A STUDY OF ASBESTOS EMISSION FROM ASBESTOS-CONTAINING PRODUCTS WITH PARTICULAR REGARD TO PUBLIC SCHOOLS IN THE HOBART AREA

by

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STATEMENT

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university and to the best of the authors' knowledge and belief the thesis contains no copy or paraphrase of material previously published or written by other persons except when due reference is made in the text of the thesis.

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GLOSSARY*: FORMS OF ASBESTOS

ACTINOLITE	A monoclinic amphibole, containing iron, green in colour, and generally showing an elongated or needle-like habit; occurs in schists and altered basic igneous rocks.
AMOSITE	A monoclinic amphibole form of asbestos, the name embodying the initials of the company exploiting this material in the Transvaal, viz. the "Asbestos Mines of South Africa".
AMPHIBOLES	An important group of dark-coloured, rock-forming silicates, including hornblende, the commonest.
ANTHOPHYLLITE	An orthorhombic amphibole of grey-brown colour usually massive, and normally occurring in metamorphic rocks; a metasilicate of magnesium and iron.
CROCIDOLITE	A silicate of sodium and iron, crystallising in the monoclinic system and belonging to the amphibole group of rock-forming minerals.
CHRYSOTILE	A fibrous variety of serpentine, occurring in small veins. It forms part of the asbestos of commerce. Also called CANADIAN ASBESTOS.

* From COLLOCOTT, T.C. and DOBSON, A.B. (eds), 1975; *Chambers Paperback Reference Books*, Chambers Dictionary of Science and Technology, Volumes One and Two; Chambers, Edinburgh.

SERPENTINE

A hydrous silicate of magnesium which crystallizes in the monoclinic system. The three chief polymorphic forms are *antigorite*, *chrysotile* and *lizardite*. The serpentine minerals occur mainly in altered ultrabasic rocks, where they are derived from olivine or from enstatite. Usually dark green, streaked and blotched with red iron oxide, whitish talc, etc.

TREMOLITE

A hydrous silicate of calcium and magnesium which crystallizes in the monoclinic system. It is usually grey or white, and occurs in bladed crystals or fibrous aggregates associated with metamorphic rocks; with the entry of iron replacing magnesium, it grades into actinolite.

VERMICULITES

A group of hydrous silicates, closely related chemically to the chlorites, and structurally to talc. They occur as decomposition products of biotite mica. When slowly heated, they exfoliate and open into long wormlike threads, forming a very lightweight water-absorbent aggregate.

GLOSSARY*: MEDICAL TERMS

ASCITES	A collection of serous fluid in the peritoneal cavity, between the membrane lining the abdominal wall and the membrane covering the abdominal organs.
COLLAGEN	Any of group of proteins found in skin, ligaments, tendons, bone and cartilage, and other connective tissue.
DNA	Deoxyribonucleic acid, organic chemical of complex molecular structure occurring in cell nuclei as a constituent of chromosomes, where it serves to encode genetic data. DNA occurs in a constant amount in all body cells of a particular species.
MACROPHAGE	A name given to certain large leucocytes, from their supposed power of devouring other organism, especially pathogenic microbes.
PHAGOCYTOSIS	Process by which living cells ingest or engulf other cells or particles. The phagocytic cell may be a free-living, one-celled organism, such as an amoeba, or one of the body cells, such as a leucocyte (white blood cell). The particles commonly phagocytized include bacteria, tissue cells (usually dead), protozoa, various dust particles, pigments, and other minute foreign bodies.

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* From *The New encyclopedia Britannica* (1982) and *The New Columbia Encyclopedia* (1975)

1. INTRODUCTION

1.1 OCCURRENCE OF ASBESTOS EMISSIONS AND HEALTH RISK IN THE GENERAL ENVIRONMENT

For a long time, exposure to asbestos has been considered as an occupational health hazard for asbestos workers. Recently, research studies have shown that almost the entire community is exposed to low levels of airborne asbestos. According to Scientific Authorities (U.S.E.P.A.* 1979) in cases where exposures are very low, it is not possible to establish a threshold level of exposure below which there is no evidence of some health risk. This statement has raised concern throughout the world regarding general public health because asbestos is ubiquitous and low levels of asbestos contamination can be demonstrated everywhere.

Asbestos fibre emission causing risk for the general population might be associated with open-air construction activities such as where asbestos products are used for roofing, side cladding, guttering, and ducting for ventilation systems as well as during the demolition or renovation of structures containing asbestos. Asbestos fibres released from automobile brake linings, or during the handling of asbestos waste, may also cause a health risk.

Demolition processes may constitute the most significant source of short-term exposure to the general population living nearby. According to the Canadian Asbestos Information Centre (Candaian A.I.C. 1982), even high density products will liberate fibres as they are severely fragmented by explosive demolition. The same source provides data of measurements made in the Federal Republic of Germany during the demolition of an asbestos cement facade. It states that, in the breathing zone of the apparatus, a concentration level of 0.4 to 0.8 fibres per millilitre,

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* United States Environmental Protection Agency

with a fibre length longer than 5 micrometres, was measured. At 8 to 100 metres down-wind distance, the concentration was lower, but still significantly higher than the background concentration in that area. Generally, the hygiene standard at demolition sites is breached from time to time and the people living nearby such operations are exposed to elevated levels of asbestos fibres.

Also, in areas directly neighbouring industrial users of asbestos, the levels of air population with asbestos fibres have been shown to be high. Such a situation is a direct result of difficulties encountered in reducing the emission of fine particles of asbestos during factory operations and asbestos transportation.

Measurement studies of the air pollution of several cities have proved that, in some industrial countries, exposure to asbestos dust has extended from occupational to environmental situations. Monitoring programmes in European countries have determined the levels of asbestos fibres in samples from major city locations. Sampling locations have been designated to provide information on levels of asbestos in air in some typical urban sites such as crossroads with heavy traffic, areas with building construction or in the vicinity of a freeway. The assessment of environmental air pollution by asbestos has been accomplished with the transmission Electron Microscope or the SEM in a quantitative way chrysotile fibres were present in every sample analysed. Data on sampling and number of samples analysed in Paris and its suburbs are given in Table 1.1. As can be seen, analysis of samples yielded very similar results. Mean value derived from the analysis of samples taken in areas with buildings under construction was highest, but all results obtained were approximately more than 10 thousand times lower than hygienic standards for the occupational exposure (Sebastien *et al.* 1979).

Data in Table 1.2 lists results from a number of studies conducted in various environments in North America. This is a good example of comparison of the concentration levels of airborne asbestos ranging from an occupational exposure (asbestos mines) to paraoccupational exposure (near the mine) and exposure to airborne asbestos in urban

TABLE 1.1 Levels of Chrysotile Asbestos Air Pollution in Paris and its Suburbs, 1974-1977
(Adapted from Sebastien *et al.* 1979, page 404)

Sampling Site	Number of Samples	Range ng/m^3 (f/ml x 10^{-5})	Mean ng/m^3 (f/ml x 10^{-5})
Typical Urban Site	76	0.1 - 5.4 (0.3 - 16.2)	0.6 (1.8)
Crossroad Location	43	0.1 - 6.2 (0.3 - 18.6)	0.9 (2.7)
Area with Buildings Under Construction	19	0.7 - 9.0 (2.1 - 27.0)	1.8 (5.4)
Vicinity of Freeway	15	0.1 - 0.6 (0.3 - 1.8)	0.2 (0.6)

TABLE 1.2 Levels of Airborne Asbestos in Selected Areas by EM Measurement
(Adapted from Canadian Asbestos Information Centre 1982, page 344)

Area	Number of Samples	Range ng/m^3 (f/ml)	Mean ng/m^3 (f/ml)
Mine (Thetford)	3	113778-185417 (3.4 - 5.6)	141620 (4.25)
Near Mine (Black Lake)	14	160-11000 (0.0048-0.33)	2392 (0.072)
Town n. Mine (Thetford Mines)	7	170-3467 (0.0051-0.10)	1157 (0.035)
Montreal City	20	1-10 (0.00003-0.0003)	2 (0.00006)
49 US Cities	187	0.1-100 (0.000003-0.003)	2.4 (0.000072)
New York City	22	2-65 (0.00006-0.00195)	17.4 (0.00052)

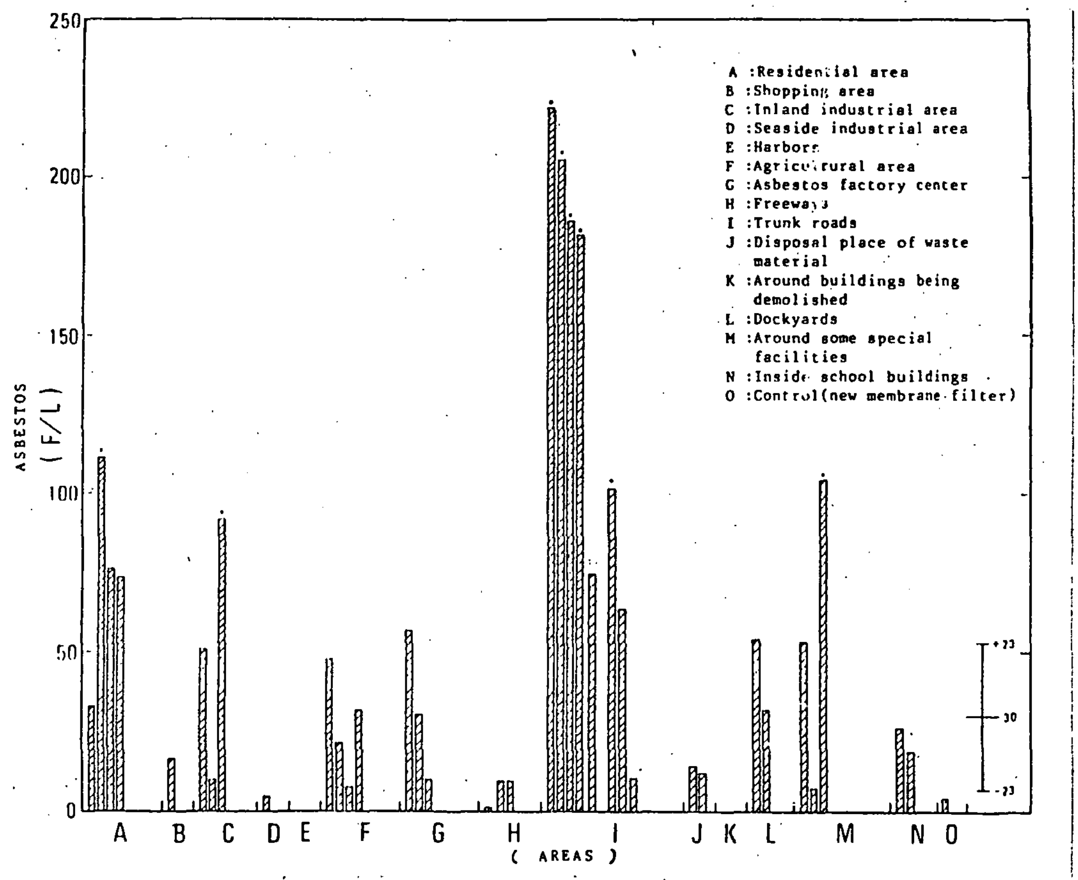
environments. As can be seen, the paraoccupational exposure is approximately 100 times lower than occupational, and non-occupational exposure can be as much as 8000 to 250 000 times lower than occupational. The highest concentrations in urban environment have been found in New York City, concentrations in other cities being more similar to those measured in European cities. In New York City level of airborne asbestos was 2000 times lower than hygiene standard for occupational exposure. Asbestos fibres have been detected also in rural locations.

Similar study of airborne asbestos concentrations has been done in urban and suburban ambient air from various kinds of locations in Tokyo, Kanagawa, Osaka, and Fukuoka in Japan. All the identification of asbestos fibres was done by using an analytical transmission electron microscope (National Research Institutes of Government 1982). Figure 1.2 shows remarkably high concentrations of airborne asbestos around sites of trunk roads as well as from residential areas. From these results, it can be deduced that motor vehicles in Japan are an important source of airborne chrysotile asbestos fibres and the influence appears not only on trunk roads but also in residential areas.

There is also some concern regarding health effects to consumers by exposure to asbestos from consumer products. The United States Consumer Products Safety Commission has started a programme to obtain information from producers of consumer products regarding the use of asbestos in products, as well as a programme to test products for asbestos release (Canadian Asbestos Information Centre). Table 1.3 indicates the use of asbestos components in some consumer products.

It should be mentioned here that many water supplies are also contaminated with asbestos. The origin of this contamination is from natural sources, such as where water reservoirs are located in asbestos mineral deposits, and from man-made sources, where fibres are leached from asbestos cement pipe, for example, or where asbestos waste is dumped into the water supply. The distribution of reported asbestos concentrations in drinking water in 365 United States and 69 Canadian cities is shown on Table 1.4.

FIGURE 1.2 The Fibre Concentrations of Airborne Asbestos Examined by Analytical Transmission Electron Microscopy (From National Research Institutes of Government Ministries and Agencies 1983, page 237)



Another area of concern is the long-term exposure of occupants of buildings incorporating asbestos-based materials in their construction. Exposure levels in buildings are associated with fibre emission from asbestos-containing products used for different purposes.

Asbestos fibre emission in enclosed spaces might originate

(a) during and following the construction phase of a building where asbestos dust from installation work is left and constitutes a long-term potential emission source;

TABLE 1.3 List of Consumer Products Containing Asbestos (From Canadian Asbestos Information Centre 1982, page 314)

Broilers	Mixers
Slow Cookers	Curling Irons
Popcorn Poppers	Textured Paint
Dishwashers	Wallboard
Refrigerators	Fire Starters
Ovens & Ranges	Safe & Safety Boxes
Clothes Washers & Dryers	Kilns
Electric Blankets	Filing Cabinets
Frying Pans & Grills	Incinerators
Deep Fryers	

TABLE 1.4 Distribution of Reported Asbestos Concentrations in Drinking Water in 365 U.S. and 69 Canadian Cities (From Canadian Asbestos Information Centre 1982, page 343)

Concentration 10^6 Fibres/ℓ	U.S. No. Cities	U.S. %	Canada No. Cities	Canada %
1	290	79.5	44	63.8
1-10	34	9.3	18	16.1
10-100	41	11.2	5	7.3
100			2	2.9

(b) during the life-time of the insulating coating where the material starts to deteriorate from age or by vibration or air movement, such as in air plenums and dusts of ventilation systems, or by accidental impact against the material;

(c) during and following the removal or renovation of insulation materials containing asbestos;

(d) during human activity within the building.

The above situations have led to speculation regarding the possible health risk for occupants of buildings incorporating asbestos in their construction. The main applications of asbestos in buildings are found in thermal and acoustic insulation, in fire retarding partitions and ceilings, and in the lagging of pipes and boilers.

Other products containing asbestos widely used indoors are asbestos reinforced plastics, compressed asbestos sheets, flooring materials, paints, and fillers. In these high-density products, the fibres are tightly locked and a large amount of fibres might be released only when the material is cut or mechanically transformed. In descending order of possible fibre release, sprayed asbestos, lagging materials, and insulating boards are to be mentioned.

According to Sebastien *et al.* (1979), an especially high asbestos concentration can be encountered inside some buildings sprayed with asbestos-containing materials. The same source provides data from measurements taken in 33 buildings in Paris, which contained sprayed asbestos. Classification of the buildings and maximum air pollution levels measured in each of the 33 buildings tested are given in Table 1.5. These values were measured from samples taken during normal operating conditions of the buildings surveyed. As can be seen, generally the readings are relatively low but, in some locations, such as parking garage areas, asbestos exposure was 100 000 ng/m^3 (equivalent to 3 amphibole fibres/ml) and exceeded 30 times the standard workplace level. In some other locations, such as schools, universities and workshops the

TABLE 1.5 Spray Configuration and Level of Asbestos Air Pollution Inside 33 Buildings Sprayed with Asbestos-Containing Materials
(From Sebastien *et al.* 1979, page 405)

Building Number	Type of Building	Air conditioned[a]	Type of Spray[b]	Spray Location[c]	Spray Easily Reached[d]	Contact with Ambient Air	Number of Samples	Maximum Level (ng/m³)	
								Amphibole	Chrysotile
1	school	no	Fs	Cg	no	Dt	3		0.1
2	offices	no	Fs	Se	no	Em	3		0.2
3	offices	no	Fs	Cg	no	Dt	2		0.4
4	school	no	Cs	Se	no	Em	4		1.3
5	offices	yes	Cs	Cg	no	Dt	7		2.1
6	residence[d]	no	Fs	Cg	no	Dt	4		2.3
7	bank	yes	Cs	Cg,Se	no	Em	3		2.8
8	offices	yes	Fs	Cg	no	Dt	4		3.0
9	offices	yes	Fs	Se	no	Rm	6		5.0
10	hall	no	Fs	Cg	no	Dt	1		6.0
11	offices	yes	Fs	Cg	no	Rm	3	2.0	5.1
12	residence	no	Cs	Se	no	Em	4	2.7	6.9
13	bank	no	Cs	Cg	no	Dt	3		8.0
14	school	no	Fs	Cg	no	Dt	2		11
15	library	yes	Cs	Cg	yes	Dt	5		12
16	offices	no	Cs	Cg	no	Em	3		12
17	shed	yes	Cs	Cg,Wl	yes	Dt	1	22	1.1
18	nursery	no	Fs	Cg	no	Dt	2		24
19	parking garage	no	Cs	Cg,Se	yes	Dt	3	6.2	24
20	offices	yes	Fs	Cg	no	Rm	3		27
21	school	no	Fs	Cg	no	Dt	1		29
22	post office	yes	Fs	Cg,Se	yes	Dt	4	3.2	34
23	theater	no	Cs	Cg,Wl	yes	Dt	4	11	29
24	residence[d]	no	Fs	Cg,Wl	yes	Dt	3		42
25	laboratory	no	Fs	Cg,Wl	yes	Dt	4	2.3	62
26	parking garage	no	Fs	Cg,Se	yes	Dt	2	80	8.0
27	workshop	no	Fs	Cg,Wl	yes	Dt	13	110	22
28	university	no	Fs	Cg,Se	yes	Dt	4		200
29	school	no	Fs	Cg	no	Dt	2		280
30	shed	no	Fs	Se	yes	Dt	9	490	2.8
31	university	no	Fs	Cg,Se	yes	Dt	46	460	630
32	workshop	no	Fs	Cg	no	Dt			750
33	parking garage	no	Fs	Cg,Se	yes	Dt	2	100 000	7.9

[a] Fs, fibrous; Cs, cementitious
[b] Cg, ceiling; Wl, wall; Se, structure
[c] Rm, in return air plenum; Em, in enclosed plenum, Dt, direct
[d] Spray located in the basement; no spray in the sampled room

readings were 100 to 750 ng/m^3 (3 x 10^{-3} - 22 x 10^{-3} fibres/ml).

Table 1.6 provides results of Optical Microscope analysis of airborne asbestos fibre concentrations that were measured in various buildings containing sprayed chrysotile asbestos. Measurements have been under certain conditions. Sometimes, as can be seen, the level of asbestos fibres in the air reached levels considered as hazardous, and excided from 2 to 17 times the hygiene standard for occupational exposure for chrysotile asbestos.

TABLE 1.6 Airborne Asbestos Fibre Concentrations in Various Buildings by Optical Microscope Analysis
(Adapted from United States Environmental Protection Agency 1980, page 60)

Sampling Site	Number of Samples	Mean (f/ml)
Yale University		
Exposed friable ceilings 20% chrysotile		
- Quiet conditions	15	0.02
Contact		
- Cleaning	3	15.5
- Removing ceiling section	3	17.7
- Installing lights	6	7.7
- Installing partition	4	3.1
Office Buildings East Connecticut		
Exposed friable ceilings 5-30% chrysotile		
- Custodial activities	8	2.8
Urban Grammar School New Haven		
Exposed ceiling 15% chrysotile		
Custodial activity: sweeping, vacuuming	2	0.02

In view of the increasing knowledge of the potential of asbestos as a cancer-inducing agent at low levels of asbestos contamination, particular concern has arisen with the exposure of school children. In 1979, the United States Environmental Protection Agency initiated a technical assistance programme to help State and school officials voluntarily identify and correct asbestos hazards. In May 1982, it issued a rule, under the Toxic Substances Control Act, requiring that schools be inspected for asbestos and that employees and parent-teacher groups be notified of asbestos presence (U.S.G.A.O. 1982). In August 1984, the United States Congress handed the Environmental Protection Agency (EPA) $50 million to help schools rid themselves of asbestos and promised another $550 million over the next 6 years (Bell 1984).

The Environmental Protection Agency says that children during the school year take almost one out of three breaths at school and fibres in low concentrations may cause disease 20 to 40 years after exposure. Study cited by the Environmental Protection Agency found that average levels of asbestos in schools were about one thousand times less than occupational control levels, but some asbestos levels measured in school buildings have exceeded the Federal workplace exposure level standards (U.S.E.P.A. 1979).

The results of a survey conducted in 1984 by the Australian Teachers Federation in Australian Government schools have shown a high level of potentially dangerous asbestos in schools, including a survey of 194 classrooms at 25 Victorian schools. The same survey estimated that more than 1300 classrooms throughout Australia contain deteriorating asbestos, and thousands of students could have been exposed to the asbestos fibres in every state of Australia except the Northern Territory. The Federation research officer, Mr Simon Margison, said the Government should resolve the asbestos problem in schools, and called for a three step programme involving:

* a national study of all schools to identify asbestos;
* an estimate of the building cost to replace the affected classrooms;
* provision by the relevant Governments of the necessary resources to remove the asbestos (*The Age*, 4 July 1984).

