

PLAINTIFF'S EXHIBIT

CAP-897

DEVELOPMENT DOCUMENT FOR
EFFLUENT LIMITATIONS GUIDELINES
AND STANDARDS OF PERFORMANCE

ASBESTOS MANUFACTURING

DRAFT FINAL REPORT
TO
ENVIRONMENTAL PROTECTION AGENCY

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ABSTRACT

This document presents the findings of an extensive study of the asbestos manufacturing industry by the Environmental Protection Agency for the purpose of developing effluent limitations guidelines, Federal standards of performance, and pretreatment standards for the industry, to implement Sections 304, 306 and 307 of the "Act."

Effluent limitations guidelines contained herein set forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best available technology economically achievable which must be achieved by existing point sources by July 1, 1977 and July 1, 1983 respectively. The Standards of Performance for new sources contained herein set forth the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

The proposed regulations require 95 percent or better removal of the significant wastewater pollutant constituents by the principal point sources in the industry by July 1, 1977.

The proposed regulations further require that there be no discharge by any point sources in the industry by July 1, 1983. With the exception of two subcategories, this regulation also applies to new sources.

Pretreatment Standards for "new sources" discharging to municipal sewerage systems are set forth in "Pretreatment of Discharges to Publicly Owned Treatment Works," ____ C.F.R. ____.

Supportive data and rationale for developments of the proposed effluent limitations guidelines and standards of performance are contained in this report.

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA

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SECTION I

CONCLUSIONS

That part of the asbestos manufacturing industry covered in this document (Phase I) is classified into five categories, two of which are each divided into two subcategories. The categorization is based on (a) distinct product lines and (b) applicability of waste control technology. Factors such as age and size of manufacturing plants, processes employed, and geographic location do not provide significant bases for differentiation.

The categories, with subcategories indicated, are as follows:

1. Asbestos-cement products
 - a. Pipe
 - b. Sheet; flat and corrugated
2. Asbestos paper
 - a. Starch binder
 - b. Elastomeric binders
3. Asbestos millboard
4. Asbestos roofing products
5. Asbestos floor tile

Phase II will include the following asbestos products: friction materials, textiles and fabrics, and gaskets and packings.

Recommended effluent limitations and waste control technologies to be achieved by July 1, 1977, and July 1, 1983, are summarized in Section II. It is estimated that the investment cost of achieving the 1977 limitations and standards by all plants in the industry is less than \$3 million, excluding costs of additional land acquisition. The cost of achieving the 1983 level is estimated to be about \$6 million for the industry, i.e., an additional \$3 million over the 1977 level.

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SECTION II

RECOMMENDATIONS

The recommended effluent limitations for the parameters of major significance are summarized below for the categories of asbestos products included in this document.

Using the best practicable control technology currently available, the limits are as follows:

	<u>Suspended Solids</u> kg/MT	<u>BOD (5-day)</u> kg/MT	<u>pH (Max.)</u>
Asbestos-cement pipe	0.19	0.09	9.0
Asbestos-cement sheet	0.23	0.11	9.0
Asbestos paper	0.35	0.35	8.5
Asbestos millboard		zero discharge	
Asbestos roofing	0.006	0.006	8.3
Asbestos floor tile	0.04*	0.02*	8.3

*Units: kilogram per 1,000 pieces

Using the best available control technology economically achievable, no discharge of wastewaters to navigable water is recommended as the effluent limitation guideline and standard of performance for all of the above categories of asbestos products. With the exception of asbestos-cement pipe and asbestos paper containing elastomeric binders, this limitation and standard of performance is recommended for all new point sources. These two excepted products should meet the limitations outlined as best practicable control technology currently available.

Sources discharging to municipal sewerage systems should limit all noncompatible constituents to the levels recommended for discharges from plants using the best practicable technology currently available.

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SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) to the Act. Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operation methods and other alternatives. The regulations proposed herein set forth effluent limitations guidelines pursuant to Section 304(b) of the Act for the asbestos manufacturing source category.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b) (1) (A) of the Act, to propose regulations establishing Federal standards of performances for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973 (38 F. R. 1624), a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the asbestos

manufacturing source category, which was included within the list published January 16, 1973.

SUMMARY OF METHODS USED FOR DEVELOPMENT OF THE EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

The effluent limitations guidelines and standards of performance proposed herein were developed in the following manner. The point source category was first categorized for the purpose of determining whether separate limitations and standards are appropriate for different segments within a point source category. Such subcategorization was based upon raw material used, product produced, manufacturing process employed, and other factors. The raw waste characteristics for each subcategory were then identified. This included an analyses of (1) the source and volume of water used in the process employed and the sources of waste and wastewaters in the plant; and (2) the constituents (including thermal) of all wastewaters including toxic and other constituents that result in taste, odor, and color in water or aquatic organisms. The constituents of wastewaters which should be subject to effluent limitations guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each subcategory was identified. This included an identification of each distinct control and treatment technology, including both inplant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification in terms of the amount of constituents (including thermal) and the chemical, physical, and biological characteristics of pollutants, of the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations and reliability of each treatment and control technology and the required implementation time was also identified. In addition, the non-water quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation were also identified. The energy requirements of each of the control and treatment technologies was identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the "best practicable control technology currently available," "best available technology economically achievable" and the "best available demonstrated control technology, processes, operating methods, or other alternatives." In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and facilities involved, the process employed, the engineering aspects of the ap-

plication of various types of control techniques process changes, non-water quality environmental impact (including energy requirements) and other factors.

The data for identification and analyses were derived from a number of sources. The sources included published literature, previous EPA technical publications on the industry, a voluntary questionnaire distributed through the Asbestos Information Association of North America, qualified technical consultation, information contained in Corps of Engineers discharge permit applications, and on-site visits and interviews at exemplary asbestos manufacturing plants throughout the United States. All references used in developing the guidelines for effluent limitations and standards of performance for new sources reported herein are included in Section XIII of this document.

GENERAL DESCRIPTION OF THE INDUSTRY

Although known as a curiosity since biblical times, asbestos was not used in manufacturing until the latter half of the 19th century. By the early years of the 20th century, much of the basic technology had been developed and the industry has grown in this country since about that time. Canada is the world's largest producer of asbestos, with the USSR and a few African countries as major suppliers. Mines in four states; Arizona, California, North Carolina, and Vermont, provide a relatively small proportion of the world's supply.

Asbestos is normally combined with other materials in manufactured products, and consequently, it loses its identity. It is a natural mineral fiber which is very strong and flexible and resistant to breakdown under adverse conditions, especially high temperatures. One or more of these properties are exploited in the various manufactured products that contain asbestos.

Asbestos is actually a group name that refers to several serpentine minerals having different chemical compositions, but similar characteristics. The most widely used variety is chrysotile. Asbestos fibers are graded on the basis of length, with the longest grade priced 10 to 20 times higher than the short grades. The shorter grades are normally used in the products covered in this document.

On a world-wide basis, asbestos-cement building materials and pipe currently consume about 70 percent of the asbestos mined. In the

United States in 1971, the consumption pattern was reported to be:

Asbestos-cement products	25%
Floor tile	18
Papers and felts	14
Friction products	10
Textiles	3
Packing and gaskets	3
Sprayed insulation	2
Miscellaneous uses	25

These figures do not accurately reflect the production levels of these products because the asbestos content varies from about 10 to almost 100 percent among the different manufactured products.

This document covers the first three groups in the above list. These groups were selected because they represent a major segment of the industry; water is an ingredient in the manufacturing process, with two exceptions; and they were regarded as the most important sources of water pollutants in this industrial category.

Asbestos-Cement Products

Asbestos fibers in asbestos-cement products serve the same role as steel rods in reinforced concrete, i.e., they add strength. Portland cement and silica are the major ingredients, with asbestos, of these products.

Asbestos-cement pipe is manufactured for use in high pressure and low pressure applications in diameters from 7.6 to 91.5 cm (3 to 36 inches) and in lengths up to 4 meters (13 feet). It is used to carry wastewaters, water supplies, and other fluids and in venting and duct systems. Asbestos-cement flat and corrugated sheets are used for exterior sheathing, siding and roofing, interior partitions, packing in cooling towers, laboratory bench tops, and many other specialty applications.

Asbestos Floor Tile

The shortest grades of asbestos fibers are used in vinyl and asphalt floor tile manufacture. The fibers are used to provide dimensional stability. Today, vinyl asbestos floor tile accounts for most of the asbestos used in this category, with asphalt tile serving some special applications and where darker shades are permissible.

Asbestos Papers and Felts

Asbestos papers have a high fiber content and are manufactured with a variety of binders and other additives for many applications. These include pipe coverings, gaskets, thermal linings in heaters and ovens, and wicks. Heavier papers are commonly used for roofing

materials and shingles. Millboard is a heavier, stiffer form of paper that includes clays, cement, or other additives. It is used for stove lining, filament supports in toasters, and several other high temperature applications.

Asbestos Molded Insulation

A product category that would logically be included with the above groups is asbestos molded, or block, insulation; e.g., 85 percent magnesia. This was used for covering steam pipes, boilers, etc. In recent years, asbestos has been replaced by other materials by almost all of the major insulation manufacturers. Several sources predicted that no significant quantity of asbestos molded insulation will be produced in the very near future. Because of its very limited production level at present and its predicted disappearance, this product category was not studied in depth. Wastewaters from the manufacture of molded insulation should respond to the same forms of control technology that apply to other asbestos products.

MANUFACTURING LOCATIONS

The locations of the plants that manufacture the products covered in this document are listed in Table 1. This listing includes all the plants as reported by the major manufacturers. It is known that there are a few plants, mostly in the roofing and floor tile categories, that are not included. All of the available known information from the plants at these locations was collected for use in this study. At several plants, no information about wastewater volumes or characteristics was known.

At most of the plants, only one asbestos product is manufactured. There are three reported locations that manufacture more than one category of asbestos product in the same plant in a manner that results in a combined wastewater flow. Since the wastewaters from all the asbestos products categories, except roofing and floor tile, have many common characteristics, they are generally treatable by the same types of control technology. Consequently, the combined wastewaters from the manufacture of multiple asbestos products do not present significant additional problems in control.

Of more significance from a water pollution control point of view is the manufacture of non-asbestos products with confluent waste streams at some of the locations. The most common combinations are the manufacture of plastic pipe at asbestos-cement pipe plants and the manufacture of "organic" (cellulose fiber) paper at asbestos paper plants. Plastic pipe manufacture is not likely to result in the discharge of significant pollution, other than waste heat. Organic paper manufacturing wastewaters, however, are significantly stronger and of different character than those from asbestos paper production. The raw materials are often paperstock (salvaged paper)

TABLE 1
LOCATIONS OF ASBESTOS MANUFACTURING PLANTS

State	Location	Company	Products.
Alabama	Regland Mobile	Cement Asbestos Products Co. GAF Corporation	A-C Pipe A-C Sheet
Arkansas	Van Buren	Cement Asbestos Products Co.	A-C Pipe
California	La Mirada South Gate Riverside Santa Clara Los Angeles Long Beach Long Beach Los Angeles Pittsburg	American Biltrite Rubber Armstrong Cork Company Certain-Teed Products Corp. Certain-Teed Products Corp. The Flintkote Company GAF Corporation Johns-Manville Johns-Manville Johns-Manville	Floor Tile Floor Tile A-C Pipe A-C Pipe Floor Tile Floor Tile A-C Pipe Roofing A-C Sheet, Paper A-C Pipe
Florida	Stockton Green Cove Springs	Johns-Manville Johns-Manville	A-C Pipe A-C Pipe
Georgia	Savannah	Johns-Manville	Roofing
Illinois	Kankakee Chicago Joliet	Armstrong Cork Company The Flintkote Company GAF Corporation	Floor Tile Floor Tile Floor Tile

TABLE 1 (contd)
LOCATIONS OF ASBESTOS MANUFACTURING PLANTS

State	Location	Company	Products
Illinois (contd)	Waukegan	Johns-Manville	A-C Pipe, A-C Sheet, Paper, Millboard, Roofing
Louisiana	New Orleans Marrero	The Flintkote Company Johns-Manville	Floor Tile A-C Sheet, Roofing
	New Orleans	National Gypsum Company	A-C Sheet
Massachusetts	Millis Billerica	GAF Corporation Johns-Manville	Roofing Millboard
Mississippi	Jackson	Armstrong Cork Company	Floor Tile
Missouri	St. Louis St. Louis	Certain-Teed Products Corp. GAF Corporation	A-C Pipe A-C Sheet
New Hampshire	Nashua Tilton	Johns-Manville Johns-Manville	A-C Sheet Paper, Millboard
New Jersey	Linden : South Bound Brook	Celotex Corporation GAF Corporation	Paper A-C Sheet, Roofing

TABLE 1 (contd)
LOCATIONS OF ASBESTOS MANUFACTURING PLANTS

State	Location	Company	Products
New Jersey (contd)	Manville	Johns-Manville	A-C Pipe, A-C Sheet, Paper, Roofing A-C Sheet
	Millington	National Gypsum Company	
New York	Fulton Vails Gate Brooklyn	Armstrong Cork Company GAF Corporation Kentile Floors, Inc.	Paper Floor Tile Floor Tile
Ohio	Cincinnati	Celotex Corporation	A-C Sheet, Paper, Millboard A-C Pipe Paper
	Ravenna Hamilton	The Flintkote Company Nicolet Industries, Inc.	
Pennsylvania	Lancaster Ambler Erie	Armstrong Cork Company Certain-Teed Products Corp. GAF Corporation	Floor Tile A-C Pipe Paper, Millboard Roofing Paper A-C Sheet, Millboard Paper, Millboard
	Erie Whitehall Ambler	GAF Corporation GAF Corporation Nicolet Industries, Inc.	
	Norristown	Nicolet Industries, Inc.	

TABLE 1 (contd)
LOCATIONS OF ASBESTOS MANUFACTURING PLANTS

State	Location	Company	Products
Texas	Hillsboro	Certain-Teed Products Corp.	A-C Pipe
	Houston	GAF Corporation	Floor Tile
	Denison	Johns-Manville	A-C Pipe
	Fort Worth	Johns-Manville	Paper, Roofing
Puerto Rico	Ponce	Boringuen Asbestos Cement Corp.	A-C Sheet

as well as virgin pulp and the wastes are highly colored, turbid, and high in oxygen demand.

CURRENT STATUS OF THE INDUSTRY

Until recently, little attention has been directed toward the wastewaters associated with asbestos manufacturing. The number of plants is not large, the volumes of the wastes are relatively small, and the waste constituents do not exert a heavy oxygen demand on receiving waters. There is significant internal recirculation of process waters incorporated in the manufacturing operations, and most of the plants provide at least some form of waste treatment; although rudimentary at some locations. Many of the roofing and floor tile plants are situated where they can discharge the process wastewaters to municipal sewers with minimal pretreatment. There is virtually no information in the literature on wastewaters from asbestos manufacturing. What little technical information that is available is from only a few plants and is of recent vintage.

The asbestos industry has long been concerned about the industrial hygiene aspects of the dust and fiber emitted to the air in mining, processing, transportation, and manufacturing operations. This concern has recently been expanded to include the general public. Asbestos is among the first materials to be declared a hazardous air pollutant under the Clean Air Act amendments of 1970. Stringent regulations have also been promulgated to control exposure to workers in the industry.

The increased concern with the health effects of asbestos fibers in the air has produced changes that affect, to some degree, the water pollution control aspects of the industry. The principal change has been conversion of dry processes into wet processes and the use of water sprays to allay dust from mining operations and slag piles. This shifting is expected to continue in the future.

While there has been considerable interest and much research on the health effects of asbestos in air, there has been almost no study of the effects of fibers in water. The situation is complicated by the lack of a standard method for detecting and enumerating the fibers in water. The levels in natural waters resulting from manufacturing operations are not known. It is believed that they are lower, however, than the levels in ground waters flowing from serpentine rock formations. In summary, there is no evidence today to indicate that asbestos fibers in natural waters are harmful to man or aquatic life. This, on the other hand, does not assure that they produce no health effects.

The asbestos manufacturing industry grew rapidly in the first two-thirds of the 20th century. Many observers expect that growth will be less rapid in the future. Environmental and health considerations,

plus competition from fiberglass, silicone products, aluminum sheet, and other materials, are among the factors contributing to the slowdown in growth. Many of the plants visited in this study were not operating at full capacity. New uses and markets for asbestos may be more difficult to develop in the future. Despite the decline in the rate of growth, asbestos has unique characteristics, and its use in manufacturing can be expected to continue to a significant degree in the foreseeable future.

SECTION IV

INDUSTRY CATEGORIZATION

INTRODUCTION

In developing effluent limitation guidelines and standards of performance for new sources for a given industry, a judgment must be made by EPA as to whether different effluent limitations and standards are appropriate for different segments (categories) within the industry. The factors considered in determining whether such categories are justified in the asbestos manufacturing industry are:

1. Product
2. Raw Materials
3. Manufacturing Process
4. Treatability of Wastewaters
5. Plant Size
6. Plant Age
7. Geographic Location

Based on review of the literature, plant visits and interviews, and consultation with industry representatives, the above factors were evaluated and it was concluded that the asbestos manufacturing industry should be divided into five product categories and four sub-categories. The categories are:

- Asbestos cement products
 - a. pipe
 - b. sheet; flat and corrugated
- Asbestos paper and felts
 - a. starch binder
 - b. elastomeric binders
- Asbestos millboard
- Asbestos roofing products
- Asbestos floor tile

FACTORS CONSIDERED

All of the factors listed above are briefly discussed below, even though most of them did not serve as bases for categorization.

