The Basics of Chrysotile Asbestos Dust Control

Safe and Responsible Use

CHRYSOTILE
Institute

The Basics of Chrysotile Asbestos Dust Control

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Acknowledgements

Original statement

I would like to express my gratitude to Dick Kuntze for many helpful suggestions and additions to this report. Dr. Nola K. Seymoar has been unstinting in her editorial advice, comments and suggestions. My thanks to these and the many others who have helped to bring this information together.

The assistance of the Chrysotile Institute in making these and other materials available for training and orientation purposes must be acknowledged. It is a demonstration of Canada's commitment to seeing the ILO Convention 162 on Safety in the Use of Asbestos implemented world-wide.

Gordon M. Bragg 1990

Special thanks must also be given to the following individuals, all of whom made valuable contributions in the fourth revision of this document in 2008.

Mr. Mike Williams P. Eng.
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Mr. Richard L. Jauron P. Eng., M. Eng. Industrial Hygiene and Mine Ventilation Consultant

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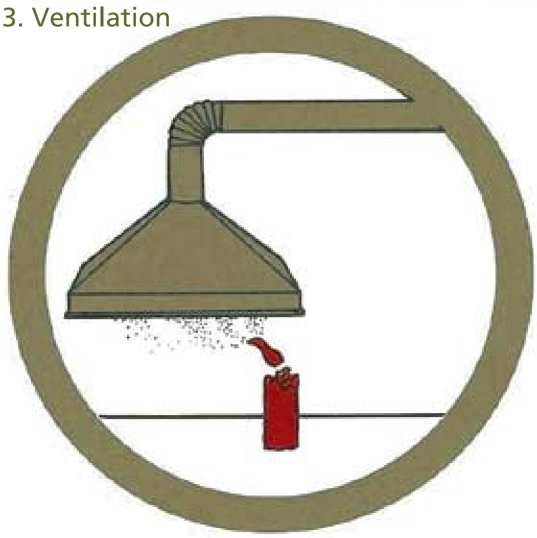
In common with all dusts, smoke and fumes the major methods of control are:

1. Containment

2. Wetting

3. Ventilation



Introduction

This manual is one of several guides to occupational safety when using chrysotile fibres. This document is aimed to represent the best available dust control procedures in use today.

In 1988, this manual "Basics of Asbestos Dust Control" was prepared by Dr.Gordon M. Bragg, designed and illustrated by Gordon J. Weber and published by the Chrysotile Institute. The manual was thereafter revised and reprinted in 1989 and 1990.

At the request of the Chrysotile Institute, in 2008, we have reviewed this important manual in light of work practices and precautionary measures in place today and updated it accordingly. In great part where no changes were necessary, we have reproduced the existing text and presentations.

Safe-use approach

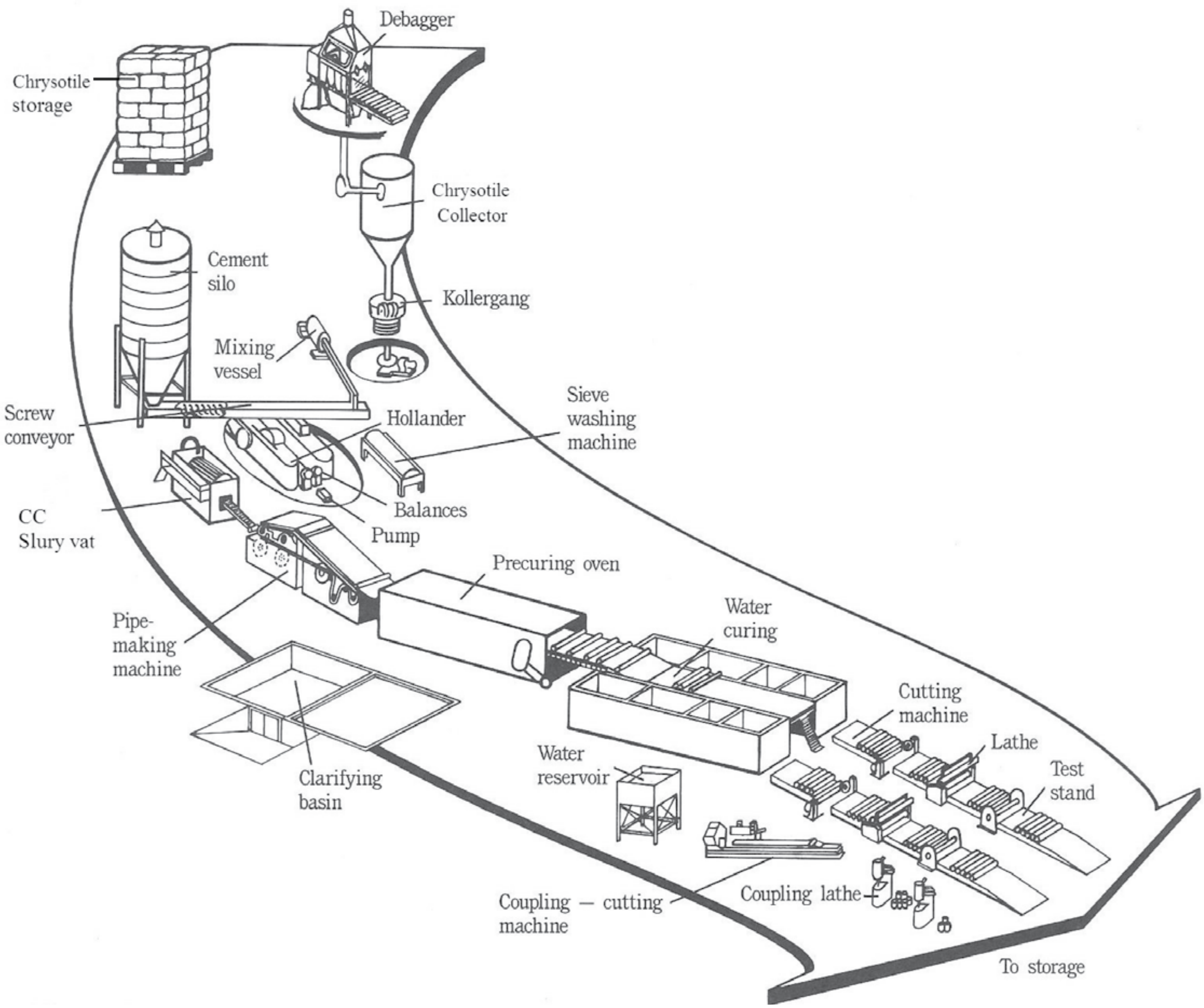
The implementation of good work practices, legislations and regulations based on the concept of the responsible and safe use approach are necessary to provide workers with a safe environment and acceptable workplace for the protection of the health and physical integrity of those who work with chrysotile.

Combined efforts of governments, labour unions, workers and industry will make it possible to put together a genuine safe use program.

The objective of this manual is to offer a quick reference to proper dust control methods in the workplace that are necessary to provide good work practices at all times. The protection of health is the main issue that must be addressed and necessary efforts, support and resources must be put together in order to reach such a great goal.

Dust control is a matter of responsibility and common sense. It should also be a common objective in order to meet the challenges that safety and health protection are calling for. It is the best way to eliminate industrial diseases, to ensure safe working environments. All these networking efforts should remain a top priority.

Figure 1
Layout of Chrysotile Cement (CC)
Pipe Manufacturing Plant



When Are Controls Needed?

Chrysotile Transportation and Receiving

The transportation of chrysotile asbestos is regulated by the Transportation of Dangerous Goods Act which is consistent with the International Maritime Dangerous Goods Code. Under this, chrysotile fibres are considered to be Class 9 and must bear the United Nations label "Asbestos-white UN No. 2590".

Nowadays, bagging and sealing chrysotile fibres are mechanical operations done under ventilated hoods at the producing mines. The shipment loads are mostly shrink or stretch-wrapped into palletized units which make it impossible to release fibre in the air.

In the event of a torn or damaged bag, vacuum or wet cleaning of the spill should be done immediately along with sealing the leak.

Manufacturing of Chrysotile Cement Products

A typical chrysotile cement pipe plant is shown in Figure 1. The chrysotile fibre is generally introduced through a ventilated bag opening station or a debagger fig.15a and 15b (a machine that opens the sealed bags) to an enclosed wet mixing stage. In many modern plants the mixing is entirely enclosed and automated. In others, the bagged chrysotile is added directly to a wet mixer. In these cases there is therefore no significant exposure to fibres except during maintenance.

When mixing is complete, the resulting slurry (mixture) runs from vats to the pipe-making machine. In a chrysotile cement pipe plant, the slurry is pulled onto screens or felts and the laminate (thin sheet) is formed on a mandrel (spindle). A pipe whose walls are 12 mm thick might be made of 80 or more layers of laminate.

> "Almost any industrial activity can constitute an occupational health risk, and can effect the environment. Sound work practices —which may well have to go beyond mere compliance with the law — are needed in all industry branches to convert potentially dangerous situations and activities into a safe and healthy working environment."
>
> H.E. Vanherle. Low-Dust Tools and Recommended Workplace Practices for Working with A/C Products on Site. World Bank Seminar Proceedings. March, 1988.

The pipe is stripped from the mandrel, precured and then cured in water or autoclaved. Finishing includes cutting the dried and hardened pipe to length, pressure testing, and fitting with couplings. It may also include the production of such specialized items as tees, elbows and reducers. Consequently, the finishing operations may entail sawing, machining, and bonding.

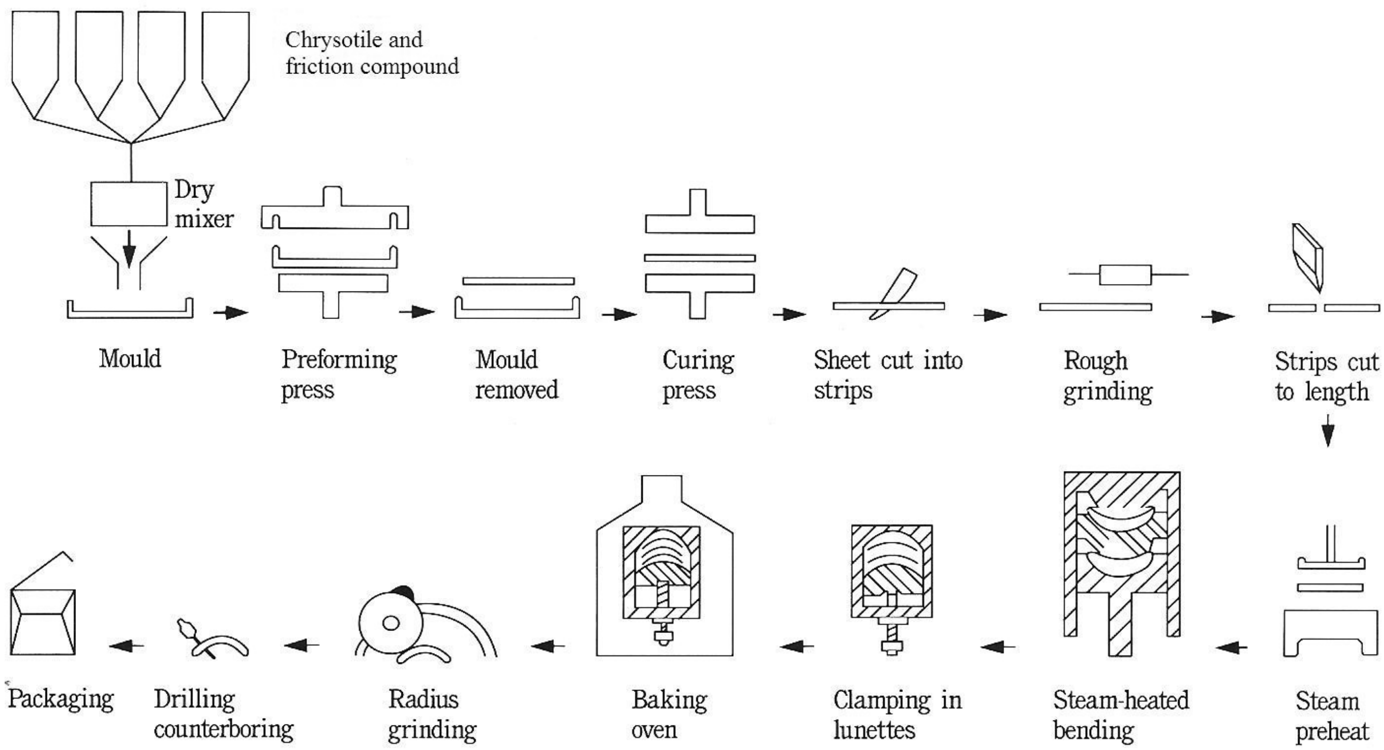
Chrysotile cement sheets are produced by a combination of materials and processes similar to the pipe process. Debagging is followed by wet mixing to form slurry. The slurry transfers onto a rotating cylinder mould where the appropriate thickness is formed. The sheet is then unrolled flat and treated with embossing rolls or presses. A 24 to 48 hour setting period follows before curing. The sheets may subsequently be cut, punched and/or receive surface treatment.

