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Air Pollution Emissions and Control Technology: Asbestos Manufacturing Industry

Economic and Technical Review
Report EPS 3-AP-80-2

Air Pollution Control Directorate
August 1980

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AIR POLLUTION EMISSIONS AND CONTROL TECHNOLOGY: ASBESTOS MANUFACTURING INDUSTRY

by

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ABSTRACT

Asbestos has been classified as a significant health hazard subject to Section 7 of the Clean Air Act and, as such, will be regulated by federal emission standards.

The close proximity of manufacturing plants to densely populated areas makes it desirable to control emissions to the lowest possible level. The Asbestos Mining and Milling National Emission Standards Regulations were promulgated by publication in the Canada Gazette, Part II, Vol. III, No. 13, July 13, 1977. Regulations are being developed for the control of asbestos emissions from asbestos manufacturing industries to the lowest possible level.

The present and future contribution to air pollution by the Canadian asbestos manufacturing industry is evaluated in this report and the best available technology to control the air pollution emissions is defined.

RÉSUMÉ

Des normes fédérales de dégagement s'appliqueront à l'amiante, assujettie à l'article 7 de la Loi sur la lutte contre la pollution atmosphérique, du fait du danger appréciable qu'elle constitue pour la santé.

Comme les usines de transformation sont situées à proximité de zones très peuplées, on devrait en limiter les dégagements autant que possible. Un règlement vise depuis sa publication dans la Gazette du Canada (Partie II, vol. III, n° 13), le 13 juillet 1977, les dégagements des mines et usines d'extraction. Un autre, visant ceux des usines de transformation, est actuellement en cours d'élaboration.

Dans le présent document, la part de la pollution atmosphérique attribuable à l'industrie canadienne de transformation de l'amiante est évaluée, et les meilleures techniques antipollution existantes sont précisées.

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1 INTRODUCTION

1.1 General

Fibrous asbestos minerals have long been used by man because of their unique combination of resistance to heat and chemical attack, high tensile strength and flexibility. Early Greek records speak of golden lamps made about 430 B.C. with non-combustible wicks of "Carpathian flax". Asbestos cloth was used by the Romans to conserve the ashes of deceased persons of rank during cremation. Marco Polo, on his return from what is now Siberia in the thirteenth century, brought news of a strange cloth which, when put into fire, was withdrawn undamaged and became white as snow. Asbestos remained an oddity until the early twentieth century when many industrial applications were developed. These would number about 400 around 1950 but by 1970 there were over 4000 known uses for asbestos.

Asbestos is the name given to a group of many hydrous silicate minerals, but by present definition asbestos is a collective term applied to six minerals, chrysotile, amosite, crocidolite, and the asbestform varieties of anthophyllite, actimolite and tremolite. Chrysotile asbestos accounts for over 90% of the world's consumption and is the only variety mined in Canada. Russia accounts for 49% of the world's production of asbestos. Canada ranks second at 29%, thus accounting for more than half the asbestos produced outside of Russia. Over 95% of Canadian asbestos is exported. Consumption by Canadian companies during 1977 amounted to only 62 500 short tons.

1.2 Purpose

Asbestos has been termed a pollutant, the emission of which to the ambient air could constitute a significant danger to human health and as such will be subject to control under section 7 of the Clean Air Act.

The primary purpose of this report is to provide the technical information for the preparation of emission standards for the asbestos manufacturing industry to control emissions to the ambient air to a very low level by the use of best available technology. Recommended emission standards have evolved from information in this report as well as from data collected from other sources such as emission testing by Environment Canada, or others, using the federal standard reference method.

This report also provides information to assist in the development of federal briefs, state-of-the-art reviews, and other documents related to air pollution emanating from asbestos manufacturing operations.

1.3 Information Sources

Discussions, regarding health hazards of asbestos, took place with members of the European Economic Community; the U.S. Environmental Protection Agency; the Quebec Asbestos Mining Association; the Asbestos Information Association, North America; and various other organizations.

Personal contacts were established with the following departments of the Federal Government: Health and Welfare; Energy, Mines and Resources; Industry, Trade and Commerce; and Statistics Canada.

Copies of original articles were obtained through the Environment Canada library, the U.S. Environmental Protection Agency, the U.S. Occupational Health and Safety Administration and other agencies. Articles in the trade literature were also reviewed.

2 INDUSTRY DESCRIPTION

2.1 General

Asbestos is one of the more important industrial minerals. There were about 400 uses for it about 30 years ago, but due to industrial expansion and development of new products there are now over 4000 industrial applications.

To ensure that similar grades of asbestos from competing companies will achieve the same end result in the product manufactured, Quebec asbestos mines all use the Canadian Chrysotile Asbestos Classification. This is more detailed than the general classification used elsewhere. While only 34 grades are listed, over 100 grades are tailor-made, in the general categories listed, to manufacturer's requirements. The general grades are determined using the Quebec Standard Testing Machine (1) and are shown in Table 1.

TABLE 1 CANADIAN CHRYSOTILE ASBESTOS CLASSIFICATION (2)

CRUDE ASBESTOS

Class	Standard Designation of Grade	Description
Group No. 1	Crude No. 1	Consists basically of crude 3/4-inch staple and longer
Group No. 2	Crude No. 2	Consists basically of crude 3/8-inch staple up to 3/4-inch
	Crude run-of-mine	Consists basically of unsorted crudes
	Crude sundry	Consists of crudes other than above specified

MILLED ASBESTOS

Group No. 3 to No. 9	Standard Designation of Grade	Guaranteed Minimum Shipping Test (oz) 2 Mesh	4 Mesh	10 Mesh	Pan
Group No. 3 (Spinning Fibres)	3F	10.5	3.9	1.3	0.3
	3K	7.0	7.0	1.5	0.5
	3R	4.0	7.0	4.0	1.0
	3T	2.0	8.0	4.0	2.0
	3Z	1.0	9.0	4.0	2.0

TABLE 1 CANADIAN CHRYSOTILE ASBESTOS CLASSIFICATION (2) (Continued)