The school population is very active and differs from other non-occupational populations in age. If asbestos contaminates the school environment, the exposure of children and adolescents to harmful fibres in the school buildings occurs early in their life span, and their remaining life expectancy provides a long development period between first exposure and the onset of symptoms. Consequently, there are difficulties in detecting asbestos-related diseases in children. Considerable amounts of asbestos fibres might be released during normal school activities, or from damaged asbestos-containing materials as the result of students' destructive behaviour. Contamination can be very high for brief periods of time during disturbance and then gradually decreases as the fibres settle. Under these circumstances, a large proportion of the school population can be exposed at one time to asbestos, and the duration of exposure is of concern, since children attend school daily for most of the year. Fibres that have been released can remain suspended in the air for many hours. After the fibres settle, they can be resuspended in the air by a disturbance created by students or by custodial work such as dusting or sweeping. Resuspension of asbestos fibres in the air may cause repeated exposure. In summary, the building contamination with asbestos fibres involves the following mechanism:

(a) contact or impact damage of the material;
(b) fall-out of fibres from the material;
(c) the re-entrainment or redispersion of settled dust.

1.2 SOCIAL AND POLITICAL ASPECTS OF ASBESTOS EXPOSURE PROBLEMS IN AUSTRALIA

The harmful effects of asbestos dust to humans were known and well documented for many years, but the knowledge of these facts did not reach the general public for some time. Since the late 1970s there has been increasing public debate over the health risk associated with usage and wide application of asbestos-containing materials. The debate has witnessed large differences of opinion over the degree to which asbestos constitutes a health risk to workers and all others who come into contact with it. The interest and the participation of the public in the debate is evidenced by the increasing frequency of articles, letters and reports appearing in the daily press, on radio and television programmes. In further context of this section the evidence of the public and unions' concern over the use of asbestos products and consequently a presence of airborne asbestos dust in the general environment will refer to. There was no other source of information such as scientific research available except only those based on appearance in the media.

The first radio programme which initiated a series on occupational health hazards relating to work practices involving asbestos was broadcast in Australia on 18 July 1977. It was designed to increase public awareness of the dangers which are facing workers and possibly even the general public. The programmes were later transcribed into a book entitled "Asbestos-Work as a Health Hazard" and published by the Australian Broadcasting Commission. Since the series began, a number of things have changed and, no doubt, they will continue to change as public knowledge about asbestos increases. It is worth noting that this programme first brought to public attention the plight of the Aboriginal asbestos miners at Baryulgil, near Grafton. Since the mine was first opened in 1944, it has employed predominantly black labour. Some have worked regularly at the mine there for over twenty years. Aboriginal children have played in the mine tailings for years, and the dust has blown across the playground in the wind. There is a clear history of asbestos disease occurring in the general community as a result of household or neighbourhood contamination. There is also a number of cases on record of children who have played in asbestos mine tailings dying, some twenty years later, from asbestos-induced cancers (Australian Broadcasting Commission 1978). The Baryulgil mine in N.S.W. is currently the subject of an enquiry by the House of Representatives Standing Committee on Aboriginal Affairs which is investigating the effects of asbestos mining on the largely Aboriginal community of Baryulgil.

A similar problem has arisen in Western Australia, where former workers and residents of the mining town of Wittenoom in the Pilbara are demanding changes to laws governing compensation, after the discovery that dozens more people associated with the mine appear to have asbestosis. Wittenoom's asbestos mine was closed 17 years ago. Since then, an estimated 100 former residents have died from asbestos diseases (*The Australian*, 1 November 1983). Under the present laws, people seeking civil damages can make claims only within six years of the alleged damage occurring. Former workers of Wittenoom mine presently are seeking immediate action from the State Government to change the State's Limitation Act.

Following the recent attention given to the asbestos problem in the media, asbestos seems to have become a public issue. The present agitation in regard to the danger inherent in the use of asbestos seems mainly confined to its incorporation in building construction. According to information from the daily press, dozens of buildings around the country are being investigated or have had asbestos taken out. Among such building which contained or still contain harmful material are hundreds of public buildings. The removal of asbestos in buildings throughout Australia is developing recently into a million-dollar business. According to *The Mercury* (6 February 1984), the Melbourne manager of Bestobell, a company specialising in this work, said the cost of stripping a 10-storey office block could be between $200 000 and $1 000 000. The total cost of removing all asbestos from the Melbourne University Student Union building, which began on 21 May 1984, is estimated around $100 000 (Reilly 1984).

These facts create different reactions and opinions. For example, some people believe it is safer in terms of risk to leave the asbestos where it is so long as it is properly and regularly inspected. Other people are of the opinion that the hazard of asbestos in the community is overstated and that it is not cancer-producing (Reilly 1984). On the other side, Health Commission experts estimate that, in Victoria, had one person a year died from the asbestos, about 20 develop the lung lining cancer and an unknown number have the smoker's cancer. The figures for New South Wales and Western Australia, where asbestos used to be mined, could be even higher (*The Mercury*, 6 February 1984).

In Tasmania, the results of a survey done by the Builders' Labourers' Federation and Social Welfare students at the Hobart Technical College show that 22 people may be victims of asbestos disease. Representatives of 16 unions at a seminar on asbestos, which was held in Hobart on 29 October 1983, pledged to continue their fight against the use of products containing asbestos, banning of the sealing of asbestos. This meeting voted overwhelmingly for the establishment of an Asbestos Advisory Board in Tasmania.

The establishment of such a committee, which would collect and collate data on the subject, has been one of the top priorities of the unions. According to *The Mercury* (4 February 1984), the committee should consist of trade union representatives and members of Government departments, and should have a charter to establish a register of asbestos content in State Government owned, leased or occupied buildings. It should make recommendations as to priority for removal of the asbestos, monitor asbestos information, and ensure the development of guidelines for handling the substance.

The Tasmanian Government agreed to set up the Asbestos Advisory Committee, and made the decision to ban the use of asbestos from new public building projects in Tasmania, and steps have been taken to remove asbestos in exposed situations. The ban will stop the use of products such as asbestos lagging on piping, and asbestos cement sheets on Government works, but will not stop the use of asbestos in private works. Tasmania is not the first State to ban the use of asbestos. Victoria, New South Wales and South Australia have banned the use of asbestos as well (*The Mercury*, 5 January 1984).

In an article in *The Bulletin* on 8 January 1985 reports that, in 1984, the Victorian Government committed millions of dollars, under union pressure, to the removal of asbestos from public buildings. The cost of the evacuation of staff and removal of asbestos was originally estimated at $5 million, but that has been cut back to $2.25 million. Decisions regarding operations have been made following investigation carried out by an industrial scientist, Dr David Kilpatrick from the Royal Melbourne Institute of Technology in July 1984. Dr Kilpatrick, who was commissioned to investigate the Premier's Department boardroom at 1 Treasury Place to determine any hazard in locations where asbestos insulation had been used, recommended that fibre counts of asbestos in the air be carried out. He found that all floors in the building had a cement mix containing asbestos which was also used as a filling agent around hot water pipes which emerge through the floor into small heater units below the windows.

Of the 21 air tests performed by Dr Kilpatrick, only four registered fibres at or above a detectable level. The rest of the test registered at or below 0.01 fibres per millilitre. The highest reading was 0.05 fibres per millilitre. Dr Kilpatrick concluded, in his investigation, that no health risk existed to the occupants of the building, but maintenance work would provoke further disturbance of asbestos. Dr Kilpatrick's investigations provided the basis for the total removal of asbestos material from the buildings he examined.

At a meeting on 15 August 1984, where representatives from the Department of Industrial Relations and from the Occupational Health and Safety Commission attended Dr. Kilpatrick said that the fibres in his report which had registered at or above the detectable level were definitely rockwool insulation fibres and not asbestos. However, it is just as important to note that, although Dr. Kilpatrick defined the fibres in his report to the Industrial Relations and Occupational Health and Safety Commission as being rockwool fibres and claimed no real health risk existed, he promptly recommended the total removal of all material in the building that contained asbestos.

Finally, mention should be made of the opinion of one of Australia's leading authorities on occupational respiratory disorders, Professor Bryan Gandevia, who says that, in most cases, it would be better to seal asbestos in buildings than to remove it. Professor Gandevia is head of the Department of Respiratory Medicine at the Prince of Wales group of hospitals in Sydney and has acted as consultant to a number of unions and companies on asbestos and dust disease issues. Presenting a lecture in Canberra in December 1983, Professor Gandevia said that

> although each case had to be judged on its merits in terms of health risk and cost, in most cases the best solution was to seal the asbestos rather than remove it, regardless of the type of asbestos involved.

He said this particularly applied to community exposure in public buildings.

> There are occasional exceptional instances where the material should be removed, such as in circumstances where the lagging is deteriorating or where it has a high proportion of blue asbestos, and where there are really measurable dust counts,

he said. He also considered that some people may face increased health risk if the asbestos is removed rather than left in place. Gandevia said he was prepared to put his reputation on the line and say that today's recommended level of 1 fibre/millilitre chrysotile is safe in relation to asbestosis (Acme Office Service Pty. Ltd. 1984).

1.3 THE ROLE OF THE NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL OF AUSTRALIA IN RELATION TO ASBESTOS ISSUES

Although it has been suspected since the early years of this century that asbestos dust may be a health hazard, it was not until the 1940s and 1950s that there was documented evidence of the link between asbestos and various sorts of cancer. In the mid-1960s, the British Occupational Hygiene Society established a Committee to examine the asbestos problem and it proposed safety standards of 2 fibres/ml air for chrysotile. In 1969, regulations in the United Kingdom set the acceptable level of crocidolite at 0.2 fibres/ml.

During the ensuing years, a world-wide interest in the asbestos health hazard topic has developed. Public awareness of the scientific reports and the inability of experts to define a level of exposure to asbestos below which no risk could be expected has generated an increasing demand for authoritative guidance on the control of its use.

In Australia, since the early 1970s, the National Health and Medical Research Council has maintained an active interest in the health aspects of asbestos. Studying international literature and initiating research programmes, the Council has made the first recommendations for implementation by Governments. The following documents have been issued during the period from 1971 to 1978:

(a) model Asbestos Regulations (1975);

(b) membrane Filter Method for Estimating Airborne Asbestos Dust (1976);

(c) occupational Health guide on Asbestos (1970);

(d) recommended Code of Practice for Handling Consignments of Asbestos Fibres in Australian Ports and Container Terminals (1971-1978);

(e) code for the Handling of Asbestos by small users (1971-1978).

In 1978, the Chairman of the National Health and Medical Research Council approved the setting up of the Asbestos ad hoc Subcommittee. The Subcommittee's Terms of reference were to enquire into and report on risks to health caused by exposure to asbestos, products containing asbestos, and substitutes for asbestos.

The subject of Subcommittee interest was not only the occupational exposure to asbestos dust, but also the exposure of the general public from work activity and from consumer products as well. As a result of the work of the Subcommittee, the National Health and Medical Research Council endorsed the following documents.

(a) the Medical Aspects of the Effects of the Inhalation of Asbestos (1979, amended 1981);

(b) code for the Safe Removal of Asbestos-Based Thermal/Acoustic Insulating Materials (1979, amended 1981);

(c) statement on Health Hazards Associated with the use of Asbestos in the Construction Industry (1979).

The Subcommittee also initiated action for publication of Codes of Practice on the various subjects such as handling, processing and repairing of asbestos-based materials, working with fibrocement in the building industry, or involving the demolition of products using asbestos.

A very important task for the National Health and Medical Research Council is the recommendation of hygiene standards for asbestos dust exposure. The Threshold Limit Values recommended by the National Health and Medical Research Council in the 1970s were determined after consideration which included the 1968 Recommendations of the British Occupational Hygiene Society. These values were time weighted average concentrations of 2 fibres per millilitre for chrysotile and amosite and 0.1 fibre per millilitre for crocidolite. The new methods used to measure dust concentrations have increased the efficiency of estimation on which the recommendations were based. In 1981, the Subcommittee recommended new hygiene standards for the occupational exposure to asbestos dust with Threshold Limit Values:

1.0 fibres per millilitre for chrysotile and amosite;
0.1 fibres per millilitre for crocidolite.

As some authorities considered that the danger from amosite is greater than that of chrysotile, from 30 June 1984, the Threshold Limit Value for amosite was changed to 0.1 fibre/ml of air.

The Subcommittee noted also the need for research into the exposure of airborne asbestos in the general environment and recognised the need to minimise this exposure. As a result of the work of the Subcommittee, a list of Recommendations was prepared and specified in the "Report on the Health Hazards of Asbestos" published in 1982. Among the 12 Recommendations were the following:

(a) importation, mining and use of crocidolite be prohibited in Australia.

(b) statutory provision be made for the control of the demolition of, or structural alteration to, buildings or structures containing asbestos-based insulation materials.

(c) all products containing asbestos be labelled by the manufacturer or importer so as to alert the user to potential hazards.

(d) exposure to asbestos should, in all phases of the asbestos industry, be reduced to the lowest practicable level by the most efficient technology currently available (Commonwealth of Australia, National Health and Medical Research Council 1982).

In December 1983 the National Consultative Committee on Occupational Health and Safety consisting members from Federal Government, State and Territory Governments, Australian Council of Trade Unions and Confederation of Australian Industry established a working party to examine the issue. The terms of reference were:

(a) to examine the current occupational health and safety standards and guidelines on exposure to asbestos;

(b) where standards were found to be appropriate, to incorporate them in interim guidelines on handling asbestos occurrences;

(c) where deficiencies and gaps in standards and guidelines were identified, to develop interim guidelines to remedy the deficiencies; and

(d) to report to the National Consultative Committee on these matters as a matter of urgency.

National standards and guidelines developed by the working party and endorsed by the Committee have been published in 1984. The methods, procedures and work practices recommended for the identification, evaluation and control of asbestos hazards are listed in guide titled *Controlling Asbestos Hazards*, details of asbestos management are included in guide titled *Asbestos Management*.

1.4 AIMS OF THE THESIS

In general, it has been recognised without any doubts that the inhalation of excessive amounts of asbestos dust by the occupational group of workers handling raw asbestos constitutes a health hazard. An open question still exists whether the contamination of air by some amounts of asbestos fibres from building products, insulation, brake linings, or other sources is hazardous in regard to the health of the general population. In any case, public concern is of such proportions that every precaution needs to be taken in respect of asbestos under all conditions in which it is used or is in continuing use as a result of past applications. In this respect, it is important to be well informed about the scientific basis for medical caution. Accordingly, this thesis will review the health aspects of asbestos (Chapter 2) as a basis for pursuing an investigation into the occurrence of asbestos materials in Hobart schools to evaluate the extent to which airborne asbestos levels may constitute a health hazard for school populations.

The remainder of the thesis will be devoted to this investigation. In 1984, a survey conducted by the Australian Teachers' Federation investigated 40% of government schools in Tasmania. This showed 6.8% of these schools had classrooms in which asbestos-bearing materials were present in a deteriorating condition (*The Mercury*, 4 July 1984). So far, no detailed studies have been conducted to determine the hazard to health this situation may pose to children in Tasmanian schools. Hence, the aim of this study's investigation was to identify the extent to which asbestos-containing materials have been used in Hobart schools and to determine the levels of airborne asbestos present. As a comparison, airborne asbestos levels were tested in a multi-storey city car park, a location which, from other studies, could be likely to give positive asbestos readings. It was suspected, and later confirmed, that the methodology of air sampling and techniques for laboratory identification of asbestos fibres would form an important part of this study.

The concluding chapter presents the assessment of the health risk from exposure to asbestos in schools in the Hobart area as a result of these findings. The results involve a discussion of the accuracy of conclusions made about the levels of asbestos contamination of buildings when these techniques have been used to assess the pollution problem.

2. HEALTH ASPECTS OF ASBESTOS

2.1 INTRODUCTION

This chapter reviews the available literature in an attempt to indicate the general way in which asbestos is used in modern society, the different types of asbestos minerals, and the health hazards associated with the common use of those asbestos minerals.

Interest in the effects of asbestos on human health has risen dramatically over the last decade and Ross (1981) has given a detailed summary of the findings of recent research. Zielhuis (1977) published an in-depth report of the public health risk of asbestos for the Commission of the European Communities. The gravity of the situation and the importance of finding a proper solution to the asbestos problem were underlined by the Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario (1984). The most recent findings of the medical effects of asbestos are summarised by Doll and Peto (1985). These, and other major studies, are reviewed. In addition, data collected from the Australian Bureau of Statistics and from Barnes (1983) have been used by Jackiewicz (1984) to discuss the occurrence of asbestos-related diseases in the Australian context and this study is discussed at length. Finally, the role of the National Health and Medical Council of Australia is discussed with respect to:

(a) the inducement of public awareness of asbestos health hazards by publication of the results of scientific and medical research;

(b) the implementation of a proper Code of Practice for various subjects concerning asbestos and its products;

(c) the establishment of an appropriate set of safety standards for asbestos dust exposure.

2.2 GENERAL DESCRIPTION AND USES OF ASBESTOS

Asbestos is one of the most desirable industrial minerals. It possesses an unusual combination of exploitable properties, such as long fibrous shape, high tensile strength, and flexibility. At first, asbestos was the name of the mineral. Now it is a commercial term applied to fibrous materials used in industrial processes. The proper mineralogical term, "asbestiform habit", specifies a unique crystallization habit. When minerals crystallize in this habit, they attain some or all of the industrially required properties of asbestos. There are not many minerals known to crystallize in such a habit in large quantities and possess all the properties of the commercial asbestos. There is a substantial number of other minerals, which may crystallize in the asbestiform habit and have all properties of commercial asbestos, but these minerals are not available in sufficient quantity for industrial exploitation.

The terms, "fibrous" and "asbestiform" are not synonymous. For example, a mineral is said to have crystallized with a fibrous habit if it gives the appearance of being composed of fibres, whether the mineral actually contains separable fibres or not. The term asbestiform, on the other hand, is more restricted: the mineral must resemble asbestos. Even if this resemblance was limited to visual observation in the past, it suggested the presence of asbestos properties by the fact that the characteristic appearance of asbestos is a consequence of its special and unique properties which are:

(a) hair-like elongated shape resembling organic fibres. Their cross sections may be polygonal, circular, or irregular, and the faces are very smooth and display unusual hardness or silky brightness;

(b) greater strength, more flexibility, and more durability than the same mineral crystallized in other habits. The development of these physical properties is gradational, and they are well represented in high quality commercial asbestos. The strength of well-developed asbestiform fibres may be up to 50 times higher than that of single crystals of the same minerals (Zoltai 1981);

(c) a habit of crystallizing in bundles of easily separable fibres which are composed of a very small diameter units called fibrils.

Asbestiform fibres of various qualities may occur in different habits of crystal aggregation. The columnar habit is the most common. Most of commercial asbestos crystallizes in columnar sets. Fibres are arranged in parallel columnar sets in veins of differing widths. Fibres perpendicular to the wall are called cross fibres, inclined fibres are described as slip fibres.

There are a number of types of asbestos, each with its own characteristic properties and uses. The term asbestos is a commercial one and applies to a number of silicates of iron, magnesium, calcium, sodium, and others. Generally, asbestos ores have been classified into two broad groups:

(1) SERPENTINE GROUP - CHRYSOTILE White Asbestos
Mg_3
$(Si_2O_5)\ (OH)_4$

(2) AMPHIBOLE GROUP - There are five asbestiform Amphiboles:

AMOSITE Grey Brown Asbestos
$(Fe,Mg)_7$
$(Si_8O_{22})\ (OH)_2$

CROCIDOLITE Blue Asbestos
$Na_2FeII_3FeIII_2$
$(Si_8O_{22})\ (OH)_2$

ANTHOPHYLLITE White Asbestos
$(Mg,Fe)_7$
$(Si_8O_{22})\ (OH)_2$

TREMOLITE White Asbestos
Ca_2Mg_5
$(Si_8O_{22})\ (OH)_2$

ACTINOLITE White Asbestos
$Ca_2(Mg,Fe)_5$
$(Si_8O_{22})\ (OH)_2$

The last three of the Amphibole Group (Anthophyllite, Tremolite, Actinolite) are of much less commercial importance than the others.

Of all the types of asbestos, chrysotile is most widely used and accounts for 95 per cent of world's annual production. The remaining 5 per cent is shared equally by amosite and crocidolite. The other two amphiboles, anthophyllite and tremolite, are of very little use. Each of these types of asbestos minerals possesses distinguishing properties and characteristics. Chrysotile, having a high magnesium content, is characterised by relatively long white flexible and silky fibres of not less than 0.03 mm in diameter. Its resistance to alkaline attack is very high. Length of fibres and their softness are extremely useful properties in production of asbestos cloth and tape. Fibres of other types of asbestos, like amosite and crocidolite of high iron content, have a harsh, spiky texture, and a diameter not smaller than 0.1 mm. The fibres are also very long and occur in thick bands or seams up to 30 cm wide. The chemical composition and characteristics of the main types of asbestos are given in Table 2.1.

Asbestos is used in many products which find applications in industries involved in building construction, engineering, and ship building. In addition to these main applications, there are many other uses. It has been estimated that asbestos is used in over 3000 products.