In chrysotile cement plants the most likely sources of dust are warehousing (resulting from torn or damaged bags), debagging, sawing, drilling, machining (including the cutting off of couplings), and reworking. Various combinations of dust controls are used, including wetting, local ventilation and good housekeeping (that is, keeping the area clean by wet sweeping or vacuuming). In addition, there are many special tools which use low speed or other techniques to reduce dust.

Manufacturing of Friction Products

Friction product plants have similar potential dust sources to chrysotile cement plants. A schematic outline of the process is given in Figure 2. The main sources of dust include warehousing, debagging, mixing, dry pressing, grinding and drilling. Control procedures consist mainly of local exhaust, good housekeeping and wet machining in a limited number of operations.

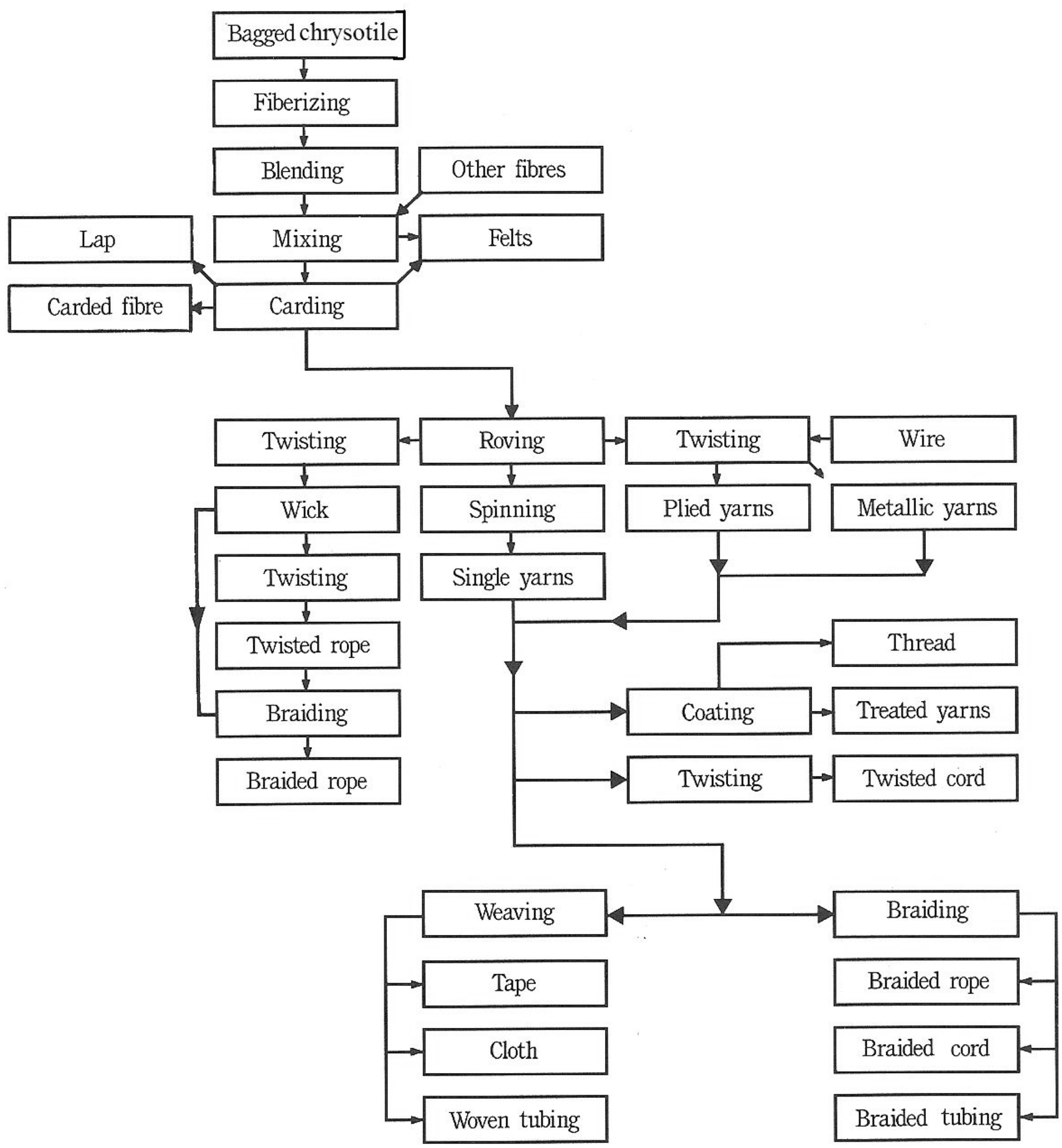
Figure 2
Manufacture of Brake Linings



Dust Control in Industrial Textile Plants

Chrysotile textile products process is shown in Figure 3. In many cases wet processing is possible. However, in other situations highly specialized tools and enclosures are necessary. All stages of textile processing require careful consideration of tools, enclosures and ventilation rate since the most challenging fibre control situations arise in these plants.

Figure 3
Manufacture of Chrysotile Textile Products



Installation, Maintenance and Repair of Chrysotile Products

The installation, maintenance and repair of manufactured asbestos including chrysotile products, where the fibre is bound in plastic, cement, or resin present little hazard to workers, provided proper work practices are followed. These products include chrysotile cement sheets, pipes, roofing tile, vinyl products, gaskets, seals, brake pads, shoes and clutch facings. Dust emissions are controlled by wetting techniques and by using hand tools or power tools which are specially equipped with dust collectors (see pages 13, 14, 15 and 29).

In the past, amphiboles or a mixture of amphibole and chrysotile fibres were used in many friable insulation applications. This practice was banned many years ago as per the ILO Convention 162.

Improper maintenance, repair or removal of sprayed insulation may involve significant exposures to both workers and occupants. There are special techniques for dust control when friable products must be disturbed because of major damage, renovations, or demolition. These techniques are described in various other publications available from The Chrysotile Institute, Montreal, Quebec.

Where Are Controls Needed?

As shown, dust may be collected and controlled (1) at its source, at some location (2) in the air path between that source and the worker, or (3) at the receiver. It is almost invariably best to control the dust at source. It is there that the dust is most concentrated and therefore most effectively and economically collected. Also, dust-collecting equipment usually works better at higher dust concentrations.

Perhaps most important is that collecting dust at its source helps keep the rest of the workplace clean.

When dust has entered the air path, a number of control procedures are commonly employed. Semi-automatic or remote-control devices enable operators to isolate themselves from the dust source. The use of personal respirators and isolation should be used when necessary in the chrysotile industry. Personal and area monitoring are a must in all dust release industries including the chrysotile manufacturing plants. Appropriate dust control systems along with good maintenance practices improve the efficiency of all control procedures. Dilution ventilation and general exhaust ventilation are usually ineffective and uneconomical uses of ventilation power.

If it is difficult to control dust exposure to the permissible exposure level (PEL) such as during certain repair and maintenance operations without hoods or enclosures or because of equipment failure, personal protective devices (respirators and clothing) are needed. This is an example of controlling dust at the receiver.

Workers who may be exposed to dust can reduce the hazard if they are trained to identify possible dust exposure, to maintain effective housekeeping and cleanliness in their work areas, and to use all control measures efficiently. Knowledgeable workers can dramatically reduce the possibility of exposure.

"...it is our strong conviction that any unnecessary exposure is too much, and therefore cannot be justified"

H.E. Vanherle. Low-Dust Tools and Recommended Workplace Practices for Working with A/C Products on Site. World Bank Seminar Proceedings. March, 1988.

What controls Are Needed?
Good Work Practices

Housekeeping

Housekeeping is unquestionably the most important of all dust control methods. Simply cleaning up all possible emission sources as quickly as possible is the most effective dust suppression technique. Such practices as vacuuming and wet floor cleaning not only prevent high dust levels, they also improve already clean, efficiently controlled chrysotile using environments. By introducing these simple housekeeping techniques, a factory can reduce dust levels by half or even three-quarters.

Good housekeeping and work practices require workers' time; however, because they are labour intensive rather than capital intensive, they may be used in plants working at any level of technology.

When chrysotile fibre is received in shrink or stretch wrapped bags on pallets, an inspection should be carried out. All cut or broken bags should be taped or rebagged, and all loose fibre adhering to other bags cleaned up by vacuuming before transfer to the warehouse. All spilled fibre should be cleaned up immediately (wet sweeping, vacuuming), and contaminated packaging material disposed of (see page 18).

When a dust control strategy is introduced, the dust levels may be dramatically reduced as shown in Figure 4. In this chrysotile cement plant for example, by modifying the exhaust hood of the debagging station (1) the dust level was reduced from about 7 to 2.3. More careful handling of empty fibre bags (3) reduced the level to 1.3. Levels of less than 1 were achieved by enclosing the feed station (5). A similar effect can be identified because of receiving chrysotile fibres on pallets (2), which reduced the number of broken bags and eliminated the use of hooks. Conversely, receiving fibres in burlap bags (4) had a disastrous result. While these single effects are impressive, there is no doubt that improved housekeeping and better working practices had considerable influence on reducing fibre levels in this particular plant.

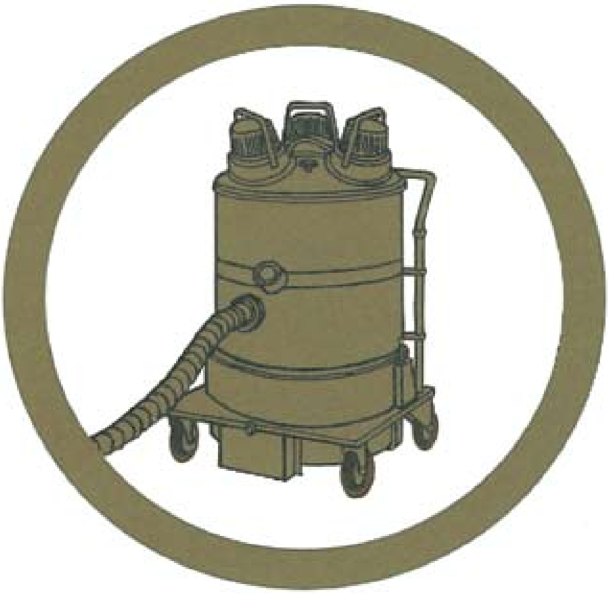
Figure 4
Exposure Level Reduction in an Asbestos-Cement Pipe Plant

Survey Date	Debagging		Unloading Fibre	Area Sample Under Pipe Machine Bins	Large Coupling Cut-Off
May, 1969	(HR)	6.1	16.9	DNO	6.5
March, 1970	(HR)	7.8	6.2	4.9	5.3
March, 1971	(HR)	2.3[1]	2.1[2]	2.0	1.7
June, 1972	(HR)	1.3[3]	3.1	0.2	0.6
December, 1972	(HR)	1.7	104[4]	0.7	1.1
June, 1973	(HR)	0.9	DNO	0.5	1.4
January 1974	(HR)	DNO	5.6	DNO	DNO
July, 1974	(HR)	DNO	1.4	DNO	0.9
December, 1974	(HR)	2.8	1.8	2.3	1.7
April, 1975	(HR)	3.3	0.4	1.0	0.4
October, 1975	(HR)	2.3	0.8	0.1	0.8
August, 1976	(TWA)	0.3[5]	0.2	0.2	0.3
December, 1976	(TWA)	0.9	DNO	0.2	1.8
April, 1977	(AVG)	0.3	0.1	0.3	0.3
November, 1977	(HR)	2.6	DNO	0.1	0.8
June, 1978	(AVG)	1.0	0.1	0.2	0.2
November, 1978	(TWA)	0.2	0.1	0.1	0.7
June, 1979	(TWA)	0.6	DNO	0.1 (avg)	0.1
November, 1979	(TWA)	0.3	0.0	0.2 (avg)	0.2
April, 1980	(TWA)	0.5	0.1	0.1	0.1
October, 1980	(TWA)	0.1	DNO	0.2 (avg)	0.3
March, 1981	(TWA)	0.4	0.1	0.5 (avg)	0.5
September, 1981	(TWA)	0.4	0.1	0.2 (avg)	0.1
March, 1982	(TWA)	0.1	DNO	0.1 (avg)	0.4
October, 1982	(TWA)	0.4	DNO	0.1 (avg)	0.2
September, 1983	(TWA)	0.07	0.02	DNO	0.02[6]

1. Exhaust hood modified.
2. Fibre received on pallets for first time.
3. Empty filter bags placed in plastic bag. Previously stacked and compacted loose.
4. Blue fibre in burlap bags, not on pallets.
5. Carousel added, feed station enclosed.
6. Sept. 83 data are based on results of a different laboratory than previous data.