Group No. 3 to No. 9	Standard Designation of Grade	Guaranteed Minimum Shipping Test (oz) 2 Mesh	4 Mesh	10 Mesh	Pan
Group No. 4 (Shingle Fibres)	4A	0.0	8.0	6.0	2.0
	4D	0.0	7.0	6.0	3.0
	4H	0.0	5.0	8.0	3.0
	4J	0.0	5.0	7.0	4.0
	4K	0.0	4.0	9.0	3.0
	4M	0.0	4.0	8.0	4.0
	4R	0.0	3.0	9.0	4.0
	4T	0.0	2.0	10.0	4.0
Group No. 5 (Paper Fibres)	5D	0.0	0.5	10.5	5.0
	5K	0.0	0.0	12.0	4.0
	5M	0.0	0.0	11.0	5.0
	5R	0.0	0.0	10.0	6.0
Group No. 6 (Waste)	6D	0.0	0.0	7.0	9.0
Group No. 7 (Short or Refuse)	7D	0.0	0.0	5.0	11.0
	7F	0.0	0.0	4.0	12.0
	7H	0.0	0.0	3.0	13.0
	7K	0.0	0.0	2.0	14.0
	7M	0.0	0.0	1.0	15.0
	7R	0.0	0.0	0.0	16.0
	7T	0.0	0.0	0.0	16.0
	7W	0.0	0.0	0.0	16.0
Group No. 7 (Floats)*	7RF			No test	
	7TF			No test	
Group No. 8 (Sand and Gravel)	8S	Less than 50 lb per ft^3 loose measure			
	8T	Less than 75 lb per ft^3 loose measure			
Group No. 9	9T	More than 75 lb per ft^3 loose measure			

* The suffix "F" designates "Floats" in the case of 7RF and 7TF grades.

2.1.1 End Uses of Asbestos. Asbestos is a mineral adaptable to many uses because of its high tensile strength, flexibility, heat and chemical resistance and favourable frictional properties. Asbestos, depending upon the length of fibres and other favourable characteristics, can be:

- carded, spun or woven
- used as fillers, binders and as structural reinforcement for materials such as cement, plastic and asphalt

- laid and pressed to form paper.

The properties of asbestos fibres determine the end uses to which the fibre is put. Of major importance are fibre length, amount of fibre bundles, harshness, tensile strength and surface area. In some instances, color and iron content are also matters of concern.

Table 2 shows some of the potential uses, as a function of the various fibre grades.

TABLE 2 POTENTIAL USES OF ASBESTOS AS A FUNCTION OF FIBRE GRADE (2)

Grade	Remarks	Applications
Crudes and Group 3	These asbestos textile fibres are used primarily in the manufacture of various types of asbestos yarns, and rovings which are in turn used to fabricate the products listed in the next column:	Belting (transmission, conveyor) Blankets (fire protection) Boiler mattress covers Braided packings Brake blocks (woven type) Brake linings (woven type) Clothing Clutch facings Diaphragms for electrolytic cells Dryer felts Electrical insulating tapes Gaskets (woven type) Lagging cloth Laminated plastics Lap for wire insulation Rope and rope packings Tape or listings Theatre and decorative curtains, draperies Thermal insulating tapes Tubing or sleeving Turbine blankets Wicks, and wick packing
3Z and 4A	The shorter asbestos textile fibres, besides being used in asbestos yarns, are more often employed in the manufacture of the products listed in the next column:	Brake blocks (moulded type) Brake linings (moulded type) Calcium silicate insulation Compressed sheet packing (jointing) Gaskets (compressed packing types) High-pressure asbestos-cement pipes Lithaflex (asbestos foam) Moulded high-temperature insulation Special webbing, and non-woven felts Wet dispersion asbestos threads, yarns

TABLE 2 POTENTIAL USES OF ASBESTOS AS A FUNCTION OF FIBRE GRADE (2) (Continued)

Grade	Remarks	Applications
4D to 6D	These medium-length fibres are used extensively in the manufacture of asbestos-cement products such as listed in the next column:	Clapboard Hand-moulded products (all types, including rain gutters, flower pots, and boxes) Pipes (high and low pressure, air ducts, and conduits) Sheets (flat and corrugated) Shingles (roofing and siding) Wall boards, and panels (sheeting, building, electrical insulating panels)
	Among the applications other than asbestos cement the products listed in the next column are typical:	Acoustical tile Asbestos felting Asbestos paper for use in the fabrication of such articles as: Air cell pipe coverings Gaskets (asbestos paper) Linings (for stores, garages, electric switch boxes, and ovens) Wrapping (electrical wires, and hot air pipes) Brake blocks (moulded, and extruded) Calcium silicate insulation Electrical insulating compositions Friction materials in general (such as clutch facings) Millboard Plastic moulding compounds Special sheet products (such as latex bonded linoleum underlays) Sprayed acoustical insulation Sprayed thermal insulation (limpet)
7D to 7T	The use of asbestos shorts and floats is primarily in the role of a fibrous mineral filler in a great variety of manufactured products such as listed in the next column:	Asphalt roofing compounds Asphalt pavement Boiler coverings Brake linings (moulded) Caulking, and sealing compounds Conduit pipes Flooring compositions Friction materials in general (including disc brake pads) Grease (fibre filled) Hot and cold moulded products

TABLE 2 POTENTIAL USES OF ASBESTOS AS A FUNCTION OF FIBRE GRADE (2) (Continued)

Grade	Remarks	Applications
		Insecticide carriers Joint cements Paint fillers Paper fillers Plastic filler (PVC, polyester, and propylene) Stucco, grouting, and concrete compositions Thermoplastic compounds Tiles (asphalt, synthetic resin, and vinyl asbestos) Undercoatings and sound deadeners Welding rod coatings Waterproofing, and damproofing compounds
8S to 9T	These products are falling into disuse	Asphalt paving Fillers Soil conditioners (for acid soils and magnesium-deficient soils)

2.2 Size

Over 95% of the chrysotile asbestos produced in Canada during 1977 was exported. The most important foreign market is for use in cement products. In Canada, this use is less than in manufacturing of asbestos paper and felts. Greater consumption in Canada can be anticipated for the manufacturing of asbestos paper and felt products and of brake linings where transportation of end products presents no problem and there is less competition restricting plant expansion.