Figure 2.1 provides a schematised picture of asbestos applications incorporated in EEC* countries. The various products are listed in three main groups:

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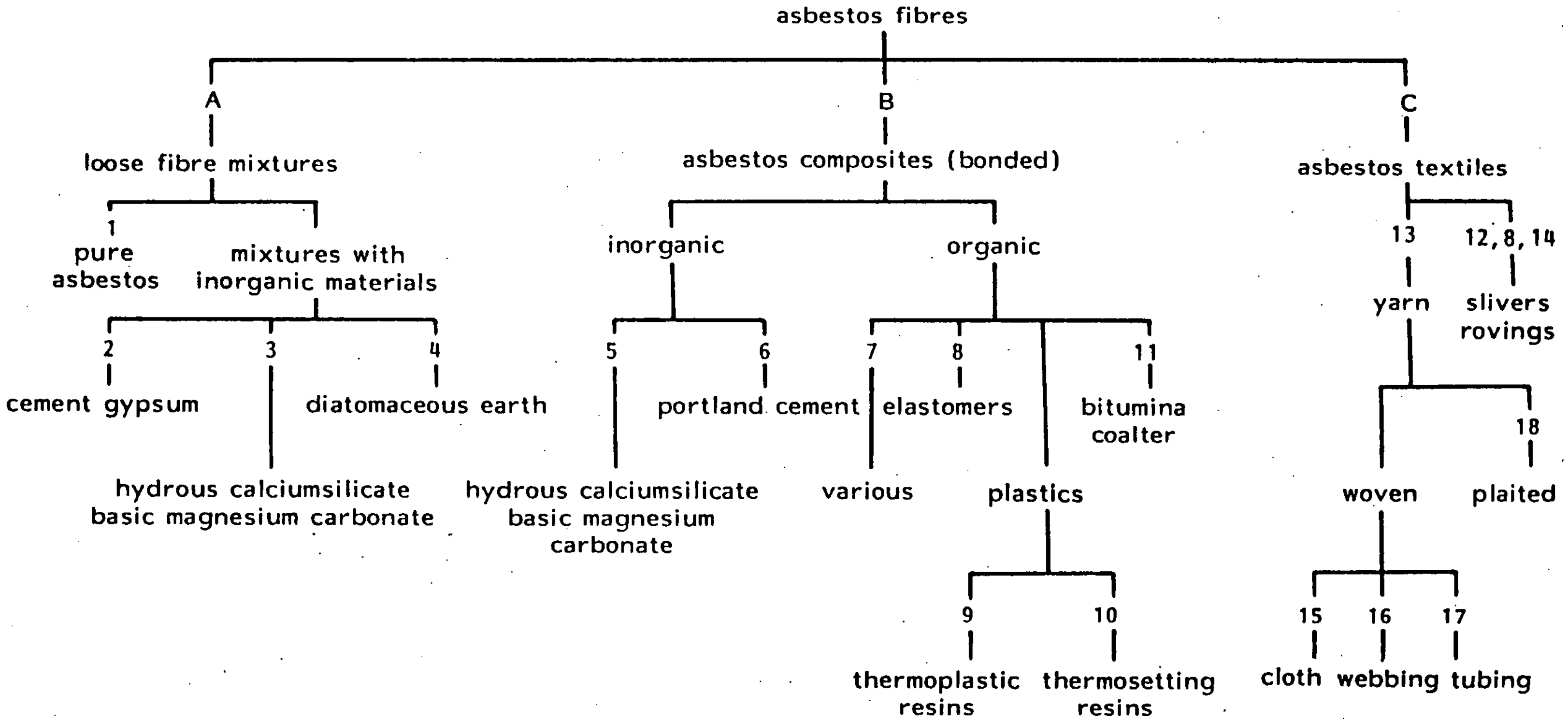
* European Economic Community

TABLE 2.1 Characteristics of the Main Types of Asbestos Fibre
(From Zielhuis 1977, page 23)

Characteristic	Chrysotile	Crocidolite	Amosite	Anthophyllite	Tremolite	Actinolite
Theoretical Formula	$Mg_3(Si_2O_5)(OH)_4$	$Na_2FeII_3FeIII_2(Si_8O_{22})(OH)_2$	$(Fe,Mg)_7(Si_8O_{22})(OH)_2$	$(Mg,Fe)_7(Si_8O_{22})(OH)_2$	$CaMg_5(Si_8O_{22})(OH)_2$	$Ca_2(Mg,Fe)_5(Si_8O_{22})(OH)_{22}$
Chemical Analysis (range of major constituents - per cent)						
SiO_2	38-42	49-56	49-52	53-60	55-60	51-56
Al_2O_3	(0-2)*	(0-1)	(0-1)	(0-3)	(0-3)	(0-3)
Fe_2O_3	(0-5)	13-18	(0-5)	(0-5)	(0-5)	(0-5)
FeO	(0-3)	3-21	35-40	3-20	(0-5)	5-15
MgO	38-42	(0-13)	5-7	17-31	20-25	12-20
CaO	(0-2)	(0-2)	(0-2)	(0-3)	10-15	10-13
Na_2O	(0-1)	4-8	(0-1)	(0-1)	(0-2)	(0-2)
H_2O+	11.5-13	1.7-2.8	1.8-2.4	1.5-3.0	1.5-2.5	1.8-2.3
* Bracketed figures denote substituents often present in asbestos						
Colour	Usually white to pale green yellow[1], pink[1]	Blue	Light grey to pale brown	White to grey pale brown	White to grey	Pale to dark green
Decomposition temperature* (°C)	450-700	400-600	600-800	600-850	950-1040	620-960
Fusion temperature of residual material (°C)	1500	1200	1400	1450	1315	1400
Density g/cm^3	2.55	3.3-3.4	3.4-3.5	2.85-3.1	2.9-3.1	3.0-3.2
Resistance to acids	Undergoes fairly rapid attack	Good	Attacked slowly	Very good	Very good	Attacked slowly
Resistance to alkalis	Very good	Good	Good	Very good	Good	Good
Mechanical properties of fibre as taken from rock samples:						
Tensile strength $10^3 kg/cm^2$	31	35	17	(<7)	5	5
(Average) (10^3 psi)	(440)	(495)	(250)	(<100)	(<70)	(<70)
Young's Modulus $10^3 kg/cm^2$	1.620	1.860	1.620	-	-	-
(Average) (10^4 psi)	(23)	(27)	(23)			
Texture	Usually Flexible, silky and tough	Flexible to brittle and tough	Usually brittle	Usually brittle	Usually brittle	
Producing countries	USSR Canada China Rhodesia USA Italy South Africa Swaziland	South Africa	South Africa	Finland USA Mozambique	USA Italy	

Notes: * Dehydroxylation or dehydrogenation accompanied by disruption of cyrstal lattice and major loss of strength.
[1] From serpentinised dolom to deposits.

FIGURE 2.1 Applications of Asbestos Fibres
(From Zielhuis 1977, page 26)



A - loose fibre mixtures
B - bonded asbestos composites
C - asbestos textiles.

The asbestos products in group A are not end products but are generally used in conjunction with water as insulating plasters, cement, or spray mixtures.

The largest use of asbestos fibre applies to the manufacture of composites (group B). Asbestos-cement constitutes by far the largest component of this group. Other important products are friction materials, insulation boards, jointing, millboard, and paper, reinforced plastics, and vinyl tiles and sheets. Asbestos can be spun into yarn and woven into cloth. The resulting textile products (group C) may be used for further processing into friction materials, packing, and laminates or directly applied on insulation covering, protective clothing, fire protection materials and electrical insulation.

Table 2.2 provides a list of the most important asbestos products and their approximate fibre contents. The references in the right-hand column relate to Figure 2.1.

In Australia, building and construction materials represent the major part of asbestos containing products. Availability and low price made the use of these products very attractive for many years. The discovery of the harmful and deadly characteristics of asbestos for human health influenced drastically its application. The use and production of asbestos products then declined very rapidly, except for asbestos cement pipes used for water supply and sewage conduits. However, because of the wide-spread use of asbestos in building and construction materials in the 1970s and earlier, a legacy of buildings containing asbestos materials is in place in all industrial countries. At present, only two types of asbestos are used in Australia: chrysotile (approximately 85 per cent) and amosite (15 per cent). The most dangerous one, crocidolite (blue asbestos), has been used in the past and may be found in some products and buildings.

TABLE 2.2 Asbestos Products and Asbestos Contents
(From Zielhuis 1977, page 27)

	Approx. asbestos content % (wt)	Asbestos fibre type	Ref. Figure 1
1. Asbestos-cement building products	10-15	C A (Cr)	B6
2. Asbestos-cement pressure, sewage and drainage pipes	12-15	C (Cr) A	B6
3. Fire-resistant insulation boards	25-40	A C	B6,B5
4. Insulation products including spray	12-100	A C (Cr)	A1,A2, A3,A4, B5
5. Jointings and packings	25-85	C (Cr)	B8,C18
6. Friction materials	15-70	C	B10
7. Textile products not included in (6)	65-100	C (Cr)	C
8. Floor tiles and sheets	5-7.5	C	B9
9. Moulded plastics and battery boxes	55-70	C (Cr)	B9,B10
10. Fillers and reinforcements and products made thereof (felts, millboard, paper, filter pads for wines and beers, underseals, mastics, adhesives, coatings, etc.)	25-98	C (Cr)	B7,B11

Explanation of asbestos fibre types:

A = Amosite

C = Chrysotile

Cr = Crocidolite

(Cr) = not used in all EEC countries

Note: (Cr) denotes the usage of crocidolite fibre in manufacturing in all EEC countries except U.K. and Ireland.

In the developing countries, the use of asbestos products like sheeting, roofing, and piping has started to grow. Ease of use, cheapness, and availability of raw materials has prevailed over the health risk according to Venkataraman (India) and Ushewokunze (Zimbabwe) at the World Symposium on Asbestos in 1982 (Canadian Asbestos Information Centre 1982).

2.3 HEALTH HAZARDS ASSOCIATED WITH ASBESTOS AND THE PATHOGENESIS OF ASBESTOS-RELATED DISEASES

During the last century, with the development of modern industry, the use of asbestos started to grow very rapidly. Wide application of asbestos fibre has found its way into the construction and manufacturing industries which have produced thousands of end products containing asbestos.

Consequently, in the process of mining, milling, handling, construction and manufacturing of asbestos, more and more workers became exposed to asbestos dust. Those most affected were trade workers directly exposed to asbestos dust and their families via contaminated clothing brought home. But, the presence of asbestos in building materials, paints, friction materials, sealing compounds, sprays, and many others, has also exposed the general public to the effects of asbestos.

Uptake of asbestos fibres in the human body has two pathways: the respiratory tract and the digestive tract. The degree of harm caused by asbestos dust will depend on

(a) particle size (the smaller the size of the particles, the further into the lungs they reach);

(b) the nature and chemical composition of the particles;

(c) the quantity and concentration of the particles;

(d) the time a worker spends in a contaminated environment (in most cases, the time that workers are exposed to dust plays a big role; the longer the exposure, the bigger the risk).

The hazard potential of asbestos depends on the fibre shape and size. Asbestos particles resemble sharp barbs. Fibre diameter and length determine the degree to which asbestos fibres are hazardous. Fibres with dimensions of less than 5 microns in diameter and less than 100 microns in length are thought to constitute a hazard. Doll and Peto (1985) consider that the most lethal asbestos fibre dimensions are those of between 5 and 100 microns in length and diameters less than 2.0 - 1.5 microns.

Generally, the asbestos fibres enter the human body through the respiratory tract. To prevent the entry of dust particles to the lungs, the human air passages are equipped with a defence mechanism as described by Ross (1981).

> The airways of the lung form the bronchial tree, which is subdivided into the main stem and then into 22 additional branchings. The first several branchings constitute the bronchi, the last several the bronchioles. The terminal bronchioles lead to the respiratory bronchioles, which are lined with alveoli; the latter constitute the lower respiratory tract. Most particles which enter the upper respiratory tract (the main stem, bronchi, and bronchioles) are quickly and effectively removed by the mucocilliary escalator; this is a system of mucous membranes and cilia lining the airways of the upper respiratory tract, which moves foreign particles upward to the pharyngx, where they are unconsciously swallowed or spit (sic) out.

According to Ross, this mechanism works very efficiently for particles larger than 5 microns in diameter and longer than 200 microns in length. Particles with diameters smaller than 5 microns can penetrate to the bronchioles and even to the alveolar sacs, the critical gas exchange portions of the lung.

The ability of the body to eliminate asbestos dust which has entered the respiratory tract is limited because asbestos fibres tend to split up easily into numerous fibres of relatively great length and very small diameters, particularly in the case of amphibole fibres and short chrysotile fibres. These may reach the pleura, passing through the lung tissue in a mechanical way. It has been established that, in these circumstances, asbestos fibres may be found in the lymph nodes and spleen (Zielhuis 1977). A second lung clearance mechanism operates in the lower respiratory tract. Here, pulmonary macrophages engulf the foreign particles (phagocytosis) and then either

(a) move to the upper respiratory tract, where the mucocilliary escalator is operative, or

(b) penetrate the alveolar wall into the interstitium and eventually to the lymph channels (Ross 1981).

The uptake of asbestos fibre via the digestive tract can be either direct or indirect. Direct ingestion of fibres occurs through the mouth. It takes place in eating and drinking or from smoking in asbestos contaminated ambient air. It occurs in unhygienic conditions for hands and clothing and from swallowing of asbestos fibres trapped in the nose and mouth from a contaminated respiratory air tract.

Indirect ingestion occurs when sputum, produced in the normal physiological processes from the lower lung respiratory tract, is swallowed regularly. After exposure to asbestos-containing ambient air, a multitude of asbestos fibres will be found in the sputum. In this way, ingested asbestos fibres will penetrate the intestinal walls and find their way into various organs such as the spleen, liver, kidneys, lungs, brain, lymph nodes, and even blood (Zielhuis 1977).

Although the human body possesses a defensive system against infiltration of dangerous dust particles, some asbestos fibres will find their way into the lungs through the respiratory system. As stated above, that process depends on the type and size of the fibres. The danger lies in the indestructibility of asbestos fibres which lodge themselves in lungs or other organs. The body's biological defences are not able to decompose asbestos readily. Asbestos fibres penetrate the air sacs and stay there, virtually for life. Consequently, a number of specific diseases associated directly with the uptake of asbestos fibres have developed.

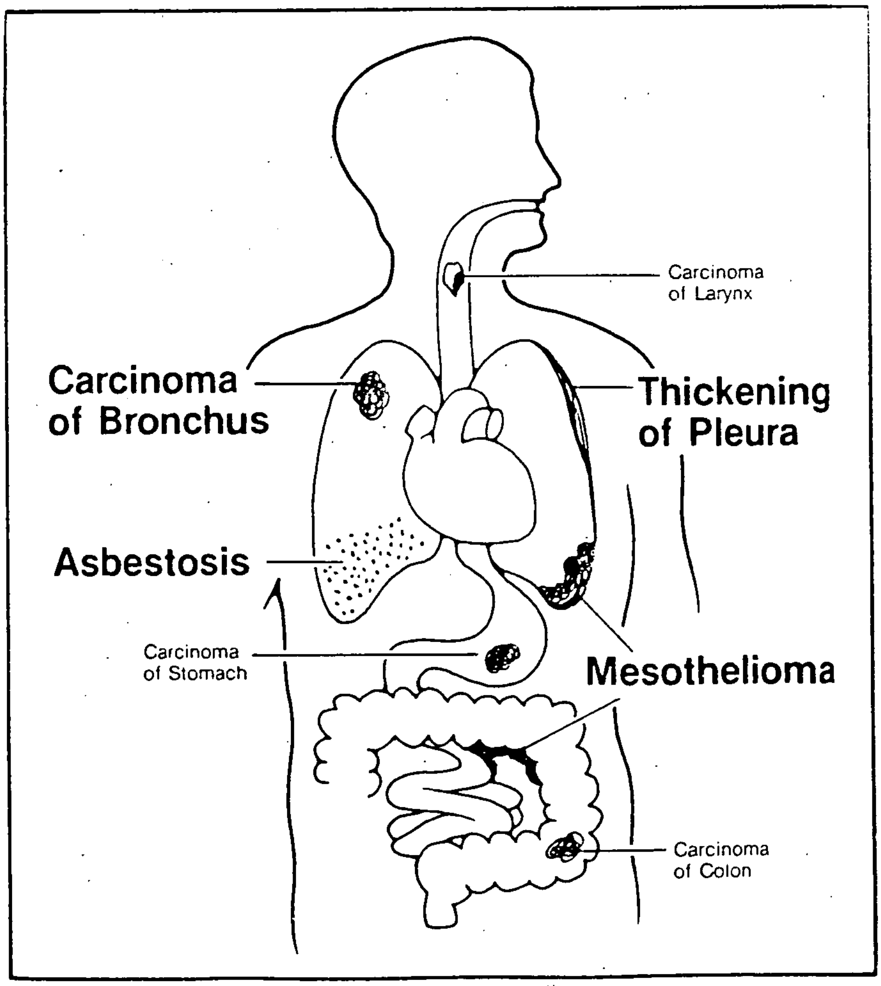
There are three principal diseases which are related to the exposure of one or more of the commercial asbestos minerals (Figure 2.2). These are:

(a) Asbestosis: a diffuse interstitial fibrosis of the lung tissue often leading, after long exposure, to severe loss of lung function and respiratory failure.

(b) Lung Cancer: includes cancer of the trachea, bronchus, and lung proper.

(c) Mesothelioma: a cancer of the pleural and peritoneal membranes which develop in the tissues of the lung and abdominal cavities respectively.

FIGURE 2.2 Principal Asbestos-Related Diseases and Conditions and Their Sites in the Human Body
(From Ontario, Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario 1984, page 95)



Asbestosis

Asbestosis is a chronic, restrictive lung disease. The sickness is defined as a diffuse interstitial fibrosis of the lung, which results from exposure to asbestos dust and loose asbestos fibres inhaled in the process of breathing. The fibrosis itself is the formation of fibrous or scar tissue at the lower lobes of the lungs, usually as a reparative or reactive action by macrophages against asbestos fibres. The disease causes a progressive incapacity to saturate tissues with oxygen, the passage of this gas from respiratory air to the blood being blocked by a fibrotic thickening of alveolar walls. Asbestosis may develop from exposure to all types of asbestos regardless of the dimensions of the inhaled fibres, the longer fibres seeming to be the more dangerous.

The first symptoms are breathlessness and a cough, with sharp transient pains in the chest; the second stage is characterised by the presence of high-pitched fine crepitations (crackles), especially after coughing. Asbestosis, being manifest, will progress whether the patient continues to be exposed or not. It is difficult to diagnose the disease in early stages as there is no sharp point in the development of signs and symptoms at which a change of state from healthy to diseased has occurred. The severity of asbestosis depends both on the amount of asbestos to which the individual has been exposed and the length of time since exposure first began. Asbestos fibres can remain in the lungs for long periods and the fibrosis, that results from their presence, continues to develop for many years after exposure stops. The disease can become seriously disabling. Asbestosis is, therefore, more often a cause of morbidity among asbestos workers affected than it is a cause of mortality. Consequently, those with asbestosis are susceptible to death from related causes, often infection or cardio-respiratory complications. The mortality rate caused by asbestosis becomes significant 15 to 20 years after first exposure and apparently reaches its peak at 40 to 45 years after first exposure.

There is no effective treatment for asbestosis itself. The disease is irreversible. However, the physician's improved ability to treat some of the symptoms and secondary effects of the fibrosis has made the life of patients suffering from asbestosis more bearable.

Present-day medical therapy now makes it possible to give the asbestotic some relief from the discomfort associated with complications arising from asbestosis (Ontario, Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario 1984).

Most affected by this disease were workers employed in the asbestos textile industry, asbestos insulation industry (at ship building) and workers engaged in protective asbestos spraying. The incidence of asbestosis can be reduced quite drastically or even eliminated by taking appropriate precautions against exposure to asbestos. In one case, an asbestos factory in Rochdale, England, precautionary measures have been shown to be effective in eliminating asbestosis. No deaths from asbestosis were recorded in factory workers first employed after 1950 (Doll and Peto 1985).

A disease, which may occur alone or with asbestosis, is known as pleural plaques. Patches of thickening may appear on the lining of the chest wall and over the diaphragm in the pleural membrane that lines the chest. Similarly, patches may occur over the pericardium, where this membrane lies between the lungs. Plaques may appear in the absence of any other chest disease resulting from asbestos inhalation and have minimal effect on lung function; also, the disease is not malignant. In some cases, the salts of calcium may form in the plaques, which makes them appear striking on chest X-rays. The plaques may never be discovered in life, and may not affect general health in any way.

Lung Cancer

Lung cancer is a term which includes cancers of both bronchial tubes and the alveoli, but not the pleura. While the medical profession has been familiar with the causes and symptoms of asbestosis for a number of decades, the acknowledgement that lung cancer could be caused by asbestos came much later. In 1955, after many years of observations and studies, the risk for workers employed in the asbestos textile industry was firmly established (International Safety and Health Information Centre

1978). It was also established that all types of asbestos are harmful, but that the quantity of asbestos inhaled and the years of exposure were dominant factors. Usually, the development of disease (the so-called lag period) takes approximately 25 years from the first encounter with asbestos to the discovery of the malignant cancerous tumour and subsequent death. The development of lung cancer is directly related to the degree and period of exposure. Therefore, more people with asbestosis will develop lung cancer, than those asbestos workers with insufficient exposure to induce the scar tissue formation in their lungs.

The mechanisms by which carcinogenesis develops are not, as yet, clearly known. In many cancers, it is thought that the disease may be induced by DNA damage and consequent cell transformation. While it is not certain whether asbestos-induced cancers develop in this way, there is strong evidence to suggest that the presence of asbestos accelerates the multiplication of malignant cell and the spread of cancer (Ontario, Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario 1984).

It has also been suggested that the presence of asbestos in conjunction with cigarette smoking promotes this process even more rapidly. An explanation for the increased numbers of cancers in asbestos workers who smoke has been well documented by Doll and Peto (1985) and in the Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario (1984). Studies have discovered that cigarette smoking-workers in asbestos factories were more prone to the disease than non-smokers and as a consequence of a very strong interaction between those smoking and asbestos inhalation. This conclusion, drawn from various independent studies supported by experimental evidence, suggests that asbestos particle clearance in smokers is considerably lower than non-smokers. This suggests that smoking may impair the clearance of asbestos fibres from the lung. The chronic smoking over a period of time will initiate a process that results in the death of the ciliated cells, thereby reducing the effectiveness of the important clearance mechanisms in the lung. Accordingly, it is also suggested that cigarette smoke would interfere with the other main defence against asbestos fibres, the macrophages. As cigarette smoke is also a material foreign to the body, the same macrophages used to clear asbestos fibres will be required to clear cigarette smoke.

Mesothelioma

This term is used to describe diffuse cancers spreading over the outer covering of the lung (the pleura) and on the lining of abdominal organs (peritoneum). The cancer-affected pleura, which is normally very thin, becomes markedly thickened when mesothelioma occurs. This tumour, which may eventually enclose the lung totally, thickens the pleura with malignant growth, which could be several centimetres thick. Mesothelioma of the pleura causes effusion with rapidly increasing breathlessness and chest pain. When the peritoneum is involved, pain, ascites and symptoms of obstruction occur. Almost all diffuse mesothelial tumours show evidence of malignancy by direct and rapid infiltration of adjacent tissues and organs.

