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

Prepared for:

Asbestos Information Association/North America
Washington, D.C.

WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

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Technological Feasibility
and Economic Impact
of OSHA Proposed Revision
to the Asbestos Standard
(Construction Exclude)

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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 percent 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.

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.

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").

- 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.

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.

- 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.

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.

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	6	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

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 tnan 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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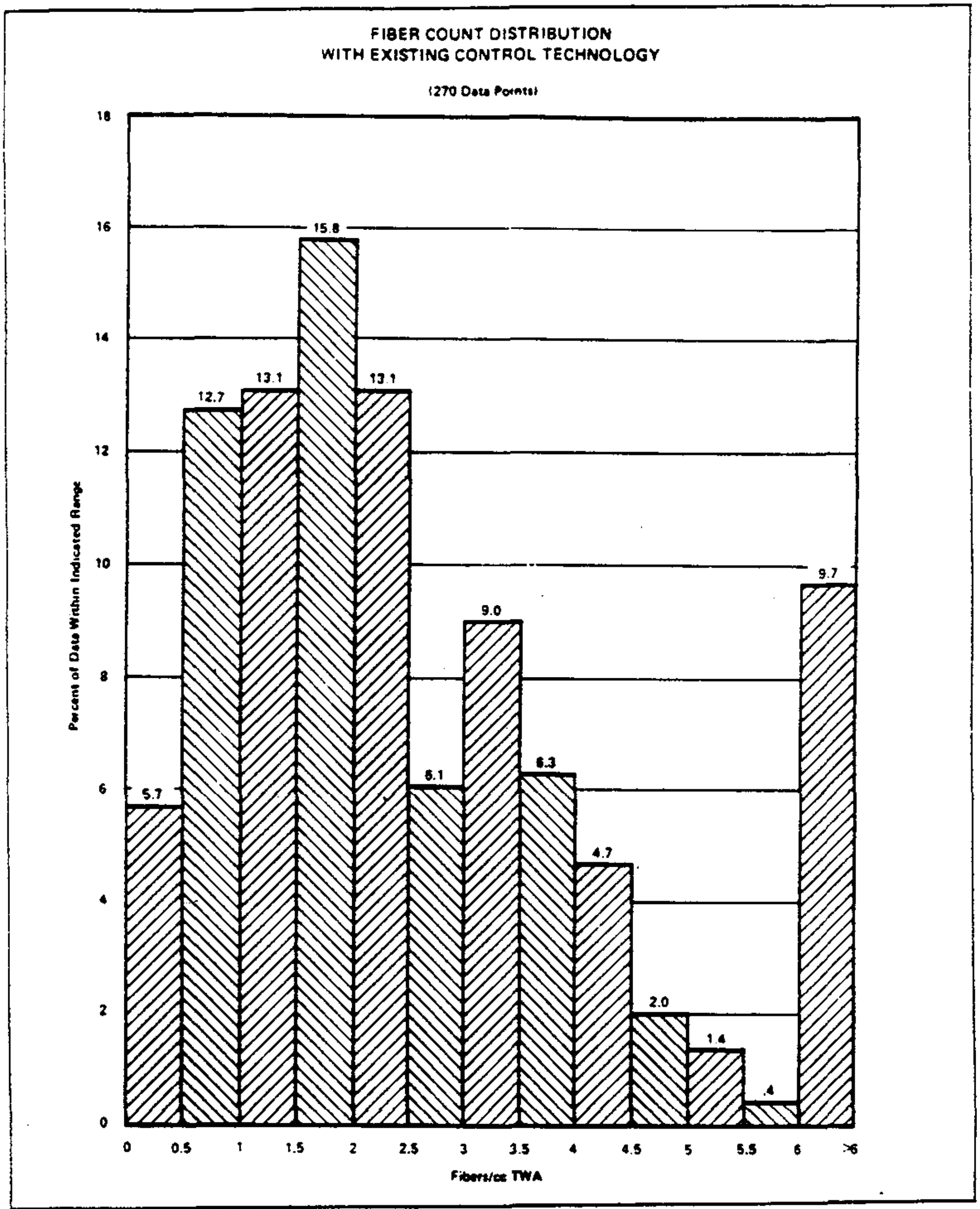

FIGURE 3-1 FIBER COUNT DISTRIBUTION WITH EXISTING CONTROL TECHNOLOGY

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.