At present, less than 4% of the asbestos produced by Quebec asbestos mines is consumed by manufacturers in the province, which is much less than that desired by government. The Quebec Asbestos Mining Association commissioned Sores Inc. and Arthur D. Little to do a "Study on the Opportunities of Manufacturing Asbestos Products in Quebec", which was completed in December 1977(4). The Quebec government then proposed to establish and expand the asbestos industry in the province with the objective of increasing the consumption of Quebec asbestos to 12% in ten years, with the ultimate

goal set at 20%. The Société Nationale de l'Amiante was established to further this policy. The Lupel division has already been formed to make asbestos paper for backing of congoleum and will be making roofing felts and other products at a later date. This could lead to an annual production of 40 000 tons of end products with an asbestos content of 85% (34 000 tons of asbestos). They have also funded a program to increase the output of a Quebec company making brake linings.

The amount of Canadian asbestos used by manufacturers in Canada during 1977 was supplemented by the addition of 2130 tons of imported asbestos of different types, necessary to obtain the required strength in certain end products. A breakdown of the asbestos used by Canadian companies is shown in Table 3.

TABLE 3 ASBESTOS CONSUMED BY CANADIAN COMPANIES, 1977 (3)

Product	Asbestos Used (short tons)	%
Paper, Roofing Felts, Dryer Felts*	27 035	41.8
Asbestos Cement Products	19 820	30.8
Floor Tiles	6 420	9.9
Brake Linings*	4 412	6.8
Joint Cement, Sealants	3 866	6.0
Asbestos Sheets	951	1.5
Textiles	806	1.2
Asbestos Asphalt	728	1.1
Moulding Compounds	500	0.8
Filter Pads	90	0.1
	64 630	100.0

* Does not include consumption by new Quebec ventures established after 1977.

2.3 Manufactured Products

Although innumerable products contain asbestos, only a few processes that are major consumers of asbestos are described below.

2.3.1 Asbestos Paper. A thick asbestos paper can be made on a multiple cylinder machine; thinner types are better made on a fourdrinier machine such as that used in

making newsprint. Types of products would range from thin varieties for gasket paper, pipe wrapping, congoleum backing, through roofing and flooring felts up to and including one-half-inch thick millboard which contains up to 97% asbestos.

The feed for the paper machines is prepared by mixing short fibres with appropriate binders such as starch, glue, water glass, resins, latex or gypsum.

In the case of the cylinder machine, the feed stock, at proper dilution, is distributed to the cylinder tanks. The pulp is picked up by suction applied to the part of the cylinder emersed in solution. The ply of paper is peeled off the top of the cylinder and other piles are added from the other cylinders. At one such plant an eight-cylinder machine is used. The paper is then conveyed through the presses where a considerable amount of water is removed, after which it passes through the dryer rolls. On leaving the dryer section it is passed through a calender to impart a smooth finish to the paper and then to the winder. The large finished rolls are removed from this machine and then placed on another which prepares the finished product by unwinding the large roll, cutting the paper to the required width and rewinding the cut sections on individual bobbins or rolls for shipment, all sections being rolled in unison. These are then removed from the machine and placed in storage. This operation is shown in Figure 1.

Some of this thick paper containing about 85% asbestos is covered with asphalt for Canadian clients, and is exported in raw form to other markets. This operation is shown in Figure 2.

In the case of the fourdrinier machine, the feed mix is diluted to contain as little as 1.5% asbestos at this stage. It is evenly distributed, by the feed box, across a moving wire screen, through which water is drained off with the aid of suction and roller pressure. The paper then goes through a series of rollers making up the press and proceeds to the dryer section, from which point the procedure followed is the same as for the cylinder-type machine.

2.3.2 Asbestos-Cement Products. Asbestos-cement products contain 15-30% asbestos, mostly in the form of chrysotile, although limited amounts of crocidolite and amosite are imported for use in larger-size asbestos-cement pipes to give the required strength. The "Asbestos Fact Book" for 1970(5) lists 20 uses of flat and corrugated sheets and wallboard and seven uses for asbestos-cement pipe.

Asbestos-cement sheets are made from cement containing up to about 20% asbestos. The proper amount of asbestos is added to the mixer in a dry state along with a weighed batch of cement. Water is added at this point. The mixer is under negative air