HR - Highest reading of all samples taken at each station
TWA - Time-Weighted-Average of all samples
AVG - Simple average of all samples
DNO - Did not operate during survey

Data is based upon measurements by a single laboratory. (Values in f/ml)



Plants using good housekeeping commonly employ one of two procedures. In the first, each worker is responsible for keeping his or her work area clean at all times. For example, a worker responsible for cutting lengths of chrysotile cement pipe may have a vacuum-cleaning hose to remove chips from the pipe after the saw cut is complete and also for removing chips and cuttings from the floor. The alternative method is to employ separate non-production personnel for the cleaning and vacuuming. This is usually done for the vacuuming of walkways and open spaces. Small modifications in plant design or procedures can enable cleaning operators to work near the production equipment also, keeping the working areas clean.

In general cleaning, **compressed air or dry sweeping must never be used**. If sweeping is absolutely necessary, only wet chips should be moved. The recommended method is dry vacuum cleaning using a high-efficiency particulate air (HEPA) filter. This filter allows the air to be exhausted from the vacuum cleaner back into the plant.

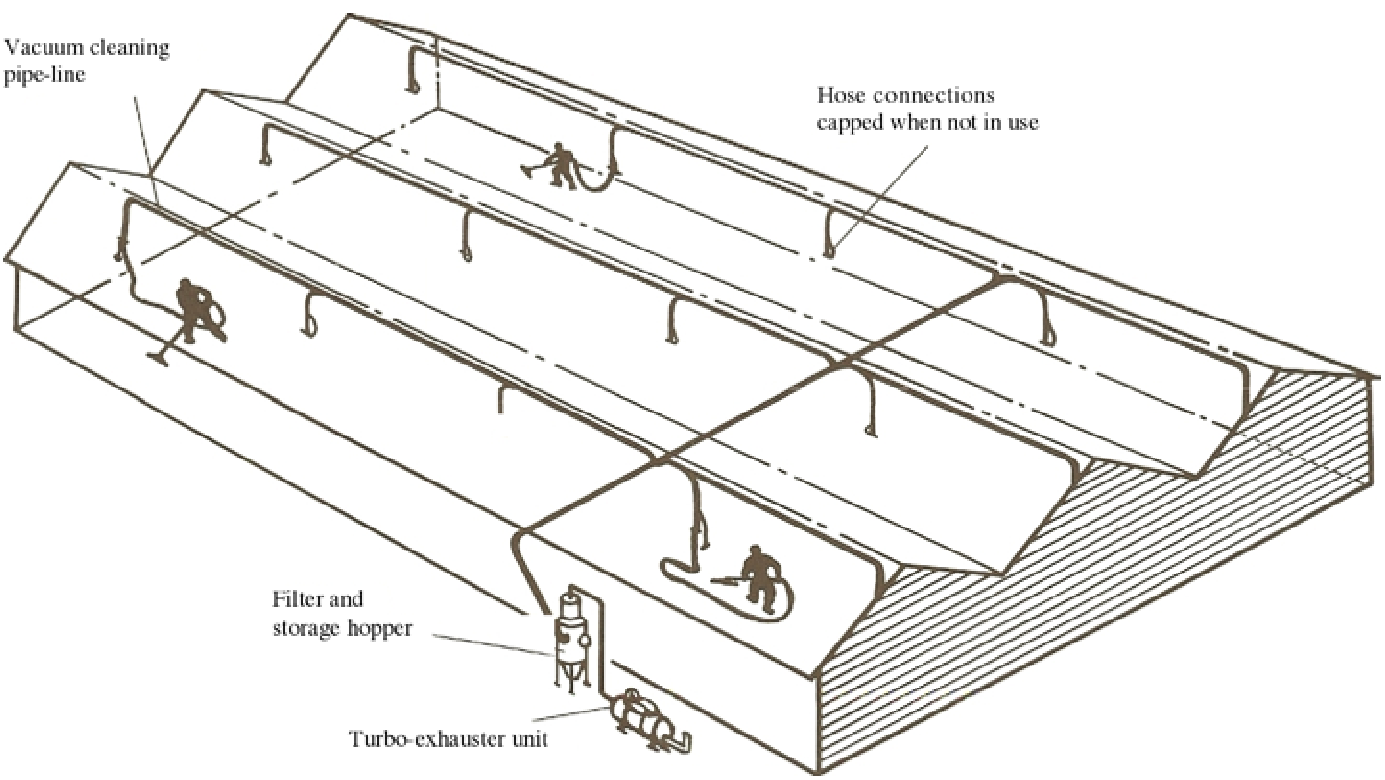
A second method of vacuuming, which may be used for production work stations such as saws and other machines, provides hose outlets from a central vacuum fan (Figure 5). This fan should be a high-pressure type producing suction pressures of at least 500 mm of water. For efficiency, these vacuum lines should be capped when not in use. Use of these vacuum hoses will enable small chips and any potential sources of dust to be quickly removed to a central bag house of the type described in the section on engineering controls.

Throughout plants using sheet, piping, gaskets or similar products, breakage and wear frequently produce fugitive piles of chips and cuttings. Careful attention to these locations with immediate vacuuming and cleanup will provide efficient dust control.

In all plants performing manufacturing processes, visible dust will eventually accumulate on wall surfaces, steel beams, machine surfaces and similar places. Cleaning personnel should remove this accumulated dust periodically with vacuuming systems. Annual cleaning is the minimum recommended.

Good housekeeping and cleaning procedures are considerably helped by smooth wall surfaces, floors without cracks and similar simplified and smoothed plant surfaces.

Figure 5
Typical Arrangement of Central Vacuuming System



> ... one of the most important steps toward a safe and easy chrysotile control program is training of the workers. When any 'job' involving the possible exposure to chrysotile is undertaken, the persons responsible for the supervision of the work should ensure that everybody on the work site has a proper knowledge of the type of risks associated with their work, the protective measures and their application, and the appropriate work'methodology'. "
>
> Canadian Centre for Occupational Health and Safety.
> Techniques for Asbestos Control in Buildings.
> Hamilton, Ont., August, 1985.

Containment or Enclosure

An example of effective and simple containment in the chrysotile industry is the use of plastic bags. If wet mixing is possible, debagging may be circumvented by using water soluble paper bags in conjunction with a suitable hydropulper. If that can be done successfully, no exhaust ventilation is required.

One way to control dust at the source is to enclose the source. For manual debagging, bags must be cut, emptied and disposed of inside a hood fitted with an exhaust connection (Fig. 15a). Cutting bags in half and handling empty bags outside the hood should be avoided.

Enclosure is practical when the operator does not need to have contact with the operation. In chrysotile cement plants a number of machine operations, such as the interior machining of couplings, can be enclosed. Enclosure is more common for the processing of smaller pieces. It is important that all parts of the enclosure should be at a lower pressure than the associated worker's area. This may be achieved with a small amount of suction air. However, small local system failures may disturb the negative pressure and result in dust emissions.

It is important to note that when enclosures are opened for maintenance, workers who must go inside the enclosures should use respirators approved by competent authorities.

Operators' booths are used only as a last resort, because the surrounding air will have high dust levels.

Another possibility is to isolate the process in space or time. This is not usually possible in chrysotile using operations.

Wetting

Wet processing is extremely effective in reducing the possibility of dust generation. Processes which may be wetted typically have much lower dust levels than processes that must be run entirely dry.

In a chrysotile cement plant, the dust from the vat to the curing tanks can be controlled by keeping the product, equipment and floor area wet at all times. If proper tools and wet spraying are used in conjunction with immediate clean-up of debris, the finishing section of a chrysotile cement plant can also be kept clean.

Of course, the wetting procedure requires some attention to electrical safety and other operational problems associated with water in the presence of lathes, drills, saws, etc. Many plants spray water over machining processes such as drilling and lathe cutting. This process usually produces significant reductions in fibre levels.

Due to the water droplets which frequently remain in the air during spraying, wetting in the presence of local exhaust ventilation systems is not recommended. The water spray will enter the exhaust ventilation system and produce a slurry with the chrysotile fibres, cement and other additives. When hardened, this slurry can contaminate the ventilation ducting and destroy the effectiveness of the bags in the bag house (an industrial filter which cleans the dust from the air).

A possible problem with floor spraying is that over time, chrysotile and water paste can collect in floor cracks, forming a hard, cement like substance. If allowed to dry out, this material can be a minor source of dust when walked on or when vehicles pass over. The solution is to perform complete sluicing operations during floor cleaning.

The water used for wetting purposes may be incorporated into the process if it is appropriate for chrysotile cement application. Otherwise, it may be directed to settling tanks where the solids can settle before the slurry is removed.

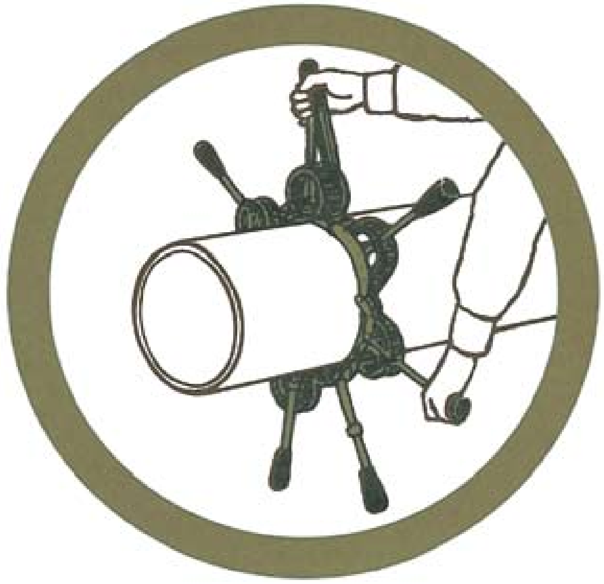
For the disposal of bag house waste or other operations where large quantities of chrysotile chips and powder are present, wetting can be made significantly more effective by the use of wetting agents. Waste material should be recycled in manufacturing processes or discarded in an approved disposal area.

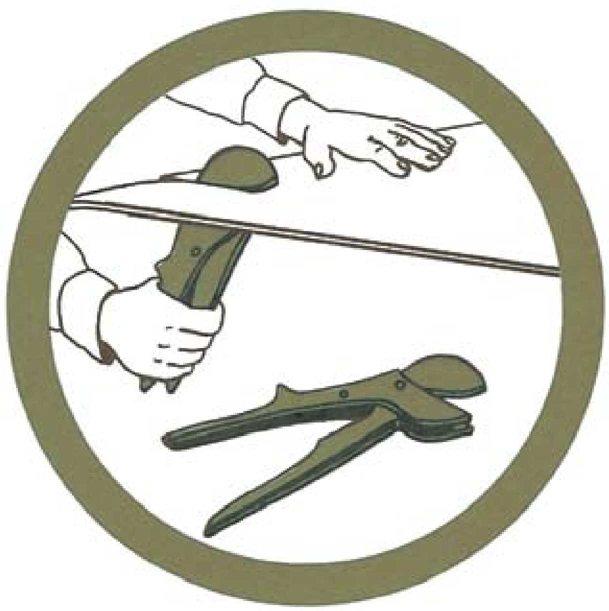
Work Practices in Construction

Construction and repair activities typically include the following: installing or removing manufactured chrysotile containing products, such as cement, vinyl, gaskets and seals. Dust control is achieved by using appropriate hand tools to shape the products or drill into them. The use of high speed power tools should be avoided when cutting, shaping or drilling products. Alternatives to high speed power tools are nibblers, rasps, files, shears, knives, hand drills, hand saws and special low speed tools producing large chips. Normal power tools should only be used if fitted with adequate dust collectors (see page 29).

Waste should be removed in large pieces, as intact as possible. The waste, after being placed into containers, should be disposed of according to local regulations, usually in specified landfill sites.

These control methods can be applied to the installation or removal of friction products; brake pads, shoes and clutch facings. Only hand tools or specially equipped power tools should be used. An air hose, dry brush or rag should not be used as this would promote exposure to dust particles. Particles can be removed with a HEPA equipped vacuum cleaner, a low pressure water spray, or similar process.





