NICNAS

National Industrial Chemicals Notification and Assessment Scheme

Chrysotile Asbestos
Priority Existing Chemical No. 9

Full Public Report

February 1999

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Preface

This assessment was carried out under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS). This Scheme was established by the *Industrial Chemicals (Notification and Assessment) Act 1989* (the Act), which came into operation on 17 July 1990.

The principal aim of NICNAS is to aid in the protection of people at work, the public and the environment from the harmful effects of industrial chemicals, by assessing the risks associated with these chemicals.

NICNAS is administered by the National Occupational Health and Safety Commission (NOHSC) and assessments are carried out in conjunction with Environment Australia (EA) and the Therapeutic Goods Administration (TGA), who carry out the environmental and public health assessments, respectively. NICNAS has two major programs: one focusing on the risks associated with new chemicals prior to importation or manufacture; and the other focussing on existing chemicals already in use in Australia.

As there are many thousands of existing industrial chemicals in use in Australia, NICNAS has an established mechanism for prioritising and assessing these chemicals. Such chemicals are referred to as Priority Existing Chemicals (PECs).

The scope of the PEC assessment is to establish the risks to workers, members of the public and the environment from importing, manufacturing, using, storing, handling and disposal of a chemical in Australia. This permits recommendations to be made which will assist in the management and/or further evaluation of such risks. Recommendations may be specifically directed at industry (employers and employees), union bodies and Federal and State/Territory regulatory authorities or may be of a more generic nature, such as those identifying further research needs. NICNAS is a national scientific assessment scheme and cannot make regulatory decisions which fall within the responsibility of the State/Territories or other Commonwealth authorities. Recommendations can only be given effect through consideration of risk management practices and processes by those agencies/authorities charged with regulatory decision making.

This Full Public PEC report has been prepared by the Director (Chemicals Notification and Assessment) in accordance with the Act. During all stages of preparation, the report has been subject to internal peer review by NICNAS, NOHSC, Environment Australia and Therapeutic Goods Administration. Specific sections of this report were also peer reviewed by WorkCover, New South Wales; University of Sydney, Department of Public Health and Community Medicine and US EPA Office of Prevention, Pesticides and Toxic Substances (Risk Assessment Division).

Under Sections 60D and 60E of the Act, applicants were provided with a draft copy of the report for correction of errors and variation (for a period of 56 days). The corrected draft was also available for public comment on 6 October 1998 (as notified in the October 1998 edition of the *Commonwealth Chemical Gazette* and the Weekend Australian on 10/11 October 1998) for a period of 28 days. Over 150 draft reports were requested during this period and 17 formal requests for variation were received. The Director's decision (concerning each request) was made available to each respondant and to other interested parties (for a period of 28 days) by way of notice in the December 1998 edition of the *Commonwealth Chemical Gazette*.

In accordance with Section 62 of the Act, publication of this report revokes the declaration of chrysotile (white asbestos) as a PEC. However, notwithstanding current State/Territory regulations regarding the use of chrysotile, an introducer of chrysotile must inform the Director (under Section 64(2) of the Act) of any new circumstances that may require a further assessment of risks to human health and the environment. For further details refer to Section 14 (Secondary Notification) of this report.

For the purposes of Section 78(1) of the Act, copies of Full Public Reports for New and Existing Chemical assessments may be inspected by the public at the Library, Worksafe Australia, 92-94 Parramatta Road, Camperdown, Sydney, NSW 2050 (between 10 am and 12 noon and 2 pm and 4 pm each weekday). Summary Reports are published in the *Commonwealth Chemical Gazette*, which are also available to the public at the above address.

Copies of this and other PEC reports can also be purchased from NICNAS either by using the prescribed application form at Appendix 10 of this report, or directly from the following address:

GPO Box 58

Sydney

NSW 2001

AUSTRALIA

Tel: +61 (02) 9577 9437

Fax: +61 (02) 9577 9465 or +61 (02) 9577 9465 9244

Other information about NICNAS (also available on request) includes:

- NICNAS Service Charter;
- information sheets on NICNAS Company Registration;
- information sheets on PEC and New Chemical assessment programs;
- application forms for chemical assessment;
- subscription details for the NICNAS Handbook for Notifiers; and
- subscription details for the Commonwealth Chemical Gazette.