The carcinogenesis of mesothelioma of pleura and peritoneum is similar to all asbestos-induced cancers as earlier mentioned at description of lung cancer. It is suggested that inhaled asbestos fibres which are not removed by the defensive mechanisms will reach pleura or peritoneum via three different ways:

(a) by lymphatic transport within macrophages

(b) or by the direct penetration of free fibres

(c) or through the bloodstream.

Once deposited in the pleura, some of the fibres are able to cause the development of peritoneal mesothelioma. There is no effective treatment for mesothelioma. A large proportion of mesothelioma patients die within a year of diagnosis, and few survive longer than five years (Ontario, Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario 1984). Mesothelioma like the other asbestos-related diseases, is a disease for which the prevention is far more effective than the cure.

The incidence of mesothelioma has been extremely high among three occupational groups exposed to asbestos: insulators, workers in asbestos plants, and shipyards. Cases of mesothelioma have been also occurring among persons living in the same household as asbestos worker, or among persons living close to asbestos mining or manufacturing activities.

The interval between the initial exposure to the asbestos dust and the development of the tumours is rarely less than 20 years and averages about 40 years. Increasing exposure increases the risk of developing the disease, but not increase the length of the induction period (Doll and Peto 1985).

The first observed associations between asbestos and the occurrence of mesothelioma were published in the 1950s (Zielhuis 1977). The association of occupational and neighbourhood exposure between this deadly disease and asbestos dust was soon established. Studies in South Africa (International Safety and Health Information Centre 1978) and England (Ross 1981) confirmed that the most dangerous type of asbestos involved were those of crocidolite followed by the less potent amosite, chrysotile, tremolite, and finally, anthophyllite, in descending order of danger.

Other Asbestos-Related Cancers

Firm evidence has proved beyond any doubt that asbestos causes all of the abovementioned diseases. The position with other types of cancer is different. Some researchers suspect that asbestos might cause gastro-intestinal cancers (esophagus, stomach, colon, and rectum), and several other types of neoplastic disease, including laryngeal, renal and ovarian cancers. However, the interpretation of available evidence is not convincing and leads to different conclusions (Doll and Peto 1985). Future studies, utilizing greater data sources are necessary in order to make possible definitive results concerning the relation between asbestos and these diseases.

2.4 MEDICAL STATISTICS OF ASBESTOS RELATED ILLNESS AND DEATH IN AUSTRALIA

Asbestos use in Australia has also produced deadly health hazards to workers exposed to asbestos fibres. As a consequence, a number of workers have been affected by asbestos-related diseases with fatal results. Unfortunately, the available data to the year 1980 are very limited. The data available from the Australian Bureau of Statistics were used for composition of Table 2.3 showing the total asbestosis mortality for 19 years from 1962 to 1981. From this table, it can be noted that the years 1980 and 1981 brought a substantial increase in the number of deaths caused by asbestosis.

Table 2.4 shows asbestosis mortality for the years 1980 and 1981 with age groupings every 5 years (from 45 years when the first case of death occurred) to 85 and over. The age groups mostly affected are between 55 to 74 years representing some 66.7 per cent of all cases. This is logical, as the dormant period for development of asbestosis could vary from 20 to 25 years or more.

Table 2.5 illustrates mesothelioma mortality for the years 1980 and 1981 with age and sex grouping every 5 years to 85 and over. The very first case of death occurred in the age group 25-29 years. Similarly, as with asbestosis, the most affected age group begins at 50 and drops out at 74. These groups represent 75.01 per cent of all recorded deaths.

The data for the carcinoma of the lung are not available, as all malignant cases of trachea, bronchus, and lung are grouped together under one category 162 of the International Classification of Diseases and Causes of Deaths.

A very interesting study regarding asbestos-related diseases and their distribution affecting workers of the different trades is reported by Barnes (1983) in *The Medical Journal of Australia*. The study is of 197 workers who have been recognised by the Workers' Compensation Board of New South Wales as having died from asbestosis or an asbestos-associated disease between February, 1968 and 31 December, 1983. Of these 197 deaths, 29 have been from asbestosis, 67 from bronchogenic carcinoma, and 101 from malignant mesothelioma of the pleura or peritoneum.

The types of work performed by these workers are shown in Table 2.6. The majority of the workers were employed in the asbestos-products industry. Asbestos laggers and sprayers were the most commonly affected, followed by powerhouse workers, boilermakers, welders, and carpenters. Table 2.7 shows the average age of death, mean length of asbestos exposure, and length of latent period in relation to each disease. The average survival times from diagnosis for the three conditions are shown in Table 2.8. Barnes' opinion is that both bronchogenic carcinoma and malignant mesothelioma would be expected to be diagnosed reasonably

TABLE 2.3 Asbestosis Mortality in Australia from 1962 to 1981
(Source: Australian Bureau of Statistics)

Year	Number of Deaths			Remarks
	Male	Female	Total	
1962			8	See Note [a]
1963			9	"
1964			10	"
1965			8	"
1966			11	"
1967			9	"
1968			4	"
1969			2	"
1970			6	"
1971			2	"
1972			5	"
1973			6	"
1974			10	"
1975			3	"
1976			4	"
1977			6	"
1978			7	"
1979			9	"
1980	14	-	14	For age group division
1981	12	1	13	See Table 2.4
TOTAL			145	

[a] No information available regarding age group, division, and sex.

TABLE 2.4 Asbestosis Mortality in Australia for Two Years (1980 and 1981)
(Source: Australian Bureau of Statistics)

Age Group Years	Year 1980		Year 1981		Total	
	Number of Deaths	Per cent	Number of Deaths	Per cent	Number	Percent
45-49	1	7.14	1	7.69	2	7.41
50-54	3	21.43	-		3	11.11
55-59	5	35.71	-		5	18.52
60-64	2	14.29	3	23.08	5	18.52
65-69	2	14.29	2	15.38	4	14.81
70-74	1	7.14	3	23.08	4	14.81
75-79	-	-	2	15.38	2	7.41
80-85	-	-	-	-	-	-
85 & over	-	-	2	15.38	2	7.41
TOTAL	14		13		27	100.00

TABLE 2.5 Mesothelioma Mortality in Australia for Two Years (1980 and 1981) by Age Group Division and Sex (Source: Australian Bureau of Statistics)

Age Group (Years)	Year 1980				Year 1981				Total			
	Number of Deaths		Total	Per Cent	Number of Deaths		Total	Per Cent	Number of Deaths		Total	Per Cent
	M	F			M	F			M	F		
25-29	–	–	–	–	–	1	1	2.17	–	1	1	1.04
30-34	–	1	1	2	–	1	1	2.17	–	2	2	2.08
35-39	1	–	1	2	1	–	1	2.17	2	1	2	2.08
40-44	1	–	1	2	–	2	2	4.35	1	2	3	3.12
45-49	3	–	3	6	3	–	3	6.52	6	–	6	6.25
50-54	6	1	7	14	2	1	3	6.52	8	2	10	10.42
55-59	10	–	10	20	4	1	5	10.87	14	1	15	15.63
60-64	6	1	7	14	7	1	8	17.40	13	2	15	15.63
65-69	8	–	8	16	9	1	10	21.75	17	1	18	18.75
70-74	5	3	8	16	4	2	6	13.04	9	4	14	14.58
75-79	1	–	1	2	2	1	3	6.52	3	1	4	4.17
80-84	1	–	1	2	3	–	3	6.52	4	–	4	4.17
85 & over	–	2	2	4	–	–	–	–	–	2	2	2.08
TOTAL	42	8	50		35	11	46		77	19	96	

TABLE 2.6 Type of Work Performed and Causes of Death
(From Barnes 1983, page 222)

Disease	Number of Deaths									
	Asbestos products	Lagger and sprayer	Power house	Boiler-maker	Carpenter	Welder	Miner	Wharf Labourer	Other	Total
Asbestosis	13	10	1	3	-	-	1	-	1	29
Bronchogenic carcinoma	34	6	11	-	-	-	-	5	11	67
Mesothelioma	22	30	3	6	9	5	2	4	20	101
TOTAL	69	46	15	9	9	5	3	9	32	197

TABLE 2.7 Average Age at Death, Latent Period, and Mean Length of Asbestos Exposure
(From Barnes 1983, page 222)

	Age at death (years)	Exposure (years)	Latent period (years)
Asbestos	63	19	31
	(46-81)	(2-35)	(17-59)
Bronchogenic carcinoma	60	21	30
	(43-80)	(6-50)	(7.51)
Mesothelioma	60	21	33
	(41-80)	(0.8-52)	(11-55)

promptly, while a worker with asbestosis may have already advanced disease before the condition is recognized. Therefore, the survival from the development of asbestosis to death could be longer than the average of 7.3 years shown in Table 2.8.

Now, when comparing the proportional representation of the total deaths caused by asbestosis and mesothelioma in Table 2.4 and Table 2.5 against Table 2.6, the results are very close. Table 2.4 shows 27 cases of asbestosis against 96 cases of mesothelioma in Table 2.5. In Table 2.6 there are 29 cases of asbestosis against 101 of mesothelioma. Both proportions are very similar, and typical for Australia only.

TABLE 2.8 Average Survival Times
(From Barnes 1983, page 223)

Disease	Average age at diagnosis (years)	Average age at death (years)	Life expectancy (years)
Asbestosis	55	63	7.3
Bronchogenic carcinoma	58.2	60	1.8
Mesothelioma	59.3	60	0.7

3. SCHOOLS SURVEY IN HOBART

3.1 METHODOLOGY OF THE SURVEY

In order to determine a presence of asbestos or asbestos-containing materials in Hobart schools, as well as to assess the potential exposure to asbestos, a school survey in various suburbs of Hobart was carried out. The programme began with seeking permission from the Minister for Education, Mr. Beswick, to conduct an inspection of school buildings for the survey. A positive reply was received regarding a survey and a sample collection. As a consequence, before the school survey was commenced, the following general preparations were made.

1. A list of Public Schools in the Hobart area was obtained and a detailed weekly timetable of schools to be surveyed was worked out.

2. An introductory letter to the principals and staff of schools to be included in the survey was sent explaining the reasons for and the aims of the survey.

3. To determine the factors that might influence the concentration of asbestos dust produced inside school buildings, a standardized questionnaire was prepared for collection of technical information regarding:

   (a) the type of building
   (b) the construction details
   (c) the ventilation system
   (d) the heating system
   (e) the configuration and extent of insulation coating within the building
   (f) the accessibility, friability, and condition of materials.

To assist in the collection of this information, schools surveyed were also supplied with:

(g) a list of sites which could contain asbestos
(h) a typical cross-section of a building showing localities where asbestos could be encountered.

4. Time for electron microanalysis of bulk samples collected was booked in advance with the Central Science Laboratory of the University of Tasmania.

5. All items required for bulk sampling (such as surgical instruments, petri dishes, self-adhesive labels, and protective masks) were ordered and obtained.

6. A bulk samples record sheet was prepared.

7. A plan to select some schools for the purpose of conducting air sampling was made.

8. In order to make air sampling possible in a selected number of State schools, contact was made with the Department of Labour and Industry with a request for the loan of proper equipment (this equipment was not available from the University of Tasmania).

9. Contact was made as well with the Government Analyst at the Department of Health Services, with a request that the Department perform the microscopic analysis of filters used for air sampling. The Government Analyst works in cooperation with the Department of Labour and Industry.

10. Finally, familiarization with the methods, procedures, and work practices recommended for the identification and evaluation of asbestos hazards was carried out.

Information on the asbestos problem held by the Department of Labour and Industry and by the Health Department were obtained. This was supplemented by reviewing the available literature in technical and academic libraries. The initial intention was to carry out a survey in all public primary and secondary schools in the metropolitan area of Hobart, but limited time for research has prevented the completion of inspection.

The inspection of schools was conducted during the period from 3 September 1984 to 5 December 1984 in 40 public schools, which represents 57 per cent of all schools. The details regarding the number and type of schools which were surveyed in relation to the total number of schools are shown in the Table 3.1. All buildings belonging to each school visited were visually inspected for asbestos-containing materials. At the time of the inspection, access was obtained into all areas of the school building including student, administrative, maintenance, and custodial areas. If suspected material was located during inspection, samples of the material were collected for laboratory analysis according to the sampling procedure outlined below.

TABLE 3.1 Number of Primary and Secondary Schools Inspected in Comparison to the Total Number of Public Schools in the Hobart Area

Classification	Number of Schools	Number of Schools Surveyed	
			Per Cent
Infant	7	5	71
Primary	40	19	48
High	13	12	92
College	3	1	33
Special	7	3	43
TOTAL	70	40	57

3.2 BULK ASBESTOS SAMPLE COLLECTION AND ANALYTICAL TECHNIQUE IN THE LABORATORY

During inspection of school buildings, 160 bulk samples were collected to determine whether insulation materials or construction materials in schools (for instance: walls, ceiling, or partitions) contained any asbestos mineral. For this purpose, sterile Petri dishes (50 millimetres diameter), and surgical instruments were used. In the case when the material was friable, samples were collected by inserting the collection container into the material and twisting to break off a sample. In many cases, samples were taken by using a small surgical knife to cut out, or scrape off, a small piece of material and then placing it into the container. Containers were sealed with tape and labelled with the specifications of the sample source location, address, date and identification number.

Laboratory analysis of the bulk material collected was performed with the use of the Scanning Electron Microscope (SEM) and by using X-ray microanalysis techniques. Primary bulk samples were crushed and randomly selected pieces were mounted on aluminium stubs and coated. Different coating methods were used for different mode of observation, namely: vacuum coating with carbon for combined SEM/X-ray microanalysis and sputter coating with gold for high resolution SEM. The approximate thickness of the coating in both cases was between 25 and 30 nanometres. Two types of Scanning Electron Microscopes were used: a Philip 505 SEM and a JEOL JXA 50 combined with a SEM/X electron probe microanalyser.

The X-ray microanalysis technique allows the chemical elements present in the sample to be identified from their characteristic X-ray spectra. The CSL equipment has the capacity to record these spectra and automatically identifies qualitatively and quantitatively the elements which give rise to them.

The JEOL instrument cannot, by reason of certain physical limitations, detect and identify elements with an atomic number less than eleven. It therefore cannot be used for the estimation of the elements from hydrogen up to neon. For the rest of the elements, with an atomic number greater than ten, a quantitative analysis of the element composition to about 0.2 per cent can be made in favourable cases.

Specimens were analysed under standard conditions of accelerating voltages of 15 kv and an absorbed current of 7 x 10^{-10} amps calibrated on a sample of pure copper (Cu). All analyses were executed in limited area scan and spot modes at 1000 to 3000 magnification. Sometimes, the full frame mode was used to produce the X-ray distribution may of the particular element. A Philips 505 SEM was operating on an Accel-voltage of 15 kv and 20 kv with a spot size of 20 micrometres. Astigmation correction was introduced on the testing specimen of PS Latex polystynere particles of 1.25 micrometres diameter.

3.3 PRESENCE AND PROPERTIES OF ASBESTOS CONTAINING MATERIALS IN SCHOOLS

The results of the school survey indicated that asbestos containing materials frequently are present in Hobart schools. In 23 of the 40 schools surveyed (58 per cent), asbestos bearing materials were detected. Of the 160 bulk samples taken, asbestos fibres were positively identified in 46 (29 per cent) of cases. The number of sites in which asbestos was found to be present in school buildings is shown in the histogram in Figure 3.1.

Of the schools where asbestos was positively identified, asbestos containing material was found to occur in only one or two places within that school complex (74 per cent). In six of the 23 schools, asbestos was found in three or more locations. The details of the locations within schools where asbestos was found are given in Table 3.2.

Switchboards were the most frequent location as asbestos is universally used in the construction of the switchboard panels. Switchboards accounted for 17 (37 per cent) of the positive samples identified.

Heat protective equipment in school laboratories (asbestos mats) and pottery rooms (asbestos gloves, asbestos insulation around kilns)

FIGURE 3.1 Number of Asbestos Occurrences by Number of Schools

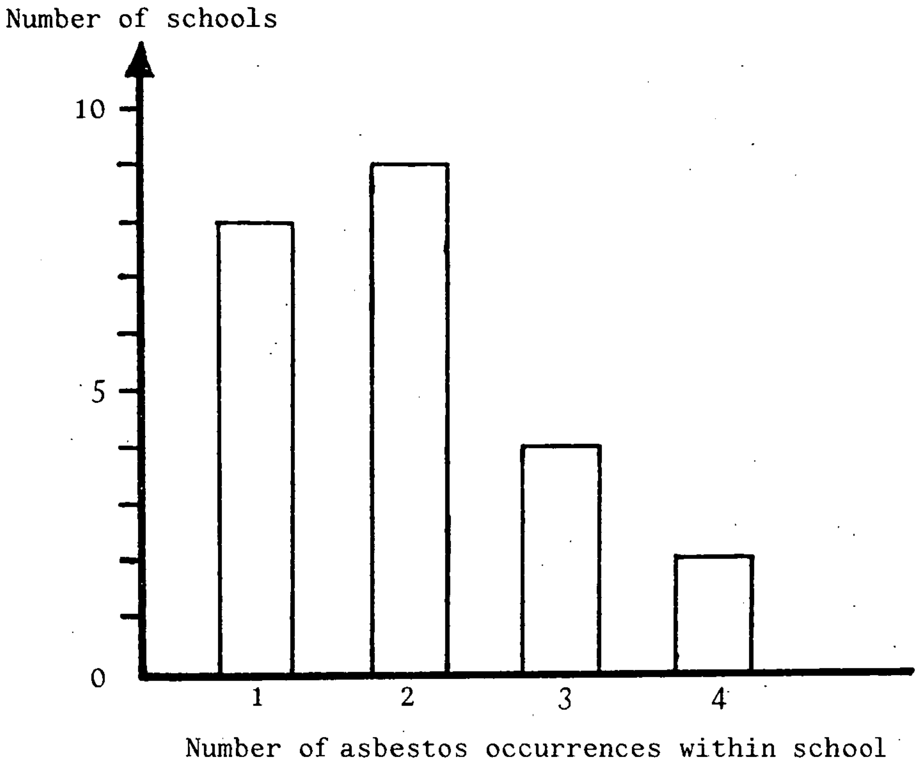


TABLE 3.2 Location of Asbestos Within School Buildings

Location	No. of Cases
Switchboard	17
Heat Protection (laboratories etc.)	10
Boiler & Hot Water Pipe Lagging (toilets)	5
Ceiling & Walls	4
Walls	3
Ceiling	2
Piping	2
Others[a]	3

[a] "Others": In one case: exterior eave (damaged)
In one case: exterior covered walkway (seriously damaged)
In one case: cornice (slightly damaged)

accounted for a further 10 cases (22 per cent) and were the second most frequent type of location identified.

Asbestos pipe lagging on both hot and cold water pipes and asbestos insulation on boilers were encountered in 7 cases (15 per cent). In five of these seven cases, the pipes lagged with the asbestos insulation were exposed in toilets.

The potentially hazardous use of asbestos in the construction of walls or ceilings occurred in 9 cases (20 per cent). In one school, a separate annex consisting of four classrooms had been constructed from mostly unpainted asbestos-cement sheeting. In three other cases, separate annexes had been built from asbestos-cement sheeting, but had been painted and/or sealed. Painted asbestos-cement sheets were also found to be used in one classroom of the main building of a primary school and used as a component of ceiling material throughout another two schools. In two cases, storage rooms were lined with asbestos-cement sheeting.

The surface area of the exposed asbestos material was calculated (m^2) in each case. Table 3.3 gives the calculated area of asbestos material in four class groups. Table 3.4 gives the surface area of the exposed material for the various location-types.

TABLE 3.3 Areas of Exposed Surfaces Containing Asbestos

Exposed Surface (m^2) Area	Number of Cases	Per Cent
<0.5	9	20
0.51 - 10	27	58
10.1 - 100	6	13
>100	4	9

TABLE 3.4 Location and Surface of Exposed Asbestos Materials

Location	No. of Cases	Open Surface of Material	
		Mean (m^2)	Range (m^2)
Switchboard	17	2.0	1.5 - 2.5
Heat Protection	10	0.4	0.02 - 1
Ceiling Walls	9	170.0	30 - 500
Boiler, Hot Water, Pipe Lagging & Piping	7	1.0	0.5 - 3
Others	3	37.0	0.5 - 100

In most cases, the area of exposed asbestos material was small (20 per cent of cases had areas smaller than 0.5 m^2 and 78 per cent of cases had areas smaller than 10 m^2). Only in 9 per cent of cases could the exposed areas be described as large (larger than 100 m^2). Analysing the quantity of asbestos in different locations (Table 3.4) showed that switchboards, heat protection, and pipe lagging were the only locations with relatively small quantities of asbestos materials (less than 2.5 m^2 for switchboard, less than 1 m^2 for heat protection, less than 3 m^2 for boiler insulation and pipe lagging). Only asbestos materials used in the construction of buildings were of more substantial areas (from 30 to 500 m^2).

Table 3.5 indicates the extent to which the asbestos containing material was readily accessible to students and school staff. As can be seen in 59 per cent of cases, the material containing asbestos was easily accessible.

TABLE 3.5 Accessibility

Case	Number	Per Cent
Totally Enclosed	19	41
Easily Accessible	27	59
TOTAL	46	100

During the survey, the friability and condition of materials containing asbestos were assessed. Friability was assessed as either hard (28 per cent) or semi-hard (72 per cent) (Table 3.6).