Personal Protective Devices

In many situations, particularly those dealing with maintenance, repair, and equipment failures, it is not possible to ensure low dust levels at all times in the plant environment. As a result, respirators and special clothing may occasionally be required. Use of respirators should be regarded as a temporary or emergency measure only and not as an alternative to other control procedures. The more common types of respirators can be uncomfortable for extended periods. In fact, workers frequently refuse to wear them except for short periods.

Figure 6

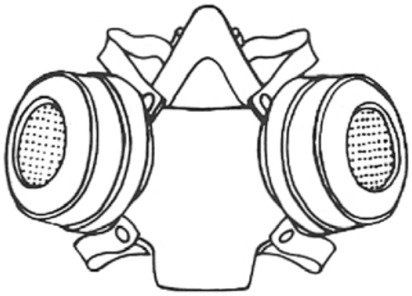


Figure 7

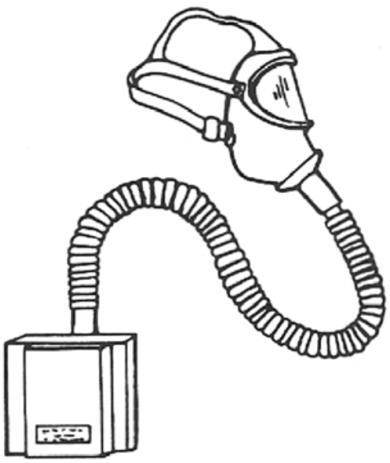


Figure 8

Figure 9a

For emissions which are above the recommended personal exposure level, negative-pressure respirators fitted with replaceable filters are necessary. These respirators are manufactured from a rubber like material and have canisters at the front with space for replaceable filters (Figure 6). For exceptionally high dust levels (which are seldom or never found in normal manufacturing processes) positive-pressure respirators which have air supplied by battery-powered pumps or other sources are required (Figures 7 and 8).

It is necessary to consult the manufacturer to check the respirator's protection factor. This is the ratio of the airborne concentration of the particulate to the concentration inside the respirator face piece. As the dust levels in the air increase, more powerful respirator equipment is required.

A helmet-style respirator has recently become available (Figure 9a). This respirator is useful for low and intermediate dust levels. It consists of a safety helmet and a fan, which pulls room air through a filter and directs the cleaned air from the forehead area of the helmet down over the worker's face behind a transparent face shield. The fan is powered from a hip-mounted battery. Another type of helmet respirator is also available for high risk application (Figure 9b). The inlet air is supplied by an air compressor. The quality of the compressed air must be assured before and during its supply to any respiratory or breathing equipment. The advantage of these helmets is that they may be worn for extended periods, unlike the less comfortable, traditional respirators.

Using a respirator properly requires adherence to a series of straightforward practices. Comfort is important, and some time and effort should be taken to fit the respirator correctly to each individual. Respirators should be considered personal equipment and not exchanged between workers.

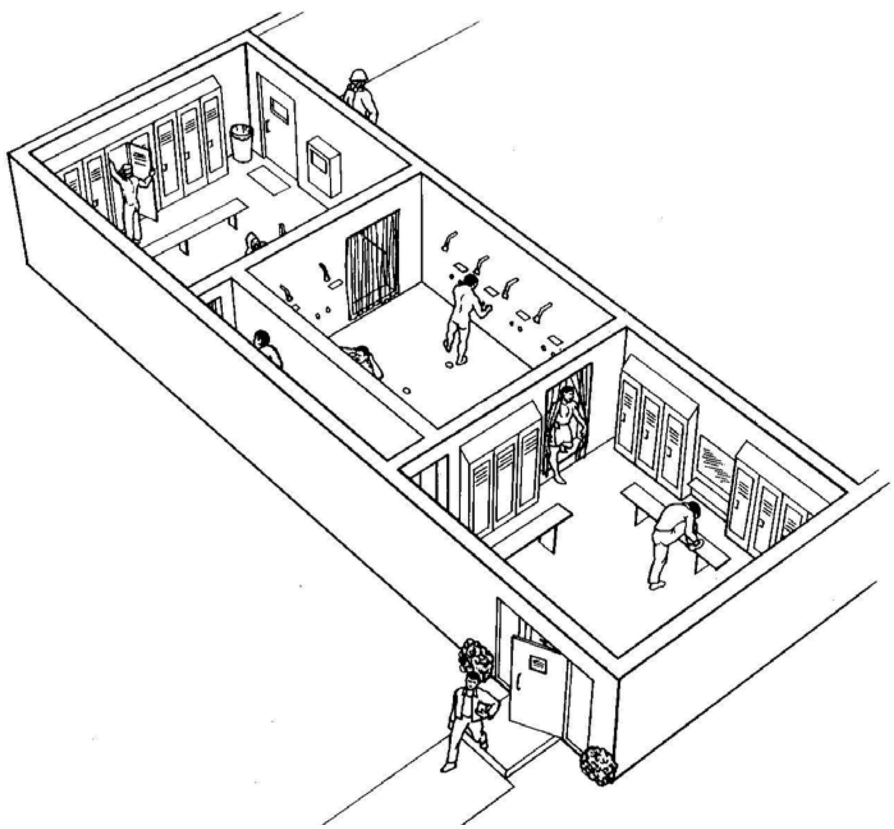
Workers should be informed by competent authorities of when and why a respirator must be used and the importance of using it continuously and properly. The equipment and how to use it correctly, as well as the procedure for checking the fit, should be demonstrated.

Equipment should be checked for correct operation and the worker instructed in the checking method. The worker should also be aware of the need for regular servicing, cleaning, maintenance and storage of respirator equipment.

Special work clothes, disposable coveralls or protective clothing may also be recommended for some chrysotile workers. Protective clothing (for situations involving high dust levels) should include a head covering and some kind of coverall to prevent chrysotile dust from being deposited on the worker's clothing or body. Both disposable and re-usable protective clothing may be used. Protective clothing should be kept separate for changing, storage, and cleaning purposes. An effective system is one in which a shower area separates a work clothing change room from a personal clothing change room (Figure 10).

Figure 9b
Full face mask with an air line

Figure 10



Waste Disposal

The procedures to be followed during disposal of waste chrysotile are rather different from those during manufacture. Economical and efficient disposal requires that waste be minimized or eliminated during production and use of chrysotile. Objectively, waste should be reduced to nil, therefore recycled into the production.

High fibre emissions can occur in the collection of waste if proper procedures are not followed. Wastes from the outlets of dust-collecting bag houses must be collected in such a way as to minimize emissions. Plastic bags are recommended for waste, and it is important not to overfill them. Bags should be sealed when full so that future handling does not allow further emissions. Respirators and protective clothing should normally be worn when bags are changed on dust collectors. Similar procedures should be used when bags are replaced in most vacuum cleaners and other collecting devices.

Sacks or bags which have contained raw chrysotile should be disposed of by bagging or by melting if it is not possible to put them directly into the manufactured product. Chrysotile bags should not be used for any other purpose. Good debagging requires that bags be crushed, the air removed, and manual bagging of the empty bags be done under effective local exhaust ventilation (fig.15a and 15b).

Wet waste is removed more easily than dry waste because dust emissions are prevented. However, wet wastes should be handled carefully to prevent spillage. Slurry waste from settling tanks should be kept wet while being moved and transported. Otherwise bagging would be necessary. Disposal should be to sites which can be covered before drying occurs or where encapsulation is possible.

The Use of Engineering Controls

A local exhaust system is a series of devices intended to capture dust at its source and to prevent that dust from being released into the atmosphere. A close-fitting exhaust hood can be used to capture the dust from a particular operation. The contaminated air can then be conveyed though a system of ducts by an exhaust fan. An air pollution control device, which is usually a fabric filter, can collect the dust from the workplace air and discharge the clean air into the atmosphere.

The elements of a complete local ventilation system are illustrated in figure 11. A source of "make-up air" or air to replace that exhausted through the hood must always be provided. The hood encloses the operation as much as possible. The velocity at the hood entry (the face velocity) should be large enough to prevent dust emissions. After the air passes through the hood entrance, it is exhausted through a series of ducts to an air cleaner, which is usually a bag house (a fabric filter chamber). The ducts may be joined cleaning systems and may have pre-cleaning cyclones (chambers where the large particles can settle).

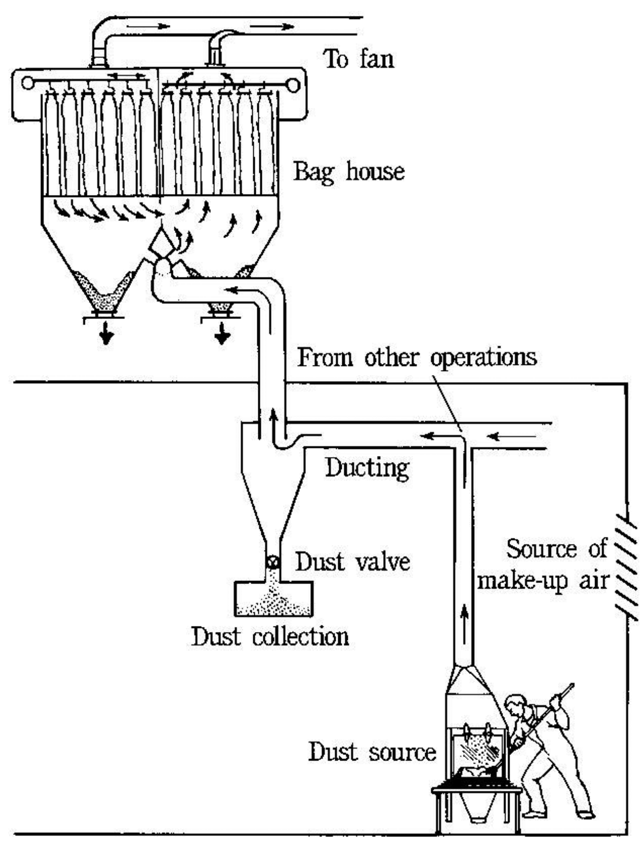
Good practice requires that the ducting have no dampers (valves that control the air flow), that the velocity be sufficiently high everywhere, that the dust not fall out and plug the ducting, and that the corners and bends of the ducts be designed to minimize wear and erosion. The bag house must be the right size to handle the quantity of air being exhausted through the hoods. The clean air passes through the suction fan and is exhausted to outside.

A dust monitor can be placed at this point. A dust monitor, however, is not an accurate measure of the level of chrysotile dust in the air, but rather of the changes in total dust concentration over time. It tells if there is a leak or blockage in the system.

Ventilation systems are expensive and are not part of the normal production machinery. As a result, considerable care should be taken to design an effective, cost-efficient system.

The engineering information needed to design ducts is summarized in **Industrial Ventilation — A Manual of Recommended Practices**, by the American Conference of Governmental Industrial Hygienists and, in The **Control of Chrysotile Dust** by Bragg and Carothers. Included in these documents are many designs for specific applications, such as grinders and saws.

Figure 11
Schematic Diagram of a Basic Local Ventilation System



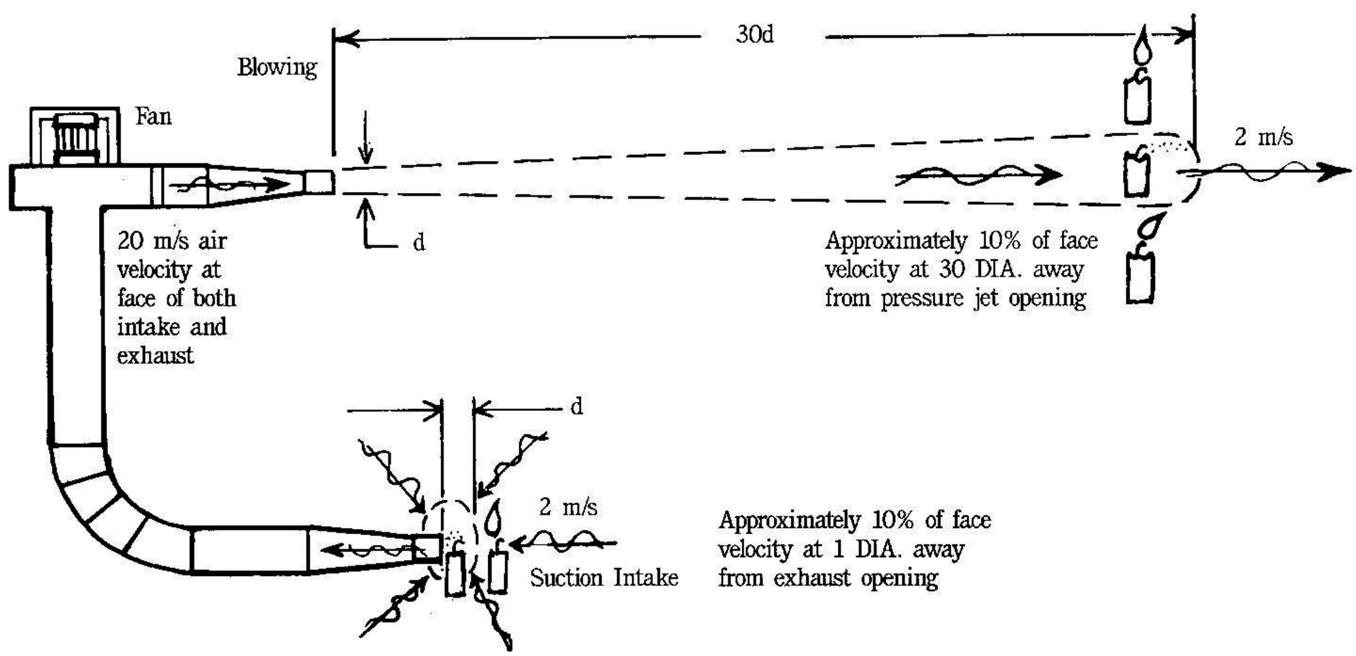
The simple question, «Have you ever tried to suck out a match ?" highlights the problem of ventilation in lay terms.

