	1.8	0.9 - 3.6	1.0

Data Base: Data collected from plants consuming 48,000 tons of asbestos, or 89 percent of the Asbestos Cement Sheet Segment.

(1) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

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introduction and dry mix steps of the A/C sheet process are higher than at the same steps in its sister process, A/C pipe. The reason for higher counts may be found in the fact that at some installations the fiber is introduced directly into the first mixer, with a resulting higher fiber emission rate and TWA exposure.

A typical TWA fiber count for the wet mixing operation is 1.25 fibers/cc. This fiber count is approximately the same as in the A/C pipe segment. Airborne asbestos fiber results from agitation in the mixer before the solids are thoroughly wetted. Conveying equipment in the area also adds to the background fiber count.

TWA fiber count in the sheet formation step and the drying and curing step is 2.0 and 1.9 fibers/cc, respectively. Counts at these two steps ranged from 1.3 to greater than 3 fibers/cc. This number is unexpectedly high for a wet processing step, and the only explanation seems to be background fiber levels from adjacent operations.

Sheet trimming and sanding represent the highest exposure levels in the A/C sheet process, at 2.5 and 3.0 fibers/cc. The very nature of these operations generates airborne asbestos fiber. Although control equipment has proven effective, it is difficult to control fiber loss from the large surface area of a sheet during sanding. In addition, loose fiber remaining on the sheet tends to become airborne as the material is handled.

The finishing and fabricating operation has a typical TWA fiber count of 1.8 fibers/cc, with a range of 0.9 to greater than 3. Actual employee exposure at this processing step is highly variable, because of variations in schedule and the extent of fabricating required.

Best Available Technology (BAT)

BAT for the fiber introduction step in an A/C sheet plant requires a well-designed hood or enclosure and adequate ventilation. Proper bag handling, both before and after the bag is emptied, is also required to achieve the lowest level of exposure. Improved hood design should provide for empty bag disposal through the rear of the hood to minimize bag handling.

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As in the A/C pipe segment, hydropulpers cannot be used to eliminate the bag slitting and dumping steps because they could contaminate the product with cellulose.

Adequate enclosure of the dry and wet mixing operations, with adequate exhaust rate, will be considered BAT at the two mixing steps. Where screw conveyors are involved, they should be tightened and maintained to minimize fiber escape. It is highly unlikely that BAT fiber levels could be achieved in a process where the asbestos is charged directly to the mixer. The large opening in the mixer, with such an arrangement, tends to result in considerable fiber loss.

If improvements elsewhere in the sheet manufacturing operations do not reduce the background fiber levels at the sheet formation, drying, and curing steps, hoods and local exhaust should be installed to control fiber exposure. Improved exhaust systems should be considered BAT control for the trimming and sanding steps. Wet sawing and sanding should be seriously considered, in addition to enclosure and ventilation, to provide minimum employee exposure. Since wet sanding in such a process has not yet been demonstrated, it cannot be truly defined as BAT; however, it appears that only minor development work would be necessary to adapt wet processing to these steps. In addition to reducing the fiber losses during the actual cutting and sanding, wet processing will tend to flush loose fibers from the sheet surface.

Improved hood and exhaust system design is considered BAT for the finishing and fabrication operations.

Projected Fiber Counts (with BAT)

If Best Available Technology is applied to the fiber introduction step, the projected exposure is estimated at 1.0 fiber/cc. The estimate at this processing step is based primarily on the projected exposure levels for the A/C pipe segment fiber introduction step. Centralized fiber introduction should also be adopted where production rates warrant, to reduce background fiber concentrations.

TWA fiber levels at the dry mixing and wet mixing steps, with BAT equipment installed, are estimated at 1.5 and 0.9 fibers/cc, respectively. The sheet formation and curing steps have projected TWA exposures of 1.25 fibers/cc. As noted above, the fiber count at these two work stations is most likely not attributable to the immediate operation, but rather a background fiber level from adjacent processing steps.

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Improved exhaust systems applied to the cutting and trimming operations should reduce TWA fiber levels to 1.0 fibers/cc. Exposure at the sanding operation is estimated at 2.0 fibers/cc, even after the application of BAT systems. A TWA fiber count of 1.0 fibers/cc is projected if wet sanding techniques are employed.

A TWA exposure of 1.0 fiber/cc is projected for BAT installed at the finishing step. This is a higher exposure level than projected for the cement pipe finishing operations, but the more extensive use of small, powered tools with less efficient exhaust enclosures will result in higher fiber emissions.

Advanced Technology

Advanced technology in the fiber introduction step should be considered as either automatic bag-opening or bulk fiber shipment and introduction. Automatic bag-opening will be the first of these technologies developed, and its use in other industry segments indicates automatic bag-openers should be available for use in the A/C sheet segment within one to two years. Bulk fiber shipments will take considerably longer to develop and implement.

Elimination of the dry mixing operation has been suggested as an advanced technology, based on comments received from the A/C pipe segments. Considerable development will be required to establish the feasibility of such a process modification.

Wet cutting and sanding lies somewhere between advanced technology and BAT control equipment. A totally automated dry-end handling system should be investigated, to eliminate or substantially reduce operator exposure at these typically high-emission-level operations. Wet finishing and fabricating techniques should also be developed for use not only at the sheet plant but also at the secondary fabricator. Automated equipment should be developed and installed where applicable.

Economic Impact

Data and information supplied to Weston represents 89 percent of the segment (Table 2-1); however, only 37 percent of this segment supplied usable data to generate cost information. The size of firms supplying usable data range from 4,000 to 6,000 tons of asbestos used annually.

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The capital costs to achieve BAT for this segment are $3,300,000. Operating costs are projected to be $130,000. This segment has 64 percent of its employees exposed. Industrial hygiene and medical costs will be $1,120,000 for this segment; this represents 54 percent of the total annual costs ($2,070,000). The total annual costs to comply with the proposed standard represent 3.0 percent of this segment's average annual sales. The toal annual costs versus average annual sales range from 1.2 to 3.5 percent. The expected capital costs estimated by industry to comply with the proposed standard represent 256 percent of this segment's typical total annual capital expenditures.

Summary of Impact
Asbestos Cement Sheet Segment

Asbestos Usage		54,000 tons/year
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		$3,300,000
Annual Costs:		
Capital	$ 820,000	
Operating Costs	130,000	
Industrial Hygiene and Medical Program	1,120,000	
Total Annual Costs		$2,070,000
Total Annual Costs versus Average Annual Sales		3.0 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures		256 percent

Conclusions

- The A/C sheet industry is currently in compliance with existing regulations. All processing steps are below the 5.0 fiber/cc TWA standard. However, four of nine processing steps currently exceed 2 fibers/cc.

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- Implementation of Best Technology Available will be required to meet the 1 July 1976 TWA exposure standard. Even with the implementation of BAT, no processing step in the asbestos cement sheet industry will be below the proposed 0.5 fibers/cc TWA exposure level.

- Implementation of BAT control equipment will require three to five years, based on industry estimates.

- The economic impact of implementing BAT requirements for this segment, while not as severe as for other segments on a percentage of sales volume, is significant because of the availability of substitutes for asbestos cement sheet. Manufacturers will have to absorb much of the anticipated production cost increase or risk a reduction in the market for their asbestos products if they pass all of the cost increases on to the customers.

Gaskets and Packings

Technological Feasibility

Asbestos is the most widely used material for gaskets and packing because of its resilience, strength, chemical inertness, and heat resistance. These asbestos materials are used in nearly every industry, household, machine, and transportation vehicle.

A wide variety of products is manufactured using raw asbestos fiber, textiles, and asbestos paper. The asbestos may be bonded under heat and pressure with materials such as nitrile rubber or chloroprene for resistance to oil and solvents. In fact, a wide range of materials is used in compounds with asbestos to engineer a product of highly specialized properties. Although some dry asbestos packing is used to seal furnance doors, rotary kins and high-temperature refractory equipment, packing generally incorporates a lubricant and is typically made by braiding asbestos yarns which are impregnated with a grease-base lubricant.

Process Description -- Gaskets

Many varied operations for the production of gaskets are known to exist. However, the information received for this industry is sparse and permits only a limited treatment. In general, however, gaskets are manufactured by the processes as described by Figure 4-7.

Asbestos bags are manually opened and dumped into mixing tanks. In some cases, the compressed raw asbestos is dumped into a fluffer for fiber opening before the mix step. Fillers and bonding materials are added to the fluffed asbestos in the mixer, and the mixture is blended. Mixing may be a dry or wet operation, according to the product requirements, and multiple production lines may be employed.

The formulation from the mixer is calendered into sheeting. The sheeting may be packaged and sold to secondary manufacturers, i.e. gasket cutters, for further processing, or it may be sold in sheet form to distributers for the maintenance market.

The gasket cutters generally form gaskets from sheets by die cutting, while the maintenance user cuts the sheet manually.

CAPCO JEN 0003591

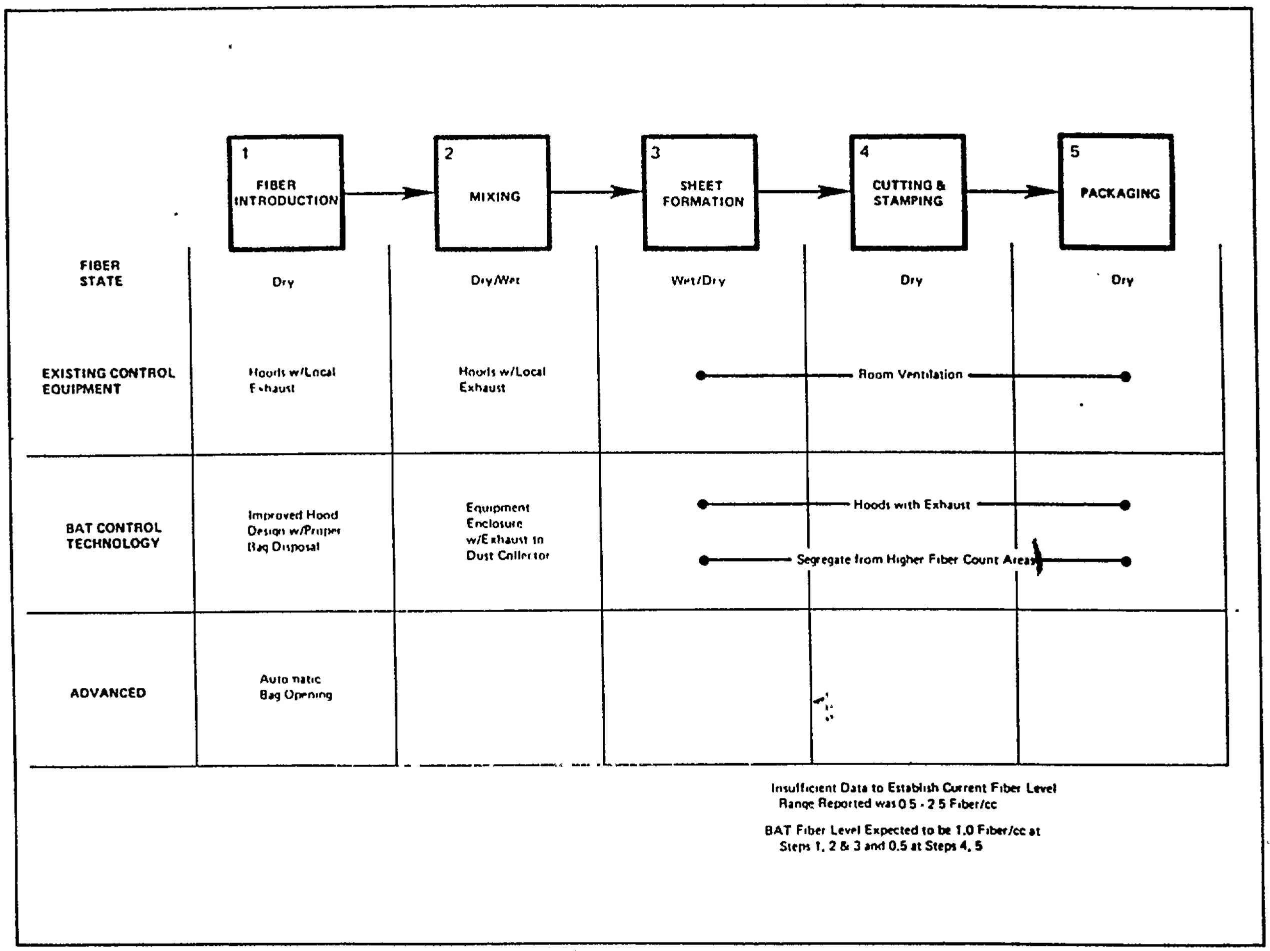

FIGURE 4-7 DIAGRAM OF PROCESS FLOW AND FIBER COUNT — GASKETS

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Process Description -- Packings

Asbestos-based packing is manufactured by a variety of processes, as illustrated in Figure 4-8. The most common process is to impregnate dry yarn with lubricants, which coats the fibers. The impregnated yarns are braided into a continuous length of packing, which is then calendered to a specific size and cross-sectional shape. It may then be coiled, boxed and sold to the maintenance trade, or it may be cut and die-formed to manufacturer's specifications. Occasionally impregnation follows braiding.

A variation of braided packing is made by extruding a mixture of asbestos fiber, binder, and lubricants, and then braiding lubricated asbestos yarns over the extrusion. For certain applications the percentage of binder in the extrusion is increased and the overbraiding is omitted.

Work Practices/Controls

The largest problem area for the segment is centered around the manual handling, opening, dumping, and mixing of raw asbestos from bags. These problems are common to all segments of the primary asbestos industry. Most companies employ dust collectors for the mixing operation. The use of respirators has also been reported.

Existing Fiber Counts

Little data has been received, and analysis is difficult. These data are listed in Table 4-7.

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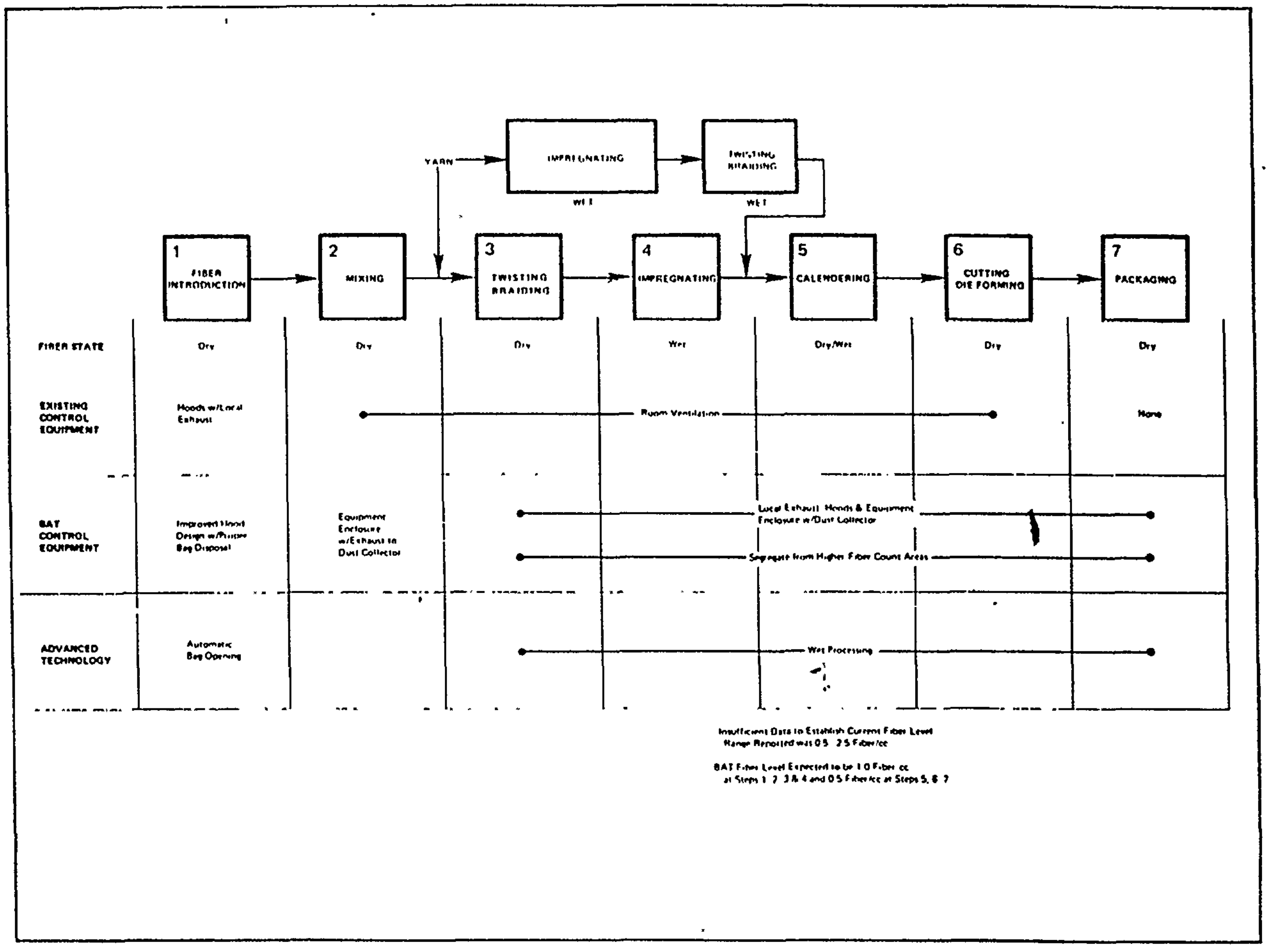

FIGURE 4-8 DIAGRAM OF PROCESS FLOW – PACKING

CAPCO JEN 0003594

Table 4-7

Existing Fiber Counts

Operation	TWA Range Fibers/cc
Fiber Introduction	0.5 - 2.5
Mixing	0.014 - 1.0
Braiding and Twisting	---
Sheet Formation	---
Cutting	---
Packaging	---

For the basic gasket and packing processes, fiber exposure levels in the fiber introduction area are of the most concern. Where mixing is accomplished with a wetted compound, fiber evolution is low. Data for fiber levels in the braiding, sheet formation, cutting, and packaging steps were not received in sufficient quantity to estimate employee exposure since these companies surveyed felt that they are complying with the existing standards and to the 2.0 fibers/cc TWA level for July 1976.