Product

Despite some basic similarities in the manufacturing processes used to make the products in the first three categories above, the final products are distinct and are well defined and recognized within the

industry. In most cases, only one asbestos product is made in a given plant. Categorization by product is a logical and useful means of classification.

Raw Materials

Many of the raw materials used in asbestos products are natural materials such as clay, portland cement, and starch. It is suspected that variations in these raw materials result in operational differences that influence the wastewater volume and strength. Changes within a product category at a given plant may occur regularly and the amounts and types of raw materials may also be changed.

While variations in raw material quality and usage do exert some influence on the wastewater characteristics, there is no quantitative information in the industry about these influences. This may account for some of the differences between plants in the same category. It should not result in serious effluent limitation control problems, however.

Manufacturing Process

Within a given product category, the basic manufacturing processes are very similar. Any differences that do exist do not greatly influence the quantity or quality of the effluent. Differences in the number and size of auxiliary manufacturing units, such as save-alls, can greatly affect the wastewater effluent, both in volume and strength, however.

Treatability of Wastewater

While seemingly similar when described by the common collective parameters (suspended solids, oxygen demand, etc.), the wastewaters from the different product categories exhibit some important differences. These are described in detail in Section V of this document. The differences relate both to the in-plant and end-of-pipe control measures and to the speed with which the category can be brought to the point where pollutants are not discharged.

Plant Size

Plant size was not found to be a factor in categorizing the asbestos manufacturing industry. All of the plants visited had either one or two "machines." The machines are roughly of about the same capacity; and, consequently, all of the plants in a given category, or subcategory, do not range widely in size. The operational efficiency, quality of housekeeping, labor availability, and wastewater characteristics of the plants do not differ because of size differences. The largest plants in the industry are actually multi-product plants and are, in reality, assemblages of individual product category manufacturing units.

Plant size does not affect the type or performance of effluent control measures. As described in Section VII, the basic waste treatment operation for this industry is sedimentation. Design is based on hydraulic flow rate and plants with smaller discharges can use smaller and somewhat less costly treatment units.

There are a few specialty plants with reported production levels that are very low. From the data provided, however, no significant differences in effluent characteristics of these plants could be detected. Not including these small plants, the approximate reported daily production ranges for the product categories are as follows:

Asbestos-cement pipe	135 to 320 MT (150 to 350 tons)
Asbestos-cement sheet	90 to 230 MT (100 to 250 tons)
Asbestos paper	45 to 90 MT (50 to 100 tons)
Asbestos millboard	6 to 14 MT (7 to 15 tons)
Asbestos roofing	(360 to 450 MT)* (400 to 500 tons)*
Asbestos floor tile	300,000 to 650,000 pieces

*The limited data from roofing plants do not permit an accurate estimate of the full range of production.

Plant Age

The ages of the plants in the asbestos manufacturing industry range from a few to 50 or more years. The manufacturing equipment is often younger than the building housing the plant, although in some cases, used machines have been installed in new plants. Plant age could not be correlated with operational efficiency, quality of house-keeping, or wastewater characteristics. The major effects of plant age may be related to the cost of providing effluent control measures. Plant age is not an appropriate basis for categorization of the industry.

Geographic Location

Asbestos manufacturing plants are primarily in the east and south and in California. There are reportedly no differences in the processes used throughout the country. As noted above, differences could exist in the locally supplied natural raw materials. These could influence the mode of operation and the effluent stream. There is no knowledge developed at present by which to describe the extent or importance of these differences.

Plants in some southwestern locations are able to accomplish zero discharge because of high evaporation losses from lagoons. This treatment option is not available throughout most of the nation, however.

General Manufacturing Process

With the exception of roofing and floor tile manufacture, there is a basic similarity in the methods of producing the various asbestos products. The asbestos fibers and other raw materials are first slurried with water and then formed into single or multi-layered sheets as most of the water is removed. The manufacturing process always incorporates the use of save-alls (settling tanks of various shapes) through which process wastewaters are usually routed. Water and solids are recovered and reused from the save-all, and excess overflow and underflow constitute the process waste streams. In all of these product categories, water serves both as an ingredient and a means of conveying the raw materials to and through the forming steps.

ASBESTOS-CEMENT PRODUCTS

The largest single use category of asbestos fibers in the United States is the manufacture of asbestos-cement products. The pipe segment is the largest component of this product category.

Raw Materials

Asbestos-cement products contain from 10 to 70 percent asbestos by weight, usually of the chrysotile variety. Crocidolite and other types are used to a limited extent depending upon the properties required in the product. Portland cement content varies from 25 to 70 percent. Consistent cement quality is very important since variations in the chemical content or fineness of the grind can affect production techniques and final product strength. The remaining raw material, from 5 to 35 percent, is finely ground silica. Some asbestos-cement pipe plants have facilities for grinding silica as an integral part of their operations. Finely ground solids from damaged pipe or sheet trimmings are used by some plants as filler material. A maximum of 6 percent filler can be used in some products before strength is affected.

The interwoven structure formed by the asbestos fibers in asbestos-cement products functions as a reinforcing medium by imparting increased tensile strength to the cement. As a result, there is a 70 to 80 percent decrease in the weight of the product required to attain a given structural strength. It is important that the asbestos be embedded in the product in a completely fiberized or willowed form, and the necessary fiber conditioning is frequently carried out prior to mixing the fiber with the cement and silica. In some cases, however, this fiber opening is accomplished while the wet mixture is agitated by a pulp beater, or hollander.

Manufacture

Asbestos-cement sheet products are manufactured by the dry process, the wet process, or the wet mechanical process. Figures 1 through

3 illustrate the sequence of steps in each of these manufacturing processes with the sources of wastes indicated. Products having irregular shapes are formed by molding processes which account for only a very limited production today. Extrusion processes are not widely used in the United States.

Dry Process--

In the dry process (Figure 1), which is suited to the manufacture of shingles and other sheet products, a uniform thickness of the mixture of dry materials is distributed onto a conveyor belt, sprayed with water, and then compressed against rolls to the desired thickness and density. Rotary cutters divide the moving sheet into shingles or sheets which are subsequently removed from the conveyor for curing. The major source of process wastewater in this process is the water used to spray clean the empty belt as it returns.

Wet Process--

The wet process (Figure 2) produces dense sheets, flat or corrugated, by introducing a slurry into a mold chamber and then compressing the mixture to force out the excess water. A setting and hardening period of from 24 to 48 hours precedes the curing operation. The large, thick monolithic sheets used for laboratory bench tops are manufactured by this process. The grinding operations used to finish the sheet surfaces produce a large quantity of dust which may be discharged with the process wastewaters. This affords a means of reducing and controlling air emissions.

Wet Mechanical Process--

The wet mechanical process, which is also used for the manufacture of asbestos-cement pipe (Figure 4), is similar in principle to some papermaking processes. The willowed asbestos fiber is conveyed to a dry mixer where it is blended with the cement, silica, and filler solids. After thorough blending of the raw materials, the mixture is transferred to a wet mixer or beater. Underflow solids and water from the save-all are added to form a slurry containing about 97 percent water. After thorough mixing, the slurry is pumped to the cylinder vats for deposition onto one or more horizontal screen cylinders. The circumferential surface of each cylinder is a fine wire mesh screen that allows water to be removed from the underside of the slurry layer picked up by the cylinder. The resulting layer of asbestos-cement material is usually from 0.02 to 0.10 inch in thickness. The layer from each cylinder is transferred to an endless felt conveyor to build up a single mat for further processing. A vacuum box removes additional water from the mat prior to its transfer to mandrel or accumulator roll. This winds the mat into sheet or pipe stock of the desired thickness. Pressure rollers bond the mat to the stock already deposited on the mandrel or roll and remove excess water. Pipe sections are removed

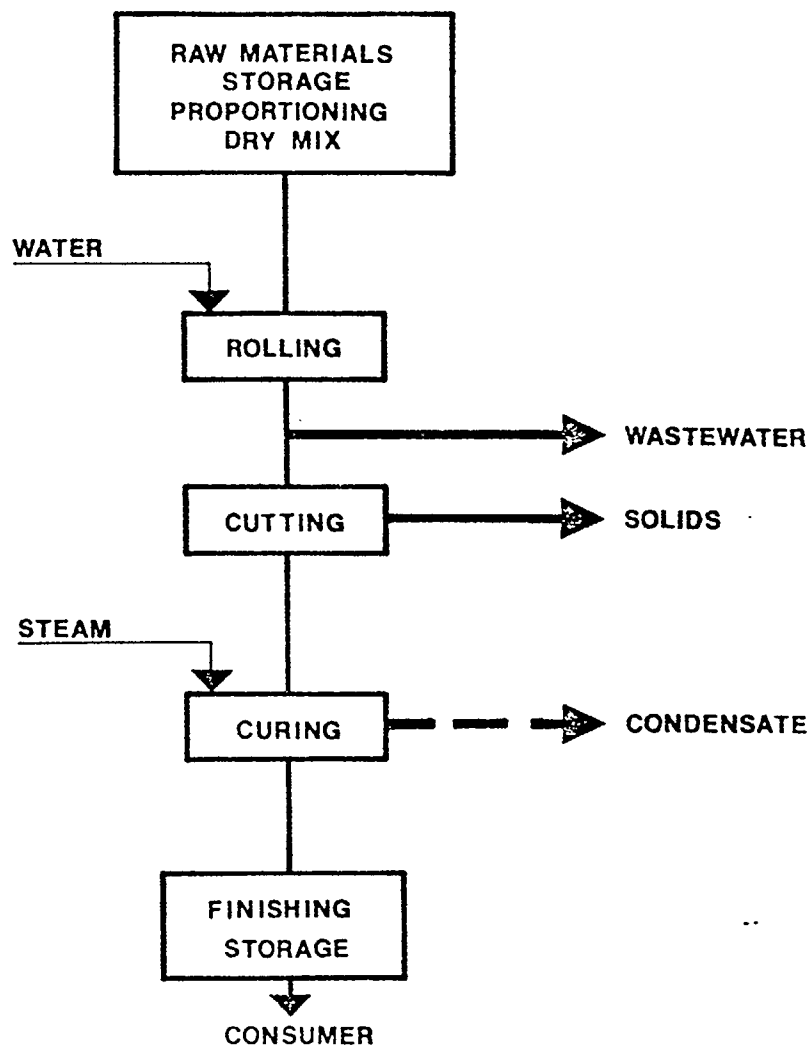


Figure.1 - Asbestos-Cement Sheet Manufacturing Operations,
Dry Process

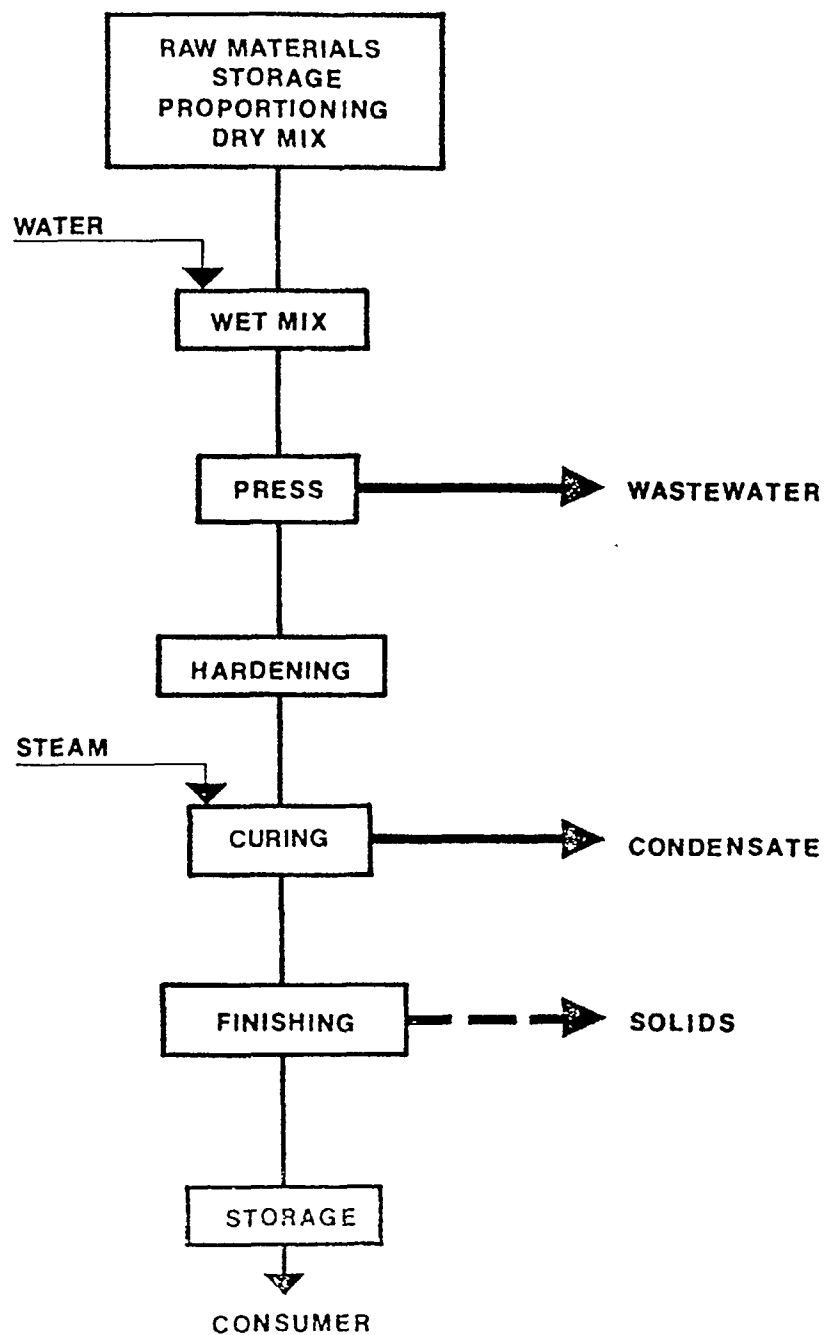


Figure 2 - Asbestos-Cement Sheet Manufacturing Operations,
Wet Process

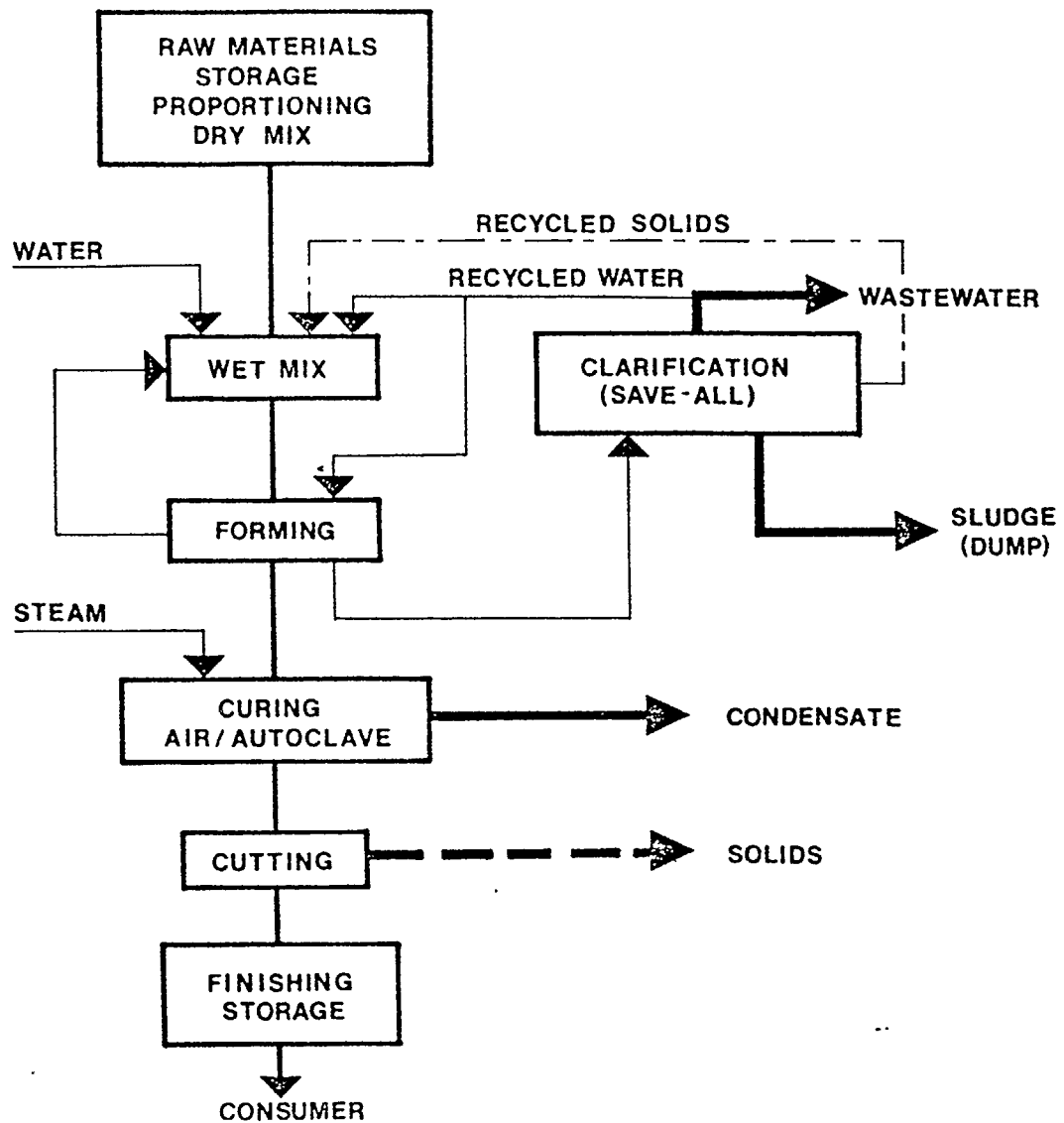


Figure 3 - Acbestos-Cement Sheet Manufacturing Operations,
Wet Mechanical Process