TABLE 3.6 Friability

Case	Number	Per Cent
Hard	13	28
Semi-hard	33	72
TOTAL	46	100

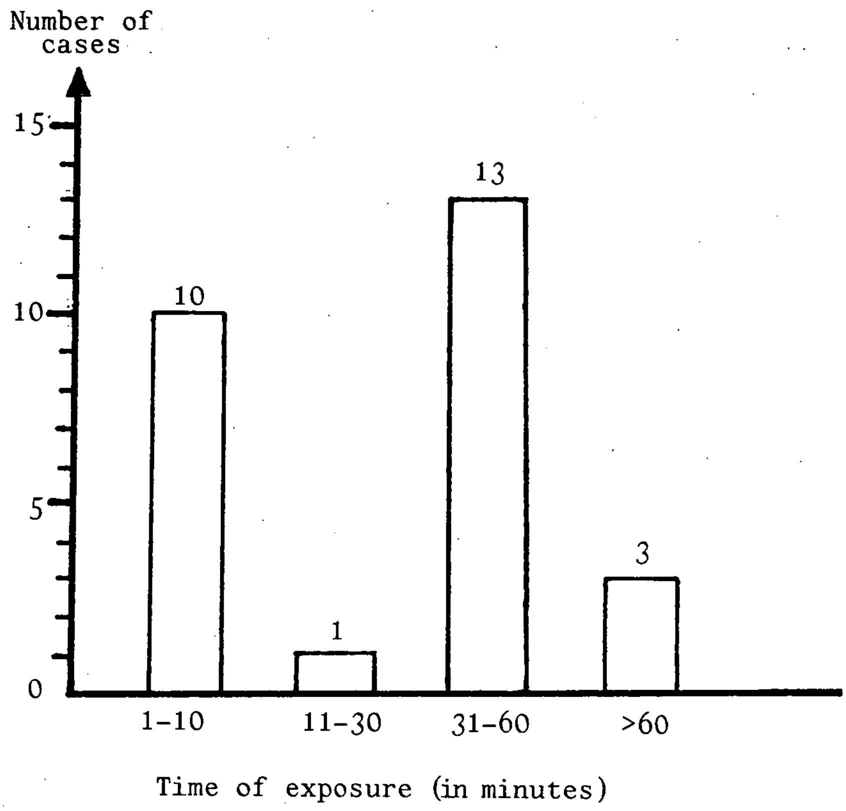
The condition of the material was assessed in terms of the extent of damage, and ranged from excellent (24 per cent), slight damage (35 per cent), severe damage (33 per cent), and multiple breaks (8 per cent) (Table 3.7).

TABLE 3.7 Condition of Material

Assessment	Number of Cases	Per Cent
Excellent	11	24
Slight Damage	16	35
Severe Damage	15	33
Break-off	4	8
TOTAL	46	100

Of great importance was the data collected relating to the time for which students were exposed to the asbestos containing material (Figure 3.2) and the number of students involved (Figure 3.3).

FIGURE 3.2 Time of Exposure by Number of Cases



In Table 3.8, this information is combined to give the time of exposure and the number of students involved to give an indication of the total exposure time.

The activity level of students near the places when asbestos was found was mostly moderate (52 per cent of cases). In one third of the cases, however, activity level was high. Only in 15 per cent of cases was the activity level low or negligible (Table 3.9).

In 41 of the 46 samples of material analysed, asbestos was identified as chrysotile. Small quantities of crocidolite or amosite were found mixed with chryostile in another five bulk samples, as shown on Table 3.10.

FIGURE 3.3 Number of Students Potentially Exposed to Asbestos Every School Day

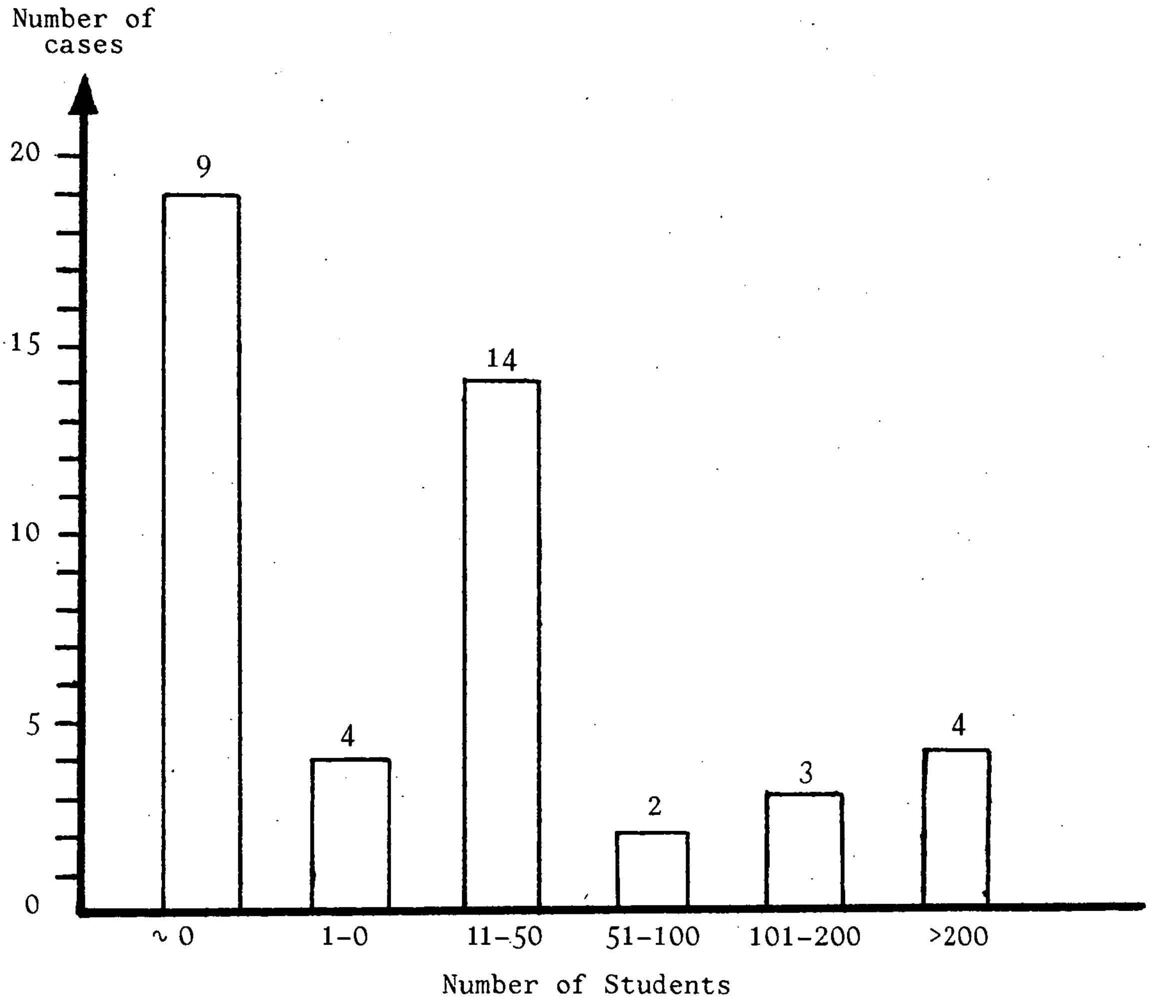


TABLE 3.8 Period of Exposure by Number of Students Exposed

Approximate Exposure Time (minutes)	Average Number of Students Exposed per Day
1 - 10	410
11 - 30	200
31 - 60	1300
Over 60	490
TOTAL	2400

TABLE 3.9 Activity Level of Students and Staff Near to Sites Where Asbestos Material Was Found

Activity Level	Number of Cases	Per Cent of Cases
Low or negligible	7	15
Moderate	24	52
High	15	33
TOTAL	46	100

TABLE 3.10 Type and Frequency of Asbestos Encountered

Number of Cases	Type of Asbestos	Location
41	Chrysotile	Various
4	Mixture chrysotile and crocidolite	Switchboard
1	Mixture chrysotile and amosite	Exterior covered walkway

The base for distinguishing of asbestos fibres was their chemical composition, as per Table 3.11.

TABLE 3.11 Chemical Composition of Some Varieties of Asbestos (From Wagner, Gilson, Berry and Timbrell 1971, page 72)

Variety	Composition (per cent)				
	Si	Fe	Mg	Na_2O	H_2O
Chrysotile (white)	40.0	2.0	38.0	0.25	13.3
Crocidolite (blue)	50.0	40.0	-	5.0	2.0
Amosite (brown)	50.0	40.0	-	0.1	2.3

As can be seen in Table 3.11, the structure of asbestos chrysotile consists of two main elements, silica (40 per cent) and magnesium (38 per cent). Amosite and crocidolite additionally contain considerable amounts of iron (40 per cent each), and crocidolite also contains 50 per cent of sodium.

Plate 3.1 below shows pure chrysotile asbestos fibres extracted from kiln insulation. The two major peaks of silica and magnesium in the X-ray spectrum confirm the presence of chrysotile fibres.

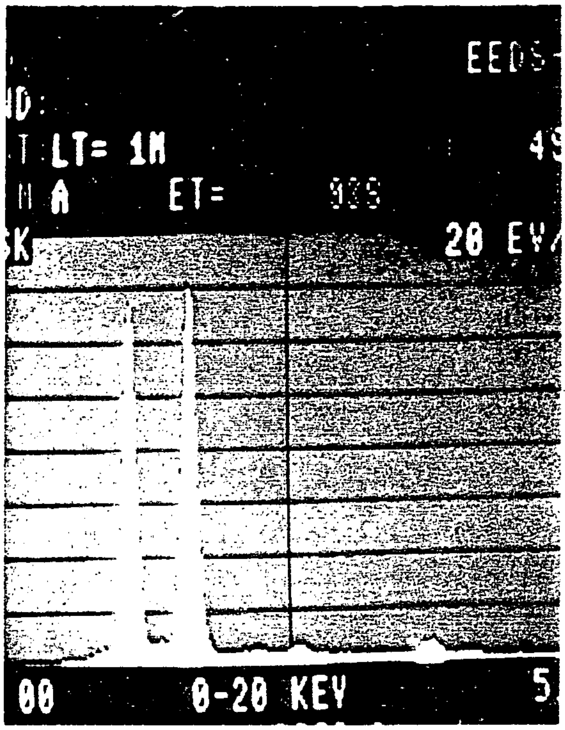
Asbestos fibres identified in bulk samples of construction material were bonded together with gypsum or cement, as well as with fibres such as glass-fibre or cellulose. Asbestos used as heat protection was applied in pure form.

In Plate 3.2, bundles of fibres are visible in several places mixed with cement, while in Plate 3.3 the bundles of fibres are distinct, and are seen coursing through areas depleted of cement.

PLATE 3.1

A

A photograph showing pure asbestos fibres.
(Magnification 1000)



B

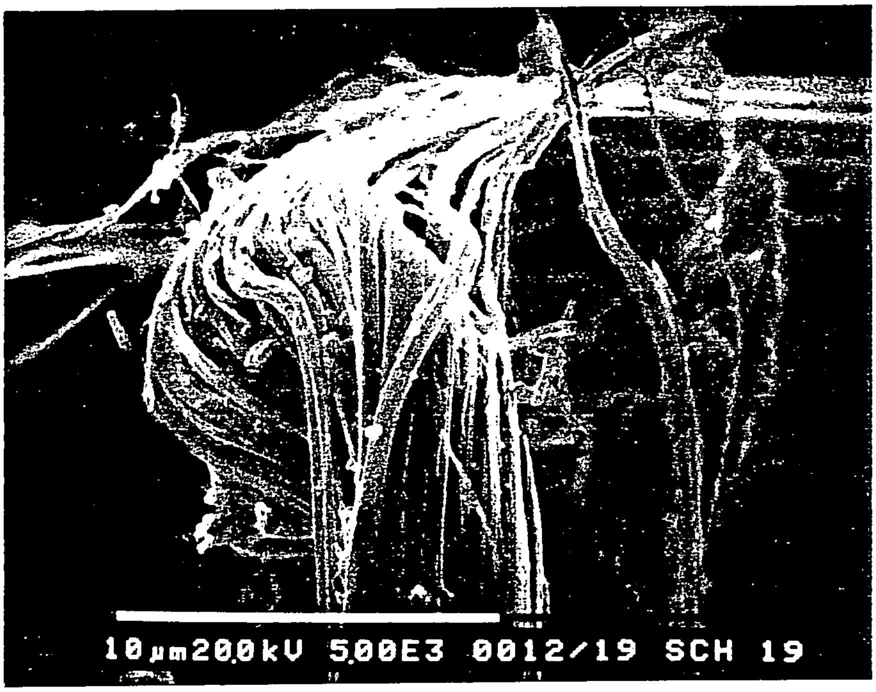
Photograph of X-ray spectrum.
The two peaks indicate the presence of silica and magnesium.

PLATE 3.2

The photograph shows chrysotile fibres in cement and concrete. The sample was taken from an asbestos cement sheet wall in the school's corridor.

Plate 3.4 shows glass-fibres and asbestos fibres together. Glass-fibres, which are smooth and straight, can be distinguished from asbestos fibres which are bundled and rough.

PLATE 3.3



The photograph (Plate 3.3) shows chrysotile asbestos fibres with very small cement particles. The sample was taken from a switchboard panel.

PLATE 3.4

The photograph shows chrysotile fibres mixed together with glass-fibre. The sample was taken from a switchboard panel. (Magnification 1000)

PLATE 3.5

The photograph (Plate 3.5) shows chrysotile fibres with organic fibres in cement. This sample was taken from the ceiling tiles in a school classroom.

4. AIR SAMPLING IN CHOSEN SCHOOLS AND ONE MULTIPLE STOREY CAR PARK IN HOBART

4.1 METHODOLOGY OF THE AIR SAMPLING

After the suspected asbestos containing material was positively identified as such, the level of asbestos dust which could enter into an occupied space was investigated using the membrane filter method with specific particle recognition and counting techniques.

The measurement of airborne concentration by the membrane filter method is approved by the N.H. and M.R.C.* of Australia and described in that organisation's publication, "Membrane Filter Method for Estimating Airborne Asbestos Dust". This method was developed mainly for use in workplaces where raw asbestos had been handled. Therefore, its use in other environments should be applied with discretion. The above-mentioned N.H. and M.R.C. publication (National Health and Medical Research Council 1976) designates all particles as asbestos fibres which are:

> greater than 5 micrometres in length, and
> with a length to width ratio greater than 3:1,
> and with a width less than 3 micrometres.

Objective measurements of the asbestos contamination using the membrane filter method are expressed as the number of fibres of the defined morphology per millilitre of air.

In the workplace for which the membrane filter method was designed, the large number of fibres might be asbestos but, in an occupied space such as in a building containing asbestos material, fibres collected on the filter may or may not be asbestos.

---

* National Health and Medical Research Council

The membrane filter method counts any particle of a certain size and fibrous shape as being asbestos when, in fact, some of these particles may come, for example, from furnishings or clothing. However, as an alternative, cheap, and simple method has not been developed to date, the N.H. and M.R.C. has extended the application of the membrane filter method of air sampling to the non-occupational environment.

The sampling equipment consists of:

(a) sampling pumps (usually five) which are battery powered and capable of sampling continuously at the selected flow rate for at least 4 hours;

(b) a flow meter which is capable of measuring the flow rate to within ± 5 per cent;

(c) connecting tubing which must maintain back proof connections;

(d) a filter holder (open-faced 25 mm, or 13 mm in line);

(e) a filter (white membrane filter of 0.8 micrometres pore size, with printed grids).

In this study, Type AA 0.8 micrometre filters were used in conjunction with the above described equipment to collect dust samples from 24 locations. These included a number of locations in the four schools where asbestos materials were found to be used as a construction material (Section 3.3). The other site sampled was a large inner-city multi-storey car park with a large through-flow of traffic and in which the emission of asbestos fibres from brake linings was suspected to be relatively high. In each case, sampling lasted approximately 4 hours using pumps with a capacity between 1500 to 2000 ml/min of air.

4.1.1 School Sites

The sites (schools) are listed below:

Site A1 - Classroom with ceiling made of asbestos containing tiles

Site A2 - Separate school building consisting of four classrooms where all walls and ceiling are lined with asbestos-cement sheeting

Site A3 - Metal trades work shop in which protective dividers (screens), and bench tops were made from unpainted asbestos-cement sheeting

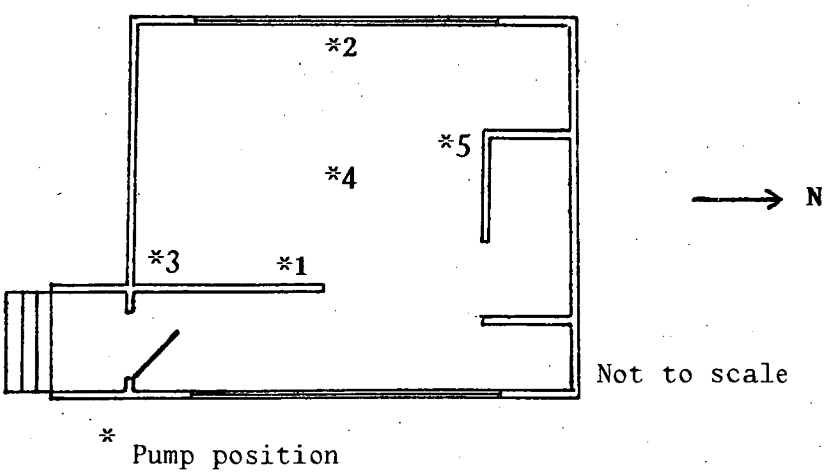
Site A4 - Store room fully lined with asbestos-cement sheeting and unpainted.

In all these sites, the material containing asbestos was slightly damaged, having holes and broken edges. As such, these situations potentially involved the exposure of students to asbestos particles.

The air sampling was undertaken in places shown and described below.

Air Sampling at Site A1 - Location of Pumps and Filters

PLAN OF PUMP POSITIONS



(1) Pump No. 5109 and Filter No. A-129-1
Position: 1200 mm above floor, 150 mm away from edge of partition.

(2) Pump No. 5116 and Filter No. A-129-2
Position: 1500 mm above in front of partly open window.

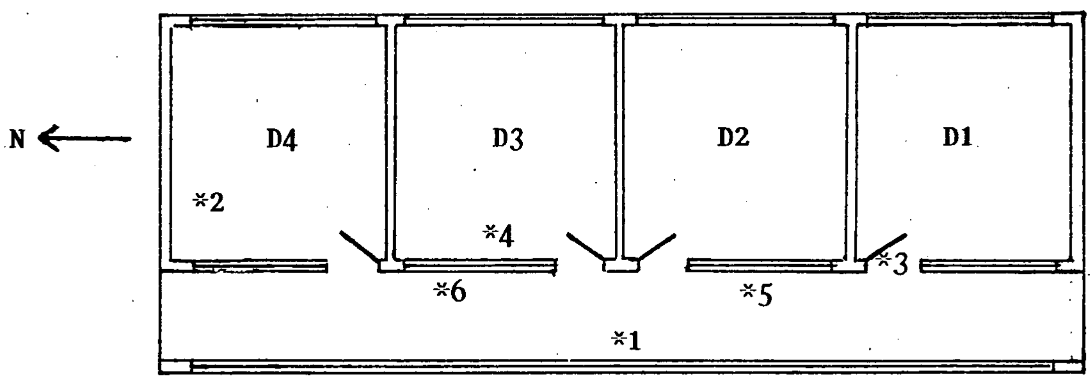
(3) Pump No. 6785 and Filter No. A-129-3
Position: 300 mm below ceiling directly under cracked tile Tile 450 mm away from partition.

(4) Pump No. 6730 and Filter No. A-129-4
Position: 1600 mm above floor on chair

(5) Pump No. 6762 and Filter No. A-129-5
Position: 1200 mm above floor against wall.

Air sampling at Site A2 - Location of Pumps and Filters

PLAN OF PUMP POSITIONS



* Pump position

(1) Pump No. 6785 and Filter No. A-132-1 mid-way along corridor
Position: against the wall hole in asbestos cement sheet directly below pump.

(2) Pump No. 5116 and Filter No. A-132-2, classroom D4, Northern
Position: wall of building close to door.

(3) Pump No. 6730 and Filter No. A-132-3, corridor outside
Position: classroom D1, on wall directly above door.

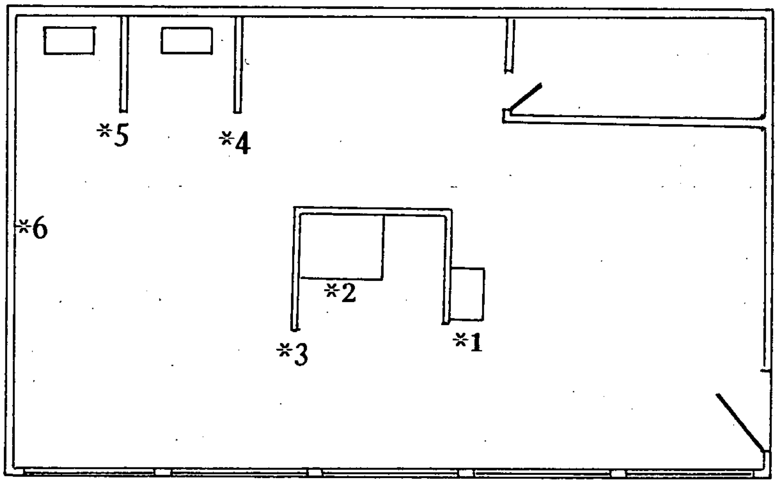
(4) Pump No. 5109 and Filter No. A-132-4
Position: D3, against wall and in front of door.

(5) Pump No. 6762 and Filter No. A-132-5
Position: corridor outside classroom D2, in centre of open window.

(6) Control Filter only (no pump) positioned in corridor.
Position:

Air Sampling at Site A3 - Location of Pumps and Filters

PLAN OF PUMP POSITIONS



Not to scale

* Pump position

(1) Pump No. 5116 and Filter No. A-127-1
Position: on wall approximately 150 mm above asbestos-cement bench top in sheet-metal shop area.

(2) Pump No. 6730 and Filter No. A-127-2
Position: under the flue hood approximately 1 m above bench top in forging and blacksmith area.

(3) Pump No. 6785 and Filter No. A-127-3
Position: on pegboard wall approximately 2.1 m above floor in sheet-metal shop area.