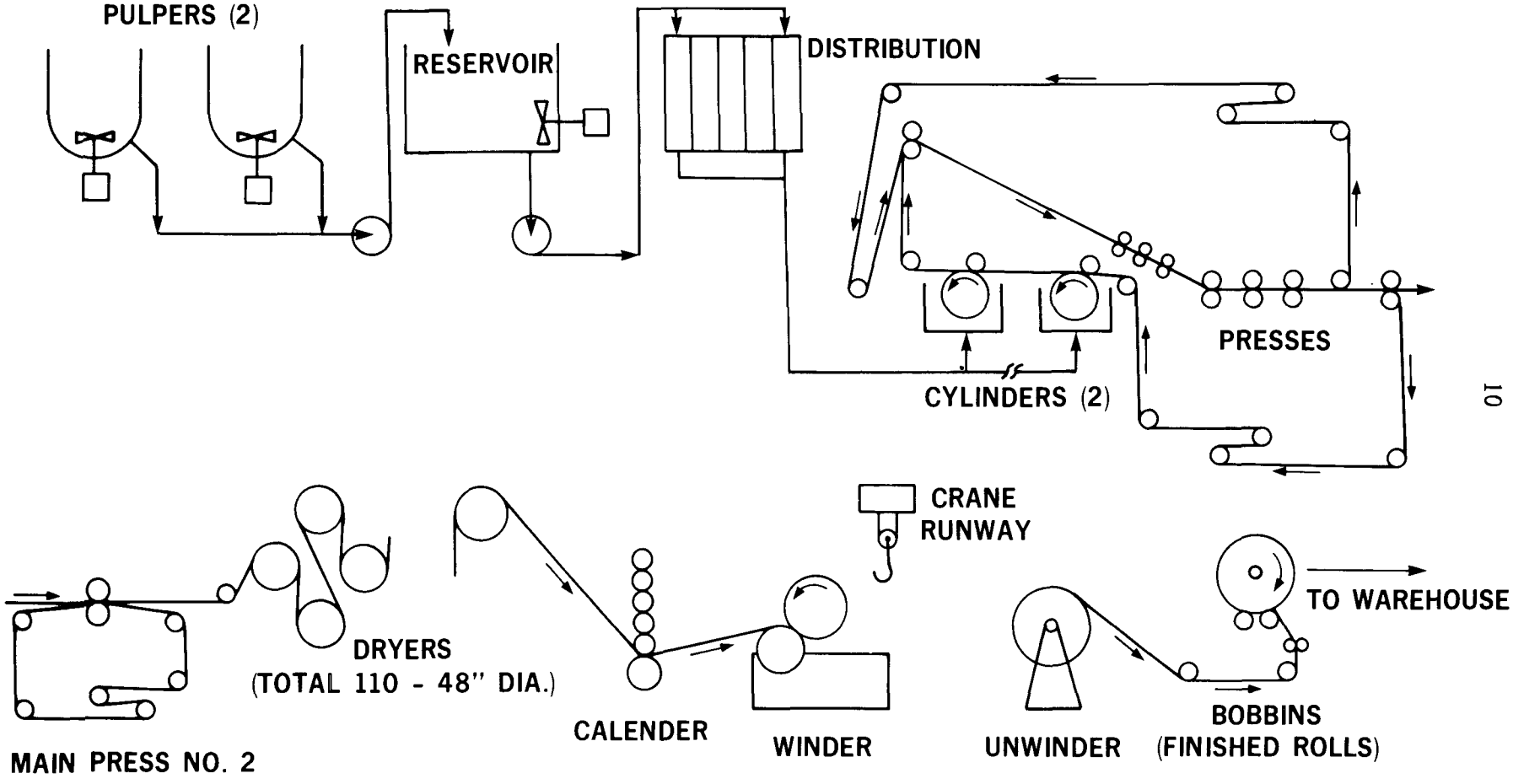

FIGURE 1 CYLINDER ASBESTOS PAPER MACHINE

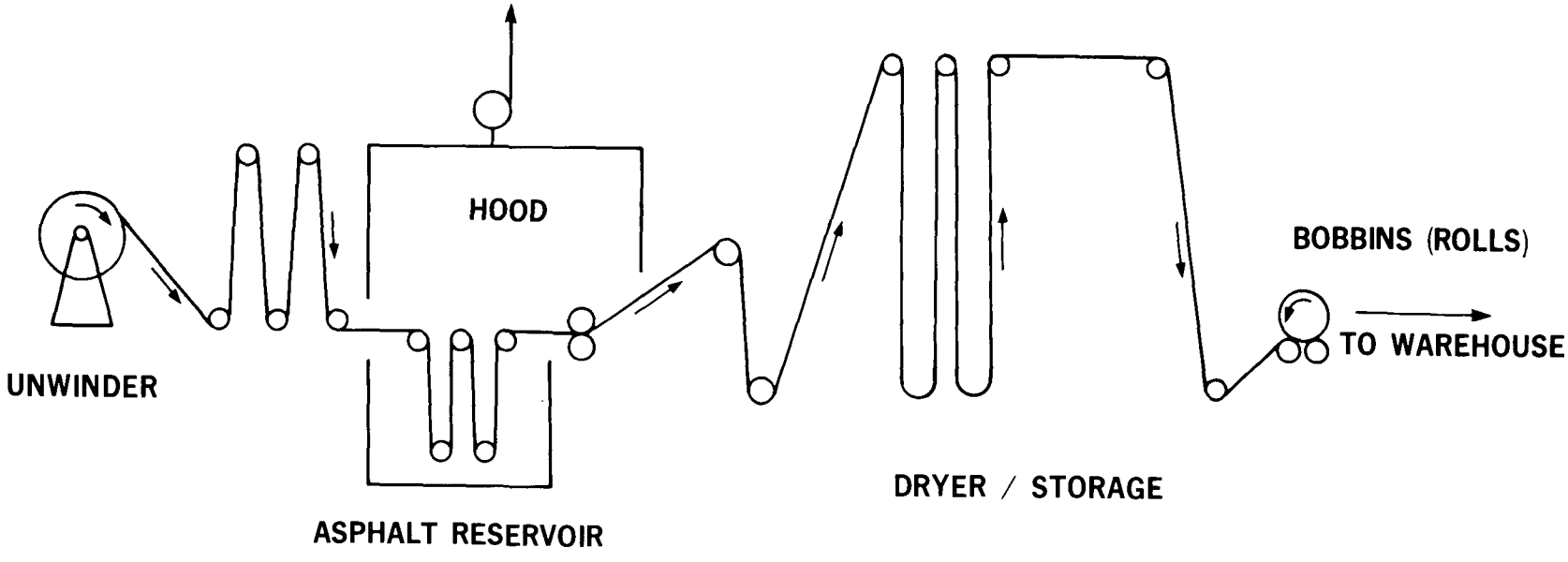

FIGURE 2 TYPICAL ASPHALT SATURATION MACHINE

pressure and any dust generated while adding the dry ingredients is removed by a baghouse filter in the dust control system. The wet mix proceeds to the secondary mixer, where the waste wet-product return is added after being repulped. The slurry is diluted to the proper consistency before being fed to vats 1 and 2 of the forming machine, illustrated in Figure 3. These contain rotating sieves which are cylinders with the entire curved surface area made of fine mesh. The solids in the slurry are deposited on the surface of the mesh in a fine lamination which is carried by rotation to make contact with the felt belt at point A. The couche rolls squeeze out some water and consolidate the laminating on the felt. The top run of the felt carries the two laminations from the vats over the vacuum box, where further de-watering takes place, to point B where the lamination makes contact with the accumulator roll. The pressure between the accumulator roll and the anvil roller causes the lamination to leave the belt and build up in layers on the accumulator roll until the required thickness is attained. The sheet is then cut off, either manually or mechanically with a cut-off wire, and the sheet travels down the reversible belt conveyor and is deposited on the awaiting template plate. The accumulator roll drops to its original position and the build-up of the next sheet commences. The sheets on the template plates are allowed to harden for 24 to 28 hours before curing. After curing the sheets are sawed and sanded to proper dimensions and finish before being stacked in the warehouse for shipment. All points where dust may be generated are under negative pressure and the air drawn off is filtered through baghouse dust collectors before being exhausted to the atmosphere. The dust collected in this manner is recirculated to the wet mix to avoid any problems in the final disposal of the dry dust containing asbestos.