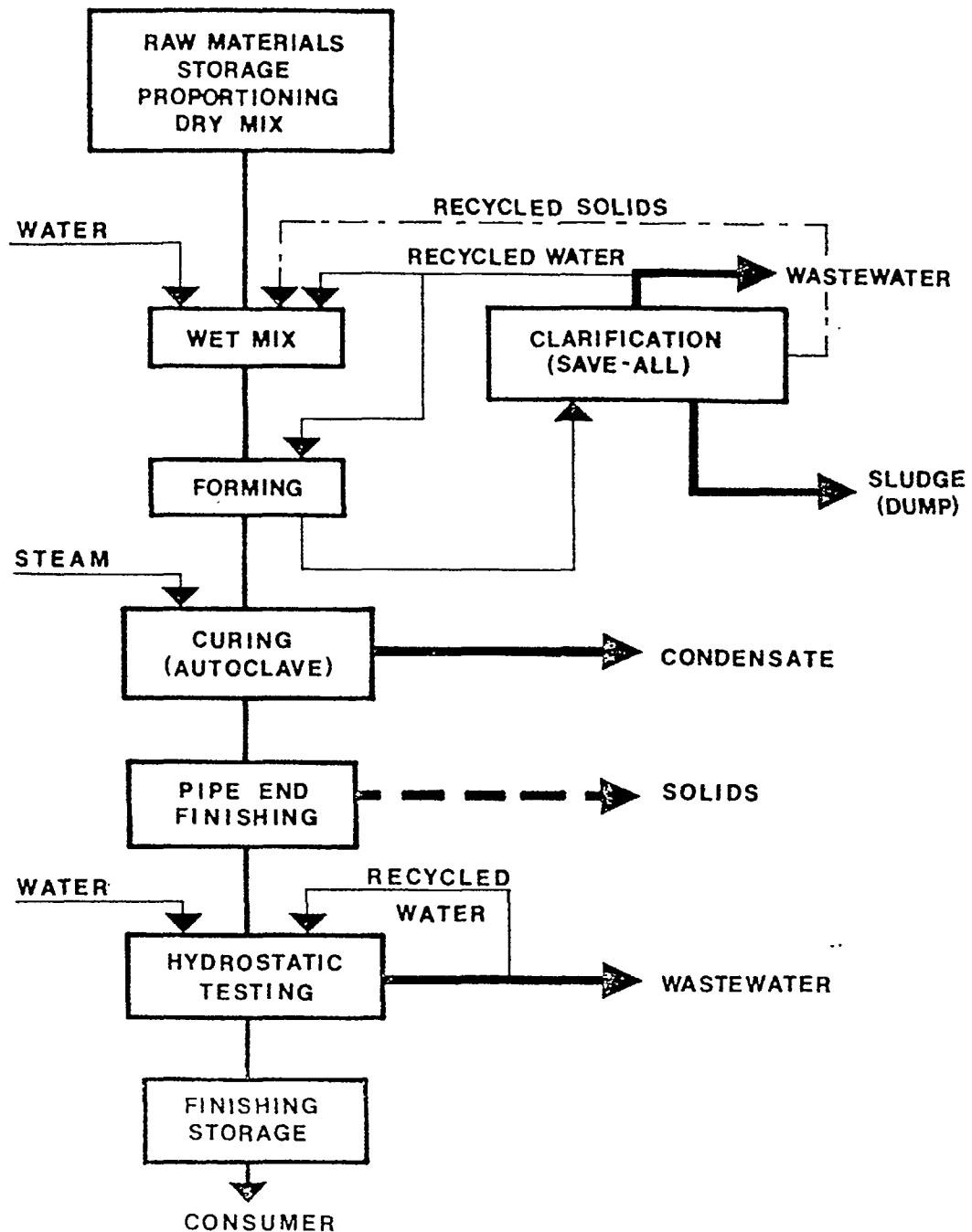


Figure 4 - Asbestos-Cement Pipe Manufacturing Operations,
Wet Mechanical Process

from the mandrel, air cured, steam cured in an autoclave, and then machined on each end.

In the manufacture of sheet products by the wet mechanical process, the layer of asbestos-cement on the accumulator roll is periodically cut across the roll and peeled away to form a sheet. The sheet is either passed through a pair of press rollers to shape the surface and cut the sheet into shingles, formed into corrugated sheet, or placed onto a flat surface for curing.

The asbestos-containing water removed from the slurry or mat is recycled to the process. Very little asbestos is lost from the manufacturing process.

Cleaning

The cylinder screen and felt conveyor must be kept clean to insure proper operation. Cylinder showers spray water on the wire surface after the mat has been removed by the felt. Any cement or fiber particles are washed out of the holes in the screen to prevent "blinding".

The cylinders, mandrels, and accumulator rolls are occasionally washed in acetic or hydrochloric acid to remove cement deposits. This cleaning may be carried out while the machine is in operation or the component, especially cylinder screens, may be removed to a separate acid washing facility.

The felt washing showers are a row of high pressure nozzles that, with the aid of a "whipper", wash fiber out of the felt after the mat of fiber has been picked up by the mandrel or accumulator roll. Fiber build-up in the felt can prevent vacuum boxes from removing excess water from the mat.

In-Plant Recycling

Asbestos-cement product plants recycle the majority of their water as a means of recovering all useable solids. All water serving as the carrying agent, 80 to 90 percent of the water in the process, passes through a save-all after leaving the machine vat. Solids that settle out and concentrate near the bottom of the save-all are pumped to the wet mixer to become part of a new slurry. Much of the clarified overflow from the save-all can be used for showers, dilution, and various other uses depending upon the efficiency of the save-all.

The save-all overflow may be discharged from the plant or may be treated and returned to the plant for whatever uses its quality justifies. This may include water for wet saws, vacuum pump seals, cooling, hydrotesting, or makeup water for plant startup. If any of these uses cannot be served by treated water, fresh water must be

used since the quality and temperature of save-all overflow water is rarely acceptable without additional clarification.

At most asbestos-cement product plants, part of the products that are damaged or unacceptable for other reasons, are crushed, ground, and used as filler in new products. The remainder is crushed and added to a refuse pile or landfill.

Asbestos-cement sheet plants trim the edges of the wet sheets as they come off the accumulator roll. The trimmings are immediately returned to the wet mixer. At this stage, the cement has not begun to react and the trimmings can be an active part of the new slurry.

Operating Schedule

Asbestos-cement pipe plants typically operate 24 hours a day and five or six days a week. Sheet plants may operate two shifts a day rather than three depending upon market demand.

ASBESTOS PAPER

Asbestos paper has a great variety of uses and ingredient formulas vary widely depending upon the intended use of the paper. The purchaser frequently specifies the exact formula to insure that the paper has the desired qualities.

Raw Materials

Asbestos paper usually contains from 70 to 90 percent asbestos fiber by weight, usually the short grades. A mixture of the various varieties of asbestos fiber is used with chrysotile as the principal type. The binder content of asbestos paper accounts for 3 to 15 percent of its weight. The content and type varies with the desired properties and intended applications of the paper. Typical binders are starch, glue, cement, gypsum, and several natural and synthetic elastomers.

Asbestos paper used for roofing paper, pipe wrapping, and insulation usually contains between 5 and 10 percent kraft fiber. Mineral wool, fiberglass, and a wide variety of other constituents are included to provide special properties and may represent as much as 15 percent of the weight.

Manufacture

Asbestos paper is manufactured on machines of the Fourdrinier and cylinder types that are similar to those which produce cellulose (organic) paper. The cylinder machine is more widely employed in the industry today. The overall manufacturing process is shown in Figure 5 with waste sources indicated.

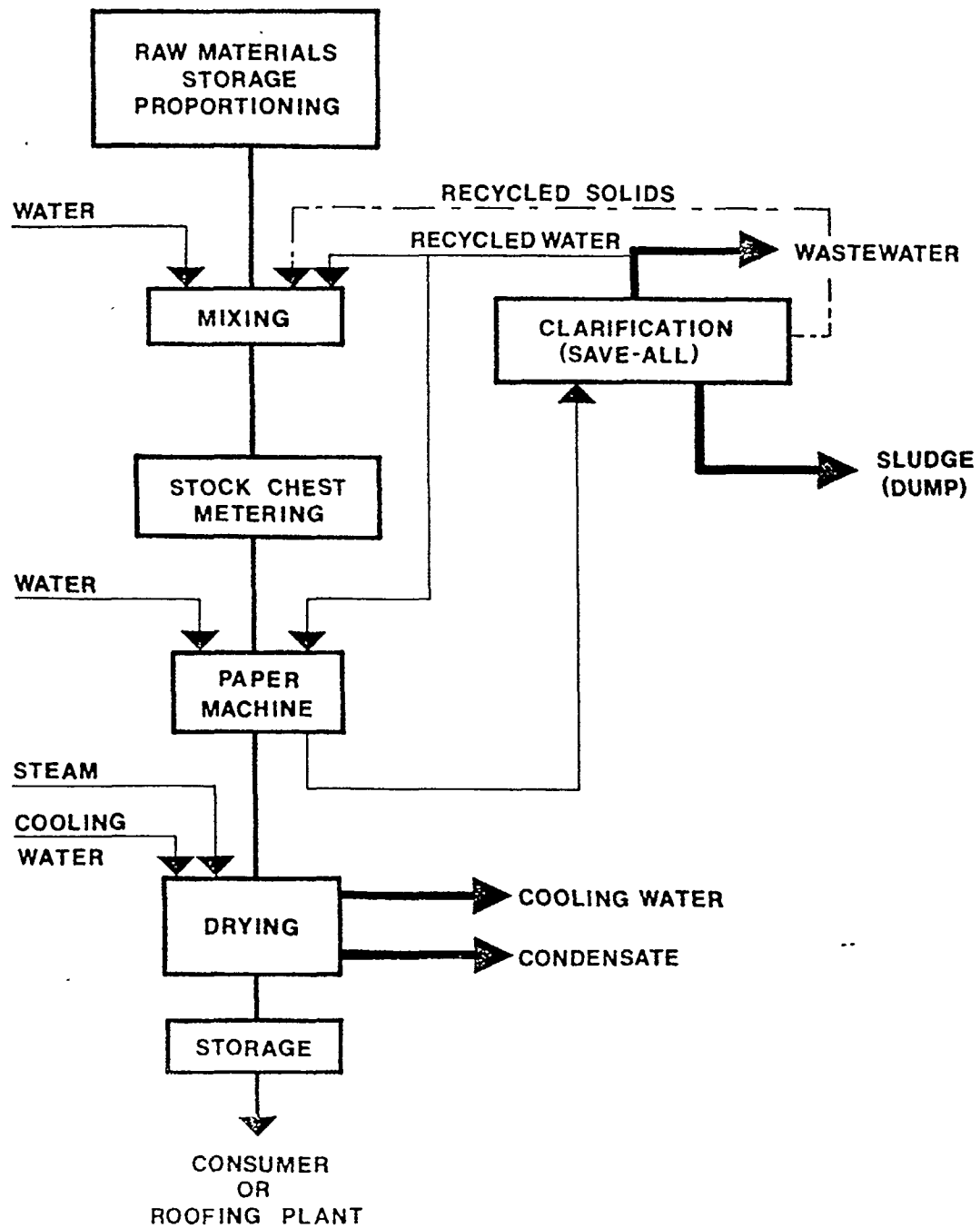


Figure 5 - Asbestos Paper Manufacturing Operations

The mixing operation combines the asbestos fibers with the binders and any other minor ingredients. A pulp beater or hollander mixes the fibers and binder with water into a stock which typically contains about three percent fiber. Upon leaving the stock chest, the stock is diluted to as little as one-half percent fiber in the discharge chest. The amount of dilution depends upon the quality of the paper to be produced.

The discharge chest of a Fourdrinier paper machine deposits a thin and uniform layer of stock onto an endless moving wire screen through which a major portion of the water is drawn by suction boxes or rolls adjacent to the sheet of paper. The sheet is then transferred onto an endless moving felt and pressed between pairs of rolls to bring the paper to approximately 60 percent dryness. Subsequently, the continuous sheet of paper passes over heated rolls, while supported on a second felt, to effect further drying. This is followed by calendering, to produce a smooth surface, and winding of the paper onto a spindle.

The operation of a cylinder paper-making machine includes a mixing operation for stock as indicated for the Fourdrinier machine. Cylinder type paper machines usually have four to eight cylinders instead of two as in most asbestos-cement pipe machines.

The stock is pumped to the cylinder vats of the machine. Each vat contains a large screen-surfaced cylinder extending the full length of the vat. The stock slurry flows through the screen depositing a thin layer of fiber on the surface of the rotating cylinder before flowing out through the ends of the cylinder. The layer of fiber is then transferred to a carrier felt moving across the top of the rotating cylinders. The layers picked up from the cylinders are pressed together becoming a single homogeneous sheet as the felt passes over each successive cylinder.

Vacuum boxes draw water out and pressure rolls squeeze water out of the sheet and felt until the sheet is dry enough to be removed from the felt. After leaving the felt, the sheet is dried on steam rolls and in ovens. The paper is then calendered to produce a smooth surface and wound onto a spindle.

The width of the paper sheet is regulated by the deckles, a row of nozzles located at each end of the cylinder screens. The deckles spray water on the screen at the edge of the sheet and wash off excess fiber.

Cleaning

The cylinder showers are a row of nozzles that spray water on the surface of the cylinder screens after the paper stock mat has been removed by the felt. They wash any remaining fiber and binder out of the holes in the screens to prevent a build-up of fiber from

"blinding" the screen and stopping the flow of water required to deposit a layer of fiber on the surface of the cylinder.

The felt washing operations are carried out using high pressure nozzles as in asbestos-cement pipe manufacture.

The asbestos-containing water, or "white water", which is removed from the stock prior to passage across the heated drying rolls is recycled to the process.

Water Usage

Water serves three basic purposes in the asbestos paper manufacturing process: Ingredient carrier, binder wetting agent, and heat transfer fluid. Other uses include water for showers, deckles, pump seals, plant make-up, boiler make-up, and cooling.

Fresh water enters the system as boiler make-up, process make-up, pump seal water, and shower water. Boiler make-up water provides steam for heating the paper stock and drying the finished paper. The steam used to heat the stock slurry becomes a part of the slurry and must be replaced. Condensate from the drying rolls is recovered and returned to the boiler. Fresh water must be used to cool the dried paper unless a cooling tower is available. Save-all overflow and other plant water is usually too hot for such purposes. Large quantities of fresh water are required during plant start-up to fill the system. This occurs infrequently, however. Small quantities of water are required continuously to replace that which evaporates during drying and that which becomes a permanent part of the paper. The characteristics of some paper products are such that fresh water must be used for part, or all, of the beater make-up water.

Cylinder and felt washing showers usually require fresh water because save-all overflow water is rarely clean enough to be used in the high pressure shower nozzles without causing plugging. Fresh water is used for the pump shaft seal water because the presence of dirt in the seal water will cause plugging and can cause scoring of the shaft. Although the cooling water and part of the pump seal water may be discharged from the plant after a single use, most of the fresh water introduced into the plant enters the ingredient carrying system and, therefore, the paper machine save-all loop.

In-Plant Recycling

The majority of the water in a paper plant serves as an ingredient carrier and continually circulates in a loop through the paper machine and the save-all. All water flowing out of the cylinder screen and that drawn by vacuum out of the wet paper sheet is pumped to the save-all. The solids settle to the bottom of the save-all and are pumped to the stock chest of the beater. Occasionally, the solids from the save-all must be discharged from the plant due to a product change, rapid setup of the binder, or

a plant shutdown. Save-all overflow water is used for beater make-up, dilution, deckle water, and occasionally shower water.

Excess overflow water must be discharged from the plant or sent to a wastewater treatment facility for additional treatment before it can be reused.

Trimnings from the edge of the paper, defective paper, and other waste paper can usually be returned to the beater and repulped for recycling.

Operating Schedule

Asbestos paper manufacturing plants typically operate 24 hours a day and 7 days a week.

MILLBOARD

Asbestos millboard is considered by some to be a very heavy paper and is in fact very much like thick cardboard in texture and structural qualities. It can easily be cut or drilled and can be nailed or screwed to a supporting structure.

Raw Materials

Millboard formulas vary widely depending upon the intended use of the product. Purchasers frequently specify the ingredients and composition of the millboard to insure that the product meets their particular requirements. Asbestos content ranges between 60 and 95 percent with the higher content for products that will be in close or direct contact with high temperature materials. Portland cement and starch are the most common binders used and represent 5 to 40 percent of the product. Clay, lime, mineral wool, and several other materials are frequently used as fill material or to provide special qualities. Water is also an important ingredient in millboard.