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.

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.

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

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.

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 la 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.

- 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

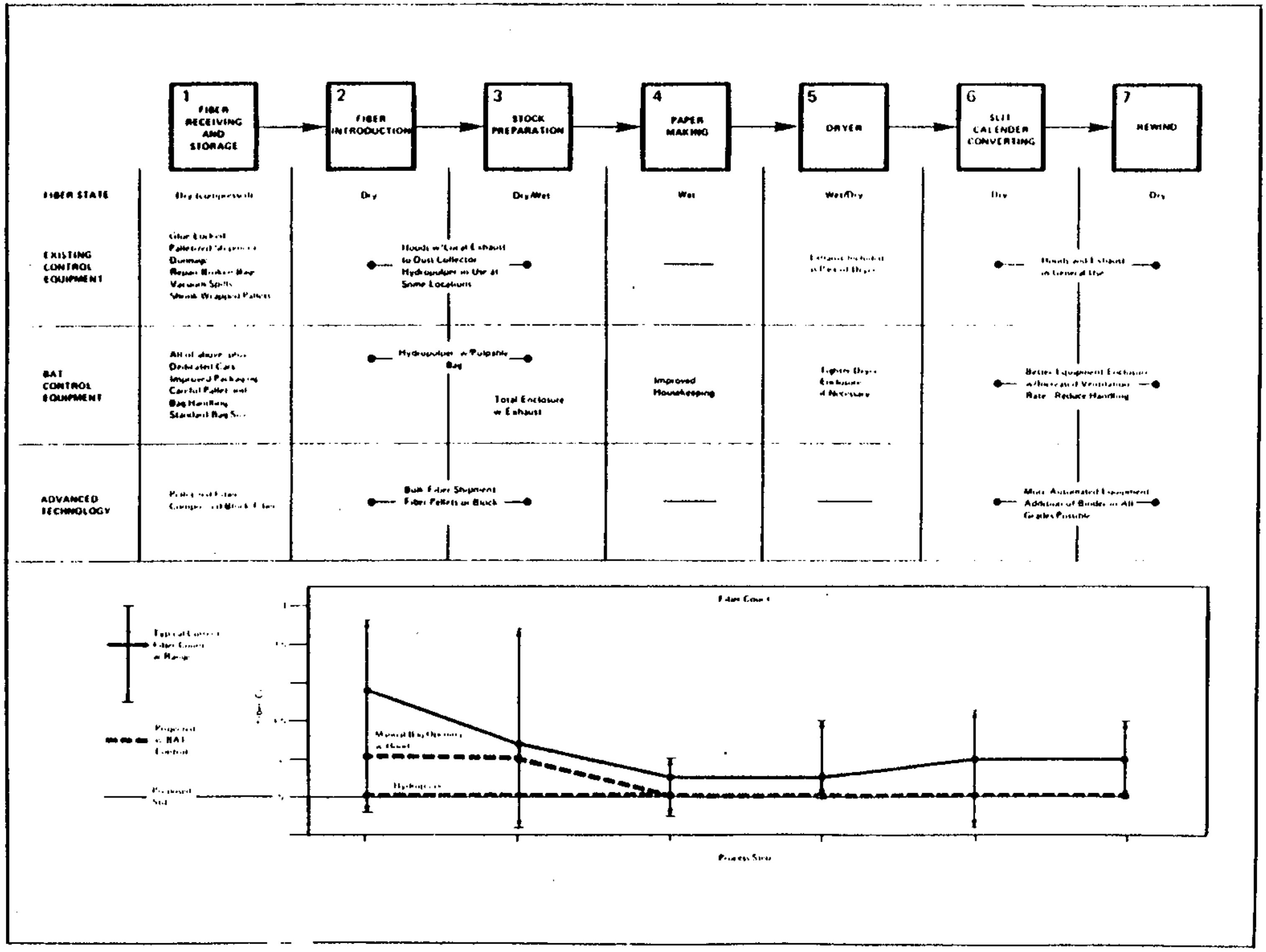

FIGURE 4-1 DIAGRAM OF PROCESS FLOW AND FIBER COUNT — ASBESTOS PAPER

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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.