Best Available Technology (BAT) and Projected Fiber Counts (with BAT)

Hoods and dust evacuators are BAT control equipment for areas where raw asbestos is handled. The data reported in the fiber Introduction and mixing steps have been obtained where this control equipment is in use.

Advanced Technology

The advanced technology for bagged asbestos handling, as described in the section on "Receiving and Storage", is applicable to the gasket manufacturing industry. This technology includes automatic bag-opening machines and improved packaging of raw asbestos.

Economic Impact

Data and information supplied to Weston represents 41 percent of the segment (Table 2-1); however, only 37 percent of this segment supplied usable data to generate cost information. The size of firms, supplying usable data, range from 2 to 2,400 tons of asbestos used annually.

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The capital costs to achieve BAT for this segment are $16,000,000. Operating cost are projected to be $1,100,000. This segment has 21 percent employees exposed. The industrial hygiene and medical costs will be $5,550,000 for this segment. This represents 52 percent of the total annual costs ($10,650,000). The total annual costs to comply with the proposed standard represents 7.3 percent of this segment's average annual sales. The total annual costs versus average annual sales range from 3.0 to 7.5 percent. The expected capital costs estimated by industry to comply with the proposed standard represent 148 percent of this segment's typical total annual capital expenditures.

Summary of Impact
Gaskets and Packing Segment

Asbestos Usage		27,000 tons/year
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		
Annual Costs		$ 16,000,000
Capital	$4,000,000	
Operating Costs	1,100,000	
Industrial Hygiene and Medical Program	5,550,000	
Total Annual Costs		10,650,000
Total Annual Costs versus Average Annual Sales		7.3 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures		148 percent

Conclusions

- The gasket and packing industry will be affected by the proposed 0.5 fibers/cc TWA; the extent of this impact, from a technical feasibility review, has not been defined because of the lack of an adequate data base.

- Larger firms are not at a higher control technology level than smaller plants; hence the market shares are not expected to change significantly. However, the 7.3 percent cost (as a percentage of sales) is expected to be difficult to pass onto customers, for it may cause customers to switch to non-asbestos based products.

CAPCO JEN 0003597

Asbestos-Reinforced Plastics

Technological Feasibility

Asbestos-reinforced plastics are polymeric materials to which asbestos fibers are added in order to modify the composite's physical and chemical characteristics. These composite materials are multi-component blends in which the asbestos fiber is the load-carrying member and the polymeric matrix fills the gaps between the fiber and distributes the applied stress to the fibers. The plastic material provides a shape and a smooth surface to protect the fibers and may also provide thermal or electrical resistance.

Since the fiber serves to reinforce the matrix, its strength properties must be superior to those of the matrix. In the case of asbestos-reinforced plastics, a typical fiber-to-polymeric strength ratio is in the order of 100-to-1. In addition to imparting excellent strength to the plastic, the asbestos fibers are not soluble in, nor attacked by the resins or polymers; nor is the fiber affected by the processing temperature of the compound.

Asbestos fibers are used to reinforce phenolic, polyester, and epoxy resin and in a wide range of thermoplastic polymers. Their industrial, commercial, and residential uses are as ubiquitous as the term "plastic" implies.

Process Description

As shown in Figure 4-9, the production of asbestos-reinforced plastic begins with the introduction of dry asbestos fiber (Step 2). In this operation, the bag of asbestos is normally opened manually, and the contents are dumped into a storage hopper and conveyed to the dry blending step. Alternatively, the asbestos may be introduced directly into the dry blending step without intermediate storage and handling. Pulpable bags are not used in the industry segment since the asbestos must be intimately mixed with resins and additives in a dry state under somewhat gentle agitation to protect the fibers from abrasion and fracture. Therefore, the bag would not be broken down sufficiently to allow the components to be used even if they were desirable.

As previously mentioned, dry blending (Step 3) is needed to achieve homogenous mixture of asbestos, catalysts, additives,

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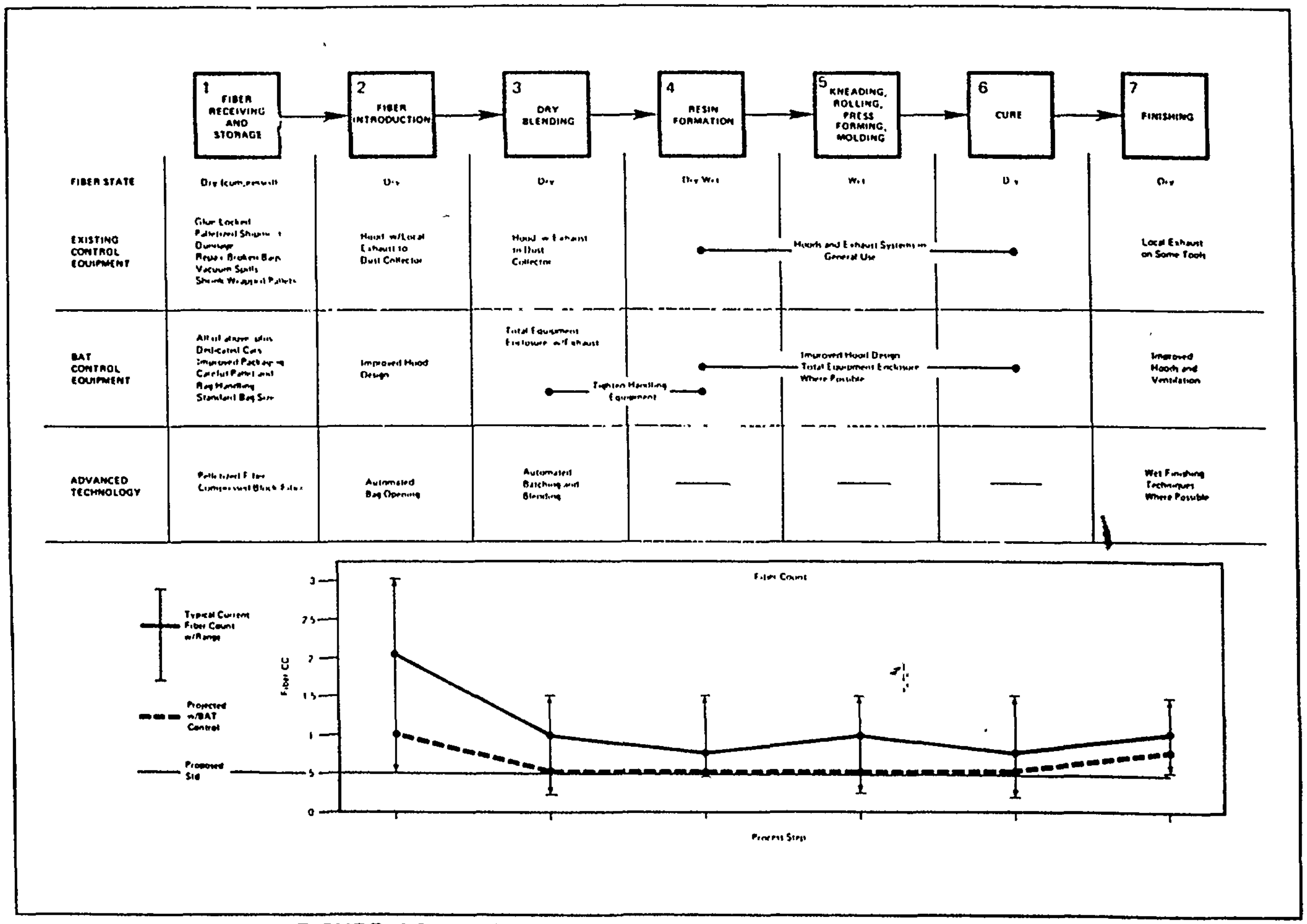

FIGURE 4-9 DIAGRAM OF PROCESS FLOW AND FIBER COUNT — ASBESTOS-REINFORCED PLASTICS

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and the matrix components (polymer). A wide variety of equipment is used throughout the industry to insure a low-shear, well-mixed blend.

From the blending step, the mixture is then formed into a resin (Step 4). Some manufacturers refer to this step as a "preforming" operation in which the mixture is heated by external energy (steam, electricity) as in extrusion, or by internal shearing friction as in a Banbury mixer. The product from these operations is a pellet, powder, or some similar "preform", which is either packaged and sold as an intermediate product or conveyed directly to a type of forming process (Step 5).

Step 5 also has many equipment and process variations incorporated under the general term of forming: rolling, stamping, pressing, and molding. Basically, the resin or preform is remelted and shaped into the final product under controlled conditions to achieve desired shape and texture characteristics.

Following the molding process, the formed product is cured (Step 6). This step involves control of cross-linking and thermosetting reactions to achieve specified strength and stiffness characteristics. When the reactions are carried to their desired ends, the rough product is then sent to a finishing step. Finishing (Step 7) operations are similar to other asbestos industry segments in that they involve sanding, grinding, polishing, drilling, sawing, etc. The degree of finishing (e.g. rough sanding vs. polishing) is dictated by product uses and the variety of applications for these plastic materials.

Although there are considerable variations to the asbestos-reinforced plastics manufacturing operation, the foregoing description is common to nearly all products. Specific processing steps, requiring greater explanation to fully describe asbestos dust exposure, will be included in the next paragraphs.

Work Practices/Controls

The asbestos content of asbestos-reinforced plastics is relatively small compared with the other ingredients involved in forming the resin. The handling of this quantity of dry asbestos fiber is normally accomplished by manual bag

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opening (and empty bag disposal) methods. Control technologies involve central ventilating systems with exhaust hoods in the area. Some large manufacturers use limited enclosure of their areas to minimize the asbestos dust exposure to outside areas and for better control of exhaust air flow. Pulpable bags are not used since the container is not suitable as an ingredient for making the resin. Additionally, the subsequent dry blending step is not designed for, nor can the product tolerate, the high shear force required to degrade the bag to a useful ingredient, if indeed its composition were a required ingredient.

Housekeeping procedures range from manual sweeping of floors and equipment to central vacuum cleaning systems and mobile sweeper/vacuum machines.

The dry blending step involves mixing the dry ingredients necessary to compound the material. These ingredients include asbestos, resins, polymers, additives, and catalysts. All substances are introduced into the mixing step in a dry form and are agitated to form a homogeneous blend. The degree of agitation may be described as gentle to moderate and is sufficient to produce a uniform mixture.

Control equipment includes exhaust hoods, local process exhaust equipment, and partial enclosures to control air flow and minimize asbestos dust exposure to surrounding areas. Housekeeping and maintenance practices are identical to fiber introduction areas.

After the individual ingredients have been thoroughly mixed, the blend is formed into the actual resin. A variety of equipment may be involved, depending upon the end-product specifications. In general, the resin is formed by either of two processes: externally heated extrusion or internally heated (friction/shear) Banbury mixer. Both processes produce a product which is sometimes called a "preform". This resin is then used in subsequent processes to form the end product. In some plants, this preform is drummed as a pellet or flake and sold as a product for other to form. In most locations the preform is transported to the next step (forming or molding) within the same plant. Control equipment in general use includes exhaust hoods and partial enclosure of process equipment. Housekeeping and maintenance practices include central vacuum cleaning systems, mobile floor sweeping/vacuuming equipment, and manual floor/equipment cleaning.

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The forming step involves actual formation of an end product from the preformed resin. The polymer portion of the resin is the shape-forming ingredient of the preform. The final product is shaped by remelting the preform and submitting it to rolling, stamping, pressing, or molding. Remelting serves to start the polymerization, cross-linking, and thermosetting reactions; forming gives the desired shape of the end product. Dust control equipment and housekeeping practices are generally similar to those in resin formation.

The curing step carries the thermosetting reactions to completion. The use of catalysts, additives, promoters, etc. in the original blend is coupled with controlled time and temperature conditions to achieve desired strength, shape, and stiffness characteristics.

This step involves close control of time/temperature conditions of the formed product. This normally requires an enclosed area, furnished with a ventilating system. In those processes where air curing is involved, hoods and local enclosures are provided. Housekeeping procedures are similar to those employed in other steps of dry processing.

After the product is cured, it is sawed, ground, drilled, machined, etc., to render the product suitable for sale as finished goods. The degree of finishing and the type of process used depends upon the end use of the product.

Asbestos dust is released when the plastic products are finished. Hand and portable tools are normally supplied with local exhaust systems connected to the central ventilation/collection system. Larger, stationary machines are supplied with local exhausts near the finishing surface and, in some cases, are supplemented with hoods over the finishing machine itself. Area or machine partial-enclosures are used to some extent where larger quantities of dust are released. Housekeeping practices are again similar to those employed in previous dry processing steps.

Existing Fiber Counts

As shown in Table 4-8, the asbestos dust exposure in fiber introduction ranges from 0.5 to 3.0 fibers/cc TWA. A typical exposure may be 2.0 fibers/cc TWA. These exposures are characteristics of a high prevalence of manual bag opening,

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Table 4-8

Time-Weighted Average Fiber Counts
Asbestos-Reinforced Plastics

Process Step		Fiber Count with Existing Control Technology: Typical Fibers/cc	Fiber Count with Existing Control Technology: Range Fibers/cc	Fiber Count with Best Available Technology (1) Fibers/cc
1	Fiber Receiving & Storage	1.0	0.25 - 2.5	0.5 or 1.0
2	Fiber Introduction	2.0	0.5 - 3.0	1.0
3	Dry Blending	1.0	0.2 - 1.5	0.5
4	Resin Formation	0.75	0.5 - 1.5	0.5
5	Kneading, Rolling, Etc.	1.0	0.25 - 1.5	0.5
6	Cure	0.75	0.2 - 1.5	0.5
7	Finishing	1.0	0.5 - 1.5	0.75

Data Base: Data collected from plants consuming 9,900 tons of asbestos, or 55 percent of the Asbestos-Reinforced Plastics Segment.

(1) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

CAPCO JEN 0003603

emptying, and handling for disposal. Control procedures are, therefore, limited to hoods and exhaust systems and partial enclosure of the bag-opening step.

The range of asbestos dust exposure for dry blending is 0.2 to 1.5 fibers/cc TWA, with a typical exposure of 1.0 fibers/cc TWA. The blending step is a dry-mixing operation employing exhaust hoods and partial enclosures.

The asbestos dust exposure for resin formation ranges from 0.5 to 1.5 fibers/cc TWA, with a typical exposure of 0.75 fibers/cc TWA. Most dust exposure is involved in handling and introducing the dry blended mixture into the resin formation step.

The range of asbestos dust exposure for the forming step is 0.25 to 1.5 fibers/cc TWA. A typical exposure is 1.0 fibers/cc TWA. The majority of asbestos dust is released before remelting, arising from handling the dry preform from the previous step. After remelting, the asbestos is bound in the polymer matrix.

The asbestos dust exposure for curing ranges from 0.2 to 1.5 fibers/cc TWA, with a typical exposure of 0.75 fibers/cc TWA.

The range of asbestos dust exposure from the finishing step is 0.5 to 1.5 fibers/cc TWA, with a typical exposure of 1.0 fibers/cc TWA. Normally, only minor finishing is provided for the cured product. Thus, the amount asbestos fiber released is less than other asbestos industry segments. Additionally, the contents of asbestos in the product is low compared to such products as asbestos cement pipe or sheet. Therefore, for the same degree of finishing, a lower asbestos fiber release is expected as the content of asbestos in the product is decreased.

Best Available Technology (BAT)

In general, BAT for fiber introduction involves the use of improved ventilation systems in the bag-opening area, minimizing the handling of empty bags, partial enclosure of this area, and revised housekeeping practices which minimize manual sweeping and maximize the use of central vacuum cleaning and mobile sweeping/vacuuming systems.

CAPCO JEN 0003604

The use of improved ventilation systems, coupled with total enclosure of process equipment, where practical, is suggested as BAT for the dry blending step. Housekeeping and maintenance procedures must be improved to prevent release of asbestos dust from equipment used in handling the blend outside of the enclosed equipment area.

The resin formation, forming, and curing steps require similar improvements as in the preceding disucssion of BAT for dry blending.

Finishing operations are common to many of the asbestos industry segments discussed in this report. Asbestos dust exposure may be controlled by: employing more extensive local exhaust systems with increased air flow; better cleaning of finished material to remove dust adhering to the surface; using more automated equipment where practical in operations that are routine or semi-continuous; and improving housekeeping to minimize dust accumulation on equipment and floor areas.

Projected Fiber Counts (with BAT)

The use of BAT in the asbestos-reinforced plastics industry segment would reduce airborne asbestos exposure in the fiber introduction step to 1.0 fibers/cc TWA.

The use of BAT in the dry blending, resin formation, forming, and curing steps will reduce asbestos exposure to 0.5 fiber/cc TWA.

By employing BAT, the finishing step will reduce asbestos dust exposure to 0.75 fibers/cc TWA.

Advanced Technology

The successful development and commercialization of a fully automated bag-opening and bag disposal operation will reduce asbestos exposure below levels attainable by BAT in fiber introduction. Variations of this equipment are available; however, reliability of operation must be improved before the concept can qualify as BAT in the asbestos-reinforced plastic segment.

Fully automated batching/blending equipment is being developed to reduce manual handling of dry compounding ingredients.

CAPCO JEN 0003605

This equipment would allow an operator to be located away from potential asbestos exposure and would control the blending step from a remote, climate-controlled environment.