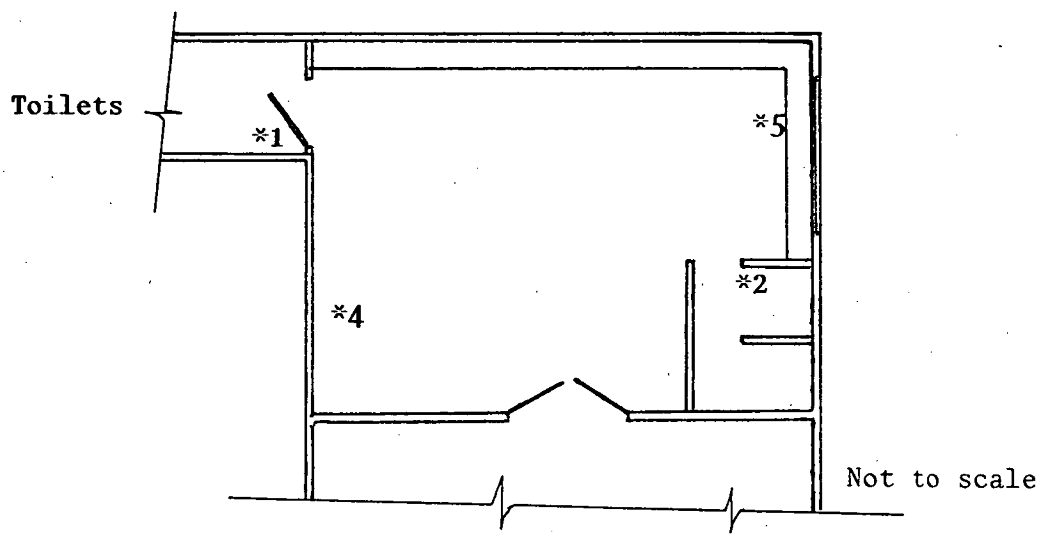
(4) Pump No. 5109 and Filter No. A-127-4
Position: welding bays above partition wall of asbestos-cement sheeting 2.1 m above floor.

(5) Pump No. 6762 and Filter No. A-127-5
Position: above partition of asbestos-cement sheeting in welding bay 2.1 m above floor.

(6) Control Filter only - (no pump) position on the wall.

Air Sampling at Site A4 - Location of Pumps and Filters

PLAN OF PUMP POSITIONS



* Pump position

(1) Pump No. 5109 and Filter No. A-138-1
Position: in corridor from physical education store to toilets.

(2) Pump No. 6762 and Filter No. A-138-2
Position: in shower room.

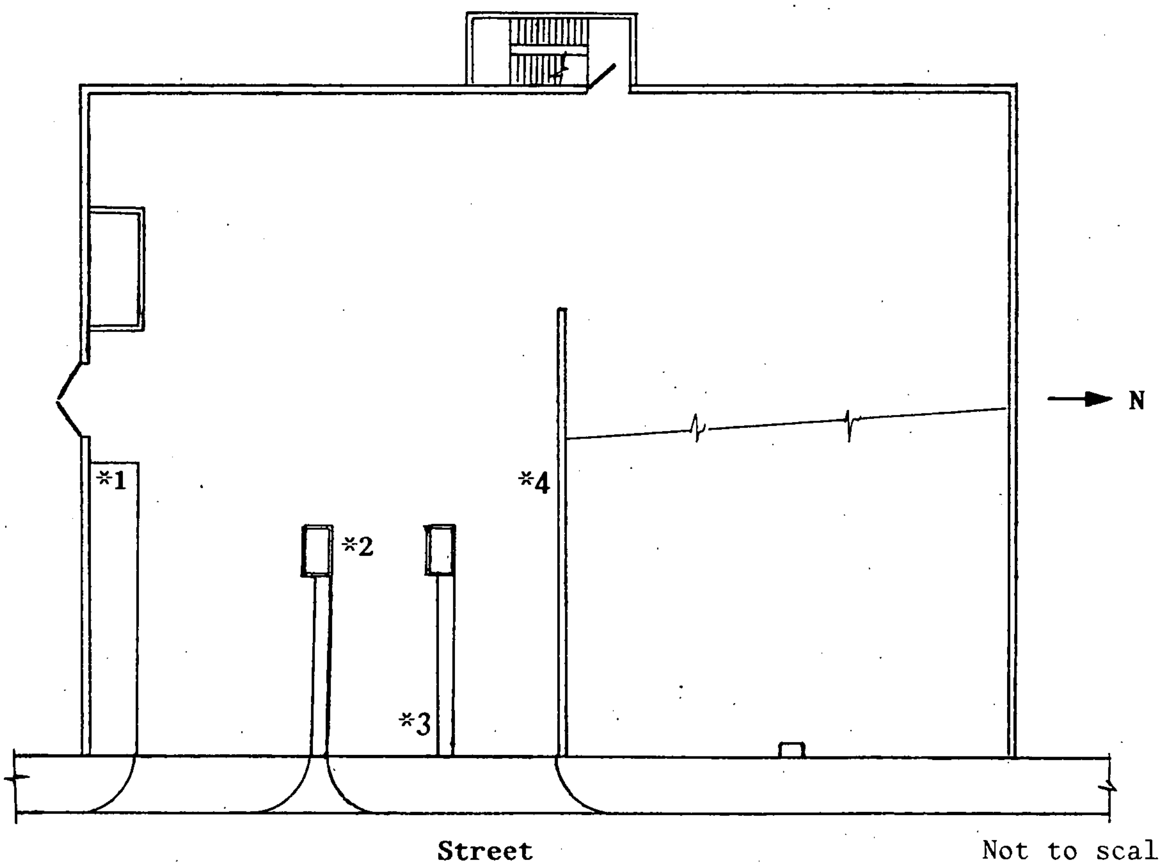
(3) Pump No. 5116 and Filter No. A-138-3
Position: physical education store, on the wall.

(4) Pump No. 6785 and Filter No. A-138-4
Position: in corridor, physical education store.

(5) Pump No. 6730 and Filter No. A-138-5
Position: physical education store, on the window.

4.1.2 City Car Park Sampling Site

PLAN OF PUMP POSITION



Not to scale

* Pump position

(1) Pump No. 5109 and Filter A1 - approximately 2000 mm above
Position: floor - south wall.

(2) Pump No. 6730 and Filter A2 - 800 mm above floor in attendant's
Position: box.

(3) Pump No. 5116 and Filter A3 - approximately 300 mm above
Position: floor at Entry to Car Park.

(4) Pump No. 6785 and Filter A4 - approximately 2000 mm above
Position: floor on the central wall (North).

4.2 ANALYTICAL TECHNIQUES AND RESULTS

4.2.1 General Description of Techniques

Airborne asbestos dust analysis on filters was conducted in order to establish the existence of asbestos contamination and to evaluate the potential exposure to asbestos in examined locations.

All filters were analysed using the optical (phase contrast) method as specified in the National Health and Medical Research Council publication for the determination of the concentration of airborne asbestos in occupational settings. Use of this method is appropriate in cases where it is known that the overwhelming majority of airborne fibres present are asbestos.

In two cases where asbestos fibre emission was thought to be relatively high (the car park and four classrooms in one school building where asbestos was used as a component in construction of walls and ceiling) a thorough analysis of filters was performed using two different techniques:

(a) Scanning Electron Microscopy (SEM);

(b) Optical Microscopy.

The two methods of analysis were chosen in order to verify the accuracy of the findings of the optical analysis used, to detect asbestos in the general environment where most fibres could be considered to be of other than asbestos origin (see Section 4.1). The SEM was particularly valuable in distinguishing between mineral, cellulose, glass, and other fibres or particles present in the material.

The same segments of each filter could not be analysed using both microscope techniques, because different methods of preparation of the specimen were required. Therefore, the filters were cut in half, and half of each filter was examined with an Optical Microscope, the other half was used to identify and count asbestos fibres using SEM microanalysis. Hence, the results obtained by SEM analysis were able to be compared with those obtained by light microscopy on the same filter.

The preparation of dust samples on membrane filters for SEM examination was similar to the previously described method in micro-analysis of bulk samples, except that the size of the SEM specimen was standardised. Four grid squares each measuring approximately 3 millimetres x 3 millimetres, were separated from the filter. These were mounted on an aluminium stub, and sealed by carbon.

Filters installed with pumps in the other three schools (sites) were analysed only with Optical Microscopy.

4.2.2 Optical Microscope Analyses

Airborne asbestos dust counting was performed in the Government Analyst's laboratory, Department of Health Services.

The filters were mounted on the microscopic slides, treated chemically to make the filter membrane transparent and examined using a Nikon Optiphol Labophot microscope operating at 100 to 400 magnification in a phase contrast mode. The particles were observed for shape and size. Any particle detected in three or four randomly chosen grid squares (fields) of each filter having a length to width ratio greater than 3:1 and a length of 5 micrometres or greater and width less than 3 micrometres, was counted as an asbestos fibre and recorded on the "Asbestos fibre counting record sheet" (see Appendix 6). Airborne asbestos fibre concentration was obtained using the following formula:

$$C = \frac{N}{n} \times \frac{1}{rt} \times \frac{A}{a}$$

C = airborne filter concentration (fibre/ml)

N = number of fibres counted

n = number of fields counted

A = effective filter area (420 mm^2)

a = area of counting field (10 mm^2)

r = flow rate (ml/min)

t = sampling time (min).

The unprocessed results of the fibre counting performed using the Optical Microscope are shown in Table 4.1.

TABLE 4.1 Number of Detected Fibres Assumed to be Asbestos Per Grid Square of Filter

Filter	Sites				
	A1	A2	A3	A4	Car Park
	Number of Fibres per Square	Number of Fibres per Square	Number of Fibres per Square	Number of Fibres per Square	Number of Fibres per Square
1	4 5 5	4 6 4 5	4 3 4	5 6 12	2 3 2 3
2	0 1 1	7 7 5 6	4 3 4	6 4 6	6 8 6 6
3	5 3 4	7 5 5 7	2 3 3	9 9 5	7 8 8 8
4	7 4 7	6 8 2 5	2 1 3	5 6 6	12 14 11 13
5	1 1 1	5 4 2 3	7 3 5 2	7 7 10 8	-

The statistical analysis of variance was used in order to compare these results and to estimate statistical errors of sampling and counting. Table 4.2 shows the results of this analysis conducted on the fibre counting results separately for each site. By using F-test the "among filters" and "within filters" components of variance were compared and the differences between filters were tested statistically.

For sites A2, A3 and A4, the observed values of F were smaller than the tabulated values of F with the level of significance 0.05; therefore, it can be concluded that no significant differences exist among the filters in the number of fibres.

TABLE 4.2 The Analysis of Variance of Fibre Counting Results

(a) Site A1

Variance	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Among filters	q - 1 = 4	65.6	16.4	17.6
Within filters	M - q = 10	9.3	0.93	
Total	M - 1 = 14	74.9	8.65	

F 0.05 = 3.49

F 0.01 = 5.99

Test result: $F > F\ 0.01$

(b) Site A2

Variance	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Among filters	q - 1 = 4	19.3	4.8	2.32
Within filters	M - q = 16	33.25	2.1	
Total	M - 1 = 19	52.55	2.8	

F 0.05 = 3.01

F 0.01 = 4.77

Test result: $F < F\ 0.05$

(c) Site A3

Variance	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Among filters	q - 1 = 4	10.7	2.7	1.92
Within filters	M - q = 12	16.75	1.4	
Total	M - 1 = 15	27.45	1.8	

F 0.05 = 3.26

F 0.01 = 5.41

Test result: $F < F\ 0.05$

TABLE 4.2 continued

(d) Site A4

Variance	Degrees of Freedom			Sum of Squares	Mean Square	F Ratio
Among filters	q - 1	=	4	26.4	6.6	1.02
Within filters	M - q	=	12	78.0	6.5	
Total	M - 1	=	15	104.4	6.9	

F 0.05 = 3.26

F 0.01 = 5.41

Test result: $F < F\ 0.05$

(e) Car Park

Variance	Degrees of Freedom			Sum of Squares	Mean Square	F Ratio
Among filters	q - 1	=	3	204	68.0	81.9
Within filters	M - q	=	12	10	0.8	
Total	M - 1	=	15	214		

F 0.05 = 3.49

F 0.01 = 5.95

Test result: $F > F\ 0.01$

q - number of filters

M - number of results of counting

For Sites A1 and car park, the F test results confirmed that there are statistically significant differences among filters in the results of counting. In the school site (A1), the smaller fibre concentrations were found in location 2 (less than 1 fibre per grid square) and 5 (1 fibre per grid square). The low levels can be explained by the draught from the window (location 2) and the open partition (location 5) which would have diluted particles suspended in the air.

In the car park (see Plan of Pump Position, page 68) the differences in the fibre counting can be partially explained by the location of filters further or closer to the open air and impact of the draught from the entrance and the exit doors. The lowest reading was obtained from the filter 1 (2.5 fibres per grid square) located very close to the exit doors and the highest readings from filter 4 (12.5 fibres per grid square) located deeper in the car park and against the partition wall. Table 4.3 shows the statistically processed results of the fibre counting.

TABLE 4.3 Statistical Confidence of Fibre Counting Results

Site	Number of Fibres per Grid Square of Filter			
	Mean	Standard Deviation (Coefficient of Variance)	95 % Confidence Limits of Mean Minimum	Maximum
A1 (F1,F3,F4)	4.89	1.29 (26.4)	3.90	5.88
A1 (F2,F5)	0.83	0.37 (44.6)	0.44	1.22
A2	5.15	1.62 (31.5)	4.39	5.91
A3	3.31	1.32 (39.9)	2.61	4.01
A4	6.82	2.56 (37.5)	5.46	8.18
Car Park (F1)	2.50	0.50 (20.0)	1.70	3.30
Car Park (F2,F3)	7.13	0.93 (13.0)	6.35	7.91
Car Park (F4)	12.5	1.12	10.72	14.28

Data for Site A1 were classified into two groups, the lower results (Filters 2 and 5) and the higher results (Filters 1, 3 and 4). In a similar manner, the results from the car park were classified into three groups of statistically different values. The standard deviation and the coefficient of variance were used as dispersion measures.

The statistical confidence of the fibre counting was calculated using the student test with 95 per cent confidence limits. As can be seen from Table 4.3, the counting results vary significantly from 0.83 fibres per grid square of filter in school A1 to 12.5 fibres per grid square of filter in the car park.

The coefficient of variance was smaller for counting results from the car park (10 - 20 per cent) than for results from schools (25 - 45 per cent) but generally represents the typical level for this kind of experiment (30 per cent recommended as a typical value by Australia, National Health and Medical Research Council 1976). Based on the fibre counting results, the airborne fibre concentrations were calculated (see formula, page 70).

Table 4.4 shows final results of the air sampling calculated separately for all filters used in the experiment.

TABLE 4.4 The Results of Air Sampling and Optical Microscopy Analysis of all Filters Installed in Four Schools and a City Car Park

Site	Airborne Fibre Concentrations (Fibres/ml x 10^{-4})				
	Filter 1	Filter 2	Filter 3	Filter 4	Filter 5
School A1	4.49	0.63	3.69	5.68	0.95
School A2	3.99	4.40	5.53	4.84	3.09
School A3	2.68	2.67	2.01	1.50	3.34
School A4	10.72	7.77	11.60	8.73	12.60
Car Park	2.36	6.16	7.55	12.42	-

Since the time of sampling and the flow rate were of similar value for all filters, the fibre concentrations are generally proportional to the number of fibres per grid square (shown in Table 4.3). This observation applies to all schools except school A4, where the test time was relatively shorter (145 minutes) than in other schools (250 - 300 minutes). Consequently, the fibre concentrations in school A4 (8.73 - 12.60 fibres/ml x 10^{-4}) are relatively higher compared to other schools (0.63 - 5.68 fibres/ml x 10^{-4}).

Table 4.5 shows the results of the analysis of variance of air sampling results.

TABLE 4.5 The Analysis of Variance of Air Sampling Results in Four Schools

Variance	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Among schools	q - 1 = 3	170.0	56.7	33.9
Within schools	M - q = 14	23.4	1.7	
Total	M - 1 = 17	193.4	11.4	

TABULATED VALUES OF F

F 0.05 = 3.34

F 0.01 = 5.56

Test Result: F>F 0.01

Based on the result of F test (F>>F 0.01), it can be concluded that the differences among schools in the level of airborne fibre concentration are statistically significant.

The concentration of airborne fibres assumed to be asbestos fibres was calculated using the following formula:

$$C = \frac{N}{n} \times \frac{1}{r} \times \frac{1}{t} \times \frac{A}{a}$$

Therefore, the components of the experimental error are as follows:

(a) Physical error associated with number of fibres counted (N) by underestimation, which can be introduced by overlooking of asbestos fibres during the counting, or by overestimation due to recognition of non-asbestos fibres as asbestos. It is extremely difficult to estimate this error.
The problem of overestimation is discussed in Section 4.2.3 by comparison with the results of fibre counting using the SEM;

(b) statistical error associated with the counting of N. This is a significant error and its estimation has been carried out in this section with the results as shown in Table 4.3;

(c) statistical error associated with the calibration of the air pump. The estimation of this error as a coefficient of variance together with the mean flow rate is shown in the Table 4.6;

(d) physical error due to the measuring the length of time during air sampling. As the length of time was measured with an accuracy of $\pm$ 1 minute, the error is relatively very small (approximately 0.5 per cent);

(e) physical error in estimation of an effective filter area (A) and area of counting field (a). Since the precise laboratory filter was used in the experiment, this error is not significant.

It can be seen that only the physical and statistical errors in the estimation of the number of fibres are of significant value, and other components of the error of experiment can be omitted.

The final results of air sampling and fibre counting using an optical microscope are shown in Table 4.7. The fibre concentrations vary considerably for each site and these variations are statistically significant as has been confirmed in this section. The mean reading for a school varied from 0.79×10^{-4} fibres/ml at Site A1 (Filters 2 and 5) to a maximum of 10.28×10^{-4} fibres/ml at Site A4.

The mean reading for the car park varied from 2.36×10^{-4} fibres/ml (Filter 1) to 12.42×10^{-4} (Filter 4). Table 4.7 shows also 95 per cent confidence limits of mean airborne fibre concentrations calculated and based on the abovementioned assumption regarding the experimental error.

4.2.3 Scanning Electron Microscope Microanalysis

Using S.E.M. microanalysis, asbestos fibres were found in three filters from school buildings (there were altogether five filters installed) and one from the car park (four filters installed). Asbestos was mostly present as single fibres but, in one case, they were detected as agglomerated fibres, as well as a component of calcium based particles (see Plate 4 and Plate 5). Altogether, in 3 filters from the school, 6 separate (2 of which were agglomerated, and 4 completely separate) asbestos fibres were detected. In one case, asbestos fibres (unknown quantity) were found associated with a calcium particle. Table 4.8 presents details of filters examined from school building (site) A2.

In filter A-132-1, with 1000 magnification, 21 particles resembling asbestos fibres were found. Although these fibres were similar in dimensions to those specified for identification of asbestos in the phase microanalysis method used to identify asbestos fibres (3 micrometres x 5 micrometres), SEM analysis indicated that these fibres were organic in nature and were not, therefore, asbestos fibres. Plate 4.1 shows particles of cement found with dimensions to approximate those of an asbestos fibre. Other inorganic particles encountered were: sodium,

TABLE 4.6 The Results of a Flow Rate Calibration with an Estimation of Statistical Error

Site	Pump	Flow Rate Mean (ml/mean)	Flow Rate Coefficient of Variance (per cent)
A1	1	1588.14	0.8
	2	1639.34	0.6
	3	1677.85	0.4
	4	1585.62	0.6
	5	1656.54	1.1
A2	1	1698.75	0.6
	2	2022.92	0.3
	3	1598.29	0.4
	4	1586.46	0.7
	5	1684.44	0.2
A3	1	1914.69	1.2
	2	1923.69	1.2
	3	1925.75	1.2
	4	1983.83	1.4
	5	1914.30	0.6
A4	1	1963.35	1.4
	2	1934.24	0.6
	3	1946.79	0.1
	4	1946.79	1.4
	5	1951.85	0.9
Car Park	1	1976.28	0.8
	2	1959.50	0.6
	3	1968.50	0.4
	4	1993.35	1.1

TABLE 4.7 The Final Results of Air Sampling with Counting Done by Using an Optical Microscope

Site	Mean	Airborne Fibre Concentration (Fibres/ml x 10^{-4}) 95 per cent Confidence Limits of Mean Minimum	Maximum
School A1 (F1,F3,F4)	4.62	3.59	5.65
School A1 (F2,F5)	0.79	0.40	1.15
School A2	4.38	3.65	5.11
School A3	2.44	1.88	3.00
School A4	10.28	8.06	12.50
Car Park (F1)	2.36	1.56	3.16
Car Park (F2,F3)	6.86	5.97	7.75
Car Park (F4)	12.42	10.40	14.43

TABLE 4.8 Scanning Electron Microscope Microanalysis of Air Samples from School (site) A2
(Counts were taken from four randomly selected grid squares of the filter)

Filter	Number of Asbestos Fibres (Particles)	Number of Organic Fibres (Particles)	Number of Inorganic Fibres (Particles)	Total Number of Fibres and Particles Detected
A-132-1	0	21	19	40
A-132-2	4	18	11	33
A-132-3	1*	15	12	28
A-132-4	2	28	16	46
A-132-5	0	19	24	43
	7	101	82	190

* 1 unknown number of asbestos fibres bonded in calcium.

From all detected fibres 3.7 per cent fibres were confirmed as asbestos.

potassium, chlorine, aluminium, gypsum and rock (altogether 19 particles).

In filter A-132-2, two single fibres and two asbestos agglomerated fibres were detected. The single asbestos fibres had approximate dimensions of 5 micrometres x 14 micrometres (Plate 4.2).

Plate 4.3 shows two asbestos fibres together with very small particles containing chlorine, calcium, titanium.

Using a magnification of 3000 (1 mm on photograph = 0.33 micrometres) produced the photograph in Plate 4.4 taken of one single asbestos fibre, two particles of calcium and four organic fibres. In four random grid squares of A-132-2, eighteen organic and eleven inorganic materials were detected.