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.

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.

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:

Table 4-1

Time-Weighted Average Fiber Counts
Asbestos Paper

Process Step	Fiber Count with Existing Control Technology — Typical Fibers/cc	Fiber Count with Existing Control Technology — Range Fibers/cc	Projected Fiber Count Best Available Technology (1) 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.

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.

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.

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.

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.

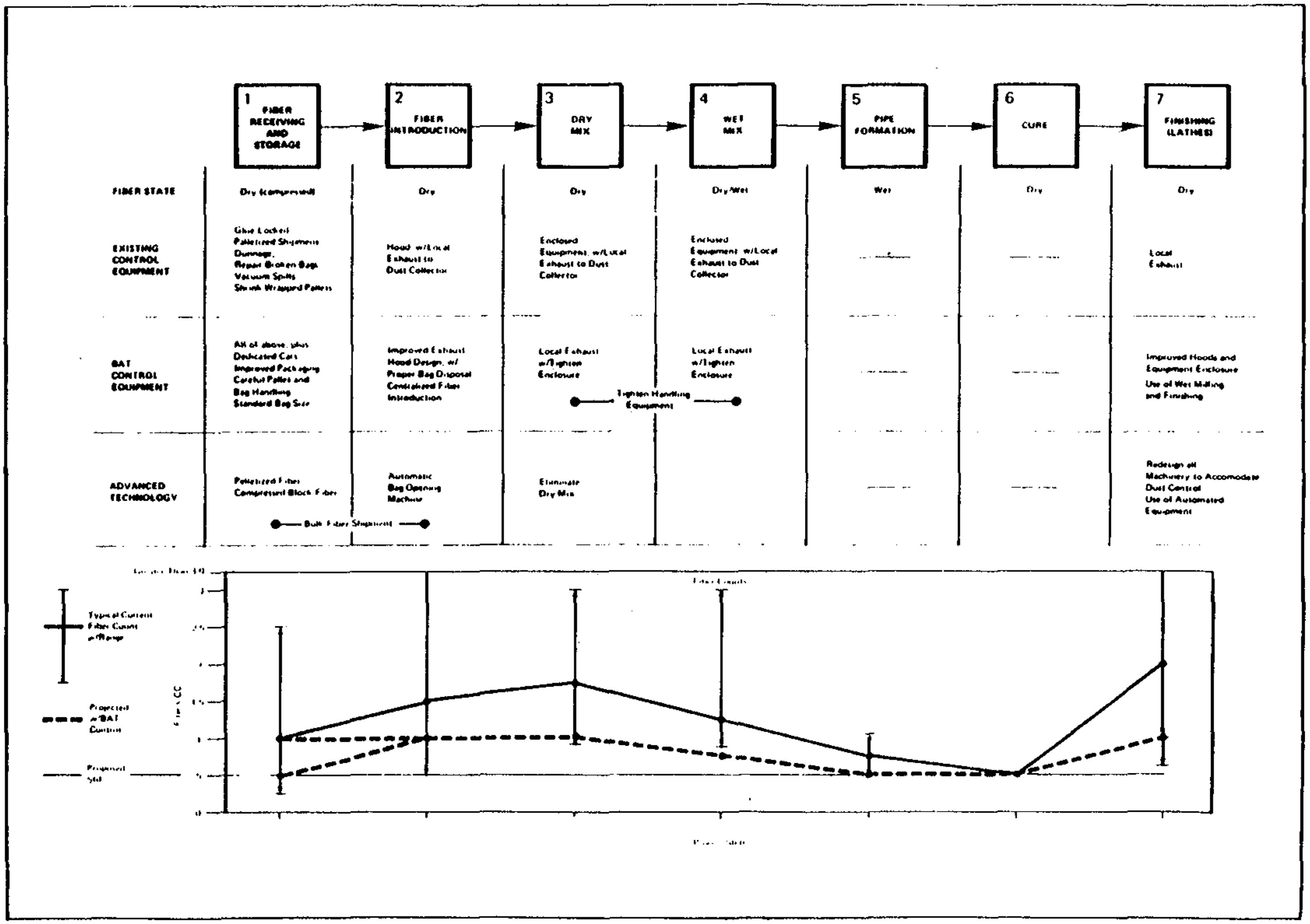

FIGURE 4-2 DIAGRAM OF PROCESS FLOW AND FIBER COUNT — ASBESTOS CEMENT PIPE

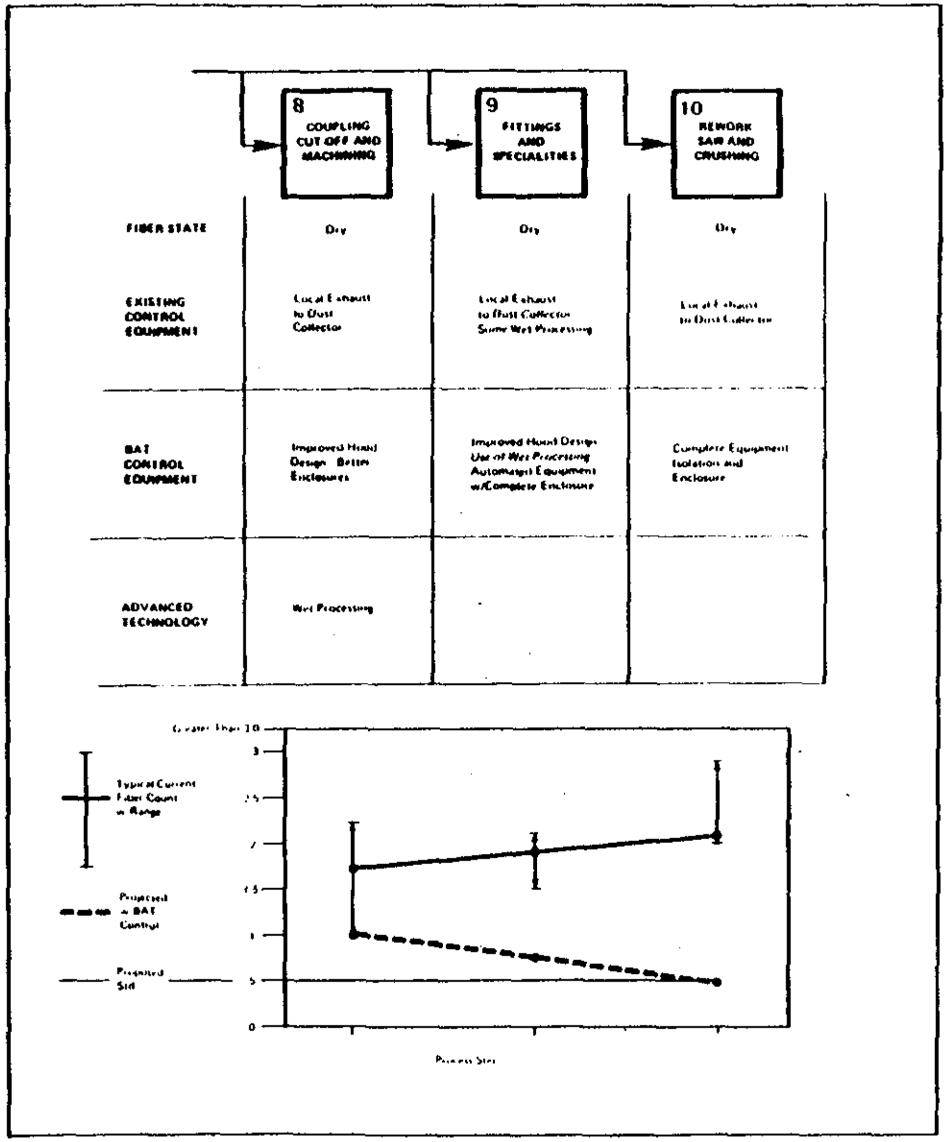

FIGURE 4-2 DIAGRAM OF PROCESS FLOW AND FIBER COUNT (Continued)

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.

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.

Table 4-2

Time-Weighted Average Fiber Counts
Asbestos Cement Pipe

Process Step	Fiber Count with Existing Control Technology		Projected Fiber Count Best Available Technology(i)
	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

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

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

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.