Wet-finishing equipment must be developed to supress asbestos dust release from sanding, grinding, and similar operations. These techniques are practiced to a limited extent in other industry segments; however, the extension of their use to plastics finishing require considerable development because of the variety of processes involved, the extensive use of highly versatile hand-operated tools, and the ultimate ending of the product.

Economic Impact

Data and information supplied to Weston represents 55 percent of the segment (Table 2-1); however, only 34 percent, of this segment supplied usable data to generate cost information. The sizes of firms supplying usable data range from 65 to 4,500 tons of asbestos used annually.

The capital costs to achieve BAT for this segment are $1,100,000. Operating costs are projected to be $110,000. This segment has 45 percent of its employees exposed. The industrial hygiene and medical costs will be $2,310,000 for this segment; this represents 86 percent of the total annual costs ($2,690,000). The total annual costs to comply with the proposed standard represent 2.4 percent of this segment's average annual sales. The total annual costs versus average annual sales range from 0.9 to 2.6 percent. The expected capital costs estimated by industry to comply with the proposed standard represent 23 percent of this segment's typical total annual capital expenditures.

Summary of Impact
Asbestos Reinforced Plastics Segment

Asbestos Usage		18,000 tons/years
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		$1,100,000
Annual Costs:		
Capital	$ 270,000	
Operating Costs	110,000	
Industrial Hygiene and Medical Program	2,310,000	
Total Annual Costs		$2,690,000

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Total Annual Costs versus Average Annual Sales	2.4 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures	23 percent

Conclusions

- Production steps involving dry blending, resin formation, forming, and curing will be capable of reduced asbestos exposure levels (to 0.5 fibers/cc TWA) after employing BAT.
- Production steps involving fiber introduction and finishing will be capable of reducing asbestos exposure levels to 1.0 fiber/cc and 0.75 fibers/cc TWA, respectively, TWA after employing BAT.
- The majority of manufacturers will be capable of achieving the 2.0 fibers/cc TWA standard by improving present operations and installing BAT in selected steps.
- Significant development is needed for equipment (control and process) capable of reducing asbestos exposure levels below 1.0 fiber/cc TWA in the fiber introduction step.
- At present, best estimates of commercilaization of advanced technologies to achieve asbestos exposure levels below 1.0 fiber/cc TWA range between three and seven years.
- At present, it is not possible to state with certainity that development of advanced technologies will be capable of reducing asbestos exposure to 0.5 fiber/cc TWA in all process operations.
- The costs to comply with the proposed standard will be greater for small companies because of their lower developed technology base. As these increased cost are passed on to customers, the smaller firms will experience a reduced share of the market.

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Asbestos Textiles

Technological Feasibility

Asbestos textiles have a variety of uses because they combine unique properties of asbestos: incombustibility, and resistance to heat, corrosion, and biological attack. A few of the uses include clutch and brake linings, boiler insulation, fire protective clothing, fire barriers in building construction, mechanical packing, gaskets, ironing board covers, insulation in electrical generators, and ship-board pipe and vessel insulation. In most uses, asbestos textiles are coated or bound with such materials as resins, elastomers, and metal before evolving into the final product. Asbestos yarns may be reinforced with many materials such as cotton, nylon, polyester, and wire.

Approximately 65 percent of the U.S. demand for asbestos textiles is supplied domestically, primarily by three major producers. Foreign imports account for the remaining 35 percent of the U.S. demand. Foreign competition is intense and is enjoying a growing market share. The asbestos textile segment is highly technical and automated, employs specialized machinery for high rate production, and uses proprietary and patented technology. The basic yarns, cloths, and other products are further processed by a host of secondary manufacturers before the ultimate product reaches the end user. Thus, although asbestos textiles account for only one to two percent of the U.S. consumption of raw asbestos, the market value per unit of asbestos is perhaps the highest of the asbestos industry.

Process Description

Two basic process variations are employed in asbestos textile manufacturing: conventional and wet. The conventional process accounts for the major portion of product and is further subdivided into a dry process and a damp process. The dry and damp processes are identical except that during the "damp" process the yarn is moistened to reduce fiber evolution. (The moisture may be applied by contact with water on a roller or a mist spray).

The dry-process manufacturers produce a small volume of highly specialized yarn without contact with water. The newly developed wet process yields a yarn by extruding a chemically dispersed slurry into a chemical coagulant. The

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resulting wet process yarn is dense and tends to hold the asbestos fibers better than the conventional process. This results in smaller amounts fibers released to the work environment. Major disadvantages with the wet process yarns are poor absorption and reduced impregnation characteristics.

A textile plant may produce 15 or more products. Thousands of operations may occur simultaneously as hundreds of strands are wound and rewound, spun, twisted, braided, and woven. With the operations speeding along throughout the entire plant, hundreds of point sources of asbestos fiber dust are generated in any given area. (See Figure 4-10.)

Raw asbestos fibers in semi-compressed bags are manually handled (warehoused, transported, slitted, and dumped), creating potential worker exposure to asbestos similar to other asbestos segments.

Asbestos yarn is normally a specific blend of different grades of asbestos (primarily different fiber lengths) to impart desired processability and product quality. Therefore, it is necessary to weigh the various asbestos ingredients before the bags are manually opened and dumped into blenders.

The raw asbestos grades and other ingredients are dumped into several blending machines. The blending machines are continuously operating devices that gently mix the components of the formulation. The mixing is achieved as the asbestos slowly moves toward the rear of the machine, is drawn up an incline, and tumbles back to the bottom. Part of the mix is carried up the incline and falls into a hopper. The rear of the blending machine is enclosed and hooded to minimize fiber elution. As the hoppers are filled with the blended fibers, they are transferred to the carding operations.

The carding machine combs the fiber mix into a paralleled (oriented) fiber mat. This mat is mechanically pressed and layered into a lap. At the finishing card, the lap is separated into thin continuous strips of fiber, called "roving". To impart strength and other characteristics to the asbestos, cotton or rayon or other materials may be added to the roving. The lap, matting, or roving may be packaged and sold to secondary industries. Otherwise, the roving proceeds to the spinning frames.

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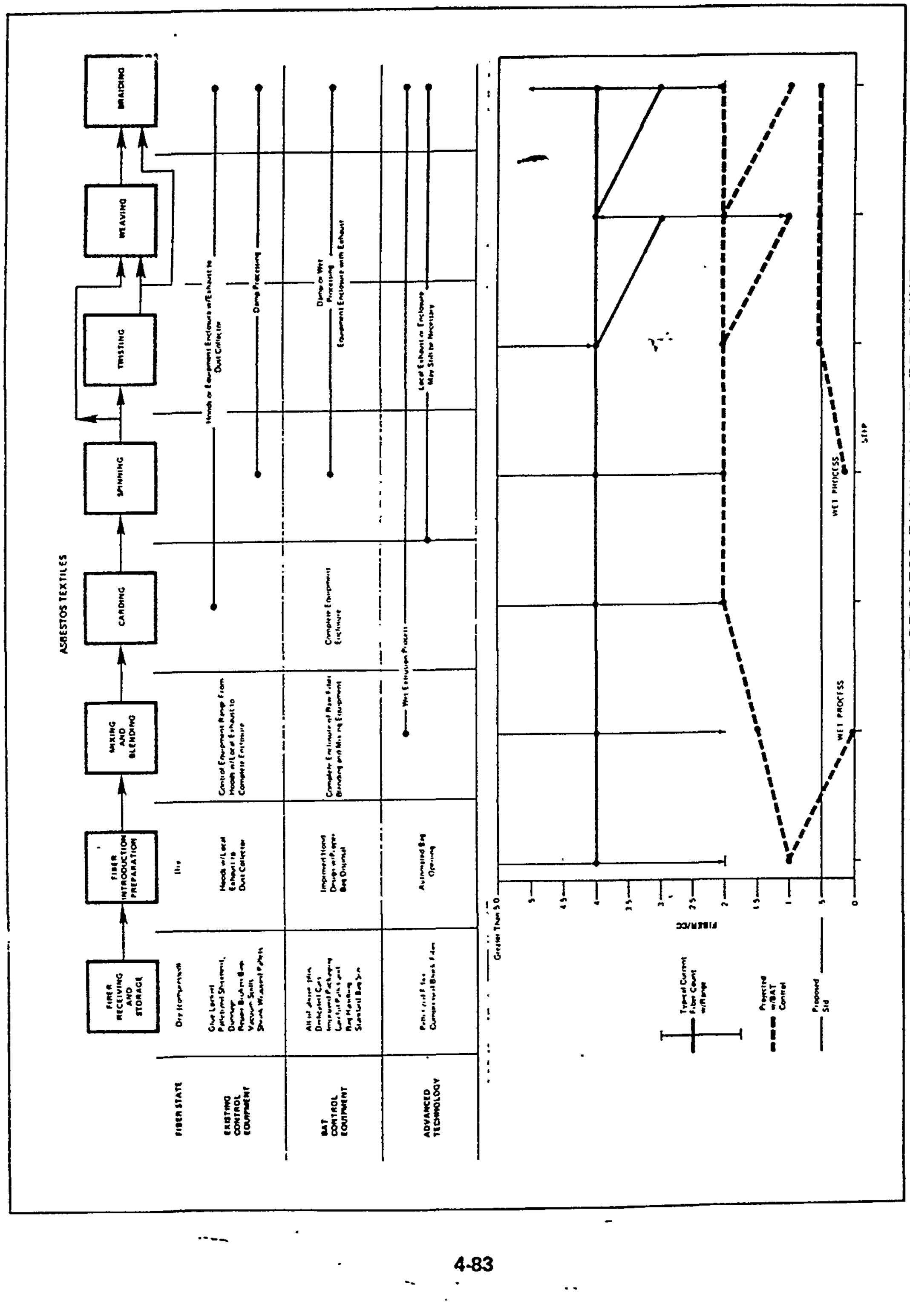

FIGURE 4-10 DIAGRAM OF PROCESS FLOW AND FIBER COUNT
– TEXTILES

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The roving is spun (twisted) to specified turns per inch to impart strength. Other materials may be added to give certain desired characteristics. In the damp process, the roving is wetted with wet rollers before spinning. This damp process is employed to reduce asbestos fiber dust during subsequent processing. Where essential for product quality, the roving is not wetted; the remainder of the processing is with dry material (dry process).

During spinning and further processing, many of the strands will break. The whipping ends released fiber dust as they fly around the spindles. During this high-speed processing, strands repeatedly break. The strands are repaired manually, requiring constant worker attention. Dust release is particularly severe in dry processing.

Spun roving, called "single yarn", may be twisted with other single yarn, wire, or other material to produce plied yarns. Plied yarns may be coated to produce thread or treated yarns. Otherwise, the plied yarn may be woven to produce tapes, cloth, or woven tubing; or it can be braided to produce cord, rope, or braided tubing. Spun yarn otherwise may by-pass the twisting steps and go directly to producing woven, braided, or treated products.

At the weaving looms, the yarn is first put on a beam or creel, which handles a large number of strands to feed the loom. A damp or dry loom may be used to create cloths of different characteristics.

The wet process differs generally from the other processes in that the raw asbestos is dumped directly into a slurrying tank with water and chemicals. The slurry is extruded directly into a strand. These strands proceed to the spinning and other operations similar to conventional processing. The wet process thus avoids blending and carding, which generate asbestos dust. Since wet-processed textiles possess different characteristics, secondary manufacturers must devise new production techniques to compensate for the altered processability and final product quality.

Work Practices/Controls

Housekeeping problems arise during fiber handling and introduction because of damaged bags and spillage of raw asbestos fibers. Continual vigilance and frequent vacuuming are

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employed to clean up spills. Hoods, dust evacuators, and bag filters are generally employed where raw fiber is dumped from the bags. The blending machines are normally partially enclosed with dust evacuators to minimize worker exposure to airborne asbestos. Blended asbestos fiber is often manually transported to the carding machine. Plastic sheet covers enclose the hoppers during this transfer. Loading raw fiber into the carding machine sometimes is a manual operation in which the worker picks the asbestos up with his hands and dumps it into the carding machine.

In some plants, special equipment layout has been incorporated to eliminate the transporting operation. Special blending machines were developed and located adjacent to the carding machines. The blender automatically feeds the carding machine. In general, fiber introduction, blending, transporting, and carding are high exposure areas because of the necessity for manual handling of raw fiber.

Where matting, lap, or roving is sold to secondary manufacturers, the handling of this material by workers results in potentially high fiber exposure. Normal tending of these areas by workers results in exposure to high background levels of airborne asbestos. The mechanical working of dry asbestos fibers in the blending and carding operations necessarily evolves asbestos fiber into the air and the entire processing area becomes a potential exposure hazard (in contrast to being a controllable point source). Respirators are used by workers in these areas.

Although spinning, twisting, weaving, and braiding are expansive operations and are highly mechanized, constant worker attendance is required to repair broken strands and to make equipment adjustments. Broken strands are a constant problem. These broken ends whip asbestos into the air until they are repaired. Additionally, the continuous high speed working of the yarn (spindling, spinning, twisting, weaving, etc.) constantly evolves asbestos fiber into the air. Since thousands of strands undergo multiple processing throughout large work areas, isolation of point sources is impractical.

<u>Existing Fiber Counts</u>

High 8-hour TWA fiber counts are incurred throughout the entire asbestos textile manufacturing. Table 4-9 presents these counts. Dry processing presents particularly severe exposure problems, because no phase of the operation uses wetted strands

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Table 4-9

Time-Weighted Average Fiber Counts
Asbestos Textiles

Process Step		Fiber Count with Existing Control Technology				Fiber Count with Best Available Technology (2)	
	Typical Fibers/cc	Damp Fibers/cc	Dry Fibers/cc	Wet (1) Fibers/cc		Conventional Fibers/cc	Wet Fibers/cc
1 Receiving & Storage	1.0	0.25 - 2.5		0.25 - 2.5		0.5 or 1.0	
2 Fiber Introduction	4.0	2.0 - 10.0	2.0 - 10.0	2.0 - 8.0		1.0	
3 Mixing & Blending	4.0	N/A	2.0 - 10.0	N/A		1.5	N/A
4 Carding	4.0	N/A	2.0 - 10.0	N/A		2.0	N/A
5 Spinning	4.0	2.0 - 10.0	2.0 - 15.0	2.0		2.0	0.4
6 Twisting	4.0	4.0 - 10.0	No Data	2.0		2.0	0.5
7 Weaving	3.0	1.0 - 4.0	No Data	1.0		1.0	0.5
8 Braiding	3.0	2.0 - 5.0	No Data	1.0		1.0	0.5

(1) Data are estimates from pilot equipment
N/A - Not Applicable

Data Base: Data collected from Conventional Plants Consuming 12,900 tons of asbestos, or 96 percent Asbestos Textile Segment.

(2) Projected fiber counts are estimates of average exposure after implementing BAT. Variations of these values are expected depending upon individual installations.

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to control dust. Dry processing exposure problems are particularly acute in the twisting area. Since damp processing wets the strands before they are spun, subsequent operations have minimized dust release (with respect to dry processing). However, both processes yield potentially high exposure levels in the fiber introduction, blending, and carding operations.

Wet processing eliminates the dust generated from the blending and carding operations since these steps are not employed. Fiber introduction is accomplished directly into a chemical slurry, and underwater extrusion is used to produce the strands. Wet processing still has asbestos fiber release into the atmosphere from fiber introduction, spinning, twisting, weaving, and braiding. Because of the high moisture or coagulum content of the strands, wet processing inherently produces the lowest level of fiber counts in the work environment for this segment.

Best Available Technology (BAT)

The complexity of operations in the textile industry makes identification of the best available technology extremely difficult. Workers must be in direct contact with most operations to effect repairs and adjustments. Complete enclosures are not possible because the worker must have direct access to the process. Partial enclosures and exhausts have been installed.

Wet processing in general is in a trial development stage. Application of this technology requires scrapping the carding equipment, and the product will not satisfy all markets. New processes will need to be developed to impregnate the wet processed yarns.

In general, enclosures, hoods, and exhausts are BAT for raw-asbestos-handling operations such as bag opening, blending, wet mixing, and conveying of bulk fiber. Vacuum systems (fixed and portable) are BAT for controlling spillage and other house-cleaning problems.

Where practical, repetitive wetting of strands is used to control fiber levels. In some cases, spindles have been designed to stop rotating if a strand breaks, but this slows spinning and twisting speeds and directly influences spinning rates.

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Projected Fiber Counts (with BAT)

Generally, application of BAT in the asbestos textile industry will lower the fiber exposure levels to 2 fibers/cc TWA. Major breakthroughs in technology or massive redesign of facilities will be required before the 0.5 fibers/cc TWA level can be achieved in all process areas.

Projected fiber counts for conventional processing are fairly complete. Fiber introduction and blending (essentially the same operation) and carding yield ranges from 1.0 to 2.0 fibers/cc TWA. The dampened spinning and twisting yield an exposure level of 2.0 fibers/cc TWA. Weaving and braiding operations yield levels of 1.0 fibers/cc TWA.

Little data was reported for the dry and wet processes. The dry process will have identical exposure levels as the damp process up to the spinning operation. The best attainable level for spinning and the remaining processes would be 2 fibers/cc TWA.

The wet process has the same handling problems with raw bagged asbestos handling as other processes. Depending on techniques and equipment employed, exposure levels in the fiber introduction area are believed to be about 1.0 fibers/cc TWA. The wet mixing operation is stated to yield exposure levels less than 2 fibers/cc TWA.

Spinning of wet fiber is reported to yield fiber counts of approximately 0.4 fiber/cc TWA, or less. Twisting, weaving and braiding are reported as 0.5 or less fibers/cc TWA.