In filter A-132-3, a calcium particle, bonded with an unknown number of asbestos fibres, is shown (Plate 4.5, magnification 3000). No other asbestos fibres were detected on this filter. Other fibres found on the filter A-132-3 were organic (15) and inorganic fibres (12) in nature. The total number of all fibres detected on the filter was 28.

In filter A-132-4, 16 inorganic particles containing sodium, potassium and chlorine, 28 organic fibrous materials, and two asbestos fibres were detected.

In filter A-132-5, 19 organic fibres, 23 inorganic, and one particle of paint was encountered.

Table 4.9 presents details of S.E.M. microanalysis of filters which were installed in a multi-storey car park in the city.

TABLE 4.9 Scanning Electron Microscope Analysis of the Filters from a City Car Park
(Counts were taken from four, randomly selected, grid squares of the filter)

Filter	Number of Asbestos Fibres	Number of Organic Fibres	Number of Inorganic Fibres	Total Number
A1	2	8	21	31
A2	0	11	19	30
A3	0	6	15	21
A4	0	17	19	36
	2	42	74	117

From all detected fibres, 1.7 per cent of fibres were confirmed as asbestos. Only in one filter (A1) from the car park two asbestos fibres were encountered. In Plate 4.6, from Filter A1 (magnification 2000), one of the two detected asbestos fibres is shown, together with one rock particle and two organic fibres. Plate 4.6 shows the X-ray distribution map with a large concentration of magnesium in a chrysotile asbestos fibre. Altogether, on filter A1 were detected 8 organic fibres, 21 inorganic particles (rock, cement, aluminium, quartz, silica, gypsum and copper), and 2 asbestos fibres.

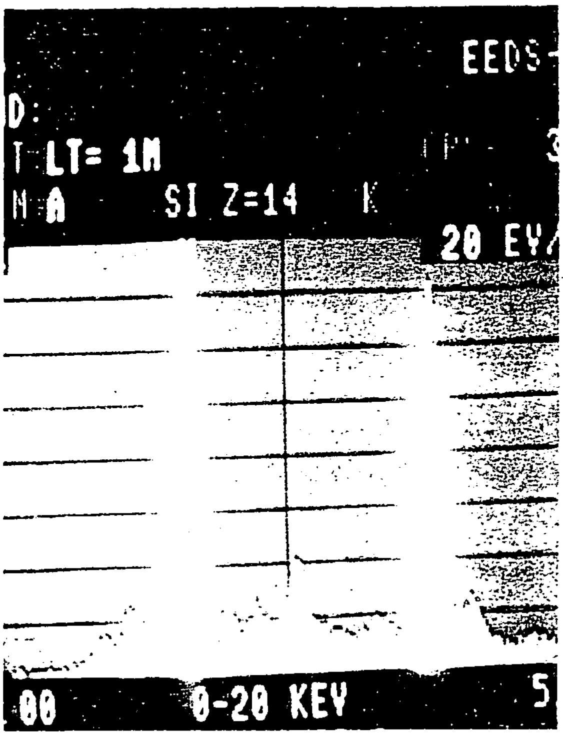
In filter A2, eleven organic and nineteen inorganic fibres (aluminium, sulphur, quartz, rock, paint) were encountered.

In filter A3, six organic fibres and fifteen inorganic fibres (rock, titanium, silica, aluminium, copper) were found.

In filter A4, seventeen organic fibres and nineteen fibres were detected.

PLATE 4.1

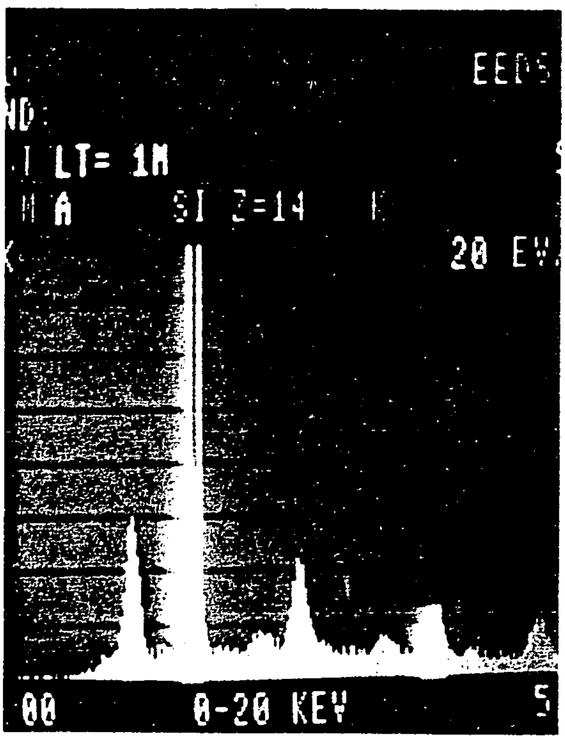
A.
Filter A-132-1
Particle of cement with dimensions similar to those of air asbestos fibre.
Magnification 1000
(1 mm = 1 micrometre)



B.
X-ray spectrum of cement particle (Plate 6). The two peaks indicate the presence of calcium and silicate materials.
(Cf. Plate 7 showing pure asbestos).

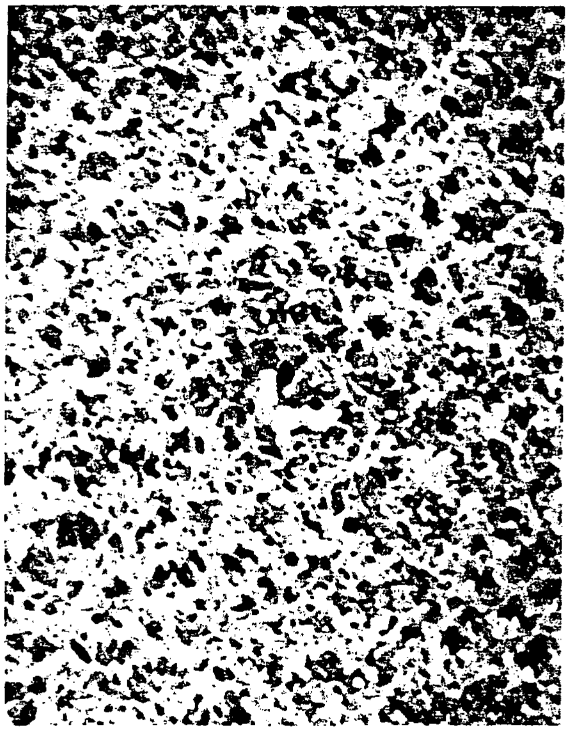
PLATE 4.2

A.
Photograph of asbestos fibre found on filter A-132-2. Approximate dimensions of fibre 5:14 micrometres. (Magnification 1000)

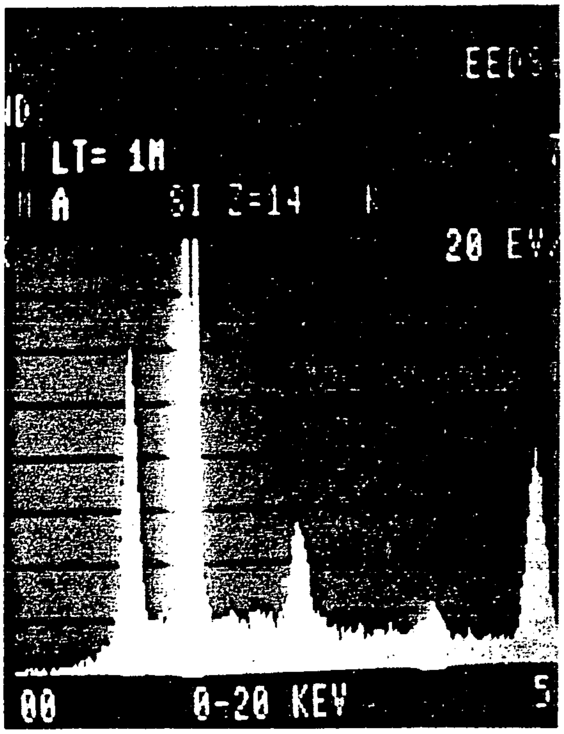


B.
Photograph of X-ray spectrum asbestos fibre. The 5 peaks indicate the presence of chlorine, calcium and titanium attached to asbestos fibre (silica and magnesium).

PLATE 4.3



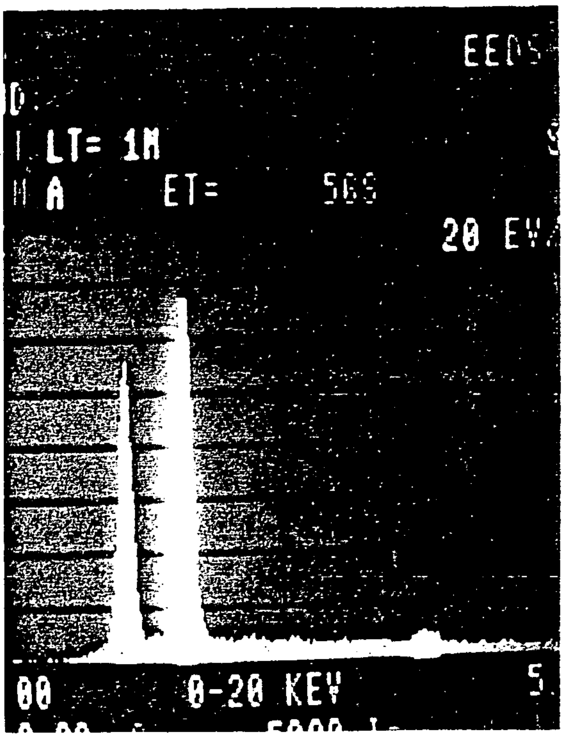
A.
Photograph of two asbestos fibres found on filter A-132-2.
(Magnification 1000)



B.
Photograph of X-ray spectrum of two fibres shown in Plate 8.1.
The two largest peaks indicate the presence of asbestos (magnesium and silica), the three smaller peaks chlorine, calcium and titanium.

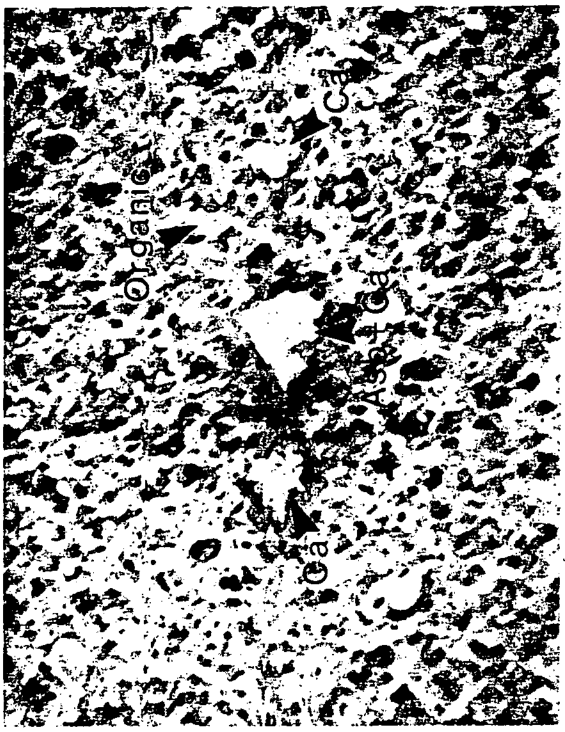
PLATE 4.4

A.
Photograph of fibres detected on filter A-132-2.
Fibre 1: asbestos (see Plate 9.1)
Fibre 2: calcium
Fibre 3: calcium
Fibre 4: organic fibre
(Magnification 3000)

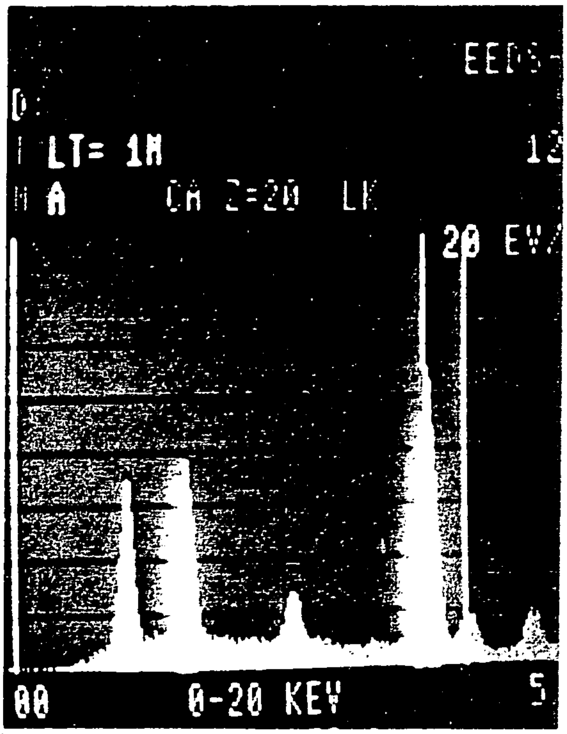


B.
Photograph of X-ray spectrum of asbestos fibre (magnesium and silica peaks).

PLATE 4.5

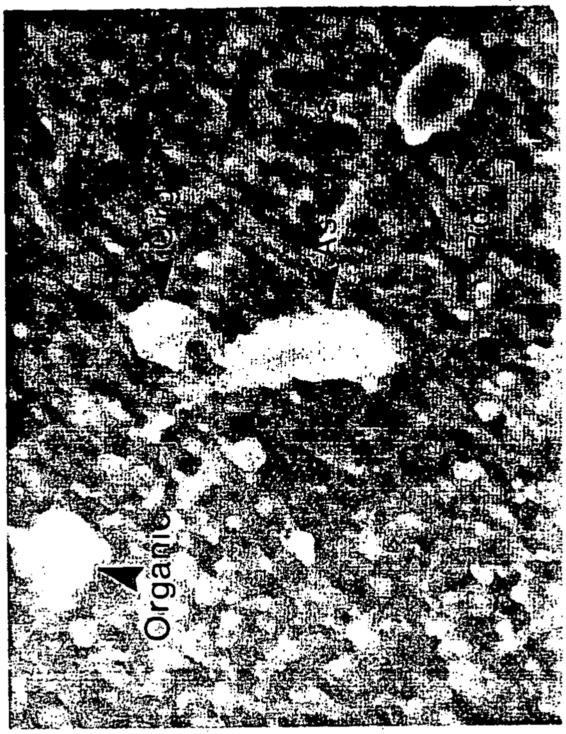


A.
Photograph of filter A-132-3 showing asbestos in calcium together with one organic fibre, and two particles of calcium. (Magnification 3000)



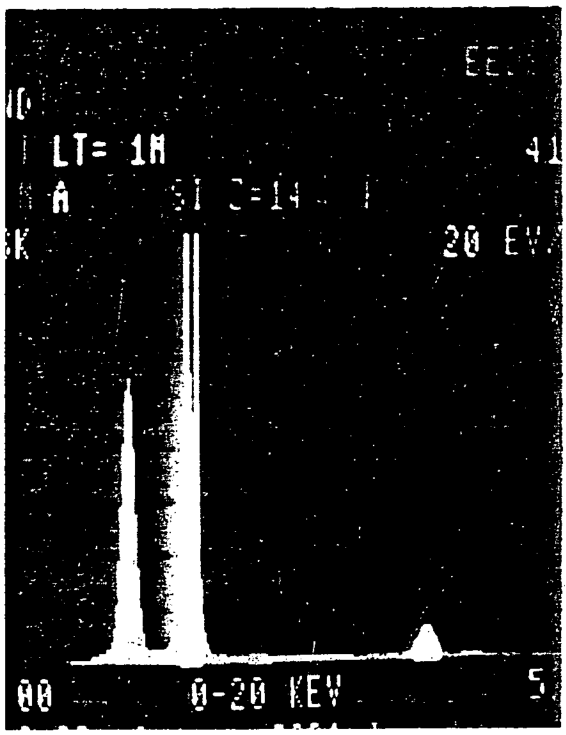
B.
Photograph of X-ray spectrum indicate four peaks: magnesium, silica, chlorine and calcium.

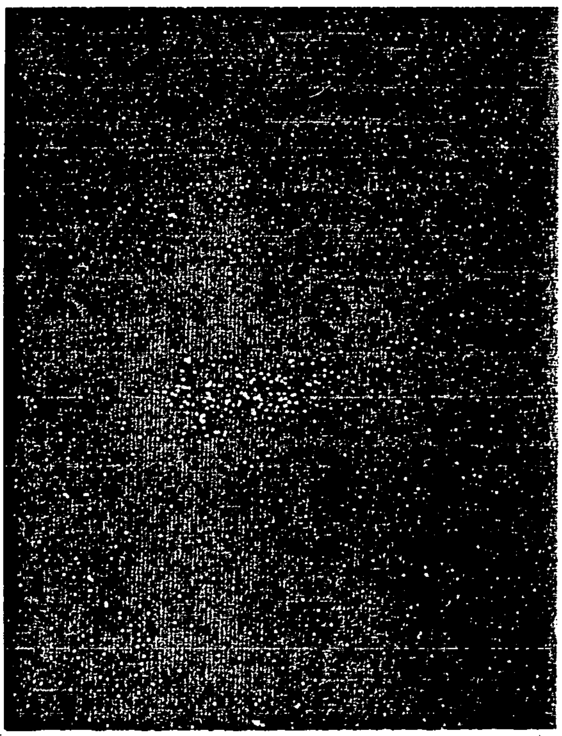
PLATE 4.6



A.
Photograph of filter A1 (car park) showing: one asbestos fibre,
one rock particle,
two organic fibres.
(Magnification 2000)

B.
Photograph of X-ray spectrum indicate the two peaks, the presence of magnesium and silica.





C.
Photograph X-ray distribution map with large concentration of magnesium in the chrysotile asbestos fibre (compare with Plate 4.6).

4.3 EVALUATION OF EXPERIMENTAL RESULTS

The assessment of exposure to asbestos in the school environment has been one of the major goals of the thesis. Two distinctive methods of fibre counting were used to estimate the level of airborne asbestos at selected locations. Optical Microscopy is routinely performed as a standard method following recommendations by the National Health and Medical Research Council. This method is simple and easy to carry out but it is a technique based entirely on the shape of the particle without giving any attention to the specific properties of a substance. Consequently, all particles satisfying a 3:1 length to width ratio are counted as asbestos fibres. Also, fibres below 5 micrometres are not counted because of the resolution limit of Optical Microscopy (see Section 4.2.2 describing the Optical Microscopy method). Electron Microscopy permits a detailed examination and identification of asbestos fibres of all sizes. As a result of this, Electron Microscopy must be seen as the definitive method for fibre counting and estimation of exposure levels. But, this method has also many disadvantages. The cost of equipment is very high, the time required for sample preparation and examination is lengthy, and requires highly trained and qualified personnel.

The results of the fibre count analysis using these two different methods indicate that the estimation of exposure differs greatly between the two methods. The filters from air sampling in the general environment were shown to absorb various types of fibres, including inorganic fibres (rock, cement, aluminium, quartz, silica, gypsum, and copper), and organic fibres (cellulose), and some asbestos fibres as well. A summary of the results of the fibre count analysis, using the two methods, is shown in Table 4.10. This indicates that Optical Microscopy cannot be considered as an appropriate method in the case of airborne-asbestos measurement when used in locations such as schools and car parks. Optical Microscopy, when used for asbestos detection in the general environment, can be seen to involve serious errors. In general, the method appears to underestimate the number of fibres present, but to greatly overestimate the number of asbestos fibres. All fibres, regardless of chemical properties, are counted as asbestos fibres. In comparison, the analysis performed using the Scanning Electron Microscope, generally gives the total number of fibres larger than Optical Microscopy. This is because this method extends counting below 5 micrometres of fibre size.

TABLE 4.10 Comparison Between two Microscopical Methods (Scanning Electron Microscope and Optical Microscope) Used in Fibre Counting

Site	Filter Number	Optical Microscope Number of Fibres Assumed to be Asbestos Fibres	Scanning Electron Microscope: Total Number of Fibres Detected	Scanning Electron Microscope: Number of Asbestos Fibres
A2	1	19	40	0
School	2	25	33	4
	3	24	28	1
	4	21	46	2
	5	14	43	0
Total Filters		103	190	7
A5	1	10	31	2
Car Park	2	26	30	0
	3	31	21	0
	4	50	36	0
Total Filters		117	118	2
The fibres were counted on three or four grid fields of filter			The fibres were counted on four grid fields of filter	

The most significant difference was the number of fibres confirmed as asbestos fibres.

Examination of the filters from air sampling carried out at school locations indicated that only 7 fibres from the total number of 190 were asbestos fibres (3.7 per cent), and for the car park location only 2 fibres from a total number of 118 fibres were asbestos fibres (1.7 per cent). In comparison, the counting by using Optical Microscope showed the total number of fibres lower than that counted on the Scanning Electron

Microscope (103 for all five filters sampled at schools compared with 190). All of these fibres were assumed to be asbestos fibres.

Since counts conducted in the two methods used the same filters, (half filter used in each method) it would not be expected that the results would differ significantly. The logical conclusion is that the Optical Microscope method is totally inappropriate in estimating the level of airborne asbestos fibres in the general environment. It can be seen that the evaluation of asbestos exposure at the examined schools based on Scanning Electron Microscope analysis was 15 times lower than the estimated exposure level based on Optical Microscope analysis. With respect to the car park locations, Scanning Electron Microscope analysis gave an estimate of asbestos exposure 59 times lower than that based on Optical Microscope analysis (Table 4.11).

TABLE 4.11 Final Results of Air Sampling in Four Schools and a Car Park (Optical Microscopy and Scanning Electron Microscopy)

SITE	Mean Levels of airborne asbestos by Optical Microscope f/ml x 10^{-4}	Conversion Ratio Number of asbestos fibres (confirmed by SEM) to total number of fibres assumed to be asbestos (based on Optical Microscopy)	Calculated levels of airborne asbestos f/ml x 10^{-4}
School A1	4.62		0.31
School A2 (both techniques used)	4.38	$x \frac{7}{103}$	0.29 0.29
School A3 School A4	2.44 10.28		0.16 0.72
Car Park (both techniques used)	7.12	$x \frac{2}{177}$	0.12
	More than 1000 times lower than hygiene standard for occupational exposure		More than 10 000 times lower than hygiene standard for occupational exposure

$\frac{7}{103} \sim \frac{1}{15}$ Evaluation of asbestos exposure at the examined school locations based on Scanning Microscope Analysis was 15 times lower than the estimated exposure level based on Optical Microscope analysis.