Exhaust Ventilation

Having considered the ventilation system as a whole, let us now consider the hood itself in more detail. Local exhaust ventilation is most effective when the inlet is placed close to the source of contamination — but not too close, or it may interfere with the operation being performed.

It is important to note the limitations of the suction process. Figure 12 helps to explain the problem. This figure shows a suction intake and an exhaust outlet with identical face velocities (20 metres per second). For the exhaust outlet (blowing), the air velocity is still 10% of its face value at a distance equivalent to 30 times the outlet diameter. In contrast, the air velocity at the suction intake has dropped to 10% of its face value at a distance equivalent to 1 times the intake diameter. Thus suction intakes must be close to the regions they are to affect as flow velocities drop off quickly with increasing distance from the intake.

Figure 12
The difference Between Blowing and Suction



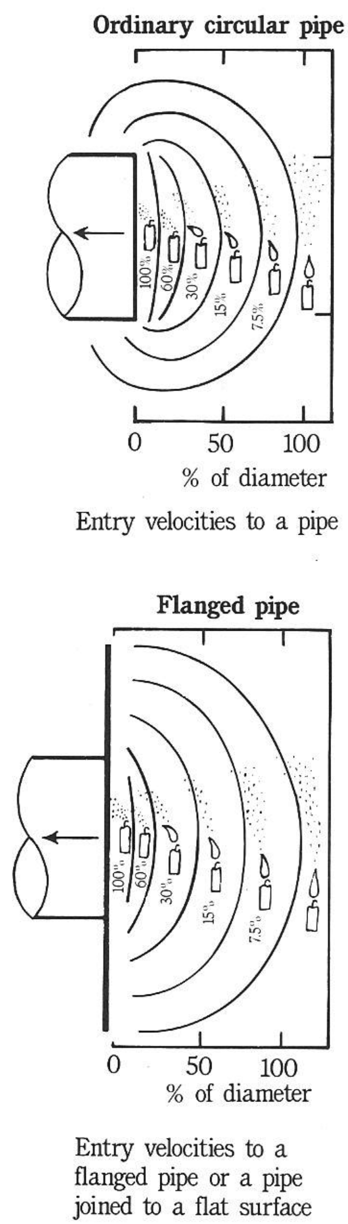
The point is again emphasized in Figure 13, where the lines of constant velocity are plotted around the ends of an ordinary circular pipe (top) and a pipe with a flange (bottom). As may be seen, the air speed is much slower only a short distance from the suction intake, and as a result, exhaust ventilation must be located very close to the operation. Hoods or special enclosures may be required for particularly dusty operations.

The design of a good ventilation system poses difficulties for both the exhaust and the supply side of the air flow. Because the general factory ventilation air supply and exhaust flows must be equal, the use of considerable amounts of exhaust air requires equal amounts of make-up air. If the make-up air is blown into the work area at high speeds, it can aggravate dust generation. Consequently, the ducts that carry make-up air must include diffusers or other devices to reduce the air velocity so that it does not disturb dust which is not otherwise in the air.

Dilution ventilation (e.g. forcing large amounts of fresh air into the plant without local exhaust ventilation) is both inefficient and ineffective as a method of dust control.

Operations performed outdoors achieve dilution ventilation naturally. The natural diffusion due to outdoor air turbulence can work reasonably well if the distance between the source of dust and the worker is sufficient to ensure that workers are not exposed to unacceptable concentrations.

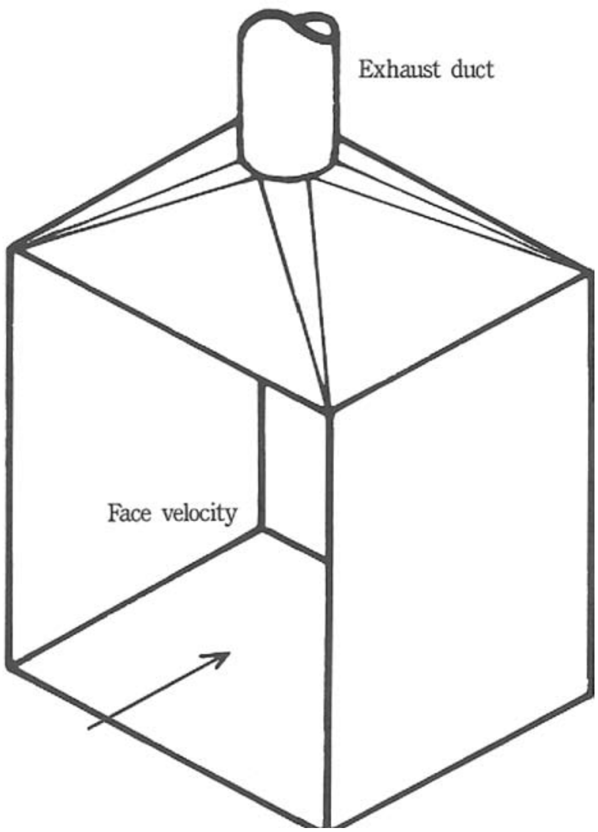
Figure 13
Flow Patterns Arround Pipe Entries



Hood Design

A basic exhaust hood is shown in Figure 14. An exhaust hood controls the intake to the exhaust duct. This is necessary to overcome local air currents where dust or fumes are generated. The exhaust hood helps to maintain air speed which drops off very quickly with simple openings (as shown in Figure 13). The air speed at the hood opening (face velocity) must be strong enough to overcome local air currents and to prevent dust particles within the hood from escaping. That is, the face velocity must be larger than the capture velocity.

Figure 14
Basic Exhaust Hood



The capture velocity or minimum air flow required to capture all dust is the beginning point in designing a ventilation system. The capture velocity will vary with the operation. The velocity at the face of the hood should be 1.0 to 1.25 metres per second (m/s). The controlling velocity at the furthest control point should be 0.25 to 0.30 m/s in a draftless environment, and 0.40 to 0.50 m/s in a very drafty environment.

In general, flanges on hoods improve the entry conditions and reduce the air drawn in from the relatively uncontaminated region, behind the hood. Improved entry conditions enable the hood intake to draw air from a larger effective area, lessen the entry pressure drop, and create a better velocity profile in front of the hood.

Debagging

Figure 15a shows the configuration of a bag-opening work station which is fully hooded. The recommended face velocity is 1.25 m/s, which, for a 1.0m by 0.75m opening, would require a total flow of 0.94 m^3/s. Figure 15b shows a bag-opening work station which is fully hooded.

Enclosures for friction products require hooding in several locations. All moulding and pressing operations should be carried out under a hood that is ventilated. The design of the enclosure depends on the type of operation, but it should avoid interference with the operator.

Cutting, grinding and drilling require properly designed hoods similar to those for chrysotile cement. This means hoods fitting close to the point where the tool touches the material, together with high velocity/low volume vacuum attachments. Similarly, the despooling operation for yarn in the manufacture of clutch facings, for example, should be fitted with a hood and a partial curtain.

Figure 15a
Debagger

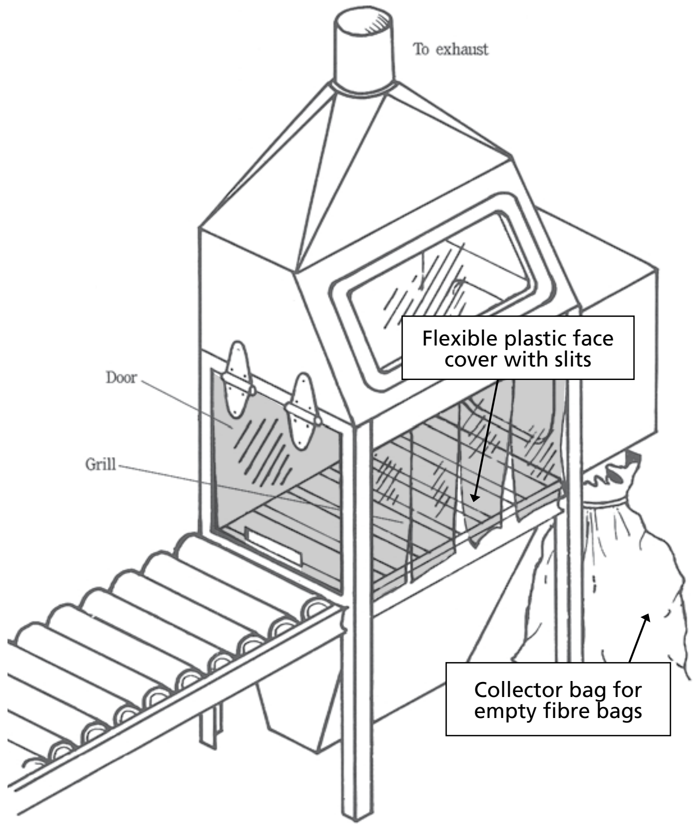


Figure 15b
A fully hooded bag-opening work station

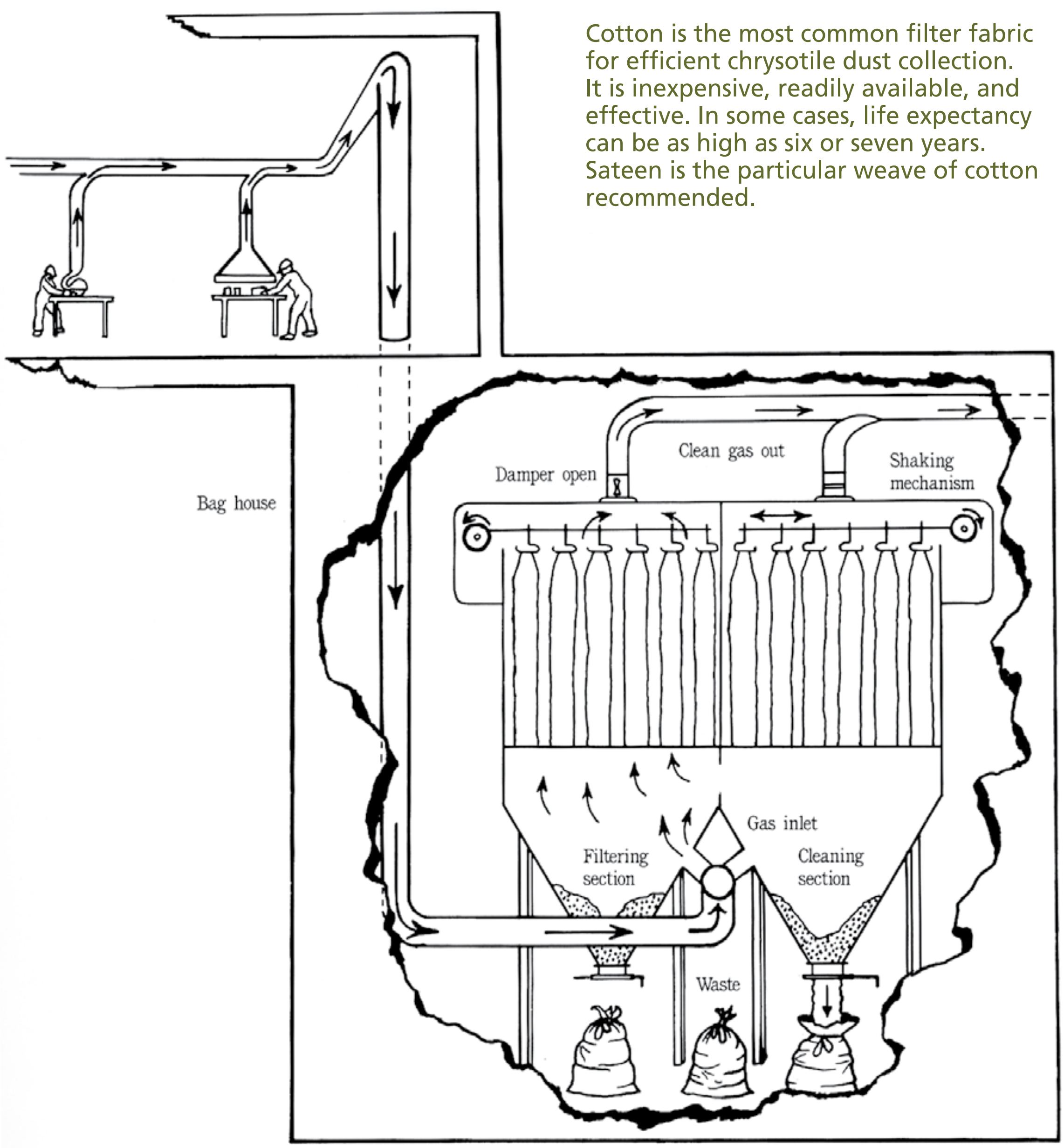
Air Cleaners

In modern practice the bag filter is the universally approved method of removing dust from the air. A basic bag filter of a common industrial type is shown in Figure 16. The system consists of a series of bags made of natural or synthetic fabrics which will filter the dust. In this instance, dusty air enters a chamber beneath the bags and is drawn through the inner surface of the bags. As a result, clean air enters the exterior chamber of the bags and is drawn outward.