Because there are several asbestos fiber sources in each operation, the fiber counts are essentially measured values by area rather than point source; these values are background levels, and therefore can significantly affect adjacent areas.

Advanced Technology

Extensive conversion to the developmental wet process is an alternative. This implies retiring some existing equipment, and extensive developmental time, and additional costs. Furthermore, all markets cannot be served with the wet-processed yarn.

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Automatic bag-opening machines and automated fiber handling would be a break-through. Complete humidification of factories has been suggested. A step-by-step and area-by-area re-evaluation and redesign of machinery and plant layout would be required to significantly reduce asbestos fiber levels. Many complex developmental alternatives beyond the scope of this report are believed to exist.

Economic Impact

Data and information supplied to Weston represent 96 percent of the segment (Table 2-1); 96 percent of this segment supplied usable data to generate cost information. The sizes of firms supplying usable data range from 1,360 to 4,500 tons of asbestos used annually.

The capital costs to achieve BAT for this segment are $19,700,000. Operating costs are projected to be $1,550,000. This segment has 82 percent of its employees exposed. The industrial hygiene and medical costs will be $3,370,000 for this segment; this represents 34 percent of the total annual costs ($9,840,000). The total annual costs to comply with the proposed standard represent 11.8 percent of this segment's average annual sales. The total annual costs versus average annual sales range from 3.3 to 74 percent. The expected capital costs estimated by industry to comply with the proposed standard represent 273 percent of this segment's typical total annual capital expenditures.

Summary of Impact
Asbestos Textiles Segment

Asbestos Usage		13,500 tons/year
Increased Cost of BAT to Industry Segment:		
Capital Cost to Achieve BAT		$ 19,700,000
Annual Costs:		
Capital	$4,920,000	
Operating Costs	1,550,000	
Industrial Hygiene and Medical Program	3,370,000	
Total Annual Costs		$9,840,000

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Total Annual Costs versus Average Annual Sales	11.8 percent
Expected Capital Costs versus Typical Total Annual Capital Expenditures	273 percent

Conclusions

- The asbestos textile segment will not achieve a 2.0 fibers/cc TWA standard by the effective date of July 1976. However, the industry is moving in this direction and, by implementing BAT, can be expected to achieve this level.
- Extensive redesign of production facilities, completely new plants, and new processes will be required by the asbestos textile segment to achieve any major reduction in fiber exposure levels below 2 fibers/cc TWA.
- The proposed 0.5 fiber/cc TWA is not achievable in the foreseeable future.
- Small firms may not be able to afford the cost to comply with the proposed standard, and therefore their market share may be lost to the larger firms or foreign competion. In 1975, foreign competion was 30-40 percent of the total asbestos textile market.

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Miscellaneous Primary Industries

Drilling Fluids

Drilling fluids (muds) are essential for drilling oil and gas wells. The use of asbestos in drilling muds is well-established and can have a significant effect on lowering the cost of drilling and completing wells. Drilling muds are pumped down through the drill pipe and back up the annulus between the drill pipe and the well bore wall. When they arrive back on the surface, they flow over a shaker screen to remove the drill bit cuttings, and into a mud pit. The fluid is then recirculated through the hole. Materials needed to maintain the properties of the drilling fluid are added in the surface pit.

The main function of the drilling mud is to remove drill cuttings from the hole and to contain formation pressures in the hole. The mud also removes heat from the drilling action, acts as a lubricant, and prevents excessive hole erosion. The drilling mud must be such that it remains fluid enough to be pumped with minimum pump pressures. It must not be lost to the formation, yet it must overcome formation pressures to prevent ingress of oil, gas or water.

Asbestos is added to the drilling mud to improve its carrying capacity without appreciably increasing the viscosity. Other methods of improving the carrying capacity markedly increase viscosity, which increases pump pressures, thus reducing the power available at the bit and slowing down drilling. Slow drilling rates increase drilling costs. Asbestos is used in concentrations of from 2-5 pounds per-barrel (1 barrel = 42 gallons) of mud.

Asbestos is added to the drilling fluid through a mud hopper or large funnel. Initially, a volume of mud of from 150 to 200 barrels is prepared. As drilling progresses, additions are made to the system for maintenance and to accomodate the volume of the hole being drilled. Typically, these conditions occur only once during an 8-hour shift. The amounts of asbestos added are small -- rarely exceeding 500 pounds at a time.

Over 30,000 wells are drilled per year in the U.S., using around 1,500 drilling rigs. The frequent moving from site to site makes fixed control equipment for asbestos fiber exposure infeasible. A normal drilling crew consists of four men working

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an 8-hour shift; that is, three 8-hour crews per day. Drilling sites may be miles from any population center and are subject to extremes of climatic conditions (for example, the north coast of Alaska to the Gulf of Mexico).

Existing Fiber Counts

Asbestos is handled in two forms. The major share of the market is divided between a wetted granular material and a coarse ground material. Worker exposure is low because of the physical properties of the asbestos and short exposure times. The coarse ground material is more dusty than the pelletized form; both are much less dusty than dry, loose fiber. TWA fiber counts were reported as 0.4 fibers/cc, with a maximum ceiling level of 1.9 fibers/cc.

Conclusions

- When using pelletized asbestos, the drilling mud industry is currently meeting the proposed level of 0.5 fibers/cc TWA.

Joint Cements

Joint cements are used to finish the installation of wall board for industry and home applications. The construction industry and the do-it-yourself home installations use this material.

There are two principal types of joint compounds. One uses a latex or water-soluble glue as a binder and "sets" by evaporation of the water. The other uses dehydrated gypsum as the binder (and principal dry ingredient) and sets by chemical reaction as the gypsum takes up the water of hydration. The first type is mainly limestone with lesser amounts of mica and 3-5 percent asbestos. This type is used in about 80 percent of the market, and is mostly sold in the ready-mixed, wet form. The gypsum-based material, with roughly 20 percent of the market, also usually contains asbestos and must naturally be sold dry and mixed just before use. The applicator mixes the compound with water in the field. Wet-mix products are manufactured and packaged in a can for ready use.

The manufacturing of joint cements incurs the common exposure potentials for handling raw asbestos fibers when bags are stored, moved, slit, dumped, and disposed of. The raw asbestos fiber is dry-blended or alternatively transferred to wet mixing before packaging.

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The product flows from the manufacturer, to wholesalers, to retailers, to small contractors, and finally to appliers. The wet-mix product has little potential for asbestos fiber exposure until it is finally applied and allowed to dry. Sanding the product after it has dried can generate dust. The dry-mix material can potentially cause exposure to asbestos through the distribution chain if there is damage to the bag. Field mixing of the joint cement can lead to additional exposure.

Existing Fiber Counts

No data have been received from this segment but the shipping, receiving, and fiber introduction steps are similar to other industries in the asbestos field.

Best Available Technology (BAT) and Projected Fiber Counts (with BAT)

Hoods, enclosures, and air bag-filters make up the best available technology for asbestos receiving and fiber introduction. The BAT projected fiber count is 2.0 fibers/cc TWA.

Conclusions

- The joint cements segment will not attain the proposed 0.5 fibers/cc TWA with BAT.

Raw Asbestos Retailing

Raw asbestos is purchased by wholesalers and warehousers in 100-pound bags, repacked in small quantities, and sold to retailers. These wholesalers repackage the asbestos in 5- to 25-pound bags for resale. The ultimate customer may be a plumber who uses the asbestos in a cement compound for repair of boiler or pipe insulation. In addition to the exposure problems of users, significant exposure may exist in the repackaging operation.

Existing Fiber Counts

No data have been received for this industry, but the operations are similar to the shipping, receiving, and fiber introduction steps of other industries.

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Best Available Technology (BAT) and Projected Fiber Counts (with BAT)

Hoods, enclosures, and bag-filters are the best available technology for asbestos receiving and fiber introduction. The BAT projected fiber count is 2.0 fibers/cc TWA.

Conclusions

- The raw asbestos retailing industry will not attain the proposed 0.5 fibers/cc TWA with BAT.

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Conclusions for the Primary Industries

Technological Feasibility

Conclusions drawn from diverse industry segments generally have little value. In this case, however, such conclusions can reasonably be drawn, since many of the processing steps are similar, if not identical, and the problems for fiber release and control technologies employed are similar.

- The 10 primary industry segments have moved expeditiously to reduce worker exposure to airborne asbestos. Our study indicates that worker exposure was significantly reduced even before the 1972 standard was promulgated. Since adoption of the existing standard, further reduction in exposure has been achieved.

- The range of existing fiber counts reported by industry (Figure 2-1) indicates that 47.3 percent are between 0 and 2.0 fibers/cc TWA and that 52.7 percent are above 2.0 fibers/cc. Further, 9.7 percent have greater than 6.0 fibers/cc exposure. At process steps where the fiber source could be confined and available dust control equipment and technology could be implemented, fiber levels were reduced to a range of 1 to 2 fibers/cc TWA. There still remain large numbers of work stations and operations where readily available equipment was ineffective, where the dust source could not be confined or the nature of the operation inherently released fiber into the atmosphere, or where the dust source was beyond the control of the manufacturer (incoming fiber shipments). While significant progress has been made at these locations, levels of fiber exposure in the 2-6 fiber/cc TWA range still occur, with occasional fiber levels as high as 22 fibers/cc TWA.

- Considerable variation is experienced in fiber count readings at the same work station, using the same control equipment. Ranges as broad as 0-22 fibers/cc TWA have been reported. A major source of variation appears to be in the test method used to determine fiber count. Another significant source of variation in fiber count is the work practices and methods of the individual employee. Careful attention of the employee to work habits which minimize dust generation is a prerequisite to achieving and maintaining lower

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exposure levels. On the other hand, poor work habits will increase fiber exposure regardless of the level of engineering control.

- A significant portion of the airborne asbestos results from materials handling, rather than directly from processing equipment. While such a distinction may appear small, it has a profound effect on the strategy of control and on the ultimate level of control achievable. In process sources, a point or points of fiber release can generally be controlled. When fiber release is due to handling the raw fiber or product, it represents an area source, rather than a point source, and is therefore much more difficult to control. An analogous situation occurs in air pollution control technology when dealing with point vs. fugitive dust sources.

- In the majority of industry segments, the two major fiber release areas are fiber introduction into the process and product finishing. The fiber introduction step often results in high airborne fiber concentrations because fiber accumulates on the outside of the bag during transportation and because the bag must be opened, dumped, and disposed of. All of these steps involve intimate handling of the raw fiber and exposure to loose fibers which may have accumulated from previous handling.

- Once the asbestos enters the processing equipment, control of the fiber release is generally good. Often water or binders are added, further reducing the potential for fiber release. The product finishing step involves the mechanical modification of the asbestos-containing product. When such modification requires abrasion, such as in sanding, sawing, etc. fiber will again become airborne.

- Few data on ceiling exposures are available. Contacts have reported their concern with the TWA standard, rather than the ceiling concentration standard; however, no data exist to support their contention.

- Implementation of BAT will not reduce TWA exposure to 0.5 fiber/cc at all processing steps in the primary segments. Only 30 of 86 (35 percent) identified work stations were projected to be at or below the proposed 0.5 fiber/cc TWA exposure standard. Therefore, 65 percent of the primary process steps are above 0.5 fibers/cc. The achievement of an exposure limit of 0.5 fiber/cc TWA is not feasible with the application of BAT for each process step.

- Application of BAT is projected to reduce TWA exposure to 2.0 fibers/cc TWA or less at all work stations in the primary industries.

- Implementation of BAT in the primary industries will require three to five years, based on industry estimates and on the implementation of the compliance schedules required by the existing standard.

- There is little question that reasonable monitoring in the work environment is necessary to determine the level of worker exposure. However, there are several factors which affect the feasibility of such a program.

  - The results of our study indicate a widespread lack of understanding and misapplication of the TWA and ceiling exposure, and personal and area sampling test methods and calculations.

  - The accuracy and reproducibility of the test procedure must be questioned in light of the wide variations in TWA fiber count reported at the same worker station, employing the same control equipment. Duplicate samples taken simultaneously from the same employee have indicated substantial variation in fiber count. While other factors can logically be expected to affect fiber count (variations in day-to-day work practices, raw materials, background fiber levels), the sampling and counting procedure must be questioned.

  - At present, only 74 laboratories are accredited by the American Industrial Hygiene Association (16) or participate in HEW's National Institute for Occupational Safety & Health asbestos counting program (58). We did not estimate in detail the total number of samples which would require asbestos counting; however, it does not appear feasible for the 74 laboratories to analyze the hundreds of thousands of samples which will be required by the proposed standard.

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Economic Impact

- Capital Costs to achieve BAT, exclusive of previous capital expenditures, in 1975 dollars are estimated at $93,950,000 (Table 4-10) for nine of the asbestos industry segments. The Capital Costs to achieve BAT for the miscellaneous segment were excluded because the diverse responses from that segment were not amenable to further analysis. Concerning Capital Costs to achieve BAT, it should be noted:

  - BAT control equipment has already been installed at many work stations in order to meet the 2.0 fiber/cc TWA standard.

  - BAT will not achieve a uniform 0.5 fiber/cc TWA standard at all work stations.

  - In many installations, BAT will be achieved by modifying existing control equipment, rather than by installing new facilities.

- Total Annual Costs to achieve BAT, exclusive of current annual costs, is estimated at $66,440,000 (Table 4-10). These costs include annual capital costs for control equipment, annual operating costs, and the annual industrial hygiene and medical program costs to the requirements of the proposed standard. However, the $66,440,000 is based upon only 9 segments (excluding Miscellaneous) and is based on improving present operations to the BAT level, rather than meeting the 0.5 fiber/cc proposed level.

- The Total Annual Costs as a Percent of Average Annual Sales for each segment range from 1.6 to 11.8 percent (Table 4-10). For most of these segments, the cost increase can likely be passed on to the consumer with little or no loss in the market, in the form of price increases. Historically, cost increases resulting from implementation of the existing standard have been passed to the consumer with no market loss. However, up to this time, these cost increases have been eclipsed by "double-digit" inflation over the past three years, and by a 30 percent increase in fiber cost during the last 18 months.

- The Asbestos Textile and Friction Products segments are most likely to suffer market losses because of cost increases. Since the mid-1950's the Textile segment has faced severe cost competition from foreign producers. We cannot

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Table 4-10

Summary of Economic Impact
Primary Asbestos Industries, by Segment

	Capital Cost to Achieve BAT	Annual Costs to Achieve BAT			% Increase in selling Price from Implementation of BAT	Expected Capital Costs (Percent) Vs Typical Total Annual Capital Expenditur
		Operating Costs	Industrial Hygiene & Medical Program	Total Annual Costs		
Asbestos Paper	$ 5,100,000	$ 200,000	$ 4,010,000	$ 5,510,000	1.7	172
Asbestos Cement Pipe	12,000,000	750,000	2,150,000	5,900,000	3.2	162
Floor Tile	2,720,000	1,380,000	6,000,000	8,060,000	3.0	33
Friction Products	29,800,000	3,360,000	6,570,000	17,380,000	7.8	316
Paints, Coatings, and Sealants	4,230,000	550,000	2,730,000	4,340,000	1.6	143
Asbestos Cement Sheet	3,300,000	130,000	1,120,000	2,070,000	3.0	256
Gaskets and Packing	16,000,000	1,100,000	5,550,000	10,650,000	7.3	148
Asbestos Reinforced Plastics	1,100,000	110,000	2,310,000	2,690,000	2.4	23
Asbestos Textiles	19,700,000	1,550,000	3,370,000	9,840,000	11.8	273
Overall Primary Industries	93,950,000	9,130,000	33,810,000	66,440,000[1]	5.1	

[1] Includes Annualized Capital Costs

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predict the extent, additional Asbestos Textile business will be lost to foreign competition because of implementation of the proposed standard. The Friction Products segment has also recently experienced foreign competition, primarily from Canada. Further loss of business can be expected, as prices for domestically produced friction materials will increase because of the cost of implementing the proposed standard.

- The Expected Capital Costs as a Percent of Typical Total Capital Expenditures range from 23 to 316 percent (Table 4-10). Only two of the nine segments expect less than 100 percent (Floor Tile and Asbestos-Reinforced Plastics) to comply with the proposed standard, the other seven industry segments will be required to devote significant capital resources to implementing BAT. As previously indicated the BAT level is above the proposed 0.5 fiber/cc in many process steps.

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Technological Feasibility

Method of Analysis

Secondary industries are those which continue the manufacturing process by receiving a material which contains asbestos (already modified by the primary industries) and further process, modify, or fabricate this product to produce another intermediate or final product. The secondary industry segments are highly diversified with respect to both the number of plants involved and the variety of final or intermediate products manufactured.

The major emphasis of this report involves the status of the primary industry segments producing asbestos products (or intermediates, excluding construction activities). However, since asbestos goods form the raw material for a great many plants, the full economic impact of the proposed asbestos standards cannot be fully assessed without a thorough investigation of the secondary industries (excluding construction activities). To achieve this, Weston solicited data and comments from a wide variety of plants representative of the secondary industries. The data are as varied as the products themselves, but have been categorized in order to derive specific conclusions. Weston is prepared to discuss the general status of the secondary industry segments; 23 percent of the responses, coupled with Weston's telephone contacts and plant visits, form the basis of the following discussion. To aid in the understanding of the secondary industries and to avoid duplication of descriptions among the segments, the secondary industries will be treated as one entity with appropriate areas of differences noted between major product segments.

Process Descriptions

The secondary asbestos industries produce products which are suitable for sale either to the customer directly as finished goods (e.g., impregnated roofing felts) or to another secondary industry (e.g., asbestos paper and metal sheets combined to form gasket material, which is then punched or cut by another secondary; asbestos textile fabric, coated with aluminum and then cut and tailored into fire protective clothing, etc.).