Manufacture

The manufacturing steps in asbestos millboard production with waste sources indicated are shown in Figure 6. Millboard is produced on small cylinder type machines similar to those used for making asbestos-cement pipe. The machines are equipped with one or two cylinder screens, conveying felt, pressure rolls, and a cylinder mold. After the ingredients are mixed in a beater, the slurry is transferred to a stirring vat or stock chest from which it is diluted and pumped to the cylinder vats of the millboard machines. Each cylinder vat contains a large screen surfaced cylinder extending the full length of the vat. The slurry flows through the screen depositing a mat of fiber on the surface of the rotating cylinder before flowing out through the ends of the cylinder. The mat of

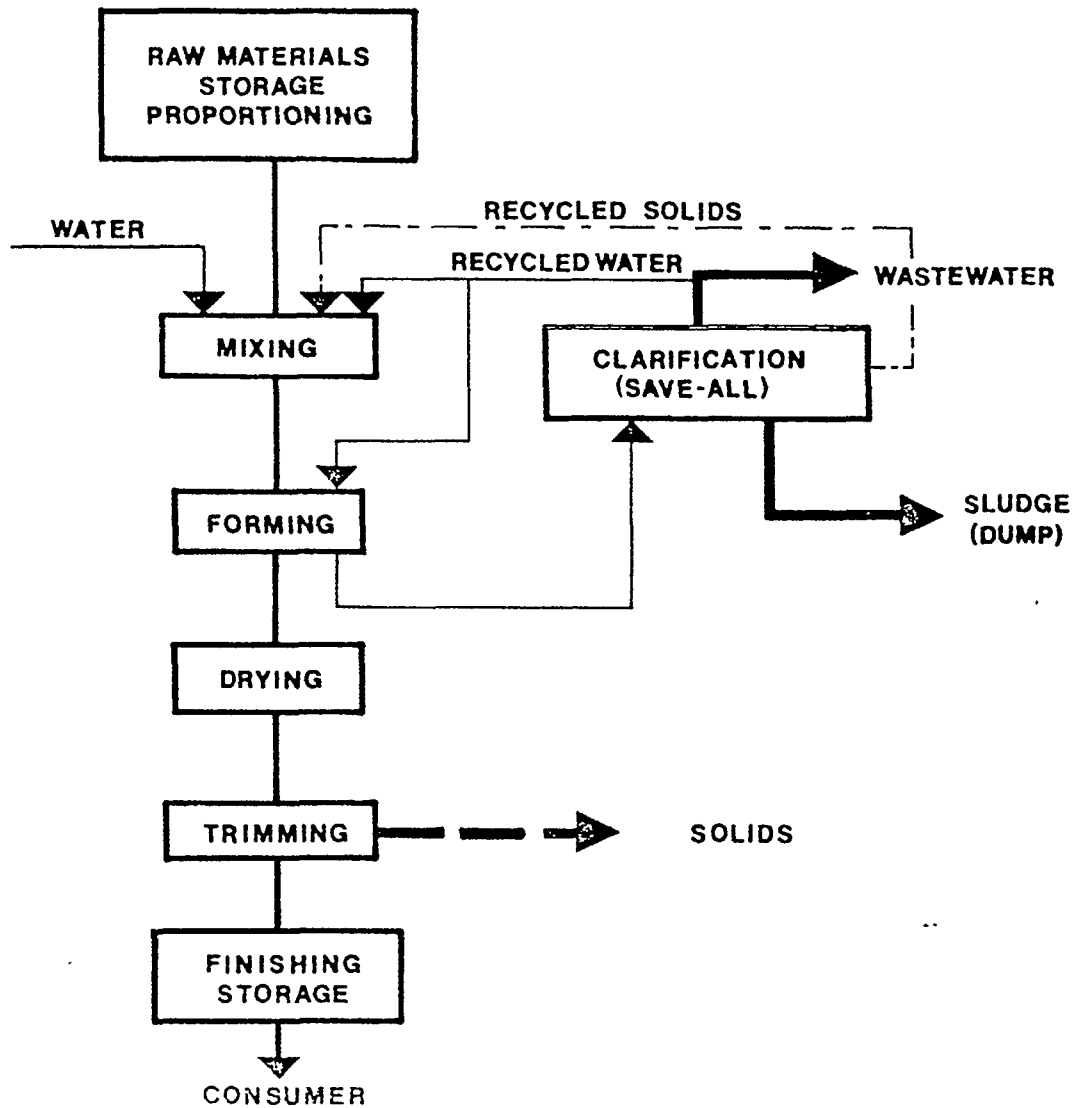


Figure 6 - Asbestos Millboard Manufacturing Operations

fiber is then transferred to a carrier felt moving across the top of the rotating cylinder. On two-cylinder machines, the mats from the first and second cylinders are pressed together becoming a single homogeneous sheet as the felt picks up the mat of fiber from the second cylinder. Pressure rolls above the felt squeeze water from the mat as it is picked up from the cylinders. Some millboard machines have vacuum boxes adjacent to the felt that draw water out of the mat of fibers. Additional pressure rolls remove more water from the mat as it is wound onto the cylinder mold.

The cylinder mold is a drum about four feet wide and usually about four feet in diameter. As the carrier felt passes the cylinder mold, the mat is transferred to the cylinder because the adhesion to the wet cylinder surface is greater than the adhesion to the felt. The cylinder mold rotates, collecting successive layers of fiber until the desired thickness is obtained. The cylinder is then momentarily stopped and the mat of fiber cut along a notch on the surface of the cylinder parallel to the cylinder axis. The sheet of millboard is removed as the cylinder starts rotating to build up another sheet. The wet millboard, containing about 50 percent water, is air dried or moved into an autoclave or oven for rapid curing. Finished millboard usually contains 5 to 6 percent water.

Cleaning

The operation of the deckles, cylinder showers, and felt washing showers is basically the same as described previously for asbestos paper.

Water Usage

The uses and flow patterns of water in millboard manufacturing operations are very similar to those in asbestos paper making.

In-Plant Recycling

As with the asbestos products covered previously, most of the water in the millboard manufacturing process serves as an ingredient carrier and continually circulates in a loop through the millboard machine and the save-all. All water flowing out of the cylinder screen and that drawn by vacuum out of the wet millboard is pumped to the save-all. Solids that settle in the save-all are pumped to the stock chest or the beater. Save-all overflow water is used for beater make-up, dilution, deckle water, and occasionally shower water. Excess overflow water must be discharged from the plant or sent to a treatment facility for additional treatment before it can be reused.

When possible, trimmings from millboard sheets are returned to the beater and repulped for use in new millboard. Most millboards can accept from 5 to 10 percent reclaimed material.

Operating Schedule

A typical asbestos millboard plant operates two or three shifts per day and five or six days a week.

ASBESTOS ROOFING

Asbestos roofing is made by saturating heavy grades of asbestos paper with asphalt or coal tar with the subsequent application of various surface treatments. The stock paper may be single or multiple layered and usually contains mineral wool, kraft fibers, and starch as well as asbestos. Fiberglass filaments or strands of wire may be embedded between layers for reinforcement.

Manufacture

Figure 7 shows the major steps in the manufacture of asbestos roofing. Asbestos paper is pulled through a bath of hot coal tar or asphalt. After it is thoroughly saturated, the paper passes over a series of hot rollers to set the coal tar or asphalt in the paper. The paper then passes over cooling rollers that reduce the temperature of the paper and give it a smooth surface finish. At some plants, cooling water is sprayed directly on the surface of the saturated paper.

Roll roofing is coated with various materials to prevent adhesion between layers and then passed over a final series of cooling rollers. The roofing is then air dried and rolled up and packaged for marketing. The manufacture of asbestos roof shingles is similar from a wastewater point of view.

Water Usage

Water is used in two ways in the production of roofing. It is converted to steam to heat the saturating baths and hot rollers and for cooling the hot paper after it has been saturated. Condensate from the saturating bath coils and the hot rollers is collected and returned to the boilers. Fresh make-up water in small quantities is required to replace boiler blowdown water, steam, and condensate that escapes through leaks. Cooling water is used once and discharged unless cooling towers or other means of cooling the water are available. The only process wastewater associated with roofing manufacture is that originating in the spray cooling step. In many cases, this contaminated contact cooling water is discharged with the clean non-contact cooling water.

Operating Schedule

A typical roll roofing plant operates one or two shifts a day on a five-day per week schedule.

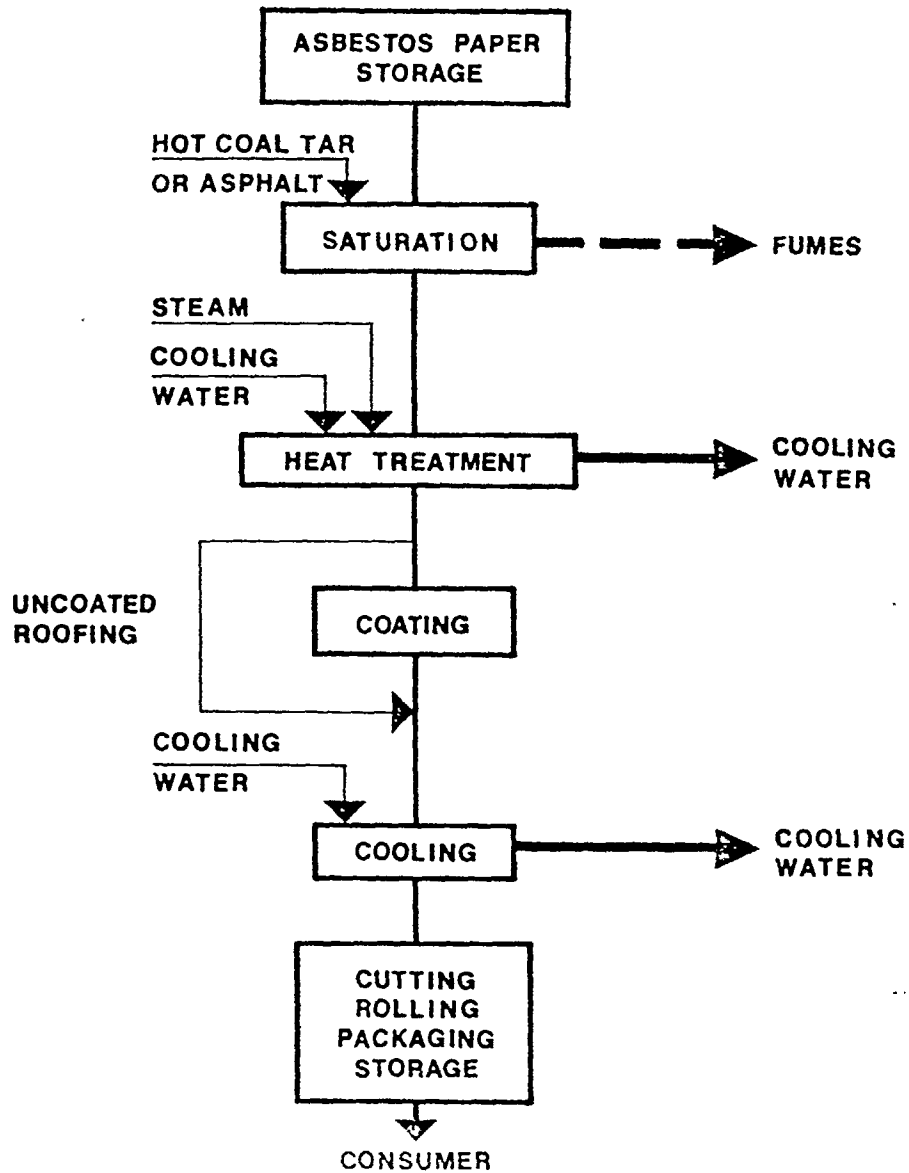


Figure 7 - Asbestos Roofing Manufacturing Operations

FLOOR TILE

Most floor tile manufactured today uses a vinyl resin, although some asphalt tile is still being produced. The manufacturing processes are very similar and the water pollution control aspects are almost identical for the two forms of tile.

Raw Materials

Ingredient formulas vary with the manufacturer and the type of tile being produced. The asbestos content ranges from 8 to 30 percent by weight and usually comprises very short fibers. Asbestos is included for its structural properties and it serves to maintain the dimensional stability of the tile. PVC resin serves as the binder and makes up 15 to 25 percent of the tile. Chemical stabilizers usually represent about 1 percent. Limestone and other fillers represent 55 to 70 percent of the weight. Pigment content usually averages about 5 percent, but may vary widely depending upon the materials required to produce the desired color.

Manufacture

The tile manufacturing process, shown in Figure 8, involves several steps; ingredient weighing, mixing, heating, decoration, calendaring, cooling, waxing, stamping, inspecting, and packaging. The ingredients are weighed and mixed dry. Liquid constituents, if required, are then added and thoroughly blended into the batch. After mixing, the batch is heated to about 150 degrees C and fed into a mill where it is joined with the remainder of a previous batch for continuous processing through the rest of the manufacturing operation.

The mill consists of a series of hot rollers that squeeze the mass of raw tile material down to the desired thickness. During the milling operation, surface decoration in the form of small colored chips of tile (mottle) are sprinkled onto the surface of the raw tile sheet and pressed in to become a part of the sheet. Some tile has a surface decoration embossed and inked into the tile surface during the rolling operation. This may be done before or after cooling. After milling, the tile passes through calenders until it reaches the required thickness and is ready for cooling. Tile cooling is accomplished in many ways and a given tile plant may use one or several methods. Water contact cooling in which the tile passes through a water bath or is sprayed with water is used by some plants. Others use non-contact cooling in which the rollers are filled with water. In some plants, the sheet of tile passes through a refrigeration unit where cold air is blown onto the tile surface. After cooling, the tile is waxed, stamped onto squares, inspected, and packaged. Trimmings and rejected tile squares are chopped up and reused.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

INTRODUCTION

Water is commonly used in asbestos manufacturing as an ingredient, a carrying medium, for cooling, and for various auxiliary purposes such as in pump seals, wet saws, pressure testing of pipe, and others. These uses are described in detail in following parts of this section. Water is used only for cooling in the manufacture of asbestos roofing and floor tile products. In the discussion below, these two categories are not included unless specifically mentioned. In most asbestos manufacturing plants the wastewaters from all sources are combined and discharged in a single sewer.

As described in detail in Section IV, asbestos manufacturing, in almost all cases, involves forming the product from a dilute water slurry of the mixed raw ingredients. The product is brought to the desired size, thickness, or shape by accumulating the solid materials and removing most of the carriage water. The water is removed at several places in the machine and it, together with any excess slurry, is piped to the save-all system.

The mixing operations are carried out on a batch, or semi-continuous, basis. Water and materials are returned from the save-alls as needed during mixing. Excess water and, in some cases, materials are discharged from the save-all system. Fresh water and additional raw materials are added during mixing. The fresh water is often used first as vacuum pump seal water before going into the mixing operations.

The major source of process wastewater in asbestos manufacturing is the "machine" that converts the slurry into the formed wet product. It is not practical to isolate individual sources of wastewater within the machine system. The water is commonly transported from the machine to the save-all system and back to the machine in a closed system. To measure the quantity of water flowing in the machine-save-all recycle system involves a rather elaborate monitoring program that was beyond the scope of this study. Only one manufacturing plant provided data on in-plant water flows that were more than rough estimates. This information is presented below under asbestos-cement pipe (Figure 9). The relative amount of internal recycling in all asbestos manufacturing plants is significant and of roughly the same relative proportion as detailed for this pipe plant.

An important factor influencing both the volume and strength of the

raw wastewaters is the save-all capacity in the plant. Save-alls are basically settling tanks in which solid-liquid separation is accomplished by gravity. Their purpose is first to recover raw materials (solids) and, second, water. The efficiency of separation is primarily dependent upon the hydraulic loading on the save-all. Plants with greater save-all capacity have greater flexibility in operation, more water storage volume, and a cleaner raw wastewater leaving the manufacturing process. In many asbestos manufacturing plants, the solids in the save-alls are dumped when the product is to be changed or when it is necessary to remove the accumulated waste solids at the bottom. It may also be necessary to dump the save-alls when the manufacturing process is shut down.

The data used in developing the water usage and waste characteristics information presented in the following parts of this Section were derived from information supplied by the industry. The results from a sampling program at selected plants were used to verify, and where necessary, supplement the industrial data.

ASBESTOS-CEMENT PIPE

Water Usage

The water balance at one asbestos-cement pipe plant was provided by the plant personnel. The values were verified in this study as far as possible. The balance is outlined diagrammatically in Figure 9. The fresh water going into the pipe manufacturing machine is only about one-quarter of the total used. The rest is water recycled from the save-all. The percentage figures in Figure 9 are in terms of the total water entering the manufacturing system, i.e., the fresh water and that returned from the save-all.

Fresh water is used for wet saws, hydrotesting, cooling, sealing vacuum pumps, and making steam for the autoclave as well as make-up in the mixing unit. Water is used with the saws to control dust and fiber emissions to the air. This is in contrast to the normally dry lath operations that finish the pipe ends.

Hydrotesting is a routine procedure in which the strength of the pipe is tested while full of water under pressure. At some plants, the hydrotest water is reused.

A pipe plant must remove solids from the bottom of the save-alls to prevent their hardening into concretions. At some plants, this dumping and clean up is carried out when the manufacturing operations are shut down for the weekend. At other plants, dumping occurs more frequently.