Pipe is the most important asbestos-cement product made from cement containing up to 18% asbestos of which 10% (i.e., 1.8% asbestos) may be an imported variety used in the larger sizes to give the required strength. The dry mix is slurried as before but the asbestos-cement sheet is formed on a machine similar to a cylinder paper machine. The sheet is partly dried in a vacuum box and transferred to a mandrel which winds it into a pipe of the required dimensions. After air curing for a few hours the pipes are removed from the mandrels and transported to a temperature- and humidity-controlled air-cure room. Final curing takes place in autoclaves where high-pressure steam completes the process. The pipe sections are then machined to size on lathes, tested, and made ready for shipment. This is shown in Figure 4.

2.3.3 Vinyl Asbestos Floor Tile. This type of tile has found increasing use for floors because of its fire resistance, impermeability to water, and good wearing qualities. The

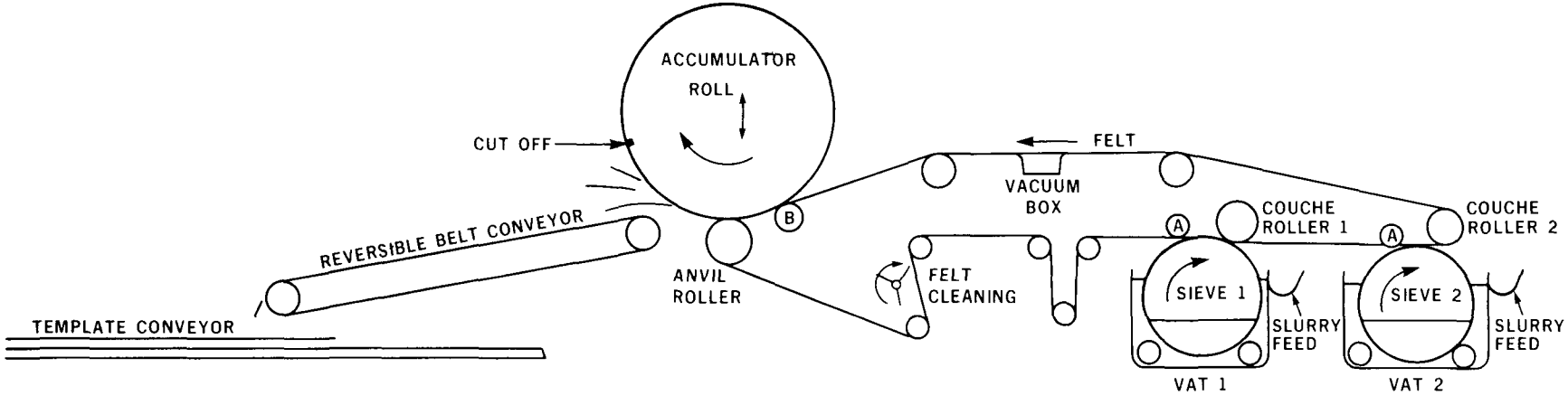

FIGURE 3 MANUFACTURE OF ASBESTOS-CEMENT SHEETS

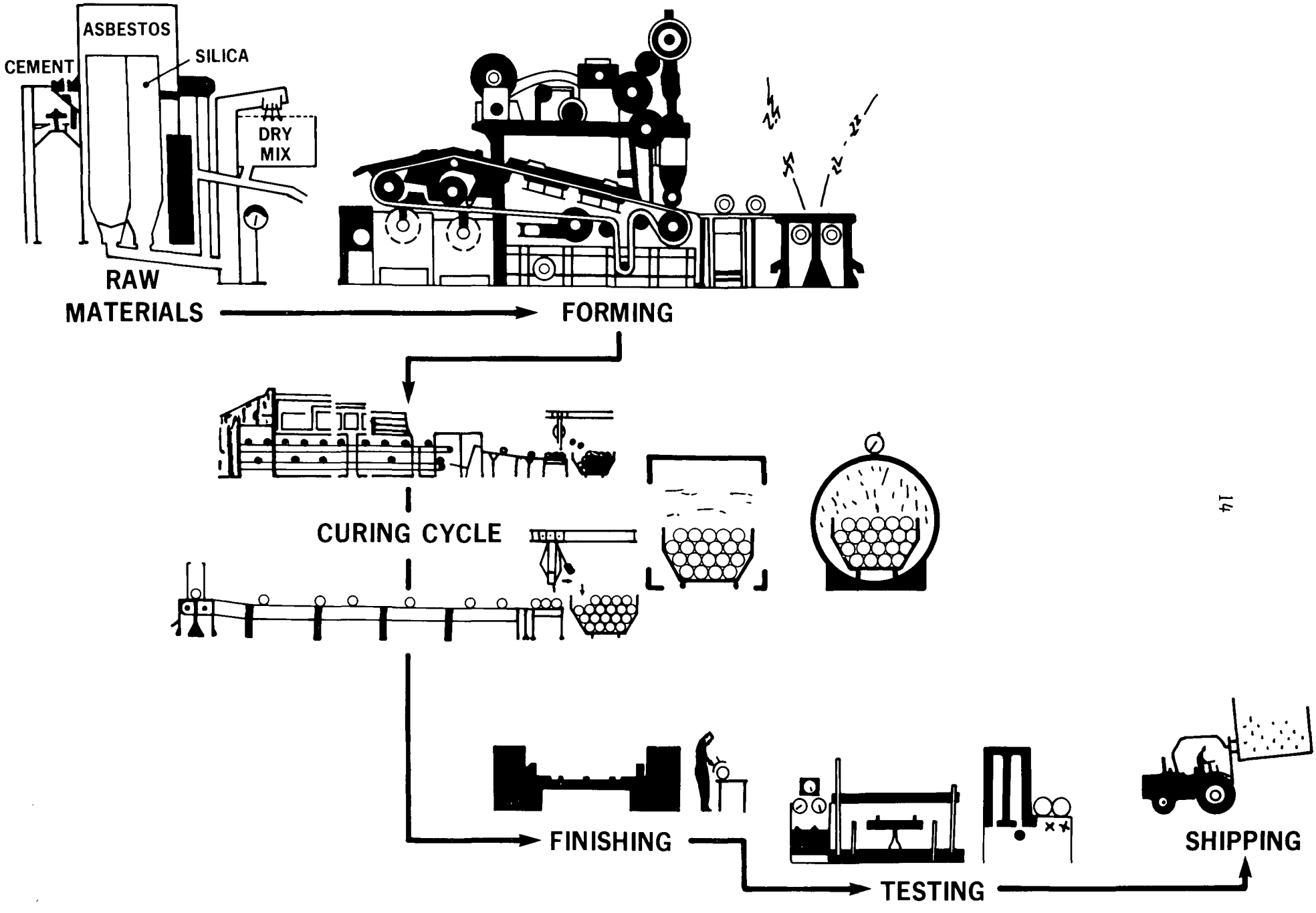

FIGURE 4 MANUFACTURE OF ASBESTOS-CEMENT PIPE

base material for vinyl asbestos floor tile consists of 18-25% asbestos contained in a polymer, formed largely from vinyl chloride or vinyl acetate. The raw material is dry-mixed and passed through hot rollers which reduce it to sheet form, and colored granules are added to produce the required pattern. The sheet is passed through calender rollers to bring it ot the required thickness and finish. A press cuts the sheet and pieces of required shapes and sizes, which are taken to a cooling chamber before packaging. Waste material from the cutting operation is broken up in hammer mills and stored in a bin. This material is added in metered quantities to the raw material being fed to the tile-forming machine.

2.3.4 Brake Linings. Woven brake linings and clutch facings for heavy use are made from high-strength asbestos fabric, reinforced with wire. This material is dried and impregnated with resin. After the resin has been dried the density is increased during curing by calendering or hot pressing after which the fabric is cut to the desired length.

Moulded brake linings are the more important type since they are used on disc- and drum-type automotive brakes. In the dry-mixed moulding process the asbestos fibres and other constituents are combined with resin that is thermosetting when fully cured but still malleable with heat and pressure in intermediate stages. The dry mix is intimately blended in a dry mixer, metered into moulds, preformed in a press, and then affixed to disc brake plates. Final treatment is curing by baking and grinding to client specifications.