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In many cases, the secondary industry overlaps the finishing area process steps carried out by the primary industries. Most secondary industries are involved with fabrication of an asbestos-containing product from one form into another. These fabricators employ techniques such as sanding, grinding, sawing, milling, punching, pressing, slitting, shearing, routing, etc., to mechanically modify the received "raw" material into a "finished" product. Therefore, the secondary industries are faced with reducing asbestos dust exposure in these steps much the same as in the primary industries. However, there are several important distinctions which must be made to separate this "common" exposure area.

The primary industries normally limit finishing steps to the end of the production process (machining of asbestos cement pipe, asbestos paper slitting and rewinding, etc.). Many of these operations occupy only a small area of the entire plant. Isolation of the finishing area from areas of lesser exposure is practical. The secondary industry often does finishing throughout the entire process operation; isolation of a high-exposure area is impractical since the entire plant is involved.

Fabrication or conversion of asbestos-containing materials into a product often involves the use of highly versatile, portable hand tools for sawing and sanding. Efficient dust control using local exhaust equipment sometimes does not serve to reduce employee exposure to below 5 fibers/cc TWA if the employee is performing this operation the entire day. It may be possible to develop a more efficient machine and dust control apparatus (wet sanding); however, the more specialized the equipment, the less versatile it becomes. The fabricator must purchase more elaborate equipment which may be used only a few times a month when he makes up an order. Alternately, he may choose to abandon this portion of his business, rather than work with a substance that produces high amounts of dust and that requires special equipment.

The primary industry segment is composed of large corporations whose level of control and process technology have evolved over many years of research, development, and experience. These large businesses have expended manpower and capital to overcome operational and dust-exposure problems. In many instances, the control technology is advanced beyond reach of the small to medium-sized fabricator. A secondary fabricator employing five to 20 people can hardly be expected to install expensive special finishing equipment without adversely affecting the

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capital stability of his business and the cost of his product. This point will be expanded in later discussions dealing with the economic impact of the proposed regulations upon the secondary industries.

Work Practices/Controls

Receiving and storage areas normally present less potential asbestos dust exposure in the secondary industry segments since their raw materials have been processed by the primaries and are received in a bound-asbestos or packaged form. Dust exposure, therefore, is limited to materials damaged either in shipping or storing operations or arising from dust clinging to products from abrasion in shipment or arriving from the primary industry supplier. These materials become exposure sources only if the fiber is released from the binding material or the package is broken and the material is abraided. (This may occur, e.g., when a fork lift operator runs over a spilled or broken piece of material.) Housekeeping practices that stress rapid clean-up of broken material with vacuum systems rather than manual sweeping are effective in minimizing dust exposure from these steps.

Basically, the secondary industry segments use the same type of control equipment and work practices as the primary industry segments to reduce employee exposure to asbestos dust. Control equipment and work practices used include: central vacuum systems for floor and equipment cleaning; down-draft tables, local exhausts on hand tools, and area hoods on large machines connected to a central ventilation system with air filtering through a bag-house; wet grinding and sawing where product integrity is not adversely affected; cleaning of raw materials and products to minimize dust exposure in handling and packaging; proper handling of scrap materials; and routine equipment and floor cleaning.

Although the control equipment and work practices employed by the primary and secondary industry segments are similar, the secondary industries are characterized by the prevalence of hand tooling and machining operations, which are more labor-intensive than primary industry's production operations in the finishing steps. The diversity of processes in some secondary industries and the "piece-work" or custom fabrication cause these secondaries to use highly versatile tools. The control practices emphasize the use of local exhausts to minimize asbestos dust exposure. These controls are effective in reducing the bulk of the dust generated, but cannot be expected to be highly efficient under all working conditions by virtue of their versatility.

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Existing Fiber Counts

The variety of processing and control techniques employed by the secondary industries and of the raw materials arising from all of the primary industry segments makes the definition of a general range of asbestos exposures meaningless. The data which Weston has acquired indicate a categorization of the secondary industries by raw materials received from the primary industry suppliers. The secondary industries are segmented according to the categories presented for the asbestos primary industries: asbestos paper; asbestos cement pipe; floor tile; friction products; paints, coating and sealants; asbestos cement sheet; gaskets and packing; asbestos-reinforced plastics; and asbestos textiles. Table 5-1 illustrates general ranges of fiber counts in these industries.

- Asbestos paper products are used to produce gasket materials, thermal and electrical insulation, roofing products, etc. Secondary segment products are characterized by slitting, sawing, punching, pressing, converting, and leminating operations. The range of fiber exposure is 1.0 to 3.5 fibers/cc TWA.

- Asbestos cement pipe is manufactured and machined in the primary industries almost exclusively. The next step for this product is the construction (or plant maintenance) industry for installation. This segment's products, when used by the construction industry, are not subject to OSHA's proposed standard.

- Floor tile is manufactured, cut, and packaged for shipment by the primary industries. The next step for this product is either the construction industry (including builders and remodelers), or homeowners use for installation. Therefore, this segment's products (when used by the construction industry or homeowners) are not subject to OSHA's proposed standard.

- Paints, coatings, and sealants are similar to asbestos cement pipe and floor tile; that is, they are used by the construction industry and home remodeling markets. Thus, this segment's products, when used by the construction industry or homeowners, are not subject to OSHA's proposed standard.

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Table 5-1

Time-Weighted Average Fiber Counts
Secondary Industries

Secondary Industry[1]	Range of Reported Fiber Levels Fibers/cc
Asbestos Paper	1.0 - 3.5
Asbestos Cement Pipe	Not Applicable
Floor Tile	Not Applicable
Paints, Coatings and Sealants	Not Applicable
Friction Products	2.5 - 6.5
Asbestos Cement Sheet	1.0 - 6.0
Gaskets and Packing	0.2 - 5.0
Asbestos-Reinforced Plastic	0.5 - 2.C
Asbestos Textiles	0 5 - 5.0

[1] Based upon the type of raw materials received by the secondary industries.

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- Friction products are used to manufacture brake and transmission assemblies for the automotive, truck, heavy machinery, and railroad industries. A wide variety of motion-controlling applications are dependent upon industrial friction components. These secondaries receive the friction products from the primaries and form them into a product which requires drilling, sawing, tapping, grinding, and cutting of the friction products to conform to the product specifications. The range of fiber exposure is 2.5 to 6.5 fibers/cc TWA.

- Asbestos cement sheets are used widely by the secondary industries for molten metal and glass supports and troughs, thermal insulation, building materials, etc. All operations require some machining -- punching, pressing, sawing, drilling, sanding, etc. -- which generates substantial amounts of asbestos-laden dust. The range of fiber exposures is 1.0 to 6.0 fibers/cc TWA.

- Gaskets and packings are used as fluid seals in a variety of devices. They may be impregnated with polymers, latex, and other materials to yield special properties. Gaskets and packings which have been treated with chemicals to further bind the asbestos fibers release less dust than unbound materials when undergoing additional processes such as pressing, punching, and slitting. For gaskets and packings which are received from a primary industry without a binder or as a yarn for making packings in the secondary segment, the range of fiber exposure is 1.0 - 5.0 fibers/cc TWA. Similarly, for those products which had been combined with a binder or impregnated in the primary industry, the range of fiber exposure is 0.2 to 1.5 fibers/cc TWA.

- Asbestos-reinforced plastics are used to make electrical switchboards and a wide variety of molded plastic products requiring a high strength-to-weight ratio. Secondary industries cut, drill, mill, and grind these materials according to product needs. The range of asbestos exposure is 0.5 to 2.0 fibers/cc TWA.

- Asbestos textiles are processed into packing materials, friction products, insulation, and protective clothing by the secondary industries. The textile product as received by the secondary may be bound with a resin which supresses dust evolution in the secondary processing; however, a portion of textile material is received as raw fabric. The secondary industries employ processes such

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as cutting, stamping, slitting, sawing, braiding, laminating, and sewing according to the specifications of the product. The range of asbestos exposure is 0.5 to 5.0 fibers/cc TWA.

Best Available Technology (BAT)

The Best Available Technology to be employed in the secondary industries to reduce employee exposure to asbestos is similar to that discussed for each of the primary segments, with the exception of the front-end processing steps (raw fiber receiving, fiber introduction, stock preparation, blending, etc.) involved with the primaries. A thorough examination of the primary industry segments indicates that technology is available to reduce employee exposures to asbestos below those which, based upon limited data, are prevalent in the secondary industries by a combination of control equipment, process modification and changes in work practices. In general, however, BAT for the secondary segments will be more difficult to implement because of the variety of processes, machining, products, and technologies present. The practical engineering and economic aspects of installing BAT in the secondary industries are more formidable and require careful evaluation on a plant-by-plant basis.

In general, BAT includes the use of central and local machine exhaust hoods; wet machining where possible; central and mechanical vacuum cleaning systems; proper handling of waste material; isolation of equipment with enclosures; and increased automation of equipment.

Projected Fiber Counts (with BAT)

It is not possible to estimate the asbestos fiber counts achievable in the secondary industries after implementing BAT segment by segment. The process, raw materials, product, and technology variations are so numerous, even within a given segment, that projections of fiber exposures are relevant only when considering a reasonably well-defined operation. For example, fiber exposure will vary between a drilling step and a sawing step even when both are processing an asbestos cement sheet product. Similarly, fiber exposure will vary between a drilling step handling a friction product versus one handling an asbestos cement sheet. Therefore, the process step, material handled, and products manufactured must all be considered when estimating the asbestos fiber exposure after implementing BAT.

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If the secondary industries installed BAT similar to the primary industry segments, it is Weston's opinion that it should not be expected that employees will reach the same level of exposure as projected for the primary segments when both segments are working with the same type of asbestos-containing material. This judgment is based upon the following two points:

- The secondary segments are composed of a higher percentage of labor-intensive and custom-fabrication industries than the primary segments.

- BAT will not be identical for both segments because there are differences in products manufactured, processing steps, material inputs, and technologies.

Economic Impact

Method of Analysis

Based upon Weston's questionnaire survey, 23 percent of the total responses represented input from the secondary asbestos industries. The data contained in these responses, coupled with Weston's telephone contacts and plant visits, are not amenable to the same economic evaluation as that developed for the primary industries. The information obtained, however, does indicate rough economic trends. These trends need much greater study to define the true economic impact of the proposed regulations on this segment of the industry. However, Weston has developed reasonably accurate "order-of-magnitude" estimates of these economic trends by applying economic and statistical methods to extrapolate current data and to forecast the expenditures likely to be required in the secondary industries for compliance with the proposed regulations.

Development of Secondary Asbestos Usage

Table 2-1 indicates the asbestos usage for each segment of the primary industries. From this allocation and a knowledge of products manufactured in the primary segments, estimates of the quantity of asbestos-containing products (by asbestos fiber content) passed on to the secondary segments are possible. The next step for products manufactured by the asbestos cement pipe; floor tile; and paints, coatings, and sealants segments is either the contruction industry or the home remodeling (contractor and homeowner) industry. These primary segments, therefore, do not have an explicit secondary segment; they are passed directly to the consumer industries. Similarly, approximately 25 percent of the asbestos cement sheet and 70

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percent of the Miscellaneous segments are without a definable secondary segment. Thus, of the 900,000 tons per year (fiber content) of primary asbestos products, only approximately 517,500 tons per year (57.7 percent) are passed through a secondary segment.

Development of Estimated ~~Plant~~ Employment Data

From the data presented in the employment section for primary industries, Table 3-1, approximately 37,539 employees are working 190 primary industry segment locations throughout the U.S. The average employment for each location is 198. In order to establish the employment in those industry segments which have a secondary segment, Weston consulted data published by the Department of Commerce, Dun and Bradstreet, and several other sources to arrive at a coefficient which represents the number of employees in the secondary industries, exclusive of those individuals engaged in repair or replacement of brake materials. This category of secondary industries (service stations, garages, dealers, and fleet repair) was given special attention due to the large number of establishments and employees exposed.

The sources of data were not all consistent, and at times differed in their estimate of number of locations. The problem is further complicated by the fact that the classification into primary segments is not totally compatible with the Standard Industrial Classification (SIC) Codes used in the data sources investigated.

However, after a thorough review of all sources (including the industry and trade association estimates of locations), Weston placed total employment in the secondary industries (excluding the brake service and repair sector) at 300,000 employees. Of this total, approximately 80 percent (240,000 employees) are considered production or maintenance personnel: the remainder are administrative and management (Source: 1972 Census of Manufacturers). In order to allocate the work force among the various secondary segments, Weston assumed that the level of employment in a segment (as a percentage of the total employment in the industry) was the same as the ratio of the quantity of asbestos (fiber content) products received by that segment to the total used in the secondary industries. (Table 5-4 gives the basis.) Following a similar line of reasoning, Weston estimated the total employment per location to be 25 employees, allowing the number of secondary asbestos industry establishments (excluding the brake service and repair sector) to be derived as 12,000 throughout the U.S.

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Establishments engaged in the repair or replacement of brake (friction) materials are categorized as secondary industries since the employees are exposed to airborne asbestos in sufficient quantity likely to exceed the proposed TWA and ceiling concentrations of asbestos. Such establishments are classified as: service stations, independent repair shops, new car/truck dealer shops, and self-service fleet shops. Data on the number of establishments and employees involved in these services were compiled from information supplied by the Automotive Parts Rebuilders Association (APRA), the 1973 Service Job Analysis report (Hunter Publishing Company), and numerous private corporations involved with brake service shops. The data from these sources were assembled and classified by establishment and employees exposed and are presented on Table 5-2. The total number of employees exposed is approximately 1,970,000 in 246,000 establishments through the U.S.

Development of BAT Capital Cost Data

Based solely upon the questionnaire responses, development of a sufficient data base to project capital costs for implementing BAT was not possible. Weston supplemented this information with phone contacts to solicit input from as broad a range of secondary segments as time would permit. Upon receiving the data on both an inter- and intra-segment basis, Weston concluded that cost estimates by the industry members were extremely diverse because of the large differences in production techniques, sizes of plant, type of product, levels of technology, etc. In order to reduce these cost estimates into meaningful data, a common divisor was necessary. After several approaches were investigated, Weston selected two methods of data comparison which seemed to yield the most consistent results: BAT capital cost per employee and BAT capital cost per ton of asbestos (fiber) received per year. As shown on Table 5-4, these methods yield results which differed by approximately 20 percent. The BAT capital costs were expressed as $850 per employee and $400 per ton of asbestos (fiber) received per year.

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TABLE 5-2

ECONOMIC IMPACT FOR BRAKE SERVICE/REPAIR SECTORS - SECONDARY INDUSTRIES

	Service Stations	Independent Repair Shops	New Car/Truck Dealer Shops	Self-Service Fleet Shops	Totals
Employee continuously exposed	340,000	190,000	145,000	225,000	900,000
Employee occasionally or infrequently exposed	325,000	470,000	140,000	135,000	1,070,000
Total employees exposed	665,000	660,000	285,000	360,000	1,970,000
Total establishments in U.S.	194,000	108,000	39,000	21,000	362,000
Establishments involved in Brake Service/Repair	136,000	70,000	25,000	15,000	246,000

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Development of Basic Industrial Hygiene and Medical Program Costs

The industrial hygiene and medical program costs include the requirements for the following paragraphs of the proposed standard:

- Monitoring
- Respiratory Protection
- Personal Protective Clothing
- Hygiene Facilities and Practices
- Medical Surveillance
- Employee Information and Training
- Recordkeeping

To determine the methods industry would use to comply with the proposed standard, Weston used the costs developed in the primary industry sector as a basis. However, it was assumed that a basic program would have to be developed due to the proposed standard. It was also assumed that 40 percent of the process steps would be above the 0.5 fiber/cc level after implementation of BAT and that 40 percent of the employees are continuously or frequently in the work environment. The estimated costs per employee per year are summarized in Table 5-3.

Thus, by applying the figure of $835 per employee per year to each total employment figure in the secondary segments, a cost of compliance with the proposed regulation can be estimated.

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Table 5-3

Basic Industrial Hygiene and Medical Program Costs
Secondary Industries

1.	Monitoring[1]	$120
2.	Respiratory Protection[2]	170
3.	Personal Protective Clothing[3]	200
4.	Hygiene Facilities and Practices[4]	180
5.	Medical Surveillance[5]	85
6.	Employee Information and Training[6]	50
7.	Recordkeeping[7]	30
	Total Per Employee Per Year	$835

1. Monitoring: 25 percent of the employees were estimated to require monitoring (from primary industries incremental cost estimate). It was assumed that a basic program monitoring was required 12 times a year.

   (.25) (12 samples/year) ($40/sample) = $120

2. Respiratory Protection: It was estimated 40 percent of the process steps would be above 0.5 fibers/cc after implementation of BAT based on data from primary process steps (65 percent). In addition, the material the secondary industries receive contain asbestos in a form more difficult to release to the work environment. However, in some cases the secondary industry, by sanding, cutting, drilling, etc., performs process steps identical to the primary industries. It was also estimated that 40 percent of the employees are continuously or frequently in the work environment. (Underlined figures represent information derived from the primary industries.)

   (.40) (.40) (<u>$2.80/filter</u>) (50 weeks/year) + (<u>0.1 hr</u>) (<u>$6.00/hr</u>) (250 days/yr) = $170.

3. Personal Protective Clothing: 40 percent of the employees are continuously or frequently in the work environment (from 2 above)

   (.40) (<u>$2.00/uniform</u>) (<u>250 days/year</u>) (<u>$6.00/hr</u>) = $200

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Table 5-3
(continued)

4. Hygiene Facilities and Practices: secondary industries will be required to install change room/shower/lavatory facilities. These costs appear in the capital costs to achieve BAT. Forty percent of the employees are continuously or frequently in the work environment (from 2 above) and will require a daily shower.