The reported wastewater discharge from 10 of the 14 asbestos-cement pipe plants ranged from 76 to 2,020 cubic meters per day (0.02 to .55 MGD). The accuracy of these values is not known. At a few loca-

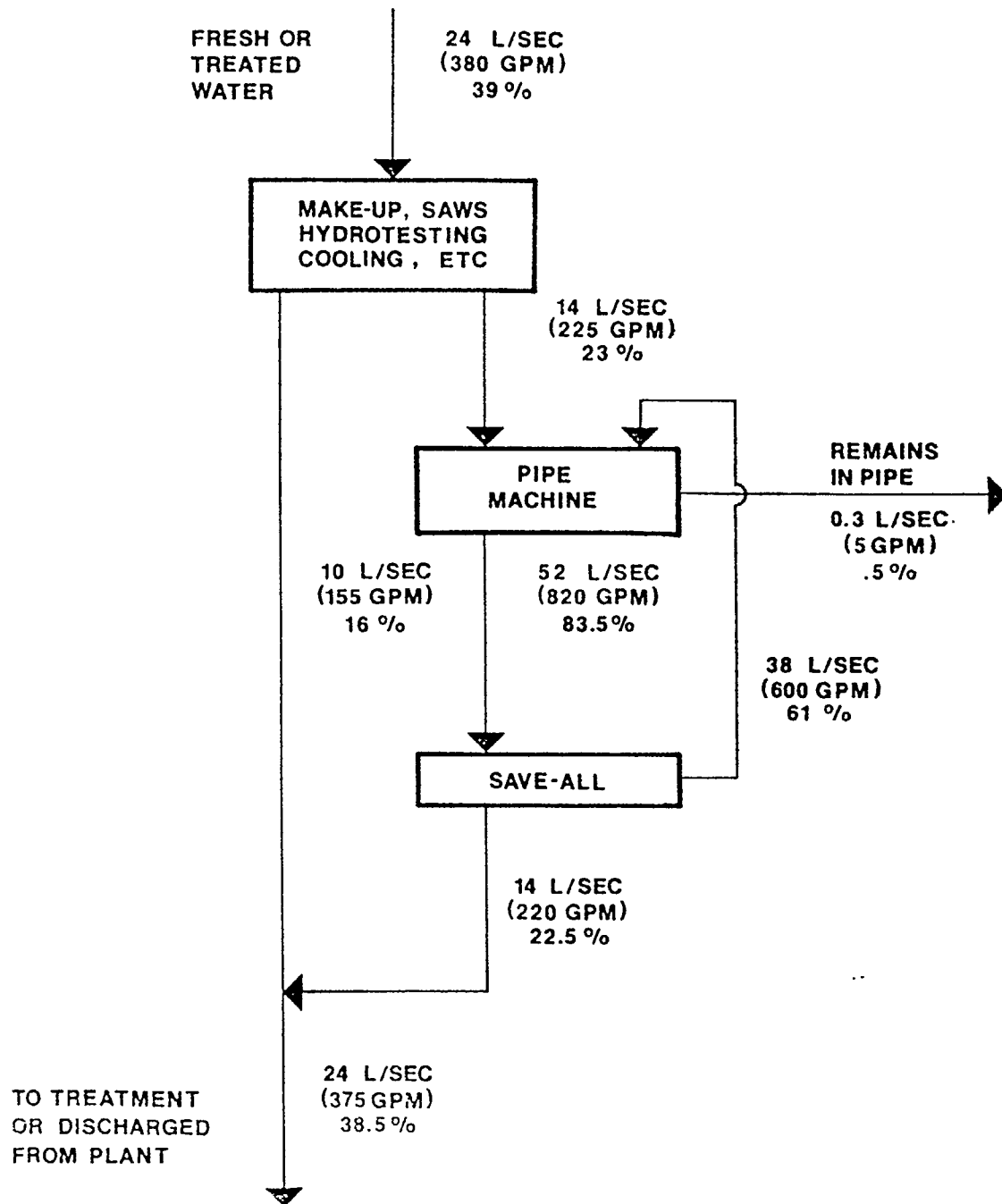


Figure 9 - Water Balance Diagram for a Typical Asbestos-Cement Pipe Plant

tions, there is little or no measurable discharge because of evaporative losses from lagoons. Discharge records for a period of a year or more were available at two pipe plants. At one plant the minimum flow was 65 percent of the average and the maximum was 145 percent. The flow figures included cooling water from the manufacture of plastic pipe, however. The maximum discharge at the other plant, which produced only asbestos-cement pipe, was 670 percent of the average. The standard deviation in 403 values at this plant was of the same magnitude as the average flow.

Waste Characteristics

The characteristics of raw wastewaters from asbestos-cement pipe manufacturing were developed from sampling data from three plants and reported values from one plant that provides minimal treatment. Two of the plants recirculated water from the external treatment system back into the plant. These plants tended to use relatively much more water and the dissolved (filterable) solids levels were much higher in the wastewaters from these plants.

Constituents--

The manufacture of asbestos-cement pipe in a typical plant increases the levels of the major constituents in the water by the following approximate amounts:

	<u>mg/l</u>	<u>kg/MT</u>	<u>(lb/Ton)</u>
Total solids	1,500	9	18
Suspended solids	500	3.1	6.3
BOD (5-day)	2	0.01	0.02
Alkalinity	700	4.4	8.8

The dissolved salts are reported to be primarily calcium and potassium sulfates with lesser amounts of sodium chloride. The magnesium levels are not known to be high. The alkalinity is primarily caused by hydroxide with a small carbonate contribution. The pH ranges as high as 12.9, but is generally close to 12.0, or slightly lower.

Temperature--The temperature fluctuations at a given plant are smaller than the differences between plants. The maximum raw waste temperature measured in this study was 40 degrees C. This plant recirculated some water from its treatment facility. The average temperature at two other pipe plants were 10 to 15 degrees C hotter than the intake water.

Oil and grease--The oil and grease content of raw waste samples taken at pipe plants was below detectable levels. Reported data indicate that at some plants there are measurable oil and grease levels in

the final plant effluent. This is believed to be from the equipment rather than the process.

Organic matter--The organic content of pipe plant wastewaters is normally low. Some plants use organic acids (acetic) to clean the mandrels and to remove scale in the plant. This could contribute BOD to the waste stream. The waste acid is neutralized when mixed with the highly alkaline process waste stream. The high pH precludes the presence of any biological forms.

Plant nutrients--The measured and reported average levels of the plant nutrients nitrogen and phosphorus in pipe plant effluents were below 2.5 mg/l and 0.05 mg/l, respectively. There are unconfirmed peak values at individual plants of Kjeldahl nitrogen values as high as 12 mg/l and total phosphorus levels of 0.4 mg/l.

Toxic materials--The information on toxic constituents was derived from reported data from a few individual plants. Most plants did not have data on every constituent. Among the toxic constituents reportedly measured in the effluents from some asbestos-cement pipe plants are chromium, cyanide, mercury, phenols, and zinc. Whether the origins of these materials are the primary raw materials or additives used in small quantities, or both, is not known.

Color and turbidity--The raw wastewaters from pipe manufacture are very turbid and of a gray-white color. When the solids are removed, the water has no color.

Fluctuations--The variations in raw waste loadings from a typical plant are not known. No plant measures or records the characteristics of the raw wastewaters. The wastewater treatment systems are designed on hydraulic principles and their operational efficiency is largely independent of the strength of the influent wastewater.

The changes in waste characteristics associated with start-up of a pipe plant are minor and less than the normal fluctuations associated with operation. When a pipe plant is shut down and the save-alls dumped, there is released a heavy charge of suspended solids in a short period of time. Other parameters remain the same or decrease slightly because of dilution by the flush water. Grab samples of raw pipe wastewaters collected during clean-up at one plant gave results in the following ranges:

Total solids	1,400 to 3,100 mg/l
Suspended solids	300 to 2,900 mg/l
Alkalinity	540 to 2,000 mg/l

Fluctuations in raw wastewater quality should not cause serious problems in the physical treatment facilities appropriate for pipe plant wastes.

ASBESTOS-CEMENT SHEET

Water Usage

No information is known to be available about the internal water balance in an asbestos-cement sheet plant. It is expected that the percent recycle from the save-alls is roughly the same as for asbestos-cement pipe (Figure 9).

The reported wastewater discharge from 4 of the 13 known sheet plants ranges from 280 to 2,040 cubic meters per day (0.07 to .54 MGD). The raw waste flows from the three sheet plants sampled during this study were 570, 650, and 920 cu m/day (0.15, .17, and .24 MGD). The largest of the three values was from a plant that discharges no effluent and, consequently, may use relatively more water.

There are no known monitoring records of discharge from asbestos-cement sheet plants and no estimate of the minimum, maximum, and variability of the flow from a plant can be made.

Waste Characteristics

The characteristics of raw wastewaters from asbestos-cement sheet manufacturing were developed from sampling data from two plants. No other data were available except that reported by one plant using the wet press forming technique to make high-density sheet. Since this product may include pigments and other additives and since it is produced at only two known locations, neither of which have adequate data, it is not properly included in this category.

Constituents--

The manufacture of asbestos-cement sheet products in a typical plant increases the level of constituents in the water by the following approximate amounts:

	<u>mg/l</u>	<u>kg/MT</u>	<u>(lb/Ton)</u>
Total solids	2,000	15	30
Suspended solids	850	6.5	13
BOD (5-day)	2	0.015	0.03
Alkalinity	1,000	7.5	15

Little information is available on the dissolved salts in sheet wastewaters, but they should be similar to those from asbestos-cement pipe manufacture. The alkalinity is caused primarily by hydroxide with a pH averaging 11.7 and ranging from 11.4 to 12.4 in all reporting plants.

Temperature--Meaningful temperature data was available from only one sheet plant. With a flow of 920 cu m/day (0.24 MGD), the tem-

perature was increased 13 degrees C in the sheet manufacturing process. The reported peak summer temperatures of wastewaters discharged from asbestos-cement sheet plants was 50 degrees C.

Oil and grease--The presence of oil and grease in wastewaters from sheet plants has not been reported. No measurable oil and grease was found in the samples analyzed in this study.

Other constituents--The discussion regarding organic content, plant nutrients, toxic constituents, turbidity and color, and fluctuations of the characteristics of asbestos-cement pipe wastewaters applies to those from asbestos-cement sheet.

ASBESTOS PAPER

Water Usage

The reported total wastewater discharges from 5 of the 12 asbestos paper manufacturing plants range from 490 to 4,900 cubic meters per day (0.13 to 1.3 MGD). The accuracy of these values is not known. The volumes of raw wastewater discharged to the treatment facility at two plants visited in connection with this study were 1,700 and 2,700 cu m/day (0.45 and 0.72 MGD). Many plants recirculate water and solids from the wastewater treatment facility to the paper making process and the effluent volume is considerably less than the raw wastewater discharge.

Information about variability of flow is available from one plant only. This is the monitoring record of the treated effluent over a recent eight-month period. The average flow was 490 cu m/day (0.13 MGD) with minimum and maximum values of 430 and 755 cu m/day (0.14 and .20 MGD), respectively. The standard deviation of the 113 readings taken during the period was 53 cu m/day (0.014 MGD). The exact quantities of water recycled from the save-all system and from the waste treatment facility at this plant are not known.

Waste Characteristics

The raw wastewater characteristics from asbestos paper manufacturing were developed from sampling data at two plants. Both plants provide high levels of wastewater treatment with low volumes of effluent discharge. Consequently, the use of water within these two plants may be higher than in plants that do not recycle treated wastewater.

Constituents--

The manufacture of asbestos paper in a typical plant increases the levels of the constituents in the water by the following approximate amounts:

	<u>mg/l</u>	<u>kg/MT</u>	<u>(lb/Ton)</u>
Total solids	1,900	26	52
Suspended solids	680	9.5	19
BOD (5 day)	110	1.5	3
COD	160	2.2	4.4

The pH of raw wastewaters from asbestos paper manufacturing is 8.0 or lower.

Temperature--The highest reported summer temperature value for treated effluent is 32 degrees C. It is believed that heated water is used in mixing the raw materials at most plants, although at least one uses cold water. Recycled water tends to have a higher temperature.

Oil and grease--Oil and grease was detected in only one of the samples collected at the two paper manufacturing plants. The level was low, 1.2 mg/l, and was believed to be from plant equipment. This type of material is not part of the product ingredients.

Organic matter--The oxygen demand is believed to be largely due to the organic binders, i.e., starch or synthetic elastomers. These latter include several materials of different chemical compositions.

Nutrients--The total nitrogen levels reported in effluents from a few paper plants averaged 16 mg/l, with the Kjeldahl fraction about 11 mg/l. Phosphorus levels ranged from 0.25 to 1.0 mg/l.

Toxic materials--Trace amounts of copper, mercury, and zinc were reported to be in the wastes from individual asbestos paper plants.

Color--The clarified wastewaters are known to have some color. The levels at two plants were 10 and 15 units.

Fluctuations--There was greater variability among the data from the two paper plants than observed in most other asbestos manufacturing operations. There are no data on the variations in quality of raw asbestos paper wastewaters other than the sampling results and these were from too limited a period of time to be of value. Results from the monitoring program at one paper plant were cited above under Water Usage. Although they refer to treated effluent, they provide some indication of the variability of the wastewater characteristics, as follows:

	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>	<u>Std Dev'n</u>
Total solids	500 mg/l	685 mg/l	870 mg/l	260 mg/l
Suspended solids	32	64	95	44
BOD (5-day)	22	57	91	48

Unlike asbestos-cement products plants, asbestos paper plants do not use portland cement and the solids in the save-alls do not tend to form concretions. Shut-down is less regular and the plants tend to operate around the clock. Shut-downs are sometimes necessary when changing products. Since the elastomeric binders are not always compatible, the save-all solids may be dumped at these times. There were no routine shut-down or start-up operations while the paper plants were being sampled in this study and there is no information on the characteristics of the raw wastewaters during these periods.

ASBESTOS MILLBOARD

There are seven known locations where asbestos millboard is manufactured. At all of these locations, the wastewaters are either discharged to municipal sewers or are combined with other asbestos manufacturing wastewaters. Consequently, there is almost no information from the industry about the quantity and quality of millboard wastewaters. The results presented below are based primarily upon the sampling program carried out for this study at two plants.

Water Usage

The water leaving the save-all systems at the two plants amounted to 41 and 136 cubic meters per metric ton (12,000 and 39,500 gallons per ton). One plant discharges its wastewaters to a large lagoon system and recycles all of the lagoon effluent into the plant. This is a multi-product plant. The other plant normally recycles all of its save-all effluent. Surges due to upsets or shut-down are released to a municipal sewer. Since neither plant has any measurable effluent on a regular basis, the amounts of water used in the manufacturing process may not be representative of the amounts discharged by a plant that does not recycle its wastewater.

Waste Characteristics

Constituents--

At the plant that discharges its wastewaters to the lagoon system, the constituents added to the water were measured as follows:

	<u>mg/l</u>	<u>kg/MT</u>	<u>(lb/Ton)</u>
Suspended solids	35	1.8	3.5
BOD (5-day)	5	0.25	0.5

The total solids and COD levels in the water leaving the millboard save-alls were the same as those of the make-up water. The pH of the raw wastewater ranged from 3.3 to 9.2. Some millboard is manufactured with portland cement and the pH would be higher in such cases.

The effluent from the save-all system at the millboard plant that operates with a completely closed water system had the characteristics listed below. In such a plant, the waste constituents accumulate until a steady-state level is reached. The contribution of each manufacturing cycle cannot be determined directly, and, consequently, raw waste loadings expressed in terms of production units are meaningless.

	<u>Average</u>	<u>Range</u>
Total solids	6,100 mg/l	3,950 to 7,800 mg/l
Suspended solids	5,100	3,060 to 6,270
BOD (5-day)	2	-
COD	60	10 to 145

The pH ranged from 11.8 to 12.1 and the alkalinity from 2,000 to 2,700 mg/l, mostly in the hydroxide form.

Temperature--The temperatures of the raw wastewaters at the two sampled millboard plants were 12 and 26 degrees C, with the higher temperature measured at the completely closed system. The highest reported summer temperature of the effluents at two other millboard plants was 31 degrees C.

Other constituents--Small amounts of oil and grease, nitrogen, and phosphorus were detected in some of the samples collected in this study.

No information is available from the millboard industry on the presence of plant nutrients, toxic constituent, or about the nature of the additive materials that are used in the many varieties of millboard.

Fluctuations--No information is available by which to accurately estimate the degree of fluctuation in millboard wastewater characteristics. Judging from the differences in the two plants that were sampled and from the relatively broad range of raw materials used, the variability of wastewaters from millboard manufacture is high.

ASBESTOS ROOFING

Unlike the asbestos products covered previously, water is not an integral part of roofing products. It is used, however, to cool the roofing after saturation. All plants use non-contact cooling and some use spray contact cooling. The roofing is largely, but not completely, inert to water and the contact cooling water becomes a process wastewater. This contaminated cooling water is discharged with the non-contact cooling water in some plants, resulting in a large volume of dilute process wastewater.

Water Usage

The discharge volumes vary widely among the few roofing plants that reported information on flows, ranging from 145 to 2,100 liters per metric ton (35 to over 500 gallons per ton) of product. The original temperature of the cooling water, whether it is once-through or recirculated, and whether non-contact water is included are factors influencing the reported amount of water discharged. The fluctuations in flow rate should be minimal at a given location.

Waste Characteristics

The characteristics of spent cooling water from roofing manufacture are developed from sampling data taken at one plant. This plant employs surface sprays and discharges the contact and non-contact cooling water into a common sewer. The combined wastewater was sampled. At the time of sampling, the roofing was being made from organic (non-asbestos) paper. Since the water spray contacts only the outer bituminous surface and not the base paper, it is believed that the samples are representative of wastes from contact cooling of asbestos-based roofing.

The added quantities of the major constituents were as follows:

	<u>mg/l</u>	<u>kg/MT</u>	<u>(lb/Ton)</u>
Suspended solids	150	0.06	0.13
BOD (5-day)	6	0.003	0.005
COD	20	0.008	0.016

The pH of the wastewater averaged 8.2.

Temperature--The temperature of the spent cooling water was 13 degrees C, a 7-degree increase over the temperature of the intake water at a flow rate of about 1,420 cubic meters per day (0.375 MGD).