The dust collects on the inner surface of the bags. Periodically, the bags are shaken and the cake formed on the inner surface of each bag breaks up and is deposited in the hopper (bin) at the bottom of the chamber.

Figure 16
Industrial Dust Collecting System

Cotton is the most common filter fabric for efficient chrysotile dust collection. It is inexpensive, readily available, and effective. In some cases, life expectancy can be as high as six or seven years. Sateen is the particular weave of cotton recommended.



For friction materials and textile plants, and in some cases chrysotile cement plants, it is recommended that a cyclone be inserted ahead of the bag house to avoid overloading of bags. The cyclone should be under suction, not pressure, to avoid leakage.

Many variations of geometry, flow direction and bag arrangement are possible. The common and recommended system shown in Figure 16 has a manual bag-shaking operating every two to eight hours, depending on the dust load.

The most important parameter in selecting a bag filter for a given application is the total amount of cloth surface to be used in the filter material. The cloth surface is ordinarily estimated by a quantity called the air-to-cloth ratio. This is the ratio of air flow in m^3/s to the total cloth area in m^2. Hence, this is actually the face velocity through the cloth. Recommended values for chrysotile are of the order of 0.6 to 1.0 m/minute. This value enables a rough estimate of filter size to be made very quickly.

NOTE : There exists on the market other air cleaning devices known as pulse jet baghouses. Dust is collected on the outside of the bags (installed on steel wire cages) and cleaned air is exhausted through the inside of the bags. Dust is removed from the bags by means of an air jet pulse every few seconds. Compressed air is required to achieve this bag cleaning operation.

Filter cleaning may be manual, semi-automatic or fully automated. Fully automated cleaning cycles may be triggered by a time cycle or when the pressure reaches a pre-set value. A cleaning cycle should be sufficiently intense and long enough to ensure thorough cleaning. Thorough cleaning is also recommended whenever the fan is turned off.

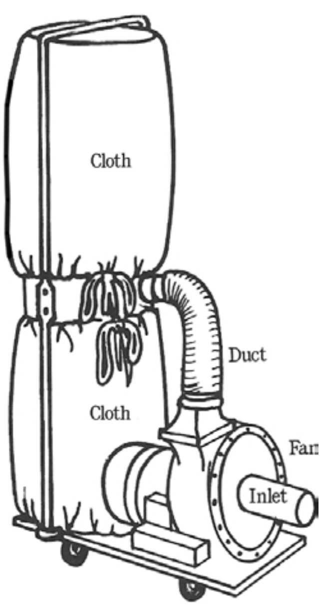
Small bag houses or bag house sections with 50 to 60 square metres of filtering area may be cleaned by hand levers. Manually operated handles "rap" (raise and drop) the framework from which the filtering elements are suspended. Thorough cleaning requires considerable vigour for several minutes. The fan should be shut off so that the bags can deflate during shaking. Also, it is useful to install a manometer (to read the pressure difference across the bags) on the baghouse wall.

The effectiveness of the cleaning may be determined by reading the manometer after the fan has been restarted. Workers performing the cleaning operation should be encouraged to do sufficient rapping so that the manometer will return to a pre-set low-pressure difference. Once the dust is collected in the hopper, it must be disposed of without creating a new dust problem.

In order to minimize dust emissions during transfer from the hopper to a truck or carrier, a long sleeve or sock of canvas can be installed at the hopper outlet to reach the floor of the carrier. The dust should then be thoroughly wetted with water or enclosed in plastic bags for transporting to the dump. These methods are suitable for installations where the emptying process is done once a day or less (this is normal in the chrysotile applications).

Baghouse maintenance mainly consists of bag replacement. A good maintenance program requires regular inspection of the bags for wear and leakage, and repair or replacement when necessary. It is often less costly to replace bags regularly, say once a year, than to inspect frequently and to repair worn or torn bags when they are found. Workers replacing and repairing bags should wear protective clothing and an approved respirator.

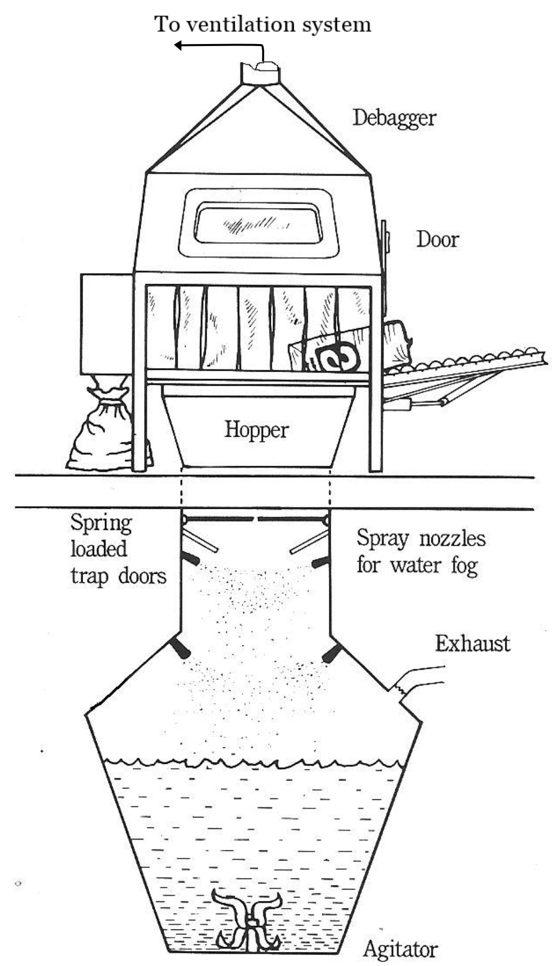
Figure 17
Low cost bag filter and fan,
for flows under 0.2 cubic metres per second



Bag filters are extremely efficient. It is not unusual for a commercial installation to filter more than 99.995% of the mass fed to it. Environmental emissions are therefore extremely small.

It is not necessary to consider the industrial filter a high-technology, high capital-cost item such as the example in Figure 16. Figure 17 shows a small bag filter mounted with a fan which is available commercially in many countries or which could easily be manufactured in most shops. This model can be as efficient as more sophisticated equipment if it uses sufficient quantity of good-quality cloth and is mounted outdoors, or in its own shelter.

Figure 18
Hydropulper

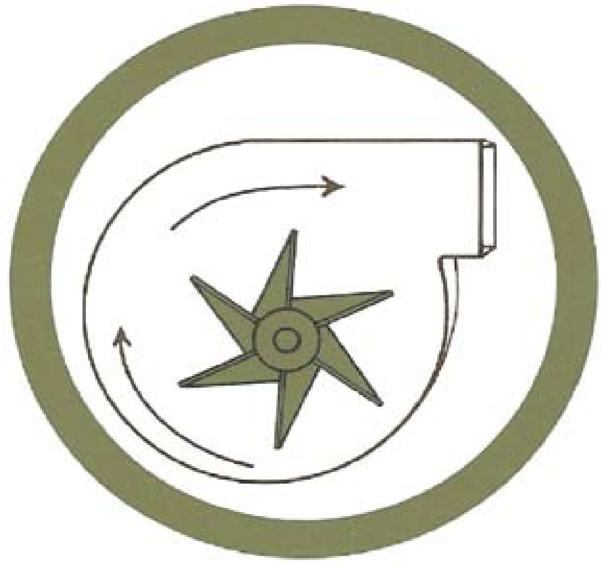


Fans

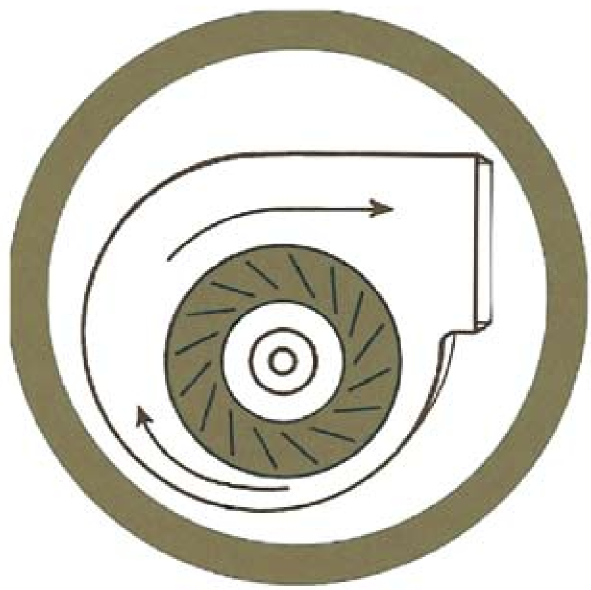
In dust-collection systems, fans may be installed either in front of or behind the filter. Fans installed in front of the filter must, of course, be capable of running in a dusty atmosphere. As a result, this type of installation is relatively uncommon and is not recommended since any leaks, in the system after the fan, are possible sources of dust. Dust can be highly erosive, especially in chrysotile cement plants and ducting should be protected against wear (lined with wear resistant material) and heavy duty fan blading are recommended.

The radial blade fan is commonly used for dusty air streams. For best operating performance, however, backward-bladed fans running on the clean side of the bags are recommended.

Fans are also used on commercial vacuum-cleaning systems for plant clean-up and on specialized cutting, sawing, and drilling machines. These units are single or multiple-stage centrifugal fans and are always backward bladed because of the wide range of loads to which they are subjected. These fans are frequently required to run against a very small friction loss and hence must have the power-limiting capability of backward-bladed fans.



Straight or Radial Blades



Backward Curved Blades

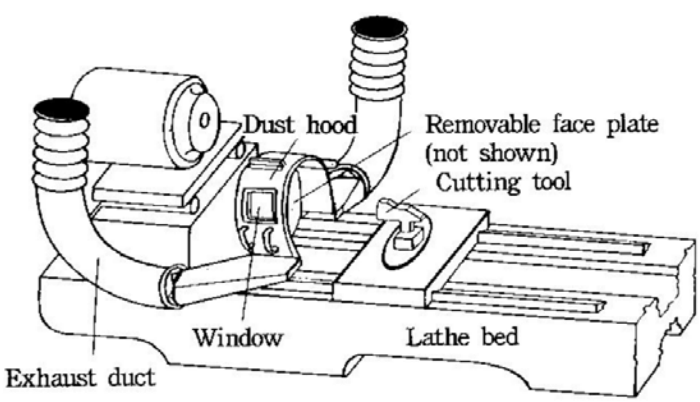
Testing and Monitoring of Ventilation Systems

Ventilation systems often work improperly, for a number of reasons. If the reduced performance is due to the fan, this can be caused by belt slippage, wear or erosion of the fan rotor, dust build-up in the housing, or incorrect electrical connections causing reversed blade rotation. The ducting may degrade the flow performance because of accumulations of dust, leaking joints, holes in the ducting due to erosion, or open inspection doors. Water vapour leaking into the negative suction side of an exhaust system can often cause accumulations of dust to solidify and so create blockages.