   (.40) (0.3 hr) ($6.00/hr) (250 days/year) = $180

5. Medical Surveillance: Annual examination to include chest roentgenograph, forced vital capacity, forced respiratory volume @ 1 sec. and sputum cytolgy. It was estimated 4.0 hrs of non-productive time would be required for the examination.

   ($60 examination) + (4.0 hr/yr) ($6.00/hr) = $85

6. Employee information and training:

   (8.0 hr/year) ($6.00/hr) = $50

7. Recordkeeping: Based on one day clerk's time @ $30.

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TABLE 5-4

ECONOMIC IMPACT - SECONDARY INDUSTRIES

Industry Segment	Primar Industry Segments: % Asbestos Usage	Primar Industry Segments: Annual Tons of Asbestos Usage	Secondary Industries: % Asbestos Usage	Secondary Industries: Annual Tons of Asbestos Usage	Estimated Employment (production/total)	BAT Capital Cost Estimates ($): Based upon Employment (4)	BAT Capital Cost Estimates ($): Based Upon Tons of Asbestos Consumed / year(5)	Estimated Industrial Hygiene and Medical Costs, ($/year)
Asbestos Paper	38.0	342,000	66.0	342,000	158,400/198,000(3)	168,300,000	136,800,000	165,300,000
Asbestos Cement Pipe	16.0	144,000	-	-	-	-	-	-
Floor Tile	12.5	112,500	-	-	-	-	-	-
Friction Products	6.5	58,500	11.5	58,500	(900,000/1,970,000(7) (27,600/34,500(8)(3)	765,000,000(7) 29,300,000(8)	Not Applicable 23,400,000(8)	1,644,900,000(7) 28,800,000(8)
Paints, Coatings, & Sealants	7.5	67,500	-	-	-	-	-	-
Asbestos Cement Sheets	6.0	54,000	8.0	40,500	19,200/24,000(3)	20,400,000	16,200,000	20,000,000
Gaskets and Packings	3.0	27,000	5.0	27,000	12,000/15,000(3)	12,800,000	10,800,000	12,500,000
Asbestos Reinforced Plastics	2.0	18,000	3.5	18,000	8,400/10,500(3)	8,900,000	7,200,000	8,800,000
Asbestos Textiles	1.5	13,500	2.5	13,500	6,000/7,500 (3)	6,400,000	5,400,000	6,300,000
Miscellaneous	7.0	63,000	3.5	18,000	8,400/10,500(3)	8,900,000	7,200,000	8,800,000
TOTALS	100.0	900,000 (1)	100.0	517,500 (2)	1,140,000/2,270,000	1,020,000,000	Not Applicable	1,895,400,000(6)

Footnotes:
1. Based upon Table 2-1
2. Estimate of tons of asbestos contained in primary industry products which are processed by secondary industries.
3. Approximately 80 percent of total employment are defined as production workers.
4. Based upon survey average of $850 per employee to install BAT on secondary industry level.
5. Based upon survey average of $400 per ton of asbestos processed per year on secondary industry level.
6. Based upon Table 5-3; Industrial Hygiene and Medical Costs of $835/employee/year.
7. Brake Service/Repair sectors only.
8. Secondary industries in Friction Products segment excluding Brake Service/Repair.

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General Profile

The Secondary Industries are highly diversified plants capable of producing an extremely wide variety of finished goods or intermediate products. In general, they are labor-intensive operations requiring significant use of hand-operated power tools. The process and control technology of the Secondary Industries has been shown to produce an employee exposure to airborne asbestos somewhat higher than for a similar operation in Primary Industries.

The plants are further typified as employing a small to medium-sized work force of varying levels of labor skills. A number of plants use a somewhat lower pay scale than others (producing the same product) but include a production incentive program ("piecework bonus") in their salary classifications or job descriptions. Large numbers of plants derive their sales from specialized or custom-made items ("jobshoppers") rather than term contracts for a specific item furnished over a period of time. It is important to note that a significant number of plants included in the secondary industries also produce materials not containing asbestos, and their level of control technology reflects generally accepted techniques for dust control not specific to reduction of airborne asbestos fibers.

With regard to the implementation of the proposed standards, the responses to Weston's survey indicate a wide diversity of opinions. Most of the plants indicated that they could not continue to manufacture certain products if the proposed standards were adopted. These plants are basically involved with production of asbestos cement sheet, friction products, and gasket and packing products and use such processes as drilling, grinding, sawing, and sanding. All produce significant quantities of asbestos-laden dusts and were unsure about what further approach was to be taken to reduce the exposure to the proposed standard levels.

Table 5-5 presents a summary of the economic impact attributable to compliance with the proposed regulations by the secondary asbestos industry as a whole and by individual segments. In developing these results, Weston used the same methodology as that described for the primary industries. In total, the secondary asbestos industries will be required to spend approximately $2,251,960,000 per year to comply with the proposed regulations. This expenditure may also be expressed as $995 per employee per year for the entire group of secondary industries, or

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TABLE 5-5

Summary of Economic Impact - Secondary Industries

Industry Segment	Capital Cost to Achieve BAT (2)	Annual Costs to Achieve BAT: Operating Costs	Annual Costs to Achieve BAT: Industrial Hygiene and Medical (3) Programs	Total Annual Costs	Total Estimated Employment	Total Estimated Number of Establishments
Asbestos Paper	168,300,000	6,600,000	165,300,000	213,980,000	198,000	
Asbestos Cement Pipe	-	-				
Floor Tile	-	-				
Friction Products	794,300,000	91,160,000	1,673,700,000	1,963,440,000	2,004,500	
Paints, Coatings, and Sealants	-					
Asbestos Cement Sheet	20,400,000	800,000	20,000,000	25,900,000	24,000	
Gaskets and Packings	12,800,000	880,000	12,500,000	16,580,000	15,000	
Asbestos Reinforced Plastics	8.900,000	890,000	8,800,000	11,920,000	10,500	
Asbestos Textiles	6,400,000	500,000	6,300,000	8,400,000	7,500	
Miscellaneous	8,900,000	710,000(1)	8,800,000	11,740,000	10,500	
TOTALS	1,020,000,000	101,540,000	1,895,400,000	2,251,960,000	2,270,000	258,000

(1) Estimated at 8% of capital cost.
(2) BAT capital costs on Table 5-4, based on employment.
(3) From Table 5-4.

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approximately $8,725 per year per average work establishment. By comparison, the primary segments (refer to Table 1-1) are estimated to require a total of $66,440,000 per year, or $1,770 per employee per year and $350,000 per establishment.

Industrial hygiene and medical program costs make up about 51 percent of the cost of compliance for the primary segments; in the secondary industries, these costs increase to approximately 85 percent of the total. From data extracted from the 1972 Census of Manufactures, the weighted average of value of shipments added per employee is $20,682 (based upon SIC Codes 3292, 3293 and 2661). After adjusting this value to 1975, the value added per employee is approximately $21,200. Based upon an average of $995 per employee to comply with the proposed regulation in the secondary industries, a minimum average price increase of 4.7 percent for products exiting from these segments may be estimated, based upon the internal cost for compliance. The increase of 4.7 percent in product price by the secondary industries does not include the increased raw material costs passed on by the primaries as their cost of compliance.

The full impact of these economic changes on those who are required to install BAT may follow one of these avenues:

- If asbestos-containing materials are a mainstay of the plant's sales, the owner may choose to install BAT and pass all, or a portion of, his cost to the next secondary or directly to the final customer. The amount of the passed-on cost may have a ceiling above which he cannot raise prices because of competition from imported products, a competitor's similar product, or an asbestos-free substitute product. In these cases, the owner will suffer a loss in profit which may ultimately cause him to discontinue all or a portion of production and reduce his work force.

- If asbestos-containing materials are a small portion of the plant's sales, the owner will be likely to discontinue processing the costly products. Similarly, in a plant which processes a variety of asbestos-containing products, the owner will likely discontinue that product line which causes his operation to exceed the standard rather than install costly BAT for a portion of his business.

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- If asbestos-containing materials are a significant portion of the total plant's sales, the owner may not be able to afford installing BAT and must close his plant with resultant unemployment of his work force.

The competition among similar manufacturers in the secondary segments is keen, with many high-volume, low-profit-margin products. Recent increases in the costs of raw asbestos fiber to the primary segments, increased labor costs, capital expenditures to achieve the present asbestos standards, and the general inflationary trend of the past few years have caused asbestos-containing products to increase significantly in cost. As costs have risen, stronger market inroads have been made by imported asbestos products and by substitutes not containing asbestos. Additional research and development is continuing to supply new products which do not contain asbestos. All of these conditions serve to heighten the competition in the asbestos industry by shrinking the marketplace. The secondary industries are caught in the middle of a decreasing product demand and increased production costs.

A necessary result of this situation appears to be a reduction in the number of secondary industry plants. However, there may be no noticeable decrease in the total work force involved. This will be true only if product demand is relatively constant and can be supplied by a smaller number of secondary plants, each employing a larger average work force. Of necessity, there will be a consolidation of this segment into a fewer number of larger companies (whose economic situation allowed them to comply with the regulations and remain financially solvent); or more processing by the primary industries (which have a higher level of technology and the stronger financial base to expand their operations and sustain product demands) than had heretofore been the case. The extent to which this consolidation may occur in light of the proposed regulations and the effects upon the national economy are uncertain at this time and require in-depth study of the economic situation of the Secondary Asbestos Industries.

Conclusions

- The majority of the secondary industries are currently meeting the 5.0 fibers/cc TWA standard.

- BAT for the secondary industries is similar to that defined for the primary segments. However, equal employee exposure levels (vis à vis similar processes in both segments) are not considered likely.

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- With the exception of a few industries in the gaskets and packings and reinforced plastic segments, all industries reported that efforts to decrease fiber exposure significantly below the current 2.0 fibers/cc TWA standard would require development of advanced technologies not as yet proven.
- Implementation of BAT in the secondary industry is estimated to cost approximately $2,251,960,000 per year, or $995 per employee per year.
- The estimated employment for the asbestos secondary industries is 2,270,000 employees, which includes approximately 258,000 locations throughout the U.S.
- Implementation of BAT is estimated to cause a product price average increase of approximately 4.7 percent exclusive of higher raw material costs passed-on by the primary segments.
- The brake (friction material) service/repair sector is estimated to bear approximately 85% of the costs to comply with the proposed standards.

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Technological Feasibility

"Consumer Industries" are those industries that purchase a finished asbestos-containing product (from a primary or secondary industry) and apply, install, erect, or consume the asbestos-containing product without further modification of the product. The consumer industries are more diversified than the secondary industries with respect to both the number of plants involved and the variety of products sold to consumers. Furthermore, in many plants the asbestos-containing materials are a very small part of the total product. In an automobile, for example, asbestos-containing material can be found in the disc brake/shoe brake, automatic transmissions/clutch assemblies, mufflers, and the sound-deadening undercoating.

The major emphasis of this report involves the status of the primary industry segments producing asbestos products or intermediates (excluding construction activities). The total economic impact of the proposed asbestos standards cannot be fully assessed without a thorough investigation of the consumer industries (excluding construction activities).

To achieve this, Weston solicited data, information, and comments from a wide variety of sources: primary, secondary and consumer industry companies, trade associations, and economic specialists. The data, information, and comments are more varied than for the secondary industries.

Many companies and trade associations contacted were either unaware that asbestos-containing materials were in their products or felt assured that the proposed standard did not include their operations.

Once asbestos products leave the primary and secondary asbestos industry, they are absorbed by the domestic economy at large. This assimilation takes place in two major groups: construction and manufacturing. This portion of the report is concerned with outlining the diffusion of the products through the latter group and indicating the magnitude of the economic impact.

The consumer industries no longer modify the asbestos-containing material but simply install or apply these materials as a portion of the finished product. In some cases, asbestos-contining products are used by the consumer industry as maintenance or repair materials. For the asbestos fiber to be dis-associated from the asbestos-containing material and to become airborne in sufficient quantities to exceed the ceiling or 8-hour TWA values of the proposed standard is improbable. Therefore, the technological feasibility discussion and the method of analysis used in the primary and secondary industries (process description, control equipment/work practices, existing fiber counts and BAT) are not applicable for the consumer industries.

Economic Impact

Method of Analysis

The basis for the economic impact analysis is a combination of information compiled from proprietary data contained in other economic studies, the National Input/Output Table, and the Census of Manufactures. The last two are published by the U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census.

The primary and secondary industries' products (excluding those going to the construction industry) are assumed to be supplied to the consumer by the asbestos manufacturing groups according to the following Standard Industrial Classification Codes: 2661 (Building Paper and Mill Boards), 3292 (Asbestos Products), and 3293 (Gaskets, Packing, and Sealing Devices).

Development of Effect of Price Increases in Primary and Secondary Industries

The products manufactured and fabricated by the primary and secondary industries (excluding those going to the construction industry) are assumed to be absorbed by the Consumer Manufacturing Group. The basis for this analysis and the development of the effect of price increases on the consumer industry are the data contained in Table 6-1. The data are organized by Asbestos Product Group (SIC 2661, 3292 and 3293) and show estimates of asbestos-containing materials as a percentage of the sales of the Consumer Manufacturing Groups. Therefore, each Consumer Manufacturing Group would be affected by price increases of asbestos products anticipated as a result of implementing the proposed standard. These price increases are estimates for the consumer industries only and do not represent the cumulative effects of price increases by the Primary and Secondary Industries as a result of implementing BAT.

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Table 6-1

Summary of Economic Impact
Consumer Industries

Consumer Manufacturing Group (Industrial Product Group)	SIC Code	Sales Of Manufacturing Group millions of $	Number of Establishments	Estimate of Asbestos-Containing Materials as a Percentage of the Sales of Consumer Manufacturing Group: Building Paper & Board Mills SIC 2661	Asbestos Products SIC 3292	Gaskets, Packing, and Sealing Devices SIC 3293	Total Employment 1,000's	Number of Employees Continuously Exposed	Industrial Hygiene and Medical Prog Costs $/year
Meat Products	201	31,477.9	N.D.	.02			307.7	720	100,800
Fluid Milk	2026	1,634.5	2,507	.07	0.000613		188.7	1,500	210,000
Narrow Fabric Mills	2241	566.2	376		.79		27.1	5,710	799,400
House Furnishings N.E.C.	2392	1,517.9	1,111		.01		50.0	4,820	674,800
Fabricated Textile Products N.E.C.	2393-9	182.2	208		.16		7.9	760	106,400
Canned Fruits and Vegetables	2033	11,478.6	1,038	.01			233.1	2,480	347,200
Frozen Fruits and Vegetables	2037	3,762.6	644	.03			83.8	6,750	945,000
Flour and Cereal Preparations	2041-43+45	2,308.0	457	.09			16.1	4,120	576,800
Prepared Feeds for Animals and Fowls	2042	12,162.2	47	.02			111.4	7,840	1,097,600
Bakery Products	2050	2,358.2	N.D.	.05	0.0042		68.7	12,450	1,743,000
Sugar	2060	6,620.1	N.D.	.01			107.1	7,590	1,062,600
Alcoholic Beverages	2082-5	4,054.4	167	.03			51.5	920	128,800
Bottled and Canned Soft Drinks	2086	5,486.4	2,687	.01			121.8	1,470	205,800
Soybean Oil Mills	2092	1,061.6	518	.03			24.7	590	82,600
Food Preparations N.E.C.	2099	3,647.9	2,099	.02			66.2	870	121,800
Paper Board Mills	2631	4,153.5	273	.01			68.5	860	120,400
Wallpaper & Building Paper & Board Mills	2661-2644	456.2	92	.02			11.6	830	116,200
Converted Paper, Product N.E.C. (No Boxes)	2641-43-45-46-493	8,452.4	426	.11			189.1	12,460	1,744,400
Sanitary Paper Products	2647	9,315.7	108	0.0032			343.8	1,680	235,200
Industrial Inorganic & Organic Chemicals	2821	97,960.0	323	0.001	0.00204		161.9	11,470	1,605,800
Cleaning Preparations	2840	977.6	N.D.		0.00204		111.6	1,950	273,000
Miscellaneous Chemical Products	2861	4,268.4	139		.06	.01	83.1	32,490	4,548,600
Prefabricated Wood Structures	2443	6,703.3	N.D.	.01	.01	0.0029	190.7	47,920	6,708,800
Logging Camps and Logging Contractors	2411	23,816.0	13,238		0.0039		691.0	N.D.	N.D.
Wood Products N.E.C.	2499	2,529.5	N.D.	0.78		0.00083	80.0	9,580	1,341,200
Saw Mills and Planing Mills General	2421	7,230.6	8,071			0.0013	204.4	13,420	1,878,800
Mill Work	2431	6,703.3	2,434	0.0030			190.7	12,200	1,708,000
Recalmed Rubber & Misc. Rubber Products	3069-31	29.7	1,103		2.45	5.5	0.9	54,760	7,666,400
Miscellaneous Plastics Products	3079	10,695.9	7,698		0.090	0.025	346.9	48,270	6,757,800
Glass Containers	3221	3,393.8	117		0.023		118.8	8,410	1,177,400
Leather Tanning & Indust. Leather Products	3121-11	1,059.5	N.D.			.019	25.7	7,540	1,055,600
Glass and Glass Products (Not Containers)	3211	937.1	31			0.95	20.9	6,980	977,200

N.D. = No Data
N.E.C. = Not Elsewhere Classified

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Table 6-1
(Continued)