Supplemental data--Information about the effluents from one other asbestos roofing plant was reported by the manufacturer. The wastewater is treated by settling, oil skimming, and passage through an adsorbant filter. The added quantities of materials are reported to be:

	<u>mg/l</u>	<u>kg/MT</u>	<u>(lb/Ton)</u>
Suspended solids	37	0.06	0.12
BOD (5-day)	33	0.07	0.13
COD	91	0.15	0.30

The average pH of the effluent is reported to be 6.8.

Other constituents of interest were measured in this treated effluent

with the following average results in terms of added quantities:

	<u>mg/l</u>	<u>kg/MT</u>	<u>(lb/Ton)</u>
Total Solids	93	0.16	0.31
Total Organic Carbon	1	0.0015	0.003
Cyanide	0.03	0.00005	0.0001
Copper	19	0.03	0.06
Iron	31	0.05	0.10
Lead	1	0.0015	0.003
Nickel	3	0.005	0.010
Zinc	71	0.12	0.24
Oil and Grease	1.6	0.0025	0.005
Phenols	3	0.005	0.010

Total nitrogen and phosphorus levels in the cooling water were each increased about 0.5 mg/l by passage through the plant. Arsenic, cadmium, and chromium were analyzed for but not detected in the effluent.

The above information on treated roofing wastewaters is presented as supplemental data. It has not been verified, but it does provide an insight into the strength and character of the wastewaters from asbestos roofing manufacture.

Fluctuations--There is insufficient information to describe variations in the characteristics within a plant or among plants in this category. Since the wastewater is spent cooling water, its characteristics should be unaffected by start-up and shut-down operations.

ASBESTOS FLOOR TILE

From a water use and wastewater characterization point of view, vinyl and asphalt tile manufacturing both produce the same result. Like roofing, water is used only for cooling purposes. Both contact and non-contact cooling are usually employed. Water does not come into contact with the tile until it has been heated and rolled into its final form. In this stage it is completely inert to water.

Water Usage

Cooling water usage information was available from six floor tile plants with an average daily production of about 400,000 pieces. The reported discharges ranged from about 80 to 1,700 liters (21 to 450 gallons) per 1,000 pieces with an average of 1,130 liters (300 gallons).

The wide range reflects differences in intake water temperatures, whether or not the water is recirculated, and whether both contact

and non-contact waters are included in the figures. Because the water is used for cooling, fluctuations within a given plant should not be large and should primarily be the result of changes in production levels or seasonal temperature changes, or both.

Waste Characteristics

Despite that floor tile itself is inert in water, the contact cooling water becomes contaminated with a diverse variety of materials including wax, inks, oil, glue, and miscellaneous dirt and debris. The material has a high organic content although the limited data available indicate that it is not readily biodegradable.

Constituents--

The added waste constituents in a typical floor tile plant are as follows:

	<u>mg/l</u>	<u>kg/1000 pc</u>	<u>(lb/1000 pc)</u>
Suspended solids	150	0.18	0.40
BOD (5-day)	15	0.02	0.04
COD	300	0.36	0.80

The reported pH of tile plant wastewaters ranges from 6.9 to 8.3, averaging 7.3.

Temperature--The reported temperature data are inconsistent among the few plants reporting. Some plants with large per unit flow volumes show a larger temperature increase than plants with much smaller flows per 1,000 pieces.

Oil and grease--Oil and grease is reportedly present in tile plant effluents, with maximum concentrations of 15 mg/l after treatment.

Organic matter--The COD is believed to be largely associated with the suspended solids with much of it being wax.

Plant nutrients--The limited data on plant nutrients indicate that the increased total nitrogen and phosphorus levels should be less than 5.0 and 1.5 mg/l, respectively.

Toxic materials--Phenol levels as high as 0.2 mg/l were reported by one plant. One plant reported a maximum chromium level of 15 mg/l and undetectable amounts of cadmium and zinc.

Color and turbidity--Data on the color and turbidity of wastewaters from floor tile manufacture are not available. The wastes do have measurable levels of both parameters, however.

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Fluctuations--There are no known data by which to assess the variations in constituent concentrations in wastewaters from floor tile plants.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

SELECTED PARAMETERS

The chemical, physical, and biological parameters that define the pollutant constituents in wastewaters from the asbestos manufacturing industry are the following:

- Suspended solids
- BOD
- COD (or TOC)
- pH
- Temperature
- Dissolved solids
- Nitrogen
- Phosphorus
- Phenols
- Toxic materials

The last four listed parameters are not normally present in high concentrations. Individual plants have reported significant levels of one or more in their effluents, however, and they are therefore included.

Asbestos itself is not included in the list for several reasons. There is no standard procedure for detecting or measuring the fiber levels in water. The effects of asbestos in water on human or aquatic life are unknown. It is likely that most of the fibers in wastewaters are associated with other solids and it is expected that control of other pollutants will significantly reduce the fiber levels in treated effluents.

Pollutants in non-process wastewaters, such as discharges from non-contact cooling systems, boiler blowdown, and wastes from water treatment facilities are not included in this document.

The rationale for selection of the listed parameters is given below. In the following paragraphs, the terms used to describe the levels of the various parameters are relative within this industrial category. For example, a BOD level of 100/mg/l is high for asbestos manufacturing wastewaters, but is low compared to many industrial wastes.

RATIONALE FOR SELECTION

The reasons for including the above listed parameters are briefly presented below. The reader is referred to other sources (Section XIII) for descriptions of the parameters and procedures for measuring them.

Suspended Solids

The suspended solids levels in raw asbestos manufacturing wastewaters are often high with levels commonly in the 500 to 1,000/mg/l range. The solids are heavy and settle quickly. They would produce sludge deposits on the bottom of receiving water bodies if discharged. The solids could also contribute turbidity and possible harm aquatic life if suspended in receiving waters. The fiber content of the solids is reported to be relatively low, with the bulk of the solids originating as cement, silica, clay, and other raw materials.

Biochemical Oxygen Demand (BOD)

The BOD levels in wastes from asbestos-cement, roofing, and floor tile product manufacture are usually very low. Important BOD contributions originate with the natural organic binders used in some asbestos papers and millboards. The typical maximum levels are about 100 mg/l.

Chemical Oxygen Demand (COD)

Moderately high COD values are typically associated with raw wastewaters from asbestos paper, roofing, and floor tile manufacturing. The binders used in paper are believed to be the major source of COD. The elastomeric binders result in high COD results, but contribute little BOD. In other words, they are not readily biodegradable. The COD in roofing wastewaters is caused by soluble bitumens, phenols, oil and grease from bearings, and other materials that contaminate the contact cooling water. It is believed that wax contributes the major portion of COD in raw wastewaters from floor tile production.

pH

Raw wastewaters from products that contain portland cement normally have an elevated pH value. The pH of asbestos-cement wastes is close to 12 or higher. This indicates a caustic (hydroxide) alkalinity that should be neutralized before discharge to receiving waters or municipal sewers. Highly caustic waters are harmful to aquatic life.

Temperature

Thermal increases are caused by chemical reactions, heating, and contact cooling in various parts of the asbestos products industry. Reported temperatures for effluents reach maximum levels of 38 degrees C (100 degrees F). Recirculated water is relatively hotter than that which is used once and discharged.

Dissolved Solids

In addition to the high suspended solids levels in most raw wastewaters from asbestos manufacture, the dissolved (filterable) solids are often of equal or greater magnitude. These originate primarily with the major raw materials, i.e., cement, clays, etc. Sulfates are reported to be one of the major dissolved components in the case of asbestos-cement products. The levels in some plant effluents are high enough to be of concern in public water supplies if not adequately diluted by the receiving water.

Nitrogen

Nitrogen levels in raw wastewaters from asbestos manufacturing are normally not high, with reported maxima for total nitrogen of about 15 mg/l. It is included here because nitrogen at this level could influence eutrophication rates in some water bodies.

In some cases, the sources of nitrogen are the minor ingredients and additives in the product, rather than the principal raw materials. These secondary ingredients are subject to change and the nitrogen levels in the wastewater should be monitored to insure that excessive levels are absent.

Phosphorus

Maximum phosphorus levels in asbestos wastewaters are typically in the 1 to 2 mg/l range. Like nitrogen, this element can influence eutrophication and should be monitored to insure that levels are acceptably low.

Phenols

The presence of measurable phenol levels have been reported in wastes from roofing manufacture. These chemicals cause serious taste and odors in water supplies and their entry to the waste stream and the plant effluent should be controlled.

Toxic Materials

Individual plants have reported that one or more of the following metals were present in their effluents; barium, cadmium, chromium,

copper, mercury, nickel, and zinc. Two pipe plants reported that cyanides were present in their wastes. In most cases, these materials were at levels below those specified as safe for drinking water. There was no consistent pattern detected among the limited data available. These materials may originate in the major raw materials or in the minor ingredients and additives. Excessive effluent levels could probably be most economically controlled by changing or elimination of the source.

CRITICAL PARAMETERS

The critical parameters that should be measured regularly on wastewaters discharged from asbestos manufacturing plants are the following:

Suspended solids
pH
Temperature

The COD (or Total Organic Carbon content) of wastewaters from paper, roofing, and floor tile plants should also be monitored regularly. The other listed parameters should be measured regularly, but on a less frequent schedule.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

INTRODUCTION

Those parts of the asbestos manufacturing industry covered in this document fall into two groups; (1) asbestos-cement products and asbestos paper and millboard, and (2) roofing and floor tile. The wastewaters from the second group are contaminated contact cooling waters and are relatively smaller in volume. The level and type of control and treatment measures for roofing and floor tile plants are different than those for the product categories in the first group. Most of the general material below applies directly only to the plants in the first group.

Waste Characteristics

The process wastewaters from the manufacture of asbestos-cement products, paper, and millboard represent the major sources of pollutant constituents in the asbestos manufacturing industry. The wastes originate from several points in the manufacturing processes and they are usually combined into a single discharge from the plant. The wastes from all of these categories are similar in many characteristics and they are amenable to treatment by the same operation, namely, sedimentation. Because of similarities in manufacturing processes, many in-plant control measures apply at all locations.

Treatment

Sedimentation, with various auxiliary operations, yields an effluent of low pollution potential when properly applied to asbestos manufacturing wastewaters. The settled solids are inert, dense, and appropriate for landfill disposal. While present practices within the industry are not achieving the best possible results in all cases, they can be upgraded without major technical problems.

Treatment beyond sedimentation and pH control is not appropriate for wastes from the major product categories in the asbestos manufacturing industry. The only pollutant constituent remaining at significant levels, other than temperature, is dissolved solids. While these levels may be at undesirably high levels for certain industrial water uses, they do not present serious hazards to human health or to aquatic life. To remove the dissolved solids burden in these wastewaters would require advanced treatment operations techniques, e.g., reverse osmosis, electrodialysis, or distillation. The initial and annual costs associated with these advanced treatment operations are so high that alternative solutions, namely,

complete recycle of wastewaters, will be implemented by the industry instead of further treatment.

During the course of the study carried out to prepare this document, representatives of at least six of the companies listed in Section III volunteered the information that complete recirculation of process wastewaters was presently under consideration, being developed, or actively being implemented.

Implementation

The in-plant control measures and end-of-pipe treatment technology outlined below can be implemented as necessary throughout the asbestos manufacturing industry. Factors relating to plant and equipment age, manufacturing process and capacity, and land availability do not play a significant role in determining whether or not a given plant can make the changes. Implementation of a particular control or treatment measure will involve approximately the same degree of engineering and process design skill and will have the same effects on plant operations, product quality, and process flexibility at all locations.

IN-PLANT CONTROL MEASURES

Many asbestos manufacturing plants incorporate some in-plant practices that reduce the release of pollutant constituents. These practices have resulted in economic benefits, e.g., reduced water supply or waste disposal costs, or both. Few plants include all of the control measures that are possible, however.

Raw Material Storage

Raw materials are normally stored indoors and kept dry. There are no widespread water pollution problems related to improper raw materials storage practices.

Wastewater Segregation

In all cases, sanitary sewage should be disposed of separately from process wastewaters. Public health considerations as well as economic factors dictate that sanitary wastes not be combined with asbestos process wastes.

Other non-process wastewaters are often combined with manufacturing wastes in asbestos plants. A careful evaluation should be made in each plant to determine if some or all of these wastes could be segregated and recirculated. Such reduction in waste volumes might result in smaller, more economical waste treatment facilities.

Housekeeping Practices

Except for roofing and floor tile plants, housekeeping practices

do not greatly influence the wastewater characteristics. The use of wet clean-up techniques are common to control fiber and dust air emissions. In view of the alternative, continuation of the proper use of such wet methods should not impair the efficiency of end-of-pipe treatment facilities.

Water Usage

Fresh water should be used first for pump seals, steam generation, showers, and similar uses that cannot tolerate high contaminant levels. The discharges from these uses should then go into the manufacturing process as make-up water and elsewhere where water quality is less critical.

Water conservation equipment and practices should be installed to prevent overflows, spills, and leaks. Plumbing arrangements that discourage the unnecessary use of fresh water should be incorporated.

Plans should be made for complete recirculation of all wastewaters. This will permit the installation of new equipment and the making of the plant alterations as part of an integrated, long-range program. In some cases, it may be more economical for a given plant to move directly toward complete recirculation rather than install extensive treatment facilities.

In line with water use practices, evaluation of the benefits of increased save-all capacity should be made at some plants. This would provide more in-plant water storage, permit greater operating flexibility, and reduce the level of pollutant constituents in the raw wastewaters discharged from the plant.

Product Categories

In-plant control measures applicable to specific asbestos product manufacturing operations are given below.

Asbestos-cement pipe--

Some pipe plants completely recirculate the water used in the hydro-test operation. Some plants reuse part of the autoclave condensate directly. Consideration should be given to piping wastewaters from wet saws to the save-all system.

At least one pipe plant recycles a major fraction of the effluent from its waste treatment facility back into the manufacturing process.

No plant making only asbestos-cement pipe has accomplished complete recirculation. A reported experimental attempt to do so by one company was not successful.

The raw wastewater flow from asbestos-cement pipe manufacture is

typically in the range of 4.1 to 5.2 cubic meters per metric ton (1200 to 1500 gallons per ton) of product.

Asbestos-Cement Sheet Products--

Many of the in-plant control measures described above for pipe plants could be incorporated in sheet plants. The raw wastewater flow from sheet manufacture is typically in the range of 5.2 to 6.2 cu m/MT (1500 to 1800 gal/ton).

One asbestos-cement sheet plant achieves complete recirculation most of the time. The manufacturing process is so balanced that the fresh water intake equals the amount of water in the wet product. Fresh water enters the system only for boiler make-up and as part of the vacuum pump seal water. This plant is connected to a municipal sewer and excess flows caused by upsets and process shut-downs are discharged intermittently. With sufficient holding capacity to accommodate these surges, discharge to the sewer could be eliminated.

The benefits of complete recycle at this plant include reduced water cost and sewer service charges, minimal asbestos loss, and possibly, a stronger product.

The major problem encountered in complete water recycle at this plant is scaling. Spray nozzles require occasional unplugging, the water lines are scoured regularly with a pneumatically driven cleaner, and fine sand is introduced into the pumps to eliminate deposits.

While one sheet plant has accomplished almost complete recirculation, this is not regarded as fully demonstrated technology. This plant makes only a few asbestos-cement sheet products. The intermittent discharge to the sewer does provide some blowdown relief to the system. Whether such complete recirculation could be applied to plants making sheet products with more stringent quality specifications is not known. The progress at this plant does indicate that complete recirculation is a realistic goal for the future.

Asbestos Paper--

The in-plant control measures outlined above for asbestos-cement pipe can be applied in part in asbestos paper making plants. One paper plant has been able to close up its process water system when making paper with a starch binder. Such operation is not possible when elastomeric binders are used and excess water is then discharged to the municipal sewer.

An asbestos paper plant that practices partial recycle of water from its waste treatment unit typically discharges within 30 percent of 11 cu m/MT (3,000 gal/ton).

Partial recycle of water and underflow solids from the wastewater treatment facility is not uncommon in the asbestos paper industry. Complete recirculation and zero discharge has not been demonstrated on a continuing basis at any plant making only paper. It is likely that paper could be manufactured using a closed system if only starch binders were used. Total and continuous recycle of water and solids when using elastomeric binders cannot be accomplished today. Since some paper plants use both types of binders, a guideline based on the type of binder used would be impractical.

That significant recycle of wastewater has been accomplished indicates that complete recirculation is a possible goal for the future.

Asbestos Millboard--

One plant that produces a wide variety of millboard products with a relatively small save-all system presently achieves almost complete recycle of the process water. The stimulus at this location was, at least in part, high costs for water and sewer services. The plant releases save-all overflow to the municipal sewer when upsets or product changes occur. With greater save-all capacity or a holding tank, this plant could accomplish zero discharge on a continuous basis.

In connection with this study, four of the seven known millboard plants in the country were visited. Since almost complete recirculation has been demonstrated in a typical plant, it is believed that zero discharge can be achieved soon by millboard manufacturing plants.

Asbestos Roofing--

The plants that practice contact cooling should evaluate the possibility of eliminating this source of process wastewater. If this were done, and leaks and other losses of non-contact cooling were closed and dry cleaning practices instituted, the asbestos roofing industry would be able to operate without the discharge of process wastewaters.

In any case, non-contact cooling water and condensate should not be mixed with contact cooling water. This practice greatly increases the volume of process wastewater to be treated.