In the case of drum brake linings, the material is extruded as a ribbon, cured and cooled. Parallel beads of thermosetting adhesive are run along the back of the lining, which is then coiled for shipment or plant use. This lining is cut to proper length for reconditioned brake shoes and firmly clamped into place. The whole assembly is placed in an oven where the beads of adhesive spread out and bond the lining to the brake shoe. Brake shoe sets are then packaged for shipment.

2.3.5 Asbestos Textiles. The inclusion of asbestos in textiles gives them high resistance to heat, fire, acids and abrasion, while the organic fibres of cotton or synthetics impart strength.

The raw asbestos fibres usually need loosening before they are blended with up to 25% rayon fibres. The mix may be compressed into a felt but is usually passed through carding machines which set the fibres in parallel and produce a mat. Strips are separated from the mat and compressed by rollers into untwisted strands called roving. This may be twisted into wicking and wicks braided into rope. Usually the roving goes to a spinning machine where it is twisted, gently pulled and spun into yarn, greatly increasing its

strength. The yarn may be further twisted, combined with fine wire, coated, woven into fabric or braded into tubing, cord or rope. The different stages of textile manufacturing are shown in Figure 5.

2.3.6 Asbestos Asphalt. Asbestos asphalt is used by some municipalities in hot mix pavement, in the surface course or in thin asbestos-asphalt overlays used to extend the life of road surfaces. Up to 1.5% asbestos is added to the dry hot material in the pug mill before the addition of hot liquid asphalt. The use of asbestos asphalt is known to impart many beneficial qualities to the finished pavement. It allows more asphalt to be used and wicks the asphalt through the mix to give a more intimate wetting of all the aggregate and fines. This results in a denser pavement having a longer life. Due to concerns about anything containing asbestos, the use of this material has tapered off in the last few years.

2.3.7 Moulding Compounds. Short asbestos is used as one of the ingredients in phenolic moulding compounds. Asbestos is added along with the other components and is ground. This mixture is run through a rolling mill where it is impregnated with resin. It emerges as a sheet which is subsequently ground and sold in granulated form.