Consumer Manufacturing Group (Industrial Product Group)	SIC Code	Sales Manufacturing Group millions of $	Number of Establishments	Estimate of Asbestos-Containing Materials as a Percentage of the Sales of Consumer Manufacturing Group: Building Paper & Board Mills SIC 2661	Asbestos Products SIC 3292	Gaskets, Packing, and Sealing Devices SIC 3293	Total Employment 1,000's	Number of Employees Continuously Exposed	Industrial Hygiene and Medical Program Costs $/year
Cement Hydraulic	3241	1,791.2	N.D.			0.33	30.0	9,810	1,373,400
Porcelain Electrical Supplies	3264	834.8	N.D.			0.044	44.9	32,850	4,599,000
Nonferrous Wire Drawing and Insulating	3356	N.D.	N.D.		0.47	0.00787		114,580	16,041,200
Copper Rolling and Drawing	3351	58,429.7	N.D.			0.318	1,142.8	7,580	1,061,200
Aluminum Rolling and Drawing	3352	2,446.2	N.D.			0.00955	50.8	10,020	1,402,800
Paper Industries Machinery	3554-51-52	12,867.6	218	.053			188.3	2,010	281,400
Heating Equipment (Not Electric)	3433	2,136.8	432		0.49	0.0527	60.7	10,150	1,421,000
Farm Machinery	3522	5,590.4	N.D.		0.055	0.877	125.3	43,210	6,049,400
Industrial Trucks and Tractors	3537	11,089.5	380		0.39		275.5	N.D.	N.D.
Special Industry Machinery N.E.C.	3559	6,207.2	1,382		0.63		190.1	N.D.	N.D.
Sheet Metal Work	3444	14,179.6	3,116	1.3		1.57	394.8	1,402,160	196,302,400
Metal Stampings	3461	9,956.9	N.D.				263.5	9,780	1,369,200
General Industrial Machinery	3567	8,433.7	900			0.246	262.0	11,240	1,573,600
Machine Shop Products	3590	4,409.5	N.D.		1.0	.1	184.4	8,470	1,185,800
Motor Vehicles and Parts	3711-14	63,921.4	2,347		0.604	.4	8,075.0	2,214,560	310,038,400
Pipe, Valves and Pipe Fittings	3494-98	8,433.7	1,202			.2	262.0	84,300	11,802,000
Fabricated Metal Products N.E.C.	3499	7,784.8	2,342			.63	344.3	92,570	12,959,800
Internal Combustion Engines N.E.C.	3519	5,507.4	179			.58	116.0	281,450	39,403,000
Machine Tools, Metal Forming Types	3542	7,267.0	383			1.22	268.1	8,650	1,211,000
Service Industry Machines N.E.C.	3589	8,711.0	703			.29	197.9	15,870	2,221,800
Transformers	3612	3,585.4	216			.2	116.0	150,210	21,029,400
Electrical Industrial Appratus N.E.C.	3629	5,412.1	259			.13	188.3	154,780	21,669,200
Electric House Wares and Fans	3634	6,938.6	299			.2	162.8	118,790	16,630,600
Wiring Devices	3643-44	5,690.1	N.D.			.3	179.2	35,120	4,916,800
Electronic Components N.E.C.	3679	8,836.6	1,840			.11	335.6	87,490	12,248,600
Engine Electrical Equipment	3694	4,297.3	290			.01	119.9	67,080	9,391,200
Trailer Coaches	3791	2,268.9	N.D.	1.9		.02	59.1	41,000	5,740,000
Transportation Equipment N.E.C.	3799	3,662.6	N.D.		.13		132.7	45,120	6,316,800
Ship Building and Repairing	3731	4,329.2	455		.70		185.2	323,010	45,221,400
Surgical Appliances and Supplies	3842	2,824.5	N.D.		.33	.12	90.8	21,890	3,064,600
Air Craft Equipment N.E.C.	3729	15,451.4	N.D.		0.068	"	438.7	43,000	6,030,000
Construction Machinery	3531	11,089.5	748		.23	.3	305.3	93,000	13,020,000
N.E.C.		9,408.2	1,728			.275	275.5	4,060	568,400
TOTALS		600,789	65,331				19,307.9(1)	5,873,320 (1)	822,250,800

N.D. No Data
N.E.C. = Not Elsewhere Classified

(1) The employment shown may include employees from the primary and secondary industry groups.

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To derive the approximate percentage of a Consumer Manufacturing Group's sales that are related to asbestos or asbestos-containing materials, the following procedure was used. The sales to each Consumer Manufacturing Group by each of the three SIC groups of interest (2661, 3292, and 3293) were obtained by applying the Input/Output Table Coefficients (I/O) to data on the industry's shipments, taken from the 1972 Census of Manufactures. This procedure provides a rough estimate of the relationships between any two SIC groups (i.e., a Consumer Manufacturing Group and an asbestos-containing product group), assuming that the I/O coefficients are still an approximate relection of the economic transfers involved. (Since more recent data are not available, there is no factual alternative to this assumption.) In prior work, data had been derived as a percent allocation by four-digit SIC of labor/materials/ other costs for outputs for each Consumer Manufacturing Group. (This allocation was based on 1971 survey data previously collected.) The approximate effect of the asbestos cost increase was obtained by combining these two sets of data. Thus, a matrix of data was formed between a given Consumer Manufacturing Group and an asbestos-containing product group to show the relationship of the portion of sales (Consumer Manufacturing Group outputs) which reflect the value of asbestos-containing materials in consumer outputs. Absolute error in this procedure is obviously present, if for no other reason than the data used are at least five years old. However, this does not present an insurmountable problem since the orders of magnitude, if not the actual numbers, are probably correct.

This procedure was applied only to first order sales; further inter-industry transfers were not explored but would probable not alter the overall picture.

The data range from thousandths of a percent to 5.5 percent for reclaimed rubber and miscellaneous rubber production (Table 6-1).

Development of Estimated Plant Employment Data

From the data in Table 6-1, approximately 19,300,000 civilian employees in the United States are employed in the Consumer Manufacturing Group. To ascertain the employee exposure levels of asbestos for the consumer industries, it was not possible to use the data available or that developed from primary and

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secondary industries. (Number of employees and percent exposed were obtained from questionnaires sent by the primary industries.) In order to determine the estimated number of employees exposed to asbestos-containing material in the consumer industries, the following procedure was used. The asbestos content of raw material input to the Consumer Manufacturing Group was expressed as a ratio of the total raw material input. (This ratio was derived from the Input/Output Table of Coefficients and data developed from previous economic surveys.) This ratio was then multiplied by the total production labor force for the Consumer Manufacturing Group to approximate the consumer employment exposed to asbestos-containing materials. As a further refinement of this estimate, the employment for each Consumer Manufacturing Group was adjusted by two additional factors: a "productivity" factor (obtained from publications by the Department of Labor and Survey of Current Business from the Department of Commerce) and a "turnover" factor (to account for total yearly plant employment). The net effect of these steps was an estimate of the Consumer Manufacturing Group employment directly involved with handling asbestos-containing materials from each of the three major asbestos product classifications (SIC numbers 2261, 3292, and 3293). These estimates are presented in Table 6-1 as Number of Employees Continuously Exposed.

Most employees are exposed for only part of their workday; however, as a standard a production-line employee whose function involves the repeated placement or handling or an asbestos-containing product is assumed to be continuously exposed.

The total number of employees continuously exposed, therefore, is approximately 5,900,000 in the manufacturing group.

The total number of employees continuously exposed in the consumer industries (manufacturing, wholesale/retail trade and services) was estimated as a ratio of the 5,900,000 employees in the manufacturing group. These ratios were based upon the 1970 Census of Population (occupation by industry) of the civilian labor force working in the following industry groups:

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Industry Group	Percentage of Total Employment
Manufacturing	25.9
Wholesale and Retail Trade	20.1
Services	7.7

The total number employed at the time of the census (April 70) in the labor force was approximately 76,600,000. This information is based upon responses to employment questions included in the 1970 census, the last complete inventory of population and economic data.

The previous total employees in the manufacturing group indicated 19,300,000 were employed (Table 6-1). Using the 25.9 percent of employees engaged in manufacturing, multiplied by 76,600,000 total employment, equals 19,800,000 employees included in the manufacturing group. Therefore, the total employment in the manufacturing group is in the range of 19-20 million. It was assumed that the number of employees continuously exposed in the wholesale and retail trade and services industry groups was at a minimum equal to the number in the manufacturing group (5,900,000). Therefore, the minimum total employment in the consumer industry becomes 11,800,000 employees.

Development of Estimated Number of Establishments

From the data in Table 6-1 the minimum number of establishments is 65,300. Several manufacturing group SIC Codes did not report data; therefore we assumed that 70,000 establishments are contained in the consumer manufacturing industries handling asbestos-containing products.

Additionally, the same rationale used for developing the total employees exposed was adopted to determine the number of establishments in the wholesale and retail trade and services groups. The total number of establishments in the consumer industries becomes 140,000.

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Development of Partial Industrial Hygiene and Medical Program Costs

Weston assumed that it was very improbable that the ceiling or 8-hour TWA values will be exceeded for the consumer industries. However, some consumer industries may decide to monitor to insure that this is in fact the case. These monitoring costs will be a one-time (two consecutive sets of data) cost and therefore is not considered as part of annual industrial hygiene and medical program costs.

Table 6-2

Partial Industrial Hygiene and Medical Program Costs to the Consumer Industries

1. Monitoring	Not required
2. Respiratory Protection	Not required
3. Personal Protective Clothing	Not required
4. Hygiene Facilities and Practices	Not required
5. Medical Surveillance	$ 85
6. Employee Information and Training	25
7. Recordkeeping	30
Total per employee per year	$140

Note: Labor costs per hour were estimated at $5.00/hr direct + 20% overhead, or $6.00/hr.

For Items 1, 2, 3 and 4, it was assumed that the levels of asbestos available to be released to the work environment are very small. Therefore, since by definition the consumer industries do not change the form or process the asbestos containing material, these items are not required.

For medical surveillance, $85 is chosen, based on secondary industries information which is applicable to consumer industries.

Employee information and training is estimated at 4.0 hrs/year to provide medical information and training;

(40 hr/year) ($6.00/hr) = $25

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For recordkeeping, $20 is assumed, based on information from the secondary industries which is applicable to consumer industries.

Recently (14 November 1975), the Occupational Safety and Health Review Commission handed down a decision on:

- Secretary of Labor, *complainant* vs. GAF Corp., Respondent. OSAHRC Docket Nos. 3203 and 4008.

- Secretary of Labor, complainant vs. United Engineers and Constructors Inc., Respondent. OSAHRC Docket No. 7355.

The issue involved in these cases was the interpretation of 1910.93a(j) (later renumbered 1910.1001(j), medical examination. Judge Robert D. Moran, Commissioner OSAHRC, in his dissenting opinion, states:

> "The rule of this case is that whenever employees are exposed to ANY trace of asbestos no matter how temporary or insignificant -- their employer must furnish (and employees must undergo) annual physical examinations and tests as prescribed Sec. 1910.93a)j). This will apply to a rather significant portion of the entire workforce of the United States -- from this day forth, the Commission decision requires annual physicals for millions of employees who, this decision concedes, are not exposed to any hazard whatsoever. The consequences of this upon the employees and the employers of America will be astonishing. Its impact on the medical profession -- and even the economy -- could be considerable. In my view, such a construction of the standard is uptopian and clearly unreasonable."

Resulting from Judge Moran's dissenting opinion, it appears that the entire work force would be required to have an annual medical examination. However, Weston assumed that the medical surveillance costs should apply only to those employees in the consumer industries who could reasonably be assumed to be in contact with or involved in handling products which have asbestos-containing materials.

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Foreign Trade Impact

Assuming a widening gap between U.S. prices and those of the rest of the world, it can generally be assumed that increased foreign competition and further loss of business can be expected as prices for U.S.-produced asbestos materials increase.

The specific question is whether the cost impact associated with the implementation of BAT in the primary and secondary asbestos industries will be of sufficient magnitude, in and of itself, to cause any displacement in the current import/export balance or trends.

Market Overview

As published in Asbestos (12/75), the U.S. Bureau of Mines calculated that in 1974 asbestos consumption in the United States had dropped about 8 percent (816,964 tons consumed in 1974 versus 876,000 tons in 1973), but that consumption was still ahead of 1972 (809,000 tons) and would rise to about 2 million tons by the year 2000. This is equal to an average growth rate of about 4 percent -- approximately the anticipated GNP growth rate. Asbestos use will thus remain proportionately stable. From a different perspective, a separate source quoted by the magazine stated that the United States is now accounting for some 16 percent of the total world use/consumption. The current usage profiles of the U.S. and the rest of the world are shown in Table 6-3.

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Table 6-3

Comparative Consumption Patterns[1]

Product Category	Percentage of U.S. Consumption	Percentage of World Consumption
Asbestos Cement Pipes/ Sheets/Siding/Shingles	21.8	69.0
Friction Materials	6.3	2.2
Asbestos Paper	37.7	7.4
Floor Tile	12.6	3.9
Paints/Roof Coatings/Cauks/ Sealants/Adhesives/Undercoatings	7.4	1.6
Asbestos Textiles	1.4	.7
Asbestos-Reinforced Plastics	2.0	.5
Joint Cements	1.5	.3
Gaskets and Packings	3.3	1.0
Miscellaneous	6.0	13.4
	100.0	100.0

(1) Source: Asbestos Magazine (1/76) and the U.S. Department of Commerce

Table 6-3 illustrates the markedly different demand/consumption patterns that emerge when the U.S. is compared with the rest of the world. It is this pattern, or changes in this pattern, that form the basis for an analysis of possible production shifts that could result from the application of asbestos standards in the domestic market.

The United States is generally not an export nation in that its industries seldom set out to produce products domestically for the export market, nor does the U.S. economy tend to encourage industries whose sole orientation is an export market. The more typical case is that an industry, already enjoying a strong domestic market, will expand its production of one or more products, to meet market opportunities abroad. Depending on the size and configuration of the industry and the technology required, the actual production site could be either in the continental United States or in or near the foreign market area. The asbestos industry seems to follow this general pattern.

Method of Analysis

Evidence of the potential impact of cost increases resulting from the implementation of regulations on the primary and secondary production sectors of the asbestos industry can be shown through a consideration of the importance of price as an absolute factor in foreign trade in asbestos. Two general relationships are of particular importance: the changes in the raw asbestos export market and the relationships of price and quantity in the U.S. imports of manufactured asbestos products.

The first of these relationships is illustrated by the export data presented in Table 6-4.

Table 6-4

U.S. Exports of Unmanufactured Asbestos[1]

Year	Short Tons	Est. Value	Average Price Per Short Ton
9/74 - 8/75	33,785	$9,308,660	$275.53
9/73 - 8/74	71,784	9,752,917	135.86
9/72 - 8/73	54,992	7,923,575	144.09
9/71 - 8/72	56,216	8,084,003	143.80

[1] Source: U.S. Department of Commerce and Asbestos Magazine.

Although these data are not unambiguous, there is evidence of a rough but expected trend that relates rising cost per short ton with declining export volume. In this case, a price/value increase of about 92 percent per short ton is matched with a volume decline of about 39 percent. Even so, caution is in order since several factors affect any

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such clear-cut exposition, and, by implication, affect any straightforward assessment of the impact of the cost increases attributable to the implementation of regulations.

The first of these is the evident volatility of raw asbestos prices, as illustrated in Table 6-5, which presents the recent price trends for Vermont production. Raw-material price fluctuations of the magnitudes evident here, if at all typical of the market, make the estimation of the impact of the smaller perturbations on the import/export balance (such as those that might result from BAT implementation in the primary and secondary asbestos industries) quite uncertain in a quantitative framework, but not impossible in more general terms.

Table 6-5

Vermont Production Prices (1)

Product Type	Date of Quotation: May 1, 1974	June 16, 1975	Jan. 1, 1976
Grades 3T & 3Z Fiber	$158-490		
Grades 4A through 4T Fiber	$250-424	$360-608	
Grade 4T Fiber			$418
Grades 5D through 5R Fiber	$180-212	$238-280	$275-324
Grade 6D Waste	$131	$173	$200
Grades 7D through 7T - Shorts	$ 57-114	$ 77-150	$ 83-160
Grade 7TF - Floats (Shorts)	$ 50	$ 66	$ 72
Grade 8S - Shorts	$ 53	$ 53	$ 54
Hooker No. 1	$524	$850	$970
Hooker No. 2	$262	$425	$485

(1) Source: Asbestos Magazine.

The second factor in the case of the example of the raw asbestos exports/price relationship is in the evident nonlinearity of the trend. A consideration of the second

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general relationship (i.e., price/quality in the importing of manufactured asbestos products) provides a better perspective. In this case, a general analysis (see Table 6-6 for the results of the regression analysis) confirms the importance of price as a central factor in import volume, and therefore in the penetration of the domestic market by foreign producers. In addition, the extremely high R^2's, which indicate a strong association between price and volume. remove the confusion caused by the non-linearity of the raw asbestos price/volume trend, while also implying that the volatility of the raw asbestos prices is somehow stabilized in the manufacturing sector so that its influence is less erratic.

Table 6-6

Analysis of Import Price/Volume Data[1]

Product Class	Results of Regression Analysis
Asbestos Yarn/Textiles	\$ = 0.81746155(Net.Q) - 4996.218632 R^2 = .873
Asbestos Pipes and Tubes	\$ = -3.96522563(Net.Q) + 107723827.6 R^2 = .008
Asbestos and Hydraulic Cement Articles, N.E.C.	\$ = 0.10020622(Net.Q) + 34771.4513 R^2 = .638

(1) Source: U.S. Department of Commerce

Q = Net Quantity of Product Class
R^2 = Regression Coefficient

Although imports have never constituted a large share of the domestic market for manufactured asbestos products (see Table 6-7), their value relative to domestic production has been increasing at a slow but steady rate, while their value considered by itself has shown dramatic growth (see Table 6-8). However, this latter trend reflects the world economic picture more than anything peculiar to the asbestos product market. For example, radical changes in product value (Table 6-8) have resulted in only a 4 percent increase in the physical quantity of products imported (Table 6-9, column 5).