Asbestos Floor Tile--

There are several in-plant measures that should be used in floor tile plants to control the release of pollutant constituents. Raw materials should be stored, measured, and mixed in an area completely isolated from the cooling water systems. Only after the ingredients are made into tile are they insoluble in water. Toxic materials should be eliminated from the tile ingredients.

If possible, contact water cooling operations should be eliminated. If this is not feasible, the contact cooling water should be protected from contamination. Bearing leaks should be controlled and escaping water protected from contact with wax, oils, glue, and other dirt.

If the contact cooling water and the non-contact cooling water that escapes were prevented from becoming contaminated, it would be much easier to treat. This contamination is unnecessary and the resulting process wastewater is costly to treat.

TREATMENT TECHNOLOGY

Most asbestos manufacturing plants currently provide some form of treatment of the raw wastewaters before discharge to receiving waters. In virtually all cases, this treatment is sedimentation. At several plants, the treatment facilities are small and of simple design. Fortunately the waste solids are dense and almost any period of detention will accomplish major removal of the pollutant load.

Technical Considerations

Sedimentation is the oldest of all treatment unit operations in sanitary engineering practice. It is well understood and its costs, ease of operation, efficiency, and reliability make it ideally suited for industrial application.

Application--

Sedimentation is an appropriate form of treatment for asbestos manufacturing plant wastewaters regardless of the plant size and capacity, manufacturing process, or plant and equipment age. Design is based on the hydraulic discharge and plants with smaller effluent volumes can use smaller units. The treatment system can be sized to accommodate surges and peak flows efficiently. Because waste asbestos solids are inert biologically, overdesign does not result in solids management problems.

Land Requirements--

If necessary, complete settling facilities large enough to treat the waste flows from any asbestos manufacturing plant can be placed on an area of 0.1 hectare (0.25 acre) or less. If more land is available, larger units that provide solids storage may be constructed. Such units would result in lower operating costs. This design is especially appropriate for wastewaters from asbestos-cement manufacture because the solids are inert. Solids with significant BOD levels may require more prompt reuse or dewatering and disposal.

The land requirements for asbestos solids disposal are not excessively high. Some plants have disposed of solids within relatively limited boundaries for decades. While this practice results in problems it does serve to indicate that land disposal, if properly carried out, is an appropriate means of disposing of waste solids from asbestos manufacturing.

Compatibility of Control Measures--

The recommended end-of-pipe technology for the industry is sedimentation, with ancillary operations as necessary. The subsequent control technology recommended is complete recirculation of all process wastewaters from all categories of asbestos manufacturing covered by this document. In most cases, complete recycle will require that the save-all system be expanded or supplemented to provide higher quality water for some in-plant uses. The wastewater treatment facility could very readily serve this function.

Consequently, the recommended end-of-pipe control technology would represent part of an overall long-term control program to achieve zero discharge of pollutant constituents at most locations.

Product Categories

Control and treatment technologies that are applicable to specific product categories of the asbestos manufacturing industry are described below.

Asbestos-Cement Products--

The applicable end-of-pipe technology for wastewaters from the manufacture of asbestos-cement products, both pipe and sheet, is sedimentation and neutralization. Designs based on total detention periods of 6 to 8 hours or loading levels of 24 cubic meters per day per square meter (600 gallons per day per square foot) of surface area yield effluent suspended solids levels of 30 mg/l or lower.

Neutralization to a pH level of 9.0 or below has been achieved at two locations in the industry by adding sulfuric acid or on-site generated carbon dioxide. At both of these locations, sedimentation precedes and follows neutralization.

The solids removed by the settling units are best dewatered by gravity thickening. They are dense and biochemically inert and are suitable for disposal by proper landfill disposal techniques.

To achieve complete recirculation of process wastewaters, surge capacity will have to be added to the water system. A sedimentation unit cannot function in this capacity. A water storage tank or reservoir would be required in the system. With complete r

cycle, the neutralization operation will not be required. Its function is to protect the receiving water. High pH levels are not a problem in the manufacture of asbestos-cement products. As noted in a previous section, additional scale control measures are necessary when complete recycle is implemented.

As noted above, complete recirculation of asbestos-cement sheet process water has been demonstrated partially. Problems with product strength have been reported in one effort to completely recycle wastewater from asbestos-cement pipe manufacture. Additional research is needed to achieve this level of control.

Asbestos Paper--

The applicable end-of-pipe technology for wastewaters from the manufacture of asbestos paper is sedimentation preceded, as necessary, by grit removal and coagulation with polyelectrolytes. This treatment has been demonstrated at three or more locations. Units designed for a loading of 24 cubic meters per day per square meter (600 gallons per day per square foot) have achieved suspended solids and BOD reductions to 25 mg/l or less.

Most of the settled solids as well as part of the clarified water should be recycled from the settling unit to the manufacturing process at paper plants. The waste solids, which are normally kept to a minimum, may be stored for later use or dewatered for land disposal with the grit. Waste solids result, in part, from the incompatibility of certain synthetic binders.

To achieve complete recycle of all process wastewaters at asbestos paper plants, surge capacity will be required. A water storage tank will be required because the sedimentation unit cannot provide this function.

As noted above, complete recirculation of asbestos paper process water has been demonstrated partially when starch is used as the binder. Additional research is needed to achieve this level of control when using elastomeric binders.

Asbestos Millboard--

As discussed above under In-Plant Controls, the applicable control measure for asbestos millboard plants is complete recycle of all process wastewaters. No end-of-pipe technology is specifically required if the plant's save-all capacity is adequate. Unlike settling tanks, save-alls can provide surge capacity.

Waste solids will normally be generated only when the plant is shut down. These will require dewatering and transportation to a land disposal site. Since asbestos millboard manufacturing opera-

tions are located in plants that make other asbestos products, the best means of solids handling and disposal will be dependent on the methods used for solids from the other product lines.

Asbestos Roofing--

The applicable end-of-pipe technology for asbestos roofing wastewaters is sedimentation with skimming or filtration as necessary to remove insoluble materials. Properly designed and operated facilities should reduce the suspended solids levels to 15 mg/l and COD to 20 mg/l or less. If the organic materials are not adequately removed, further treatment, possibly by activated carbon adsorption, will be required. There is, at present, no information available by which to assess the suitability or efficiency of such treatment for these wastes. Information is lacking on the nature of the dissolved organics in wastewaters from asbestos roofing manufacture.

To completely eliminate the discharge of pollutant constituents will require that the contaminated cooling water that constitutes the process wastewater be treated, cooled, and reused. As noted above, the precise type and extent of treatment required is not known due to lack of information.

An alternative solution would be the elimination of contact cooling and confinement of leaks so that the water remains uncontaminated.

Asbestos Floor Tile--

The applicable end-of-pipe technology for floor tile manufacturing wastewaters is sedimentation with coagulation and skimming as necessary to remove suspended solids. It is believed that the high COD levels associated with some tile plant wastes are caused by insoluble materials. Properly designed and operated facilities should reduce suspended solids levels to 30 mg/l and COD to 75 mg/l or less.

The wastes from different tile plants are somewhat different and the precise technology required to achieve these levels cannot be predicted. At present, treatment beyond plain sedimentation and skimming is not practiced by the industry. Sorption on activated carbon following filtration should remove soluble organic materials to an acceptable level.

SECTION VIII

COST, ENERGY, AND NON-WATER QUALITY ASPECTS

COST AND REDUCTION BENEFITS OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES

A detailed analysis of the estimated costs and pollution reduction benefits of alternative treatment and control technologies applicable to the asbestos manufacturing industry is given in Appendix A of this document. The basic results for each product category are summarized below.

Asbestos-Cement PipeAlternative A - No Waste Treatment or Control

Effluent waste load is estimated to be 3.1 kg/MT (6.3 lb/Ton) of suspended solids, 4.4 kg/MT (8.8 lb/Ton) of caustic (hydroxide) alkalinity, and 6.3 kg/MT (12.6 lb/Ton) of dissolved solids for the selected typical plant at this minimal control level. The pH of the untreated waste is 12.0. In-plant use of save-alls is assumed, as this is universally practiced in the industry.

Costs. None.

Reduction Benefits. None.

Alternative B - Sedimentation of Process Wastes

This alternative includes settling of all process wastewaters. Some form of sedimentation is applied at almost all plants in the industry. Costs include land disposal of dewatered sludge. Effluent suspended solids load estimated to be 0.19 kg/MT (0.38 lb/Ton). Alkalinity, pH, and dissolved solids remain high.

Costs. Investment costs are approximately \$124,000.

Reduction Benefits. Effluent suspended solids reduction of approximately 94 percent.

Alternative C - Sedimentation and Neutralization of Process Wastes

This alternative includes settling of all process wastewaters before and after neutralization to pH 9.0 or below. This alternative is practiced presently by about 15 percent of the pipe plants. Effluent suspended solids load of less than 0.19 kg/MT (0.38 lb/Ton), caustic alkalinity removed, and dissolved solids reduced somewhat.

Costs. Incremental costs are approximately \$77,000 over Alternative B; total costs are \$201,000.

Reduction Benefits. Reduction of effluent suspended solids of at least 95 percent, caustic alkalinity of almost 100 percent, and an indeterminate reduction in dissolved solids.

Alternative D - Complete Recycle of Process Water

This alternative includes complete recycle of all process power wastewaters back into the manufacturing processes and other in-plant uses. Fresh water taken into plant equals quantity leaving in wet product and other evaporative losses. Complete control of pollutant constituents without discharge is effected. No pipe plant presently recycles all of the process wastes.

Costs. Incremental costs are approximately \$104,000 over Alternative C; total costs are \$305,000.

Reduction Benefits. Reduction of all pollutant constituents, including suspended and dissolved solids and alkalinity, of 100 percent.

Asbestos-Cement Sheet Products

Alternative A - No Waste Treatment or Control

Effluent waste load is estimated to be 6.5 kg/MT (13 lb/Ton) of suspended solids, 7.5 kg/MT (15 lb/Ton) of caustic (hydroxide) alkalinity, and 8.5 kg/MT (17 lb/Ton) of dissolved solids for the selected typical plant at this minimal control level. The pH of the untreated waste is 11.7 or higher. In-plant use of save-alls is assumed, as this is universally practiced in the industry.

Costs. None.

Reduction Benefits. None.

Alternative B - Sedimentation of Process Wastes

This alternative includes settling of all process wastewaters. Some form of sedimentation is applied at most plants in the industry. Costs include land disposal of the dewatered sludge. Effluent suspended solids load estimated to be 0.23 kg/MT (0.45 lb/Ton). Alkalinity, pH, and dissolved solids remain high.

Costs. Investment costs are approximately \$56,000.

Reduction Benefits. Effluent suspended solids reduction of approximately 96 percent.

Alternative C - Sedimentation and Neutralization of Process Water

This alternative includes settling of all process wastewaters before and after neutralization to pH 9.0 or below. This alternative is used by 10 percent or less of the sheet plants. Effluent suspended solids load of less than 0.23 kg/MT (0.45 lb/Ton), caustic alkalinity removed, and dissolved solids reduced somewhat.

Costs. Incremental costs are approximately \$36,000 over Alternative B; total costs are \$92,000.

Reduction Benefits. Reduction of effluent suspended solids of at least 96 percent, caustic alkalinity of almost 100 percent, and an indeterminate reduction in dissolved solids.

Alternative D - Complete Recycle of Process Water

This alternative includes complete recycle of all process wastewaters back into the manufacturing processes or other in-plant uses. Fresh water taken into plant equals quantity leaving in wet product and other evaporative losses. Complete control of pollutant constituents without discharge is effected. One sheet plant is known to accomplish complete recycle during routine operation.

Costs. Incremental costs are approximately \$59,000 over Alternative C; total costs are \$151,000.

Reduction Benefits. Reduction of all pollutant constituents, including suspended and dissolved solids and alkalinity, of 100 percent.

Asbestos PaperAlternative A - No Waste Treatment or Control

Effluent waste load is estimated to be 9.5 kg/MT (19 lb/Ton) of suspended solids, 1.5 kg/MT (3 lb/Ton) of BOD, and 16.5 kg/MT (33 lb/Ton) of dissolved solids for the selected typical plant at this minimal control level. In-plant use of save-alls is assumed, as this is universally practiced in the industry.

Costs. None.

Reduction Benefits. None.

Alternative B - Sedimentation of Process Wastes

This alternative includes settling of all process wastewaters. Some form of sedimentation is applied at approximately 70 percent of plants in the industry. Costs include land disposal of dewatered

sludge. Effluent load estimated to be 0.35 kg/MT (0.7 lb/Ton) of suspended solids and of BOD and 16.5 kg/MT (33 lb/Ton) of dissolved solids.

Costs. Investment costs are approximately \$237,000.

Reduction Benefits. Estimated reduction of effluent solids of 96 percent and BOD of 75 percent. Dissolved solids remain unchanged.

Alternative C - Complete Recycle of Process Water

This alternative includes complete recycle of all process wastewaters back into the manufacturing processes and other in-plant uses. Fresh water taken into plant equals quantity leaving in wet product and other evaporative losses. Complete control of pollutant constituents without discharge is effected. One paper plant is known to achieve complete recycle when using starch binder under routine conditions.

Costs. Incremental costs are approximately \$57,000 over Alternative B; total costs are \$294,000.

Reduction Benefits. Reduction of all pollutant constituents, including suspended and dissolved solids and BOD, of 100 percent.

Asbestos Millboard

Alternative A - No Waste Treatment or Control

Effluent waste load is estimated to be 1.8 kg/MT (3.6 lb/Ton) of suspended solids and 0.25 kg/MT (0.5 lb/Ton) of BOD for the selected typical plant at this minimal control level. In-plant use of save-alls is assumed, as this is universally practiced in the industry.

Costs. None.

Reduction Benefits. None.

Alternative B - Sedimentation of Process Wastes

This alternative includes settling of all process wastewaters. Some form of sedimentation is applied at at least 40 percent of the plants. Costs include disposal of sludge. Effluent load estimated to be 0.8 kg/MT (1.6 lb/Ton) of suspended solids and 0.2 kg/MT (0.4 lb/Ton) of BOD.

Costs. Investment costs are approximately \$40,000.

Reduction Benefits. Estimated reduction of effluent suspended solids of 55 percent and BOD of 20 percent.

Alternative C - Complete Recycle of Process Water

This alternative includes complete recycle of all process wastewaters back into the manufacturing process and other in-plant uses. Fresh water taken into plant equals the quantity in wet product. Complete control of pollutant constituents without discharge is effected. One millboard plant is known to achieve complete recycle most of the time.

Costs. Incremental costs are approximately \$12,000 over Alternative B; total costs are \$52,000.

Reduction Benefits. Reduction of suspended solids, BOD, and all other pollutant constituents of 100 percent.

Asbestos RoofingAlternative A - No Waste Treatment or Control

Effluent waste load is estimated to be 0.06 kg/MT (0.12 lb/Ton) of suspended solids, 0.003 kg/MT (0.006 lb/Ton) of BOD, and 0.008 kg/MT (0.016 lb/Ton) of COD for the selected typical plant at this minimal control level.

Costs. None.

Reduction Benefits. None.

Alternative B - Sedimentation of Process Wastes (Contaminated Cooling Water)

This alternative includes settling of all process wastewaters (contaminated cooling water) with skimming or filtration as necessary to remove suspended matter. Effluent load estimated to be 0.006 kg/MT (0.012 lb/Ton) of suspended solids. BOD and COD waste loads remain the same as Alternative A.

Costs. Investment costs are approximately \$24,000.

Reduction Benefits. Estimated reduction of effluent suspended solids of 90 percent.

Alternative C - Complete Recycle of Process Water (Contaminated Cooling Water)

This alternative includes treatment, cooling, and reuse of process waste (contaminated cooling water). No process wastewaters are discharged and complete control of pollutant constituents is effected.

Costs. Incremental costs are approximately \$24,000 over Alternative B; total costs are \$48,000.

Reduction Benefits. Reduction of suspended solids, BOD, and COD and all other pollutant constituents of 100 percent.

Asbestos Floor Tile

Alternative A - No Waste Treatment or Control

Effluent waste load is estimated to be 0.18 kg (0.38 lb) of suspended solids, 0.017 kg (0.04 lb) of BOD, and 0.34 kg (0.75 lb) of COD per 1,000 pieces of tile manufactured at the selected typical plant at this minimal control level.

Costs. None.

Reduction Benefits. None.

Alternative B - Coagulation and Sedimentation of Process Wastes
(Contaminated Cooling Water)

This alternative includes polyelectrolyte coagulation and sedimentation with skimming as necessary to remove suspended matter. The percentage of tile plants applying this alternative is not known, but is expected to be less than 25 percent. The effluent load is estimated to be 0.04 kg (0.08 lb) of suspended solids and 0.09 kg (0.19) of COD per 1,000 pieces of tile manufactured. The BOD load may be reduced somewhat.

Costs. Investment costs are approximately \$52,000.

Reduction Benefits. Estimated reduction of effluent suspended solids of 80 percent and COD of 75 percent.

Alternative C - Complete Recycle of Process Water (Contaminated
Cooling Water)

This alternative includes additional treatment by filtration, cooling, and reuse of process wastewaters (contaminated cooling water). No process wastes are discharged and complete control of pollutant constituents is effected.

Costs. Incremental costs are approximately \$58,000 over Alternative B; total costs are \$110,000.

Reduction Benefits. Reduction of suspended solids, BOD, and COD and all other pollutant constituents of 100 percent.

ENERGY REQUIREMENTS OF TREATMENT AND CONTROL TECHNOLOGIES

The energy required to implement in-plant control measures at a typical asbestos manufacturing plant is 20 kw (25 Hp) or less. The energy requirement is primarily for pumping to recycle and reuse water.