In many installations, additional exhaust points added over many years have caused a gradual deterioration of a previously efficient system. Blast gates (dampers) are frequently adjusted without regard to the effect on the overall system. Blast gates should always be locked in position so that personnel not familiar with the ventilation system cannot make local adjustments.

Performance of the ventilation system may be degraded by the bag house. If the bag house is not cleaned regularly, if holes are allowed to exist in the bags, or if water gets into the bag house causing the dust to cake on the bags, the air flow will be altered and ventilation performance reduced.

Figure 19
Pipe Lathe Dust Hood



Hoods and Vacuums for Tools

In sawing, trimming and machining operations at the finishing end of chrysotile cement manufacture, airborne dust is best removed by a high velocity/low volume collection system. Particles are thrown from the edge of a circular saw or machine tool at considerable speed. Therefore, specifically designed dust extraction attachments such as shown in Figures 19 to 21 must be fitted as close as possible to the contact between tool and workpiece.

Most tools and machines can be hooded to provide effective dust control. Figures 22 to 24 illustrate a number of hoods and vacuum systems for portable tools. This equipment falls within the low-volume high-velocity category (LVHV), with velocities in the openings designed to be 50 m/s and higher; however, flows are ordinarily less than 0.1 m^3/s. Pressure drops in these systems are much larger than in hoods and enclosures. This type of flow can be provided by commercially available, portable centrifugal compressor units. For the list of air tools supplies, contact The Chrysotile Institute, Montreal, Quebec.

Figure 20
Saw with Lower Vacuum Box

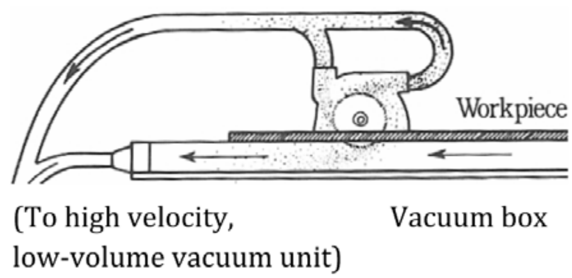


Figure 21
High-Velocity Enclosure for Table Saw

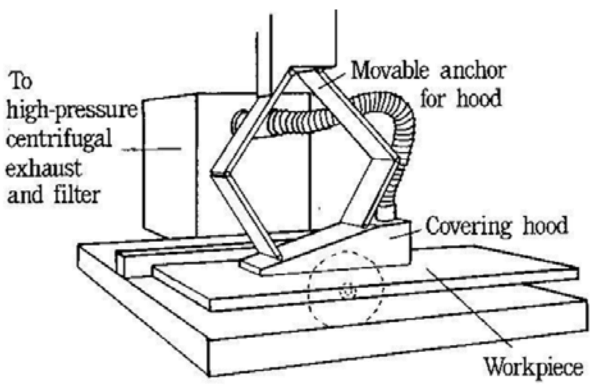


Figure 23
Saber Saw with Dust Collection Hood

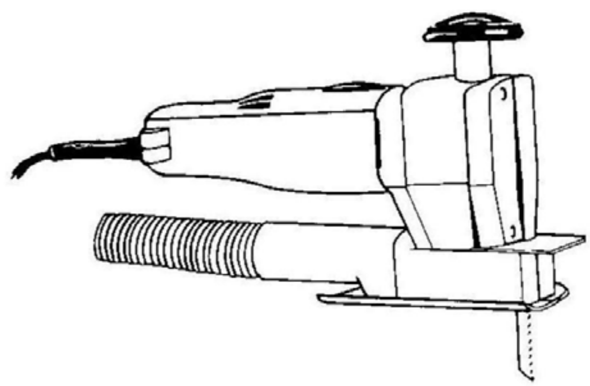


Figure 22
Power Drill with Dust Collection Hood

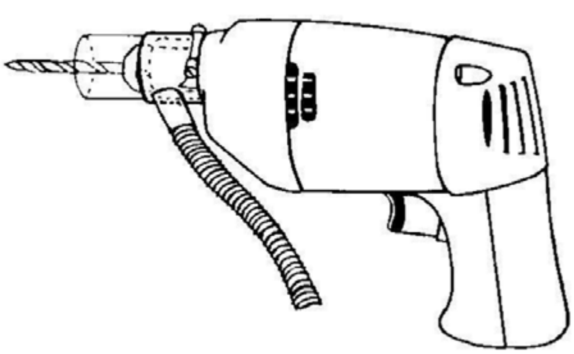
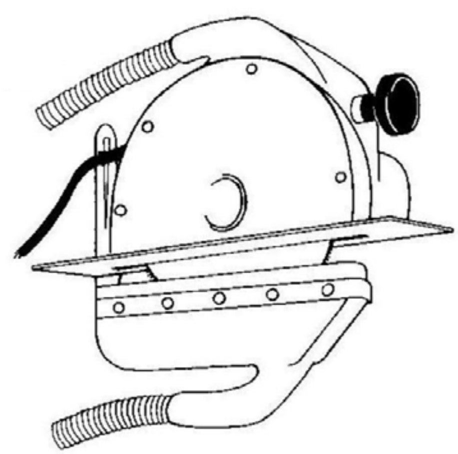


Figure 24
Fully Enclosed Portable Saw with Local Exhaust.



What Levels of Control Are Achieved?

Personal Monitoring

> «The challenge today is whether regulatory agencies will utilize current scientific knowledge even though it will necessitate a paradigm shift in long-held views on asbestos exposure and its implications for human health »
>
> Asbestos Exposure: How risky is it ?
>
> A position paper of American Council on Science and Health
>
> Ruth Kava, Ph. D. R.D. and Eun Hye Choi
> October 2007

The occurrence of airborne fibrous dust in the occupational environment is well documented. Airborne fibre levels in the respiratory breathing zone need to be monitored with reliable measurement techniques since it is the most appropriate method to establish the workers' exposure to respirable fibre (Figures 25 and 26).

The accepted method of determining fibre levels in the air is by the use of the phase contrast microscopy (PCM). The microscope measures fibre loads collected on a filter. The method is highly codified and the tests must be performed by trained personnel. The recommended procedure in most cases is that of The World Health Organisation 1998 (WHO). The results are related as fibres per cubic centimetre (or millilitre) or f/cc. For comparison purposes while looking at the accompanying data, it may be noted that the level recommended for chrysotile asbestos by many jurisdictions is 1 f/cc as an eight-hour time-weighted average.

To make valid comparisons of dust exposure levels, frequent changes in workplace conditions must be taken into consideration. These include production rates, ventilation system activity, outdoor weather conditions, the skill of the individual worker, and the influence of the measuring process. This type of variability causes strong day-to-day variations, as well as minute-by-minute differences.

Production processes and hence dust generation are seldom consistent from day to day. This is particularly true in the chrysotile industry where very few operations are continual in the sense of comprising a full eight-hour shift every day. Even continual processes must be stopped for repairs, adjustments, and maintenance. In the sheet industry, a drilling operation may be drilling chrysotile cement one day, non-chrysotile sheet another, and be turned off for the rest of the week.

In chrysotile cement pipe plants, production runs are made as and when orders for the product are received. This means that the manufacturing equipment is used in an irregular and unpredictable manner. In this situation, careful consideration must be given to measuring a worker's long-term average exposure or the exposure of a work location.

Figure 25

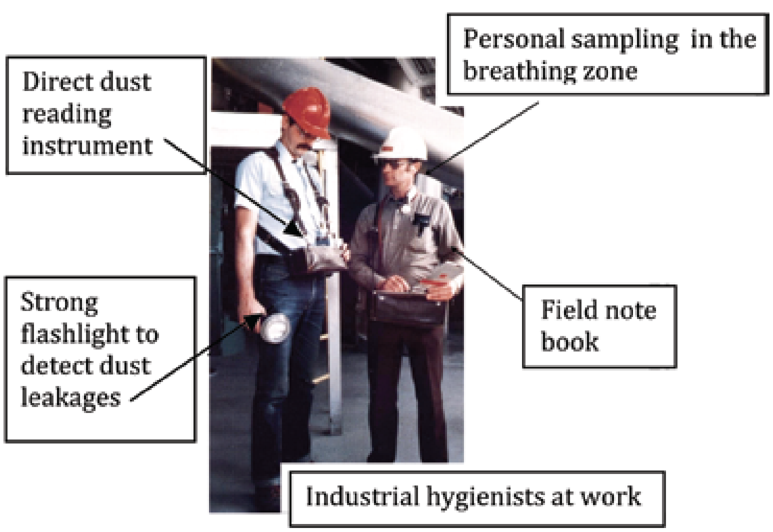
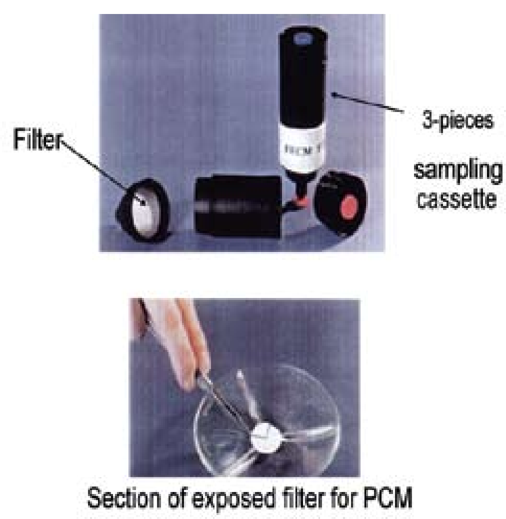


Figure 26



Asbestos-cement pipe plant air monitoring in 1983-1984

In the original publication of this manual in 1984, Dr Gordon Bragg wanted to explain in four figures (27, 28 and 29) the results on exposure levels obtained in different plants which were selected as representing good work practices with asbestos-cement pipe manufacturers. As you can see, twenty five years ago this information was most significant for that time. An example of this variation is shown in Figure 27, where exposures over ten days at a coupling lathe vary from 0.5 f/ml to 0.04 f/ml. This is typical whether the workplace is well controlled (as in this case) or poorly controlled. The geometric mean (GM) of 0.182 f/cc indicates that the long term average values in this plant will be very low. The geometric standard deviation (GSD) of 2.06 f/cc, on the other hand, indicates that the variability will be quite high.

Figure 27
Distribution of Readings During Ten Days
in an Asbestos Cement Pipe Plant

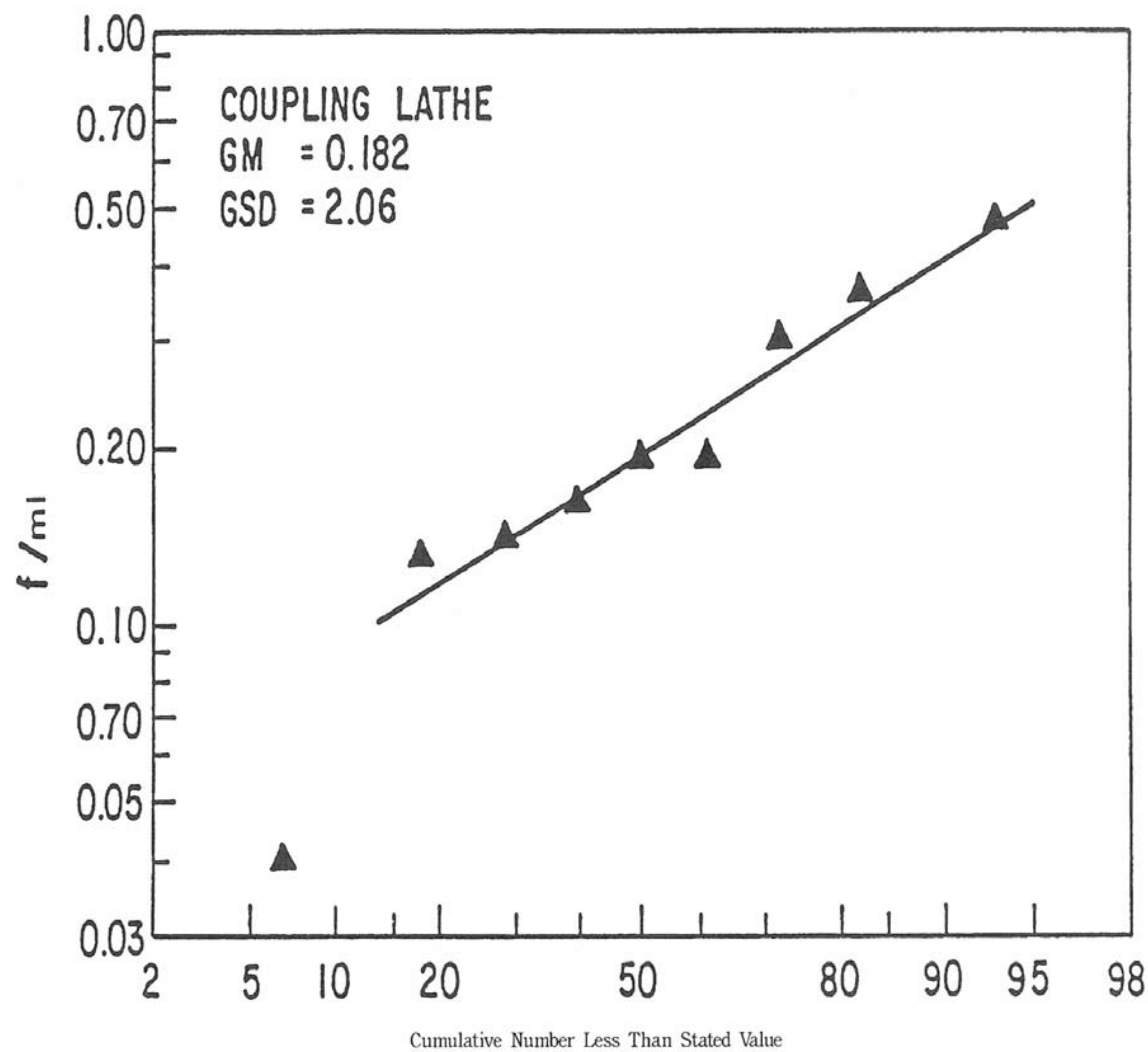


Figure 28 shows the historical behavior in 1983 and 1984 of two work stations at a single asbestos-cement pipe plant (see also Figure 4). These data show that dust control is an evolving process. Alterations, improvements, and reconsideration of the methodology of control are always necessary. As can be seen by following each operation from year 0 to year 14, changes and improvement were achieved. As the figure indicates, in later years the control was sufficiently effective that the dust levels were at or below the level detectable by the optical microscope method.