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Table 6-7

Value of Imports as a Function of Domestic Production

Time Period	Value Ratio
1965	13.39×10^{-3}
1966	11.67×10^{-3}
1967	11.30×10^{-3}
1968	12.55×10^{-3}
1969	13.35×10^{-3}
1970	18.28×10^{-3}
1971	17.23×10^{-3}
1972	15.14×10^{-3}

Table 6-8

Changes in Value of Imports: 1971 - 1975

Time Period	Total Value of Imports	Percent Change
9/74-8/75	$24,227,826	+32
9/73-8/74	$18,354,414	+35
9/72-8/73	$13,611,138	+35
9/71-8/72	$10,094,928	---

Table 6-9

U.S. Imports of Manufactured Asbestos Products (in tons)

Product Type	Term				
	9/74-8/75	9/73-8/74	9/72-8/73	9/71-8/72	Change in %
Yarn/Cloth/Tape	4,173	4,114	2,833	1,411	+196
Asbestos Cement Pipes Tubes and Fittings	8,063	6,622	10,844	22,180	- 64%
Other Asbestos-Containing Products	21,713	24,416	13,130	8,898	+144%
Total	33,949	35,152	26,807	32,639	+ 4%

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Nonetheless, these changes in gross values mask quite specular changes in the import product mix (Table 6-9). These changes, when viewed in conjunction with the changes in our exports of manufactured asbestos products (Table 6-10), show a definite, if as yet minor, weaking in our import position. The product group that is obviously being affected most radically is the asbestos yarn/textile sector.

The number of countries that are competing in this market segment has risen from five to 18. The other product sectors show a much less decisive and clear cut change, although reflecting the data in Table 6-9, the imports in asbestos cement pipe/tube sector have shrunk significantly.

Conclusions

As a result of these analyses, the following conclusions can be drawn:

- Since it is highly improbable that asbestos fibers will be released in the consumer industries--
    - All consumer industries are assumed to be meeting the proposed standards for TWA and ceiling exposures.
    - BAT is not applicable
    - The only costs are for the industrial hygiene and medical program
- Implementation of the proposed standard is estimated to be $1,652,000,000 annually (Table 6-11), or $140 per employee per year exposed or handling asbestos-containing products.
- The direct effects of the primary/secondary asbestos industry's price increases will be negligible in almost all particular industrial product groups. The only exception might be SIC 3069 (reclaimed rubber & misc. rubber products), which has a 5.5 percent sales/price ratio. Asbestos and manufactured asbestos products, while widespread throughout the economy, constitute a very minor part of most products' prices. Indeed, in many cases this diffusion could cause the price increases to be absorbed by various industrial producer groups.

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Table 6-10

U.S. Export of Manufactured Asbestos Products

Product	9/74-8/75	9/73-8/74	9/72-8/73	9/71-8/72	% Change
Asbestos-Cement Products (tons)	36,768 (tons)	35,980	23,173	20,243	+82%
Gaskets/ Packing (tons)	3,027	3,308	2,859	2,321	+30%
Textiles/ Yarn (tons)	6,173	9,013	10,331	8,098	-24%
Clutch facings/ linings, (units)	1,947,989	2,426,821	2,459,818	2,843,583	-31%
Brake linings (tons)	5,197	6,026	5,171	4,965	5%
Value	$62,478,339	$52,947,745	$38,330,269	$31,239,170	
% Yearly Change in Value of Exports	+18%	+38%	+23%	----	

(1) Base Year 1971-1972, Compared to 1974-1975.

Table 6-11

Summary of Economic Impact — Consumer Industries

Industry Group	No. of Exposed Employees	Total Number of Establishments	Total Industrial Hygiene and Medical Program Costs
Manufacturing	5,900,000	70,000	$826,000,000
Wholesale and Retail Trade + Services	5,900,000	70,000	826,000,000
TOTAL	11,800,000	140,000	$1,652,000,000

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- The greatest impact on the consumer industries will result from the industrial hygiene and medical programs that would be required for employees if the standards are strictly adhered to. While the cost per employee per year is generally low ($140), the number of employees handling asbestos-containing materials is quite high in many cases (11,800,000).

- The estimates' employment for the consumer industries is 11,800,000 employees, which includes over 140,000 establishments in the U.S.

- The product cost increase that will probably result from the implementation of the proposed standards will tend to have several specific but no general effects on our import/export balance.

    - Barring major productivity increases, the textile/yarn product sector can be expected to decline even more rapidly than at present.

    - The estimated cost increase could possibly have an adverse impact on our exports in the brake lining/clutch facing/friction materials products group. Imports would probably not be stimulated.

- Given the consumption patterns shown in Table 6-3, the U.S. will continue to be a net exporter of manufactured asbestos products, and until world consumption more closely mirrors that of the U.S., foreign production capacity (i.e., capacity other than that of U.S. multnational corporations) will not be sufficiently well-developed to present a threat to U.S. producers in most product groups.

- To the extent that foreign competition is concentrated in specific countries, Canada, Mexico, Belgium and the United Kingdom are the major competitors; of these, only one, Canada, unites a significant supply of raw asbestos (Table 6-12) with a mature production capacity.

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Table 6-12

Summary of World Asbestos Production: 1975[1]

Country	Production in Short Tons
USSR	2,500,000
Canada	1,200,000
South Africa	374,000
Rhodesia	264,000
Italy	165,000
China	130,000
West Germany	110,000
U.S.	99,000
Brazil	77,000
Australia	49,500
Switzerland	44,000
Cyprus	27,500
Japan	22,000
Yugoslavia	11,000
India	11,000
Misc.	11,000
	5,095,000

(1)Source: U.S. Department of the Interior and U.S. State Department.

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APPENDIX A

ROY F WESTON, INC
WESTON WAY
WEST CHESTER, PA 19380
PHONE (215) 692-3030
TELEX 83-5348

WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

ASBESTOS INFORMATION ASSOCIATION/NORTH AMERICA

INDUSTRY QUESTIONNAIRE(1)(2)

Company Name ______________________________

Plant Address ______________________________

Corporate Affiliation ______________________________

Name of Plant Contact ____________________ Title ____________________

Phone Number ( ) __________

Note: This cover page will be detached from the remainder of the questionnaire to insure confidential handling of all information.

(1) For assistance in completing the information in this questionnaire, please contact Mr. Jerry L. Hebb, Roy F. Weston, Inc., phone (215)692-3030.

(2) If, for any reason, you do not choose to participate in the study by completing this questionnaire, please return it directly to Mr. Jerry L. Hebb at Roy F. Weston, Inc.

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I. General Product/Process Information

1. Which of the following industry segments best describes the asbestos-containing products in your operation? (Check more than one, if appropriate).

_____ Asbestos Cement Products (pipes, sheets, siding shingles)
_____ Asbestos Paper Products (asbestos felts, latex sheets, underlayments, electrical and commercial papers)
_____ Floor Tile
_____ Coatings (roof coatings, caulks, sealants, paints, adhesives and undercoatings)
_____ Friction Materials (automotive linings, disc components, blocks, clutch facings)
_____ Gasket, Packing, Sealing Devices
_____ Joint Cements
_____ Asbestos Reinforced Plastics
_____ Asbestos Textiles
_____ Asbestos Drilling Muds
_____ Asphaltic Paving
_____ Distribution/Resale
_____ Miscellaneous (Specify) ______________________________

2. Which of the following categories best describes the operation at your plant? (Check more than one, if appropriate).
a. _____ Manufacture a product where raw asbestos is used.
What tonnage of raw asbestos do you use per year? _________
b. _____ Process a product which already contains asbestos.

3. In reference to Question 1, for each industry segment, give the specific asbestos end product(s) (siding, pipe, etc.) manufactured, handled, or used at this location and the annual volume of each (in pounds, tons, square feet, etc.).

Industry Segment	End Product(s)	Annual Volume

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4. What was the aggregate sales value of asbestos containing products manufactured at this plant during the last five calendar years:

1971 $ ____________
1972 $ ____________
1973 $ ____________
1974 $ ____________
1975 $ ____________

5. What was the level of capital expenditure for plant improvement and expansion of production facilities for asbestos containing products during the last five calendar years? (Include capital expenditures for environmental control, plant improvement and expansion).

1971 $ ____________
1972 $ ____________
1973 $ ____________
1974 $ ____________
1975 $ ____________

6. What is the total plant employment at this location? ____________

7. Give the approximate percentage of the employees whose asbestos exposure falls in the following categories:
   a. Continually in the work environment (operating, production, materials handling personnel) ____________
   b. Frequently in the work environment (maintenance, supervisory personnel) ____________
   c. Only occasionally (less than 5 times per week) in the work environment (management, engineers) ____________
   d. Never or very infrequently enter the work environment (secretaries, sales personnel) ____________

8. What unions (locals) represent your employees, if any? ____________
   a. How active have the unions been in the area of employee health and safety (demands for hazard pay, shorter work periods, etc.)?

Active Area	Extent of Activity (V--Very, M- Moderate, N--None)

   b. What is the current pay scale range of unionized personnel? ____________

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II. Control Technology/Cost Information

9. Provide a brief description of each step in your operation as it relates to asbestos handling or movement. ~~Int~~erest is primarily in the location of dust sources (bag slitting and dumping, sanding/finishing, etc.) and in dust control at these sources (hoods, etc.) rather than in the production equipment. A block flow diagram is suggested. There should be one such diagram for each product group and/or process used. Include raw materials entry and finished product handling. A blank page has been inserted at the end of this section for the block flow diagram(s) and description(s). If additional space is needed, please attach extra sheets.

10. Has control equipment been installed at each step or combination of steps in the block flow diagram(s) where asbestos is released to reduce worker exposure to airborne asbestos? Yes _____ No _____

List control equipment in use:

Step	Type of Equipment	Date Installed

11. What is the total cost of control equipment listed in Question 10?
a. Capital cost (installed) $ ____________
b. Operating cost (annual) $ ____________
(Note: give horsepower, exhaust volume, etc., if operating costs are unknown.)
c. What effect has this equipment had on your process, product or production rate? ____

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d. Did this equipment increase or decrease the plant/process energy requirements (electrical power, space heating, etc.)? Increase ______ Decrease ______ By how much? ______________________

12. What process modifications or work practice changes, if any, were instituted to reduce worker exposure to asbestos? ______________

____

____

____

a. Capital Cost (installed) $ ____________
b. Operating Cost (annual) $ ____________
c. What effects have these process modifications or work practice changes had on your process, product, or production rate? ______

____

____

d. Did these process modifications or work practice changes increase or decrease the plant/process energy requirements? Increase ______ Decrease ______ By how much? ______________________

13. Have the control equipment or work practice changes reduced airborne asbestos levels in all of the work areas? Yes ______ No ______

List the ranges of asbestos fiber counts in the work areas involved:

	Range of Asbestos Fiber Counts	
Work Area	Before Modifications/ Changes	After Modifications/ Changes

14. Have the control equipment or work practice changes reduced air- time-weighted average exposure to airborne asbestos in all of the work areas? Yes ______ No ______

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Work Area	Range of TWA Asbestos Fiber Counts: Before Modifications/Changes	Range of TWA Asbestos Fiber Counts: After Modifications/Changes

The present asbestos standard sets a maximum allowable Time-Weighted Average (TWA) exposure of 5 fibers/cc over an 8-hour period. This, by statute, will be reduced to 2 fibers/cc in July, 1976. The proposed standard would reduce this level to 0.5 fibers/cc at some time in the future. If you have already reached 0.5 fibers/cc at each step where asbestos is released into the work place, please go on to Part III; if not, please complete the following:

15. At each location where asbestos dust is released, do you feel you have installed the "Best Available Technology?" Yes ______ No ______
Best Available Technology (BAT) is defined as control equipment, process modifications, work practice changes, or combinations thereof, which have been demonstrated to provide the most effective control or reduction of contaminant emission.

16. If not, what do you consider the BAT to be, and how effective will it be in reducing airborne asbestos at each location? (Can be control equipment, work practices, process modifications, or combinations thereof).

Locations	BAT	Estimated Asbestos Fibers/cc

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17. What is the expected cost of BAT in terms of:
    a. Capital Cost (installed) $ __________
    b. Operating Cost (annual) $ __________
    c. Plant/Process Energy Requirements, Increase __________ Decrease __________
    d. Personnel Requirements, Increase __________ Decrease __________
    e. Process/Product Effects, Increase $ __________ Decrease $ __________ Explain __________
    f. By what date could BAT be implemented? __________

18. If the Best Available Technology does not reduce worker exposure to a TWA of 0.5 fibers/cc and a ceiling of 5 fibers/cc at all points, provide your considered judgment on the possibility, cost, and timing to develop new technology to achieve this level. What approach might be used? __________

19. If the proposed 0.5 fibers/cc level is adopted, what action is foreseen at your plant? __________

III. Industrial Hygiene and Health Information

20. The existing and proposed standards require certain industrial hygiene practices where workers are exposed to airborne asbestos below the established TWA or ceiling levels. Do you (provide cost data where available):

	Yes	No	Cost/ Man-Year	Total Plant Cost/Year
a. Provide preplacement employee medical exams?				
b. Provide annual employee medical exams?				
c. Provide termination employee medical exams?				

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	Yes	No	Cost/ Man-Year	Total Plant Cost/Year
d. Retain medical records (20 year period)?				
e. Maintain records of employee exposure to asbestos fiber (3 year period)?				
f. Dispose of waste materials which may contain asbestos in sealed containers?				
g. Provide caution labels for all material containing unbound asbestos?				
h. Provide initial monitoring (sampling) of the work place for airborne asbestos?				
i. Provide periodic monitoring (sampling) of the work place for airborne asbestos?				

21. Certain provisions of the existing regulation require additional industrial hygiene practices where levels of airborne asbestos exceed TWA of ceiling standards. Where these requirements apply to your plant, do you:

	Yes	No	Cost/ Man-Year	Total Plant Cost/Year
a. Have a respirator program (for use in certain work situations or emergencies)?				
b. Provide worker rotation where employee is unable to function normally while wearing a respirator?				
c. Provide protective clothing (for employee exposed to asbestos greater than the ceiling level)?				
d. Provide change rooms (where special clothing is required?				
e. Provide separate locker facilities (where special clothing is required)?				
f. Provide laundering of special clothing?				
g. Post caution signs (where levels are greater than the ceiling or TWA levels)?				

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22. Do you employ a company physician? Yes ______ No ______
If yes: Full-Time ________; Part-Time ________ Part-Time hours/week ________

23. Do you employ an industrial hygienist? Yes ______ No ______
If yes: Full-Time ________; Part-Time ________ Part-Time hours/week ________

24. Who performs your medical examinations (clinic, resident physician, etc.)?
____

25. The proposed standards expand the scope of industrial hygiene practices into areas such as: shower requirements, regulated areas, expanded respirator programs, and employee education programs. In general, how do you believe your employee will react to such practices? ______
____
____
____
____

IV. Economic Impact Information

26. Considering individually the major products manufactured at this location, has implementation of asbestos exposure control procedures and industrial hygiene programs affected the cost of these products? Yes ______
No ______
If yes, specify:

Products	Implementation Cost, $/Unit of Production Increase	Implementation Cost, $/Unit of Production Decrease

27. Have you experienced a shift or change in product sales due to the cost impact described in Question 26? Yes ______ No ______

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a. If yes, specify:

Products	Sales Change, $/Year Increase	Decrease

b. If sales have decreased, has the demand been satisfied by:

	Yes	No
Other Asbestos Products	___	___
Asbestos Substitute Products	___	___
Imported Asbestos Products	___	___

c. Which of the above has had the greatest impact on your sales?
____

28. Considering individually the major products manufactured at this location. do you expect the future implementation of BAT control procedures and expanded industrial hygiene programs to affect the cost of your products?
Yes ______ No ______
If yes, specify:

Products	Implementation Cost, $/Unit of Production Increase	Decrease

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Plant Code # ________

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29. Would you expect to experience a shift or change in product sales due to the cost impact described in Question 28? Yes ______ No ______

a. If yes, specify:

	Sales Change, $/Year	
Products	Increase	Decrease

b. If you expect a sales decrease, will the demand be satisfied by:

	Yes	No
Other Asbestos Products	___	___
Asbestos Substitute Products	___	___
Imported Asbestos Products	___	___

c. Which of the above would you expect to have the greatest impact on your sales? ________________________________

30. What is the typical age of production equipment in use at your plant in your particular industrial segment?

	Typical Production Equipment Age, Years			
Segment	0 - 5	5 - 15	15 - 25	25+

31. In your opinion, with the implementation of BAT and the proposed OSHA standard to control worker exposure to asbestos, what portion of the existing production equipment may continue to be economically utilized? (Consider the portion of capital equipment retained as a percentage of the total production area investment).

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Less than 10%	______
10 - 25%	______
25 - 50%	______
50 - 75%	______
Greater than 75%	______

32. Within your community, which estimate best describes the portion of the total work force employed at your plant?

Less than 10%	______
10 - 25%	______
25 - 50%	______
50 - 75%	______

V. Information Regarding Manufacturers/Fabricators of Asbestos-Containing Products

The proposed regulations apply to every place of employment where asbestos, or a product containing asbestos, is manufactured, processed, packaged, stored, applied, used, or otherwise handled. It is extremely important to our assessment to include estimates of the number of people involved as your products are ultimately used and the possible asbestos exposure levels of these individuals. Insofar as is possible, kindly provide the following information:

33. Who uses the asbestos-containing products you produce (construction industry, auto repair garage, fabricator, etc.)? ______

34. Describe how your products move from your plant through the final consumer ______

35. Estimate numbers of people and what levels of asbestos dust exposure, if any, may occur at each step (from further processing, fabrication, installation, etc.)? ______

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36. Provide names of your customers and appropriate trade association so that Weston might obtain more comprehensive information in these areas

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