$\frac{2}{117} \sim \frac{1}{59}$ With respect to the car park locations Scanning E. Microscope analysis gave an estimation of asbestos exposure 59 times lower than that based on Optical Microscope analysis.

5. ASSESSMENT OF POTENTIAL ASBESTOS EXPOSURE AT SCHOOLS IN HOBART

The school survey conducted in this study confirmed that asbestos-containing materials were present within the school environment. In approximately half of the surveyed schools, asbestos was positively identified using the accurate SEM method. Table 5.1 shows the general assessment of the potential exposure to asbestos as encountered at various locations tested.

Of all situations encountered in schools where asbestos material was positively identified, asbestos-cement sheets used as a basic building material represented the greatest potential hazard to human health. Such situations were discovered in 9 schools (22.5 per cent of all schools surveyed). In these cases, relatively high numbers of students and long exposure times were found to occur. On the other hand, walls and ceilings made of asbestos sheets were usually in very good condition, asbestos was bonded in cement, and the surface protected by a layer of paint.

A potential hazard was also detected in various heat protection applications, such as gloves and mats or kiln insulation. In these cases, the asbestos was in a pure form and uncoated. Such instances were observed in 10 schools (25 per cent of all schools), although the condition of this material was assessed as good and friability as hard to semi-hard. A relatively large number of students came into contact with such asbestos for approximately one hour per day or longer. With respect to various other applications of asbestos, such as switchboards, pipe lagging, boiler and hot water piping etc., the asbestos was not considered to represent a significant hazard as a very small number of students came into contact with such material and the time of exposure was relatively short.

The survey results indicated that in the 40 surveyed schools, approximately 2400 students occupied for various periods of time, a school environment in which asbestos was present. As pointed out in the literature review on the health aspects of asbestos use, a number of

TABLE 5.1 Assessment of Potential Exposure to Asbestos in Schools

Location of Asbestos Containing Material	Quantity of Asbestos Material	Accessibility	Friability	Condition	Activity Nearby	Potential of Exposure	
						Number of students	Time of Exposure
Switchboard	Medium	Totally Enclosed	Hard or Semi-hard	Slight Damage	Very High	Negligible	Negligible
Heat Protection (Laboratories)	Small	Easily Accessible	Hard or Semi-hard	Excellent or Slight Damage	Very High	Medium	Medium
Pipe Lagging (in Toilet)	Small	Easily Accessible	Semi-hard	Slight Damage	Moderate	Medium	Very Low
Ceiling and Walls	Large	Easily Accessible	Hard	Excellent or Slight Damage	Various (Low to High)	Large	Large
Boiler and Hot Water Piping	Small	Easily Accessible	Hard	Excellent or Slight Damage	None	Negligible	Negligible
Others	Small or Medium	Easily Accessible	Hard or Semi-hard	Various	High	Large	Very Low

factors would determine the existence and level of airborne asbestos fibres and, hence, the health hazard represented by such situations. Since the asbestos-related diseases are assumed to be related to cumulative exposure, two of these factors are of greatest importance. These factors are: (a) exposure time, and (b) the concentration of airborne asbestos.

Exposure time was evaluated based on the results of the school survey as the time of average daily presence of school students within or nearby the location where asbestos-containing materials were detected. The results of the survey showed that exposure times in schools can be assessed as relatively short. In most cases, the daily time of exposure was less than 60 minutes (93 per cent of all cases) and, in as much as 41 per cent of all cases, exposure time was negligible and could therefore be disregarded. In only 3 cases of the total number of 46 cases (7 per cent), the exposure time was longer than one hour. In terms of exposure time and number of students involved, from the total number of 2400 students potentially exposed to asbestos in the surveyed schools, 490 students (20 per cent) could be daily exposed to asbestos for one hour or more, 1300 (54 per cent) for approximately 45 minutes daily and 610 students (26 per cent) for a time shorter than half an hour.

In order to determine the presence and estimate the level of airborne asbestos where the number of students involved was high and the exposure time relatively long, four sites (schools) were chosen for close examination (air sampling). Two of these had a relatively large number of students involved and had a long time of potential exposure (longer than 1 hour). One had a large number of students and a time of exposure of approximately 45 minutes. The other had a very small number of students involved and a very short time of exposure but with a potentially high level of airborne asbestos.

The results of fibre countings described in Chapter 4 confirmed that the method used at present to analyse air samples has technical and methodological limitations. Standard Optical Microscopy was found to be totally inappropriate, since only particles of a certain size and shape were counted and because most fibres counted were other than asbestos fibres. Therefore, the results of such countings are likely to be misleading. SEM is a particularly valuable method in distinguishing between asbestos and other fibres and, as a result, this method gives a precise result of counting. The long time required for analysis and the significant costs involved, limit its application as a standard method.

Based on the limited experimental results provided by the air sampling technique, it was necessary to proceed with caution in drawing firm conclusions and the following reservations apply to all conclusions made:

(a) air sampling was conducted in the potentially most hazardous locations in terms of presence of asbestos material and ability of those materials to emit asbestos dust;

(b) air sampling was a random procedure and results might vary from time to time in the tested locations due to different kinds of activities or maintenance work. Therefore, results represent the level of airborne asbestos which can be encountered at those locations in rather quiet conditions;

(c) fibre counting performed using the Optical Miscroscope method, although inappropriate to estimate the number of asbestos fibres, can be seen as correct in the counting of the overall number of fibres falling into a certain range of dimensions;

(d) the results of fibre counting and identification conducted using SEM in one school location and one car park could be extrapolated to other locations by assuming that, in the general environment, the ratio of asbestos fibres to other fibres absorbed on the test filter was similar to the ratio obtained using the SEM method.

With these reservations in mind, the final results of the survey may be stated as follows: in school rooms with walls and ceilings constructed of asbestos cement sheets, the average level of airborne asbestos was approximately 0.31×10^{-4} fibres/ml (calculated level of airborne asbestos, Table 4.11). The situation which represented the greatest potential hazard in the survey was encountered in a store room fully lined with unpainted asbestos was approximately 0.72×10^{-4} fibres/ml (calculated level of airborne asbestos Table 4.11).

It is worth placing the hazard risk represented by these asbestos fibre concentrations in perspective by referring, at this point, to the findings of the Canadian Royal Commission on asbestos and health (Ontario Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario 1984). The Commissioners concluded, in their report, that the asbestos exposure of building occupants was low, and was generally below 10^{-3} fibres/ml, with a few cases (where friable asbestos insulation was used) as high as 10^{-2} fibres/ml. The Commissioners estimated, further, that a person working for 10 years in a building in which the airborne asbestos fibre concentrations were 10^{-3} fibres/ml, faced a risk of death due to asbestos of 20 per million persons exposed.

In our study of the school population in Hobart, the risk of death is even lower since only a small percentage of students is exposed. The average time of exposure is much smaller than the average working day and the level of airborne asbestos is much lower also. The calculated risk can be expressed approximately as low as only .1 case per million of students who are exposed to asbestos during normal school hours.

This was compared to other risks of death (Table 5.2). In Canada, the highest cause of deaths was cardiovascular diseases (accounting for 337.2 in 100 000 deaths per year), followed by cancer (165.4 per 100 000), motor vehicle accidents (22.5 in 100 000). The risk of death from exposure to asbestos (for 10 years at a concentration of 10^{-3} fibres/ml) was, in comparison, minimal (0.029 in 100 000).

Finally, it can be stated that asbestos air concentrations in tested locations did not exceed the hygiene standard for occupational exposure for chyrsotile. The highest reading obtained using the Optical Microscope method was approximately 1000 times lower than hygiene standard for occupational exposure. Using the SEM method, the highest reading was approximately 10 000 times lower than this standard for chyrostile.

TABLE 5.2 Risk of Death by Cause 1980 (Death rate per 100 000 population per year)
(From Ontario, Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario 1984, page 584)

Cause of Fatality	
Accidents	
Motor vehicles (traffic)	22.5
Falls	7.7
Drowning	3.4
Miscellaneous	2.9
Fire	3.1
Poisoning	1.9
Suffocation	2.2
Aircraft	0.7
Motor vehicles (non-traffic)	0.6
Firearms	0.3
Disease	
Cardiovascular diseases	337.2
Cancer	165.3
Pneumonia	19.7
Diabetes	12.0
Asbestos Disease from Building Exposure	
U.K. Advisory Committee on Asbestos (150 years)	0.007-0.24
Royal Commission on Asbestos Estimate (10 years)	0.029

These results indicated that airborne asbestos levels in selected Hobart metropolitan schools were generally low, and were not very much greater than levels of airborne asbestos which can be encountered in the general environment elsewhere on the streets, or car parks. In order to compare the exposure to asbestos in the school environment with potential exposure in the general environment, an air sampling test in a car park was carried out. The results revealed that most of the fibres and particles were of inorganic and organic origin, and not asbestos fibres. Of the total number of 118 fibres counted using the

SEM method, only 2 fibres were confirmed as asbestos fibres. The results obtained by using the Optical Microscopy method indicated that the total number of 117 fibres encountered would all be accepted as asbestos fibres with an average value 0.12×10^{-4} fibres/ml (Table 4.11).

However, it is necessary to stress that exposure levels in the school environment may increase during certain periods or under certain circumstances. Students' behaviour causing damage to asbestos material, or maintenance work, or renovation, could increase asbestos levels significantly, and special procedures should be observed in such situations.

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CONTENTS OF APPENDICES

12 Allawara Street,
HOWRAH, TAS. 7018.

Hon. J. Beswick MHA,
Minister for Education.

Dear Sir,

I write to you in an attempt to clarify and resolve a problem I have encountered regarding my post graduate studies at the University.

I am currently undertaking a joint field study for my Masters Degree in Environmental Science and have embarked on writing a paper involving research into the incidence of asbestos within public buildings in the greater Hobart area; there is to be a particular emphasis on school buildings in the survey.

The study is purely scientific and although it has no political connotations, I understand now that the subject is one of a fairly sensitive nature.

My colleague researcher and I approached the Department of Labour for assistance in gaining access to schools and initially received a favourable response, however, in more recent times it would appear that little will occur in this regard.

It is of vital concern to me that I proceed without delay on the project, it is a very time consuming undertaking which I must complete by the end of the year. You will therefore understand the frustration I feel in the considerable delays so far encountered.

While the research is purely of an academic nature it is my opinion that the results, once obtained, may well be beneficial to the Education Department in establishing an indication of the incidence of airborne fibres (asbestos and others) in schools and hence allaying fears, both real and imaginary.

Permission is sought to survey a number of schools, say 40-50 and install in each some unobtrusive air monitoring equipment. The equipment comprises an air pump and filter unit (small suitcase size) which can be installed quickly and simply and needs to be in place for about 8 hours. It is envisaged that two calls would need to be made to each school, one to install the equipment and one to collect it. The filtered residue obtained from the pump will be transported to the University and surveyed by Dr. Jablonski under the electron microscope. Results of the study could be made available to the Education Department at any time.

Enclosed please find a copy of the latest project report and thesis plan, together with a letter of authority and introduction from the Director of the Department, Dr. R. Jones, and from Professor H. Bloom. Further references or details of the research could be obtained if so desired.

As I have mentioned, time is of the utmost importance, if the study so far undertaken is not to be wasted.

If we could receive a letter of authority from yourself or your Director-General enabling us to approach school Principals directly, we would be more than happy.

One additional point that may serve to point out the non-political/industrial nature of our research concerns my own involvement. I am a qualified dental surgeon, having arrived in Australia some 2½ years ago along with my husband and family. As you would be aware, recognition of 'foreign' dental qualifications is almost impossible save through a very difficult open examination and requalification process. I intend to pursue accreditation in dentistry some time in the future but in the meantime I have secured a Commonwealth Scholarship to complete the work I am presently undertaking. My husband is a professional engineer currently employed with Telecom Australia.

My colleague researcher working conjointly on the project for the thesis is Mrs. Anna Jackiewicz, herself a qualified doctor with some 16 years experience in the field of medicine and speciality of paediatry. Our ambition and desire is to be actively engaged once again in a worthwhile community service.

Yours faithfully,

(Mrs.) Janina Anna Marek.

Appendix 2

TASMANIA

Office of the Minister for Education
Hobart, Tasmania

MH

File No. 14/14/9

Mrs. J.A. Marek,
12 Allawarra Street,
HOWRAH. TAS. 7018

Dear Mrs. Marek,

Further to my acknowledgement of 3rd August, I am pleased to advise that you have my permission to approach a sample of schools in order to gain information on the incidence of airborne fibres within school buildings.

Since the Department is always concerned to provide a suitable environment for its students I would appreciate receiving results of the study relating to schools as soon as they are available.

Yours sincerely,

(John Beswick)
Minister for Education

xecutive Buildings, Franklin Square, Hobart 7000 Telephone: (002) 30 8011 – Telex: Tasma 58155

INDEX No

ASBESTOS SURVEY IN HOBART SCHOOLS - Questionaire

I. School ....

2. Location (Suburb) ....

....

3. Description of School

A. Type of Building - single storey, two, three, temporary, separate ....

....

B. Construction - brick, weatherboard, asbestos-cement sheets, besser blocks ....

C. Roof - tiles, iron, others ....

....

D. Lining (inner) woodpanels, hardboard, plaster, asbestos-cement,

....

....

4. Presence of Asbestos Material in:

a) Thermal Insulation ....

b) Roofing (roof spaces) ....

c) Sofit cladding ....

d) Ventilation System ....

e) Acoustic Insulation ....

f) Ceiling and Partition Walls ....

g) Fire-protection ....

h) Fibro-cement Sheeting and Mouldings ....

i) Dawnpipes and Guttering ....

j) External Finishes and Cladding ....

k) Latex Flooring ....

l) Asbestos Vinyl Tiles ....

m) Foodheaters ....

n) Piping System ....

o) Boilers ....

p) Switchboard ....

r) Plant Room ....

....

....

....

....

5. Hazard Assessment

I. Accessibility:

Ia.Totaly Enclosed with no Potential for Fibre Emission ....

Ib.Potential Fibre Source ....

Ic.Other (description) ....

....

....

II. Activity and Movement:

IIa. Non or Low Activity ....

IIb. Moderate Activity ....

IIc. High Activity Level ....

....

....

III. Friability:

IIIa. Hard, Bonded in Gypsum or Cement ....

IIIb. Semi-hard and may easily dislodge or crumble................

IIIc. Loose and Flaking ....

IIId. ....

IIIe. ....

....

IV. Condition

IVa. Excellent, no damage ....

IVb. Slight damage ....

IVc. Several damaged areas..

IVd. Several break-off ....

IVe. Is material painted? ....

....

V. Is there an air conditioning system? ....

....

....

....

....

....

6. Incidental Exposure

6a. Are there students or other people in the room or adjacent to potential hazard? ....
....
....

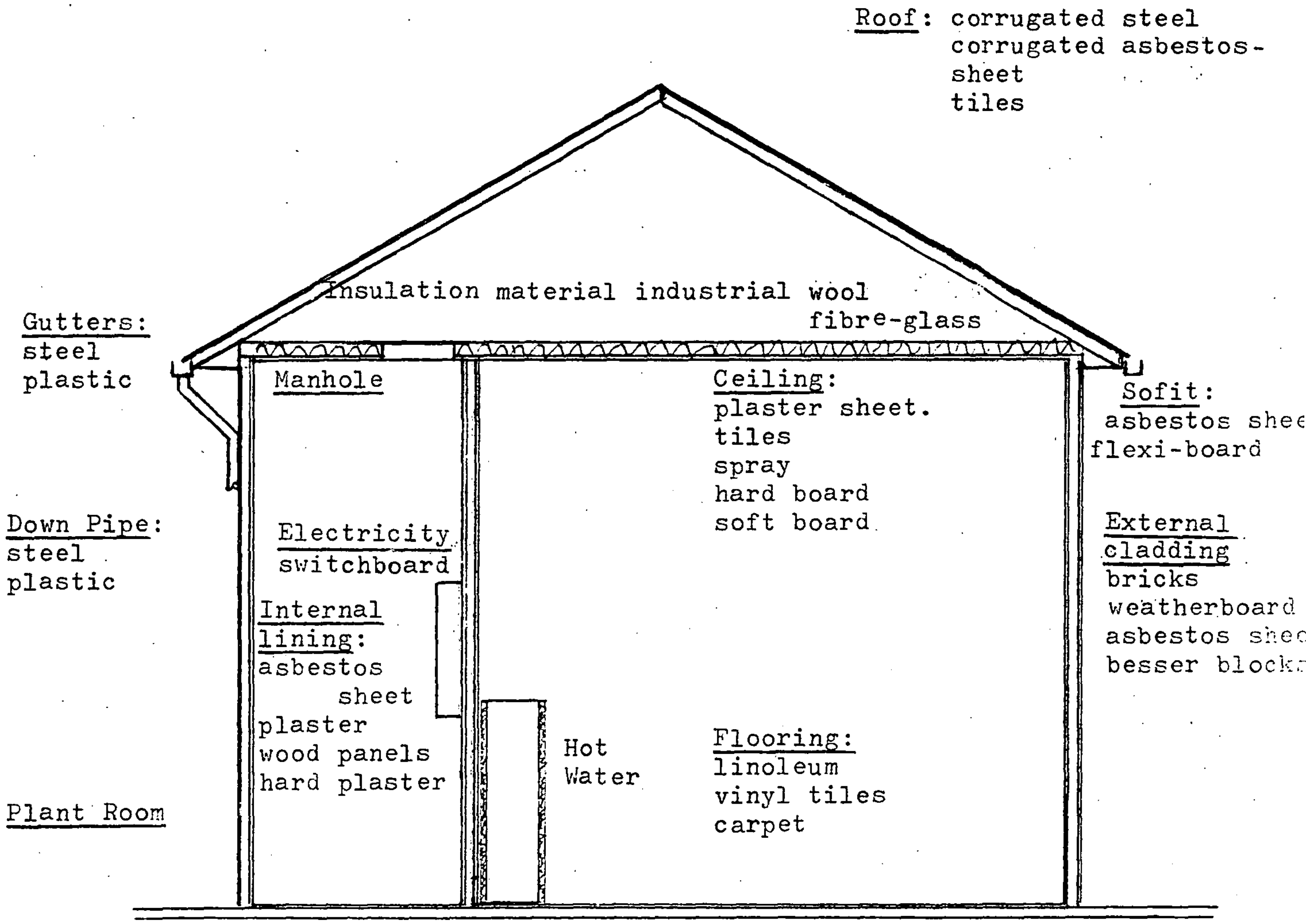
6b. If yes, determinate approximately average time of exposure per day per person ....
....
....
....
....
....

7. Recording of bulk samples (if necessary)
Marking and description of time, site, number and order ....
....
....
....
....
....
....
....

8. Air monitoring (if necessary)...................................
Recording of location ....of sample pumps and filters ....
....
....
....
....
....
....
....
....

SCHOOL AND BUILDING ....

....



X - denotes location of sample taken.

Appendix 4

BULK SAMPLE - RECORD SHEET

Date of Sample Taken ....

Sample Identification Number ....

Location within the building ....

The method used for analysis ....

The type of asbestos fibres, if any ....

....

....

....

....

....

Comment on other materials detected ....

....

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....

....

DEPARTMENT OF LABOUR AND INDUSTRY

Appendix 5

AIR SAMPLING TESTS

JOB:

ADDRESS:

REFERENCE NO: TEST DATE: TESTING FOR:

Test		Start	Finish	Remarks
	Pump No.	....	....	
	Filter Ref.	....	....	
	Battery	....	....	
	Flow	....	....	
	Time	....	....	
	Pump No.	....	....	
	Filter Ref.	....	....	
	Battery	....	....	
	Flow	....	....	
	Time	....	....	
	Pump No.	....	....	
	Filter Ref.	....	....	
	Battery	....	....	
	Flow	....	....	
	Time	....	....	
	Pump No.	....	....	
	Filter Ref.	....	....	
	Battery	....	....	
	Flow	....	....	
	Time	....	....	
	Pump No.	....	....	
	Filter Ref.	....	....	
	Battery	....	....	
	Flow	....	....	
	Time	....	....	

Reference No.	Test Time (mins.)	Flow Rate(ml/min.)	Fibres/ml
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

TESTING OFFICER: DATE:

PUMP CALIBRATIONS

Test	Pump Number	Times (secs.)	Individual Ave. (secs.)	Total Ave. (secs.)	Flow ml/min.
Start	....	....	....	....	....
Finish	....	....	....	....	....
Start	....	....	....	....	....
Finish	....	....	....	....	....
Start	....	....	....	....	....
Finish	....	....	....	....	....
Start	....	....	....	....	....
Finish	....	....	....	....	....
Start	....	....	....	....	....
Finish	....	....	....	....	....

$$\text{Flow} = \frac{30{,}000}{\text{time (secs.)}} \text{ ml/min.}$$

NOTES:

1. The pumps should be left for 30 minutes after charging before switching on.
2. The pumps should be left running for 15 minutes before commencing calibration.
3. Individual calibration times may not vary by more than $\pm$ 10%.
4. Start and finish averages may not vary by more than $\pm$ 5%.
5. The filter surface is to be pointing downward during testing and set up in a clear area.
6. Operators breathing zone is defined as the hemisphere of 300 mm radius extending in front of the face and centred on the nose.

ASBESTOS FIBRE COUNTING RECORD

Appendix 6

Date:

Microscope:

Graticule: Area: mm^2

N Sample No:

No. of fibres	No. of fields

$$C = \frac{N}{n} \times \frac{1}{rt} \times \frac{A}{a}$$

C = airborne fibre concentration (fibre/ml)

N = number of fibres counted

n = number of fields counted

A = effective filter area (mm^2)

a = area of counting field (mm^2)

r = flow rate (ml/min)

t = sampling time (min)

= ______________

= [ ] $\frac{\text{fibres}}{\text{ml}}$