Figure 28
History of Dust Control at an Asbestos Cement Plant

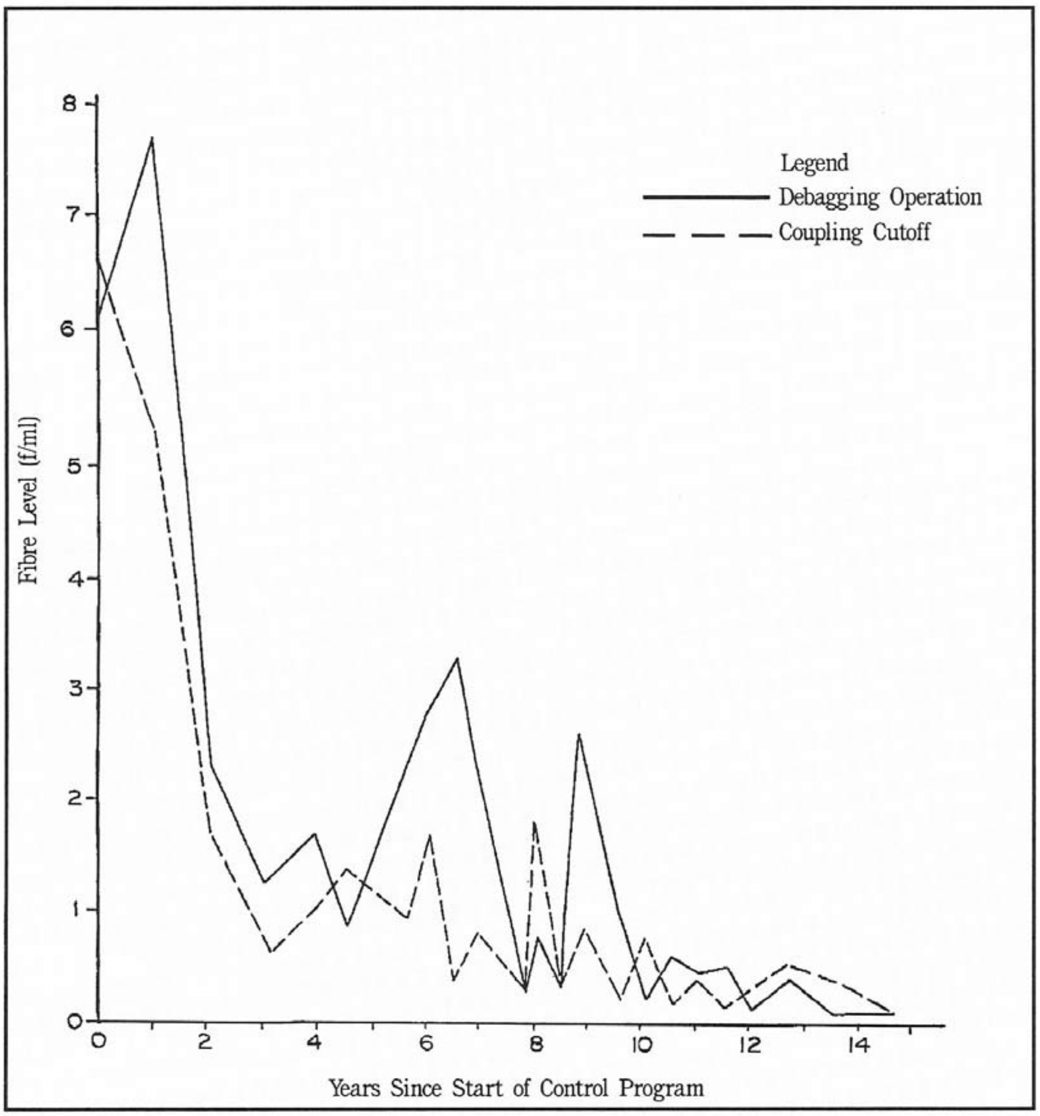


Figure 29
Exposure Data for Asbestos-Cement Pipe Values in f/ml

Process Step[1]	1983-84 Average	Range[2]	Sample Size
Fibre receiving and storage	0.03	0.02-0.08	3
Fibre introduction	0.14	0.04-0.47	9
Dry mix – wet mix	0.05	0.04-0.07	3
Pipe formation	0.099	0.005-0.47	36
Pre-curing/autoclaving	0.047	0.01-0.14	17
Sawing	0.19	0.02-0.61	4
Finishing lathes	0.09	0.01-0.19	11
Coupling cutoff and machining	0.31	0.02-2.20	20
Fittings and specialities	0.079	0.05-0.14	3
Drilling	0.32	0.04-0.60	2
Rework saw crushing	0.077	0.02-0.24	12
Floor sweeping	0.106	0.05-0.23	4
Quality control	0.074	0.01-0.18	12
Testers	0.147	0.02-0.49	15

1. Does not include every work station but does include all significant exposures. Includes all data without regard to interlaboratory variability. Small sample sizes can greatly underestimate the range.
2. 8-hr TWA values based upon data from 3 plants selected as representative of best available technology.

Figure 30
Exposure Data in a Single Well-Controlled Friction Products Plant

Values in f/ml based upon 8-hr TWA
Data is based on measurements by a single laboratory

Process Step[1]	Average Value	Range[2]	Sample Size
Debagging and mixing	0.34	0.29-0.38	2
Moulding	0.40	0.08-0.89	5
Cure operation	0.61	0.22-1.00	2
Dry press operation	0.63	0.34-1.25	8
Drilling and rivetting drum brakes	0.05	N.D.-0.62	31
Drilling and rivetting disc brakes	0.21	0.04-0.51	9
Blanking and bonding clutch plates	0.02	N.D.-0.04	4
Assembly disc brakes	0.11	0.06-0.18	3
Finishing – disc brakes	0.47	----	1

1. Does not include every work station but does include all measured exposures.
2. Small sample sizes can greatly underestimate the range.

Figure 29 shows exposure figures obtained from three plants in 1983 and 1984 which were selected as representative of good practice in chrysotile cement pipe manufacturing. In the making of friction products such as drum and disc brakes, manufacturing operations differ, but again a high degree of control is possible, as indicated in Figure 30. In the making of sealants, gaskets and coatings, the chrysotile is encapsulated immediately after debagging. As a result, dust levels are negligible or undetectable in most or all locations in these plants. These tables illustrate that levels dramatically below recommended values are achievable by the methods outlined here.

Dust Measurement Records (DMR) – 2006 Survey

In 2006, the International Chrysotile Association reported that the dust measurement records of 12,327 workers from 47 plants producing or using chrysotile in the manufacturing process that 99.81% of the dust results were below 1F/ml.

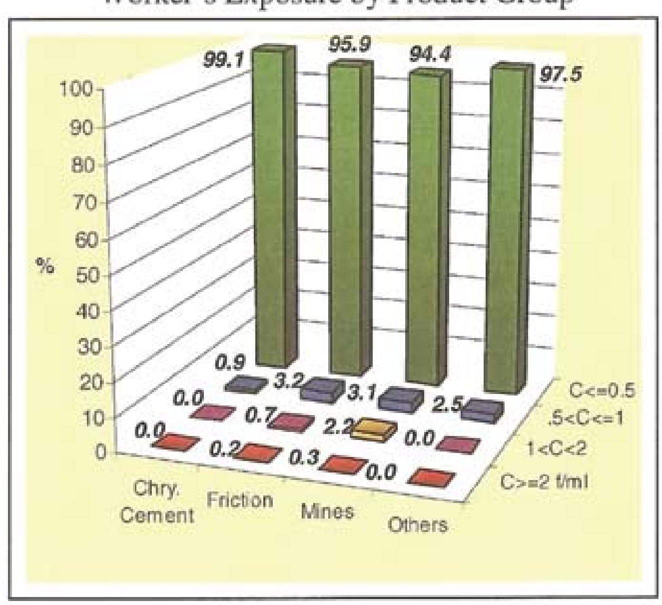
The worker exposure results were divided into 4 categories of product groups as shown in figure 31.

The results over the years show that a remarkable improvement in the work place conditions for workers involved in the use of chrysotile has taken place.

Figure 31
Dust Measurement Records (DMR) 2006 Survey

PRODUCT GROUP	No. of Results
Chrysotile-Cement	5,223
Friction Materials	463
Mines – Mills	322
Others	80

Worker's Exposure by Product Group



10 Countries – 47 plants – 12,327 workers

Education and Training

Education and training programs should be developed and all employees should be required to participate. Active involvement and commitment at all levels (manager to the last worker in the chain of production) are a must to a successful environmental monitoring program. Workers' participation in the elaboration of engineering controls and achieving clean and safe workplaces were recognized a long time ago.

Medical Surveillance

Medical surveillance goes along with supervision of the health of the workers whether they are employed in production, administration, sales or supervisory capacities. ILO Code of Practice on Asbestos including Chrysotile is the health monitoring program to follow.

It is important to note that more than 95% of the chrysotile produced in the world is used to manufacture chrysotile cement products. In these plants the chrysotile is locked-in at an early stage of the production and all waste can be recycled into the operation.

Conclusion

Emission controls of the type outlined in this report represent the best available dust-control procedures in use today. Their cost is a small fraction of the total cost of a chrysotile plant, both in capital and in operating costs. The most effective control methods (good housekeeping and wetting) are usually the cheapest procedures. In cases where engineering controls are required, ventilation systems will be effective if properly designed, moreover, they need not be expensive. Application of these methods will bring dust levels well below internationally recommended values.

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RCP2A: Catalogue of Tools for Working with Asbestos-Cement Products on Site.

RCP3: Asbestos Waste Materials.

RCP4: Asbestos Fibres: Packaging, Handling and Transportation.

RCP5: Asbestos Fibres — Bag Opening.

RCP6: Asbestos Textile Products — Manufacture.

RCP7: Asbestos Textile Products — Fabrication and Use.

RCP8: Repair and Removal of Asbestos Insulation.

RCP9: Protection Equipment Which May Be Needed in the Manufacture or Use of Asbestos Products.

RCP10: Asbestos-Containing Friction Materials. Application and Servicing.

RCP10A: Tools for Working with Friction Materials in Garages and Service Depots.

RCPll: Evaluation and Control of Friable Sprayed Asbestos Applications.

RCP12 : Practical Introduction to Fixed Factory Dust Extraction Systems and Their Maintenance.

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RTM1A: Dust Monitoring Strategy for Individual Exposure Assessment.

RTM2: Method for the Determination of Airborne Asbestos Fibres and Other Inorganic Fibres by Scanning Electron Microscopy.

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ICA Dust Measurement Records (DMR) 2006 Survey, Sept. 2007.

The Chrysotile Institute

is a non profit organization established in 1984
by the industries producing chrysotile, union labour
organizations and the Canadian and Quebec governments.

The Institute is dedicated to promoting the safe use
of chrysotile in Canada and throughout the world.

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