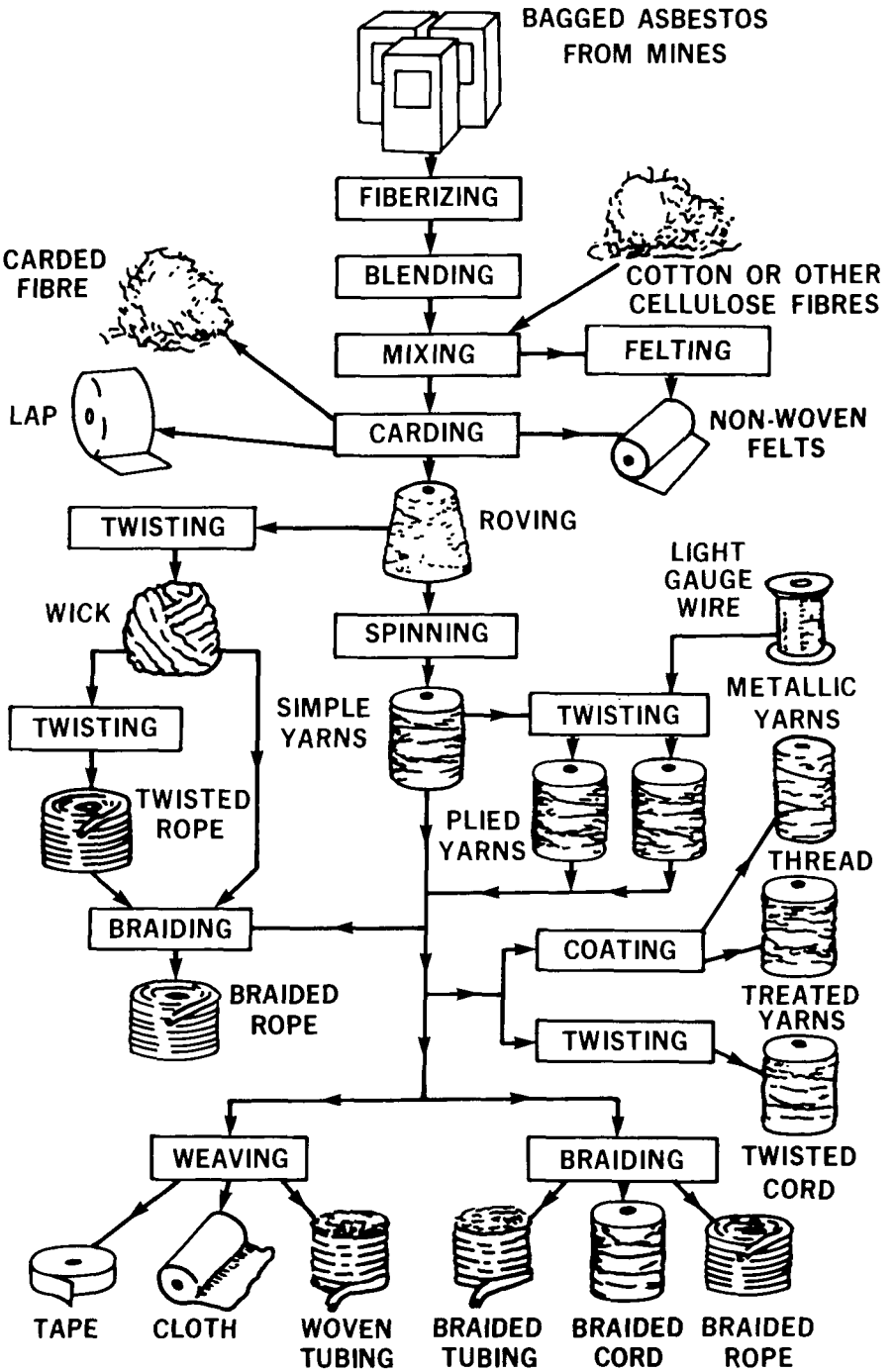

FIGURE 5 MANUFACTURE OF ASBESTOS TEXTILES

3 POLLUTION ASPECTS

The main pollution problems in the asbestos manufacturing industry arise during handling of asbestos and dry mixing of ingredients in early stages of various processes. Provincial regulations require that asbestos concentrations in the working environment be limited to 2 fibres per cubic centimetre of air, which is accomplished by the application of adequate dust control measures.

Possible sources of emissions from asbestos manufacturing are:

1	Asbestos Paper	-	feeding asbestos fibre to slurry
2	Asbestos Cement	-	feeding asbestos fibre to the dry mix
		-	blending the dry mix
		-	cutting or machining end products
3	Asbestos Textiles	-	feeding asbestos fibre to silos
		-	blending asbestos fibre and rayon in feed silos
		-	carding machine
		-	spinning
		-	weaving loom
4	Asbestos Asphalt	-	opening bags and metering feed
		-	adding asbestos fibre to the dry ingredients in pug mill
5	Moulding Compounds	-	adding asbestos fibre to formulation
		-	grinding finished product

Emissions could occur from sources in other processing operations or in the handling and/or shipment of dry materials containing asbestos.

4 HEALTH EFFECTS

It has been determined that prolonged continuous exposure to particulates containing asbestos fibres may, in some persons, result in the development of asbestosis, a bronchial or asthmatic disorder. Recent research has also disclosed a connection with certain types of lung cancer. While there is some evidence that crocidolite and other types of asbestos fibres may be more harmful than chrysotile, available data are insufficient to allow any conclusion as to the relative danger of exposure to different forms of asbestos. The asbestos manufacturing industry has done much to improve the working conditions in manufacturing plants in Canada. Concern for the health of employees and the public has been the main reason for a continuous program, dating back to the initial detailed study on the hazards of airborne asbestos to health done about 25 years ago. Adverse publicity concerning the effects of asbestos on human health made it imperative that manufacturers reduce the amount of airborne dust containing asbestos fibres to the lowest possible level in the working environment, through the use of best available technology.

Most plants are in compliance with the rigid standards designed to protect employees in the working environment, which set the limit at 2 fibres per cc of air. A few plants are still making improvements to achieve the low level of asbestos specified.

Section 7 of the Clean Air Act authorizes the Governor in Council to prescribe national emission standards where emissions constitute a significant danger to human health. The Department of National Health and Welfare concluded that it would not be prudent to permit uncontrolled contamination of the public environment with asbestos and that if the continued use of this mineral is to proceed with minimal risk to the public, the major man-made sources of asbestos emissions into the atmosphere should be subject to control. As a result of this conclusion, the asbestos manufacturing industry will be subject to a National Asbestos Emission Standards Regulation under Section 7 of the Clean Air Act.

5 NATIONAL EMISSION INVENTORY DATA - PARTICULATES

5.1 Data Previously Published

Emissions of particulates from all heavy industry during 1970 amounted to 1 039 000 tons, as reported in a national inventory of air pollution emissions. Particulate emissions from heavy industry during 1970 are listed in Table 4. It can be seen that emissions of particulates containing asbestos totalled 80 000 tons in 1970, or 7.6% of the total emissions of major pollutants in Canada.

Asbestos emissions related to the production, manufacture and consumption of asbestos are shown in Table 5 (8).

Asbestos emissions from the Canadian asbestos mining and milling industry have been reduced by more than 60% from the levels listed because of increasing use of best available technology.

Some improvement has been made in the asbestos manufacturing industry through installation of more control equipment. Also, the use of best available technology has been made mandatory in the construction of all new plants.

TABLE 4 PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESSES, 1970 (7)

Industry	Emissions (tons/year)*
Iron and Steel	153 000
Other Primary Metals	111 000
Metallurgical Coke	11 000
Petroleum Refineries	1 000
Cement	248 000
Lime	54 000
Kraft Pulp Mills	86 000
Asbestos**	80 000
Stone, Sand, Gravel	401 000
Grain Handling	83 000
Grain Mills	4 000
Other	77 000

* These figures were based on the results of a paper search of published information.
** It must be noted that only part of these particulates consist of asbestos fibres.