The energy requirements of the end-of-pipe treatment technology are not high for a typical plant. No aeration or heating operations are involved. The single largest energy use would be a centrifuge for dewatering waste solids from a paper or millboard plant. This would be used only intermittently and would require no more than 30 to 40 kw when running. The motors for the sludge mechanisms in clarifiers are normally small, 5 kw or less, and the pumping energy requirements would be similar in magnitude to those for in-plant controls.

It is estimated that the total energy requirements for in-plant control and end-of-pipe treatment technology at a typical asbestos manufacturing plant would not exceed 50 kw on a sustained basis.

No information was provided by the industry relative to the energy requirements of individual manufacturing plants. Most involve steam generation for heating, for autoclaves, and for product drying. The additional energy required to implement the control and treatment technologies is estimated to be less than 10 percent of the requirements of the manufacturing and associated operations.

NON-WATER QUALITY ASPECTS OF TREATMENT AND CONTROL TECHNOLOGIES

Air Pollution

The only significant potential air pollution problem associated with application of the treatment and control technologies at a typical asbestos manufacturing plant is the release of asbestos fibers and other particulates from improperly managed solid wastes. Exposed accumulations of dried solids may serve as sources of air emissions upon weathering. The extent or seriousness of this phenomenon is not known. With proper solid wastes management the problem can be avoided.

The biodegradable organic matter content of asbestos solids is low or non-existent. The solids do not undergo appreciable microbial breakdown and there are no odor problems associated with asbestos wastes.

There are no unusual or uncontrollable sources of noise associated with application of the treatment and control technologies.

Solid Waste Disposal

Landfilling of waste solids and dewatered sludges from asbestos manufacturing is an appropriate means of disposal. The wastes are largely inorganic and incineration, composting, or pyrolysis would not be effective in reducing their volume. The dewatered solids are relatively dense and they are stable when used as fill material. If disposed of using proper sanitary landfill techniques, solids from asbestos manufacturing should cause no environmental problems and should be beneficial for reclaiming marginal or low-lying land.

The quantities of solids associated with treatment and control of wastewaters from paper, millboard, roofing, and floor tile manufacturing are extremely small. For example, the reported volume of dewatered waste solids from a paper plant is 1.5 cu m (2 cu yd) per month. The costs for scavenger disposal are about \$600 per year. Solids are wasted only when elastomeric binders are being used, which is 25 to 35 percent of the time. Another example is that provided by one of the larger floor tile plants in the country. The sludge and skimmings from the sedimentation unit amount to about 625 liters (165 gallons) per week. Unlike other asbestos manufacturing wastes, this material is highly organic and is disposed of by a commercial firm that incinerates it. The treatment facility at this plant is not highly efficient, but is believed to capture at least 50 percent of the waste solids.

Contrary to the above categories, the waste solids associated with asbestos-cement product manufacture are significant in volume. The reported losses at one pipe plant are in the order of 5 to 10 percent of the weight of the raw materials. The losses of asbestos fibers are kept to a minimum in this industry, to 1 percent or less, and the fiber content of the waste solids is low. The solids have no salvage or recovery value.

At many asbestos-cement product plants, the waste solids are disposed of within the plant boundaries. In some cases, the solids have accumulated for decades. The resulting piles may be sources of air and water pollution. To what extent material is released to the atmosphere or to surface and groundwaters is not known. The piles are relatively stable and resistant to weathering. They are, however, clear examples of land pollution. They are aesthetically unattractive and, once accumulated, they are costly to remove. The practice of above-ground disposal of industrial residues has little merit other than low costs.

The costs of waste solids removal at two asbestos-cement pipe plants are in the order of \$25,000 per year, or \$0.30 to \$0.40 per metric ton (\$0.33 to \$0.45 per ton) of pipe production. The costs at one asbestos-cement sheet plant for solids disposal by a commercial firm are about \$0.18 to \$0.23/T (\$0.20 to \$0.25/T) of production.

In summary, the solid wastes disposal associated with the application of treatment and control technologies in the asbestos manufacturing industry does not present any serious technical problems. The wastes are amenable to proper landfill disposal. Much of the waste solid material generated by the industry is presently being disposed of and full application of control measures and treatment technology will not result in major increases at most plants. In many cases, complete recycle will result in lower losses of solids.

DISCHARGE TO PUBLIC SEWERS

In order to develop estimated costs for the whole asbestos manufacturing industry and to gain a better appreciation of the total impact of the application of alternative treatment and control technologies, an estimate was developed of the number of manufacturing operations that presently do not involve discharge of process wastewaters, directly or indirectly, into navigable waters. Except for one multi-product plant that achieves zero discharge, these plants discharge their wastewaters, with or without pretreatment, to public sewers. The percentages for each product category or subcategory are as follows:

Asbestos-cement pipe	21%
Asbestos-cement sheet	46%
Asbestos paper	42%
Asbestos millboard	57%
Asbestos roofing	44%
Asbestos floor tile	54%

SECTION IX

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF
THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE
EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations which must be achieved July 1, 1977 are to specify the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available. Best Practicable Control Technology Currently Available is generally based upon the average of the best existing performance by plants of various sizes, ages, and unit processes within the industrial category or subcategory. This average is not based upon a broad range of plants within the asbestos manufacturing industry, but based upon performance levels achieved by exemplary plants.

Consideration must also be given to:

- a. The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application;
- b. the size and age of equipment and facilities involved;
- c. the processes employed;
- d. the engineering aspects of the application of various types of control techniques;
- e. process changes;
- f. non-water quality environmental impact (including energy requirements).

Also, Best Practicable Control Technology Currently Available emphasizes treatment facilities at the end of a manufacturing process, but also includes the control technologies within the process itself when the latter are considered to be normal practice within an industry.

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A further consideration is the degree of economic and engineering reliability which must be established for the technology to be "currently available." As a result of demonstration projects, pilot plants and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of commencement of construction or installation of the control facilities.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST POLLUTION CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Based on the information contained in Sections III through VIII of this document, a determination has been made of the degree of effluent reduction attainable through the application of the Best Pollution Control Technology Currently Available for the asbestos manufacturing industry. The effluent reductions are summarized here.

Suspended Solids

The principal pollutant constituent in wastewaters from the manufacture of asbestos-cement products and asbestos paper and millboard is suspended solids. Application of this control technology will reduce suspended solids levels by at least 95 percent.

The relatively lesser suspended solids from asbestos roofing and floor tile manufacture will be reduced by 90 and 80 percent, respectively, by the application of this control technology.

Caustic Alkalinity

Wastewaters from asbestos-cement product manufacture are highly caustic. Application of this control technology will reduce the caustic alkalinity by 100 percent. The pH will be 9.0 or below.

Oxygen Demanding Materials

Wastewaters from asbestos paper and floor tile manufacture may contain organic constituents that exert an oxygen demand; BOD or COD in the case of paper wastes and COD in floor tile wastes. Application of this control technology will reduce the oxygen demand by 75 percent.

Dissolved Solids

Asbestos manufacturing may raise the dissolved solids level in water

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significantly, especially in the case of asbestos-cement products. Application of this control technology will reduce the dissolved solids by an indeterminate amount. The dissolved solids in the treated effluent will still be relatively high.

Temperature

Asbestos manufacturing operations increase the water temperature to maximum levels of 40 degrees C. Application of this control technology will not result in significant temperature reduction.

IDENTIFICATION OF BEST POLLUTION CONTROL TECHNOLOGY CURRENTLY AVAILABLE

In-plant control measures available to the asbestos manufacturing industry will not significantly reduce the level of pollutant constituents in the effluent. Application of such measures may result in economic benefits and reduced end-of-pipe treatment costs.

The Best Pollution Control Technology Currently Available for the categories of the asbestos manufacturing industry is summarized below.

Asbestos-Cement Pipe

The control technology is sedimentation and neutralization of all process wastewaters with land disposal of dewatered waste solids. Effluent limitations for suspended solids of 0.19 kg/MT (0.38 lb/Ton) and for BOD of 0.09 kg/MT (0.18 lb/Ton) and pH of 9.0 or below.

Asbestos-Cement Sheet Products

The control technology is sedimentation and neutralization of all process wastewaters with land disposal of dewatered waste solids. Effluent limitations for suspended solids of 0.23 kg/MT (0.45 lb/Ton) and for BOD of 0.11 kg/MT (0.22 lb/Ton) and pH of 9.0 or below.

Asbestos Paper

The control technology is sedimentation, with coagulation as necessary, of all process wastewaters with land disposal of dewatered waste solids. Effluent limitations for suspended solids and for BOD of 0.35 kg/MT (0.70 lb/Ton) and for COD of 0.70 kg/MT (1.40 lb/Ton).

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Asbestos Millboard

The control technology is no discharge of wastewater to navigable waters. In a plant that manufactures millboard and other asbestos products, no increase in the limitations should be allowed for the millboard if the waste streams are combined.

Asbestos Roofing

The control technology is sedimentation, with skimming and ancillary physical treatment operations as necessary, of all process wastewaters (contaminated cooling water). Effluent limitations for suspended solids of 0.006 kg/MT (0.012 lb/Ton) and for COD of 0.008 kg/MT (0.016 lb/Ton).

Asbestos Floor Tile

The control technology is sedimentation, with skimming as necessary, or other physical treatment of all process wastewaters (contaminated cooling water). Effluent limitations for suspended solids of 0.04 kg/MT (0.08 lb/Ton) and for COD of 0.09 kg/MT (0.18 lb/Ton).

RATIONALE FOR THE SELECTION OF BEST POLLUTION CONTROL TECHNOLOGY
CURRENTLY AVAILABLE

Total Costs of Application

Based upon the information presented in Section VIII and detailed in Appendix A of this document, the industry as a whole would have to invest less than \$3,000,000 to achieve the effluent limitations prescribed herein. The increased annual costs of applying this control technology are approximately \$1,500,000 for the industry.

Size and Age of Equipment and Facilities

As developed in this document, the narrow size range among manufacturing plants in the same product category is insufficient to substantiate differences in control technology based on size. Age of equipment and facilities also does not provide a basis for differentiation in application of this control technology.

Processes Employed

All plants in a given product category use very similar manufacturing processes and produce similar wastewater discharges. There

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is no evidence that operation of any current process or subprocess will substantially affect capabilities to implement this control technology.

Engineering Aspects of Application

This control technology has been applied at approximately 40 percent of the asbestos manufacturing locations in the industry. The concepts are proven and available for implementation.

Process Changes

The implementation of this control technology does not require in-plant changes or process modifications. Major developments in manufacturing processes in the future are not expected. This control technology can be applied so that upsets and other fluctuations in process operations can be accommodated without exceeding the effluent limitations.

Non-Water Quality Environmental Impact

There is no evidence that application of this control technology will result in any unusual air pollution or solid waste disposal problems, either in kind or magnitude. The costs of avoiding problems in these areas are not excessive. The energy required to apply this control technology represents only a small increment of the present total energy requirements of the industry.

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SECTION X

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF
THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE
EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations that must be achieved July 1, 1983, are to specify the degree of effluent reduction attainable through the application of the Best Available Technology Economically Achievable. This control technology is not based upon an average of the best performance within an industrial category, but is determined by identifying the very best control and treatment technology employed by a specific plant within the industrial category or subcategory, or where it is readily transferable from one industry process to another.

Consideration must also be given to:

- a. the total cost of application of this control technology in relation to the effluent reduction benefits to be achieved from such application;
- b. the size and age of equipment and facilities involved;
- c. the processes employed;
- d. the engineering aspects of the application of this control technology;
- e. process changes;
- f. non-water quality environmental impact (including energy requirements).

Best Available Technology Economically Achievable also considers the availability of in-process controls as well as control or additional end-of-pipe treatment techniques. This control technology is the highest degree that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including "no discharge" of pollutants.

Although economic factors are considered in this development, the costs for this level of control are intended to be the top-of-the-

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line of current technology subject to limitations imposed by economic and engineering feasibility. However, this control technology may be characterized by some technical risk with respect to performance and with respect to certainty of costs. Therefore, this control technology may necessitate some industrially sponsored development work prior to its application.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Based upon the information contained in Sections III through VIII of this document, a determination has been made that the degree of effluent reduction attainable through the application of the Best Available Pollution Control Technology Economically Achievable is no discharge to navigable waters.

IDENTIFICATION OF BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY ECONOMICALLY ACHIEVABLE

This control technology for all categories and subcategories of the asbestos manufacturing industry is recycle and reuse of all process waters and all cooling water that contacts the product or otherwise is exposed to contamination by pollutant constituents.

To implement this control technology requires that the quantity of fresh water supplied to the plant for manufacturing purposes equal the quantity leaving the plant with the product or lost through evaporation. A combination of in-plant control measures to conserve water usage and end-of-pipe treatment technology will be required at most plants to apply this control technology.

RATIONALE FOR THE SELECTION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Total Cost of Application

Based upon the information contained in Section VII and Appendix A of this document, the industry as a whole would have to invest up to an estimated maximum of \$6,000,000 to achieve the effluent limitations prescribed herein. The increased annual costs to the industry would be approximately \$2,700,000.

Size and Age of Equipment and Facilities

As discussed in Section IX, differences in size and age of equipment and facilities in the industry do not play a significant role in the application of this control technology.

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Processes Employed

The manufacturing processes employed within each category or subcategory of the industry are basically similar and the differences will not influence the applicability of this control technology.

Engineering Aspects of Application

With the exception of the asbestos-cement pipe and elastomeric asbestos paper subcategories, this control technology has been demonstrated for sustained operating periods by at least one manufacturing plant in the industry, or by well proven applications in other industrial classifications. To fully implement the control measures and achieve no discharge of pollutants will require that the capacity of the water recycle systems be expanded to accommodate upsets and surge flows. This expansion of capacity presents no unusual engineering problems.

Some additional study by the industry is necessary to apply this technology to the asbestos-cement pipe and elastomeric asbestos paper subcategories. Some progress has been made in these areas, but complete recycle of all water has not yet been accomplished.

Process Changes

The application of this control technology will require some operational changes in the manufacturing processes, but no fundamental changes are indicated. Many of the in-plant control measures and end-of-pipe treatment techniques with partial recycle of process wastewaters have already been implemented by many plants in the industry.

Non-Water Quality Environmental Aspects

The application of this control technology will not create any new air or land pollution problems or require significantly more energy than associated with the application of the Best Practicable Control Technology Currently Available. These aspects are discussed in Section IX of this document.

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SECTION XI

NEW SOURCE PERFORMANCE STANDARDS AND PRETREATMENT STANDARDS

INTRODUCTION

Defined standards of performance are to be achieved by new sources and by sources discharging into publicly owned sewerage systems encompassing activated sludge or trickling filter wastewater treatment plants. The term "new source" is defined to mean "any source, the construction of which is commenced after the publication of the proposed regulations prescribing a standard of performance."

NEW SOURCE PERFORMANCE STANDARDS

New sources, except as noted below, should achieve the effluent limitations prescribed as attainable through the application of the Best Available Technology Economically Achievable.

New sources manufacturing asbestos-cement pipe or asbestos paper with elastomeric binders should achieve the effluent limitations prescribed as attainable through the application of the Best Practicable Control Technology Currently Available.

PRETREATMENT STANDARDS

The pollutant constituents in wastewaters from asbestos manufacturing that are potentially harmful to, (or untreatable in,) sewerage systems employing biological treatment units are the following:

Suspended solids
Caustic alkalinity
Refractory organic materials
Toxic materials

Achievement of the effluent limitations prescribed as attainable through the application of the Best Practicable Control Technology Currently Available should render the wastewaters suitable for treatment in a biological treatment system in terms of suspended solids, caustic alkalinity, and refractory organic materials. Discharge of toxic concentrations of heavy metals, cyanides, and other elements and compounds recognized as harmful to biological treatment systems should be prohibited.

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

SECTION XII

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SECTION XIII

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SECTION XIV

GLOSSARY

1. Beater

A wet mixer used to separate the fibers, mix the ingredients, and provide a homogeneous slurry.

2. Binder

A chemical substance mixed with asbestos and other ingredients to bond them together.

3. Blinding

The plugging by fibers and binder of the pores in carrier felts and holes in cylinder screens thereby reducing or preventing the flow of water through the felt or screen.

4. Calender

A machine designed to give paper a smooth surface by passing it between a series of pressure rollers.

5. Elastomeric Paper

Paper made with a synthetic or natural rubber binder.

6. Felt

An endless belt of heavy porous cloth.

7. Mottle

Solid color granulated tile chips that are made and fed into tile production lines to provide color and pattern.

8. Vacuum Box

A box with a long, narrow opening positioned just below or above the felt in a paper machine. The vacuum maintained in the box draws water out of the sheet of fiber through the felt and into the box.

9. Whipper

A rotating paddle designed to release fiber or other particulate matter from a paper, pipe, or millboard machine carrier felt by beating the felt as it moves through the machine.

CONVERSION TABLE

<u>Multiply (English Units)</u>	<u>by</u>	<u>To Obtain (Metric Units)</u>
ENGLISH UNIT	CONVERSION	METRIC UNIT
acre	0.405	hectares
cubic feet	0.028	cubic meters
cubic feet	28.32	liters
degree Fahrenheit	0.555(F-32) [*]	degree Centigrade
feet	0.3048	meters
gallon	3.785	liters
gallon/minute	0.0631	liters/second
horsepower	0.7457	kilowatts
pounds	0.454	kilograms
million gallons/day	3,785	cubic meters/day
square feet	0.0929	square meters
tons (short)	0.907	metric tons (1000 kilograms)

^{*} Actual conversion, not a multiplier