<u>Economic Impact</u>

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.

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.

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.

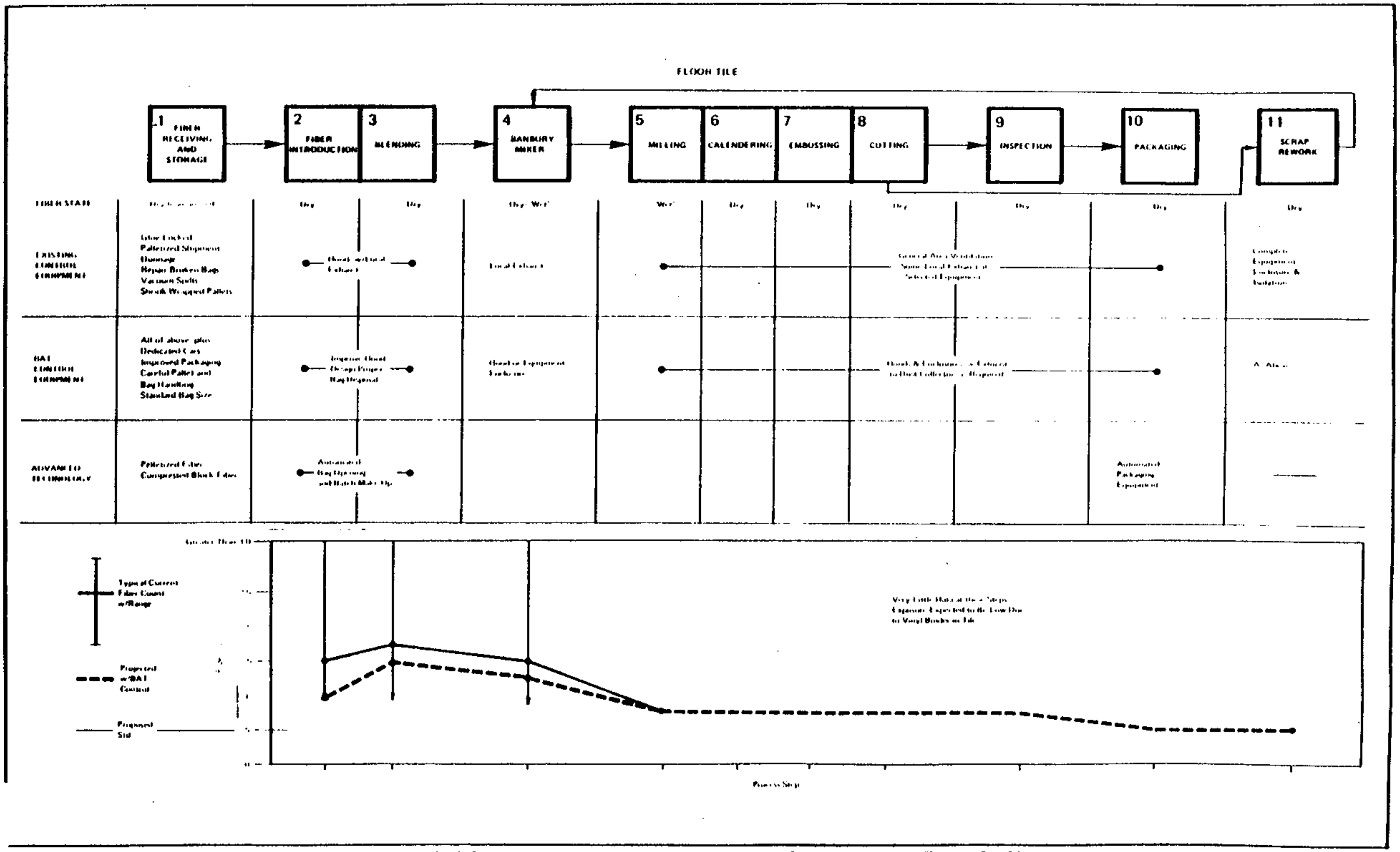

FIGURE 4-3 DIAGRAM OF PROCESS FLOW AND FIBER COUNT
– FLOOR TILE

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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.