TABLE 5 ASBESTOS EMISSIONS IN CANADA, 1970 (8)

Source	Emissions		Emission factor (lb/ton asbestos)
	tons	percent	EPS 1970 study
PRODUCTION			
Asbestos mining	6 620	40.4	8.0
Asbestos milling	9 673	59.0	11.7
Production total	16 293	99.4	
MANUFACTURING			
Asbestos-cement products	1.88	0.01	0.15
Floor tile industry	0.75	*	0.15
Paving	0.44	*	0.15
Coating, caulks, sealants	0.42	*	0.15
Insulation	0.57	*	0.30
Friction materials	0.99	*	0.90
Plastics	0.09	*	0.15
Textiles	0.11	*	0.30
Paper	0.05	*	0.15
Miscellaneous	0.13	*	0.15
Manufacturing total	5.43	0.03	
CONSUMPTION			
Construction industry	0.90	*	0.15
Sprayed insulation	2.18	0.02	10.00
Brake linings			
- installation	18.00	0.11	10.00
- wear	72.00	0.44	40.00
Consumption total	93.08	0.57	
TOTAL	16 391.51	100.00	

* Negligible (less than 0.01%)

6 CONTROL METHODS

6.1 General

Although the level of asbestos emissions from manufacturing is extremely low, as compared to the asbestos mining and milling industry, the location of most asbestos manufacturing plants in highly populated urban areas makes it essential that asbestos emissions be controlled to the lowest possible level.

6.2 Best Available Control Technology

The use of high-efficiency fabric filter baghouses at all points of possible emission is required to give the best control of asbestos emissions into the ambient air. At many plants the exhaust air from these baghouses can be directed back into the work place to minimize heat requirements during cold weather.

6.3 Existing Installations

Many manufacturing plants already have all the necessary baghouses installed but further installations or upgrading will be required in some instances. Wherever possible the dust collected in the baghouses is directed back into the process to eliminate any subsequent problems in final disposal.

Emission tests were made at an asbestos cement plant and at an asbestos textile plant to determine the level of asbestos emissions as well as to validate the federal Standard Reference Method developed for the Asbestos Mining and Milling Industry (9) for use in determining the emissions from manufacturing plants.

At the asbestos cement plant, all the dust control systems were directed towards three baghouses, one of 75 000 cfm* capacity serving the finishing end of the plant and warehousing, 20 000 cfm for the fibre handling area, and 35 000 cfm to handle dust control during pipe forming by wet process. The fibre concentrations exhausted from these baghouses averaged 0.035 fibres per cc, 0.04 fibres per cc and 0.035 fibres per cc, respectively.

The dust control system at the asbestos textile plant tested consists of 15 unit baghouses containing 192 bags each, the capacities of which range from 8 000 cfm to 12 000 cfm. Only nine or ten are required for normal operation and operate at an average of 10 000 cfm. The bag-opening operation, blending and the storage silos are all under

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*cubic feet per minute

negative pressure, air being drawn off to individual baghouses. The carding machine is almost completely enclosed and is under negative pressure created by numerous take-offs to the baghouses.

Dust is controlled during roving, spinning, winding and/or weaving by numerous air take-offs at points where some dust might be generated, and this air is then drawn through some of the baghouses.

Air from the induced draft fans serving the baghouses is exhausted in the dustroom where the baghouses are located. This air can be recirculated to the plant through louvers or exhausted through a duct to outside ambient air. The visual condition of the plant testifies as to the efficiency of the dust control system. Stack tests of emissions in the exhaust duct gave rates of 0.074, 0.062 and 0.045 fibres per cc which, if recirculated, are well below the allowable maximum level of 2 fibres per cc set by provincial regulations for occupational hygiene.

These tests confirmed that the federal Standard Reference Method (9) can be used to determine emissions from asbestos textile plants.

A moulded brake lining plant was visited, where both disc brake pad and drum-type brake linings are made. The air in the working environment was quite clean and was well below the asbestos content of 2 fibres per cc set by provincial regulations as reported from recent tests by regulatory agencies.

The dust control system consists of six fabric filter baghouses having a total capacity of 57 750 cfm, which are operated well below the rated capacity. Special care is taken in establishing hoods and air take-off points where some asbestos-bearing dust might be generated, especially before the formed lining is cured. This permanently locks in the asbestos and prevents further emissions. Other points are located where cured linings are ground to final dimensions. A baghouse is installed to clean the gas exitting from the afterburner on the oven used to burn lining off old brake shoes before it is exhausted up a short stack. Tests can be made on any of these baghouses using the federal Standard Reference Method (9).

Baghouses are used for dust control at plants manufacturing vinyl asbestos floor tile. About 10-25% asbestos is dry mixed in a blending machine with polymers and other ingredients. Dust pick-ups are installed when the asbestos is added to the mix and where blending takes place as well as where the dry mix is fed to the forming section of

the process. It is passed through hot rollers, forming the finished sheet from which individual tiles are cut. The scrap material is broken up by a hammer mill and stored in a bin from which it is added to the dry mix being fed to the hot rolls. The hammer mill is operated under negative pressure, the air removed going through a baghouse.

In the manufacturing of moulding compounds the ingredients are mixed dry, ground, and run through a rolling mill and impregnated with resins. The sheet so formed is reground and packaged in granulated form for shipment to customers. Dust control is achieved by the use of fabric filter baghouses with dust pick-up points established wherever dust might occur while handling asbestos and mixing dry ingredients, grinding the finished moulding compound sheet, and packaging the finished product for shipment. Air in the work place satisfies provincial regulations limiting asbestos to a maximum of 2 fibres per cc and since much of the air from the dust control system is sometimes recirculated, the baghouses are demonstrated to be working in a highly efficient manner. All baghouses can be tested using the federal Standard Reference Method (9).

Any emission of air from the work place of plants making asbestos products of lesser importance takes place after being exhausted from high-efficiency fabric filter baghouses used for dust control.

7 PROPOSED REGULATIONS

It is recommended that the concentration of asbestos fibres contained in gases emitted into the ambient air from any asbestos manufacturing process be limited to no more than two fibres per cubic centimetre of the gases; fibres are defined as those with a length of more than five microns and a minimum ratio of length to breadth of three to one or more.

This will assume that best available technology will be used to control all possible sources of emission of asbestos-bearing particulates at any new plants. At many existing plants all sources are well contained, but in a few instances additional equipment will be required to satisfy the proposed regulations. This will further reduce the total emissions from the asbestos manufacturing industry in Canada.

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