Information on NICNAS, together with other information on the management of workplace chemicals can be found on the NOHSC Web site:

http://www.worksafe.gov.au/worksafe/03/030000.htm

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Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
ACGIH	American Conference of Governmental Industrial Hygienists
ACS	Australian Customs Service
ADG	Australian Dangerous Goods
ADR	Australian Design Rule
AICS	Australian Inventory of Chemical Substances
ASME	American Society of Mechanical Engineers
CAF	compressed asbestos fibre
CAS	Chemical Abstracts Service
CF	compressed fibre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EC	European Commission
EINECS	European Inventory of Existing Commercial Chemical Substances
EA	Environment Australia
EEC	European Economic Community
EU	European Union
f/mL	fibres per millilitre of air
FORS	Federal Office of Road Safety (Australian)
HSE	Health and Safety Executive (UK)
IARC	International Agency for Research on Cancer
ILO	International Labour Organisation
INSERM	Institute de la Santa et de la Recherche Medicale
IPCS	International Programme on Chemical Safety
ISO	International Organization for Standardization
i.p.	intraperitoneal
LD	lethal dose
LD_{50}	median lethal dose
LOAEL	lowest observed adverse effect level
MFM	membrane filter method
MFM/PCM	membrane filter method using phase contrast microscopy
MLD	minimum lethal dose
MOS	margin of safety
mpcf	millions of particles per cubic foot
MS	mass spectrometry

MSDS	material safety data sheet
NAO	non-asbestos organic
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NOAEL	no observed adverse effect level
NOHSC	National Occupational Health and Safety Commission
OECD	Organisation for Economic Cooperation and Development
OSHA	Occupational Safety and Health Administration (USA)
PAN	Polyacrylonitrile
PCM	phase contrast light microscopy
PEC	predicted environmental concentration
PEC	Priority Existing Chemical
PNEC	predicted no effect concentration
PPE	personal protective equipment
PTFE	polytetrafluoroethylene
PVA	Polyvinylalcohol
PVC	polyvinylchloride
RCF	refractory ceramic fibres
RTECS	Registry of Toxic Effects of Chemical Substances
SAED	selected area electron diffraction
SCBA	self contained breathing apparatus
SEM	scanning electron microscopy
SMF	synthetic mineral fibres
SMR	standard mortality ratio
STEL	short term exposure limit
SUSDP	Standard for the Uniform Scheduling of Drugs and Poisons
TEM	transmission electron microscopy
TGA	Therapeutic Goods Administration
TSCA	Toxic Substances and Control Act (USA)
TWA	time weighted average
µm	micrometre
UN	United Nations
US EPA	United States Environmental Protection Agency

1. Introduction

1.1 Declaration

Chrysotile (CAS No. 12001-29-5) was declared by the Minister for Industrial Relations as a PEC under the *Industrial Chemicals (Notification and Assessment) Act 1989* (Cwlth) (the Act) by notice in the *Chemical Gazette* of 7 November 1995. In accordance with the Act, importers of 'raw' chrysotile applied for the assessment of the chemical as a PEC. Suppliers/importers of chrysotile 'products/articles' were not required to apply for assessment, but were required to provide relevant information/data. Appendix 1 provides details of applicants.

The declaration was made on the basis that:

- chrysotile is a known human carcinogen;
- there is continued widespread use of chrysotile in Australia;
- the major uses of chrysotile are in the automotive industry in friction products and in gaskets and, therefore, there is potential for occupational exposure during distribution and handling, manufacture, aftermarket processing (e.g., machining, fitting) and use of chrysotile products; and
- public and environmental exposure to chrysotile may occur during use and disposal.

1.2 Objectives

The objectives of this assessment were to:

- assess the occupational, public health and environmental risks associated with current uses and applications in Australian industry;
- characterise current and future uses of chrysotile asbestos in Australia and to compare the situation with overseas countries;
- assess the feasibility of substitution of chrysotile materials and voluntary and/or legislative action for reducing potential health and safety risks arising from manufacture and import of chrysotile and chrysotile products.
- to provide recommendations for a risk reduction strategy for chrysotile based on the assessment of available information.

1.3 Scope of the assessment

Consistent with the objectives, this report considers all relevant information relating to exposure to chrysotile from import of raw chrysotile and asbestos-containing products and manufacture of chrysotile products. Chrysotile products already in place in the community are outside the scope of this report.

With regard to health effects associated with exposure to chrysotile, reviews were used as the main source of data, due to the fact that the health effects of chrysotile have been extensively studied and understood. Similarly, an 'in-depth' evaluation of chrysotile alternatives was outside of the scope of this report and therefore international reviews were evaluated in preference to original studies.

1.4 Sources of information

Information for the different sections of the PEC assessment report required in-depth and thorough investigations through various data sources and mechanisms. These data sources and the way they were utilised are detailed in Appendix 2.

The various sources of information that were used for this assessment report included:

- Data from the Australian Bureau of Statistics (ABS) and Australian Customs Service (ACS) on import and export volumes of asbestos and asbestos products;
- Data supplied by importers (applicants) of raw chrysotile;
- Three surveys on companies importing chrysotile products, companies importing and manufacturing new vehicles and companies involved in the aftermarket use of chrysotile products;
- Exposure data obtained from a monitoring study carried out by NOHSC; and
- Consultants report on international/national regulations on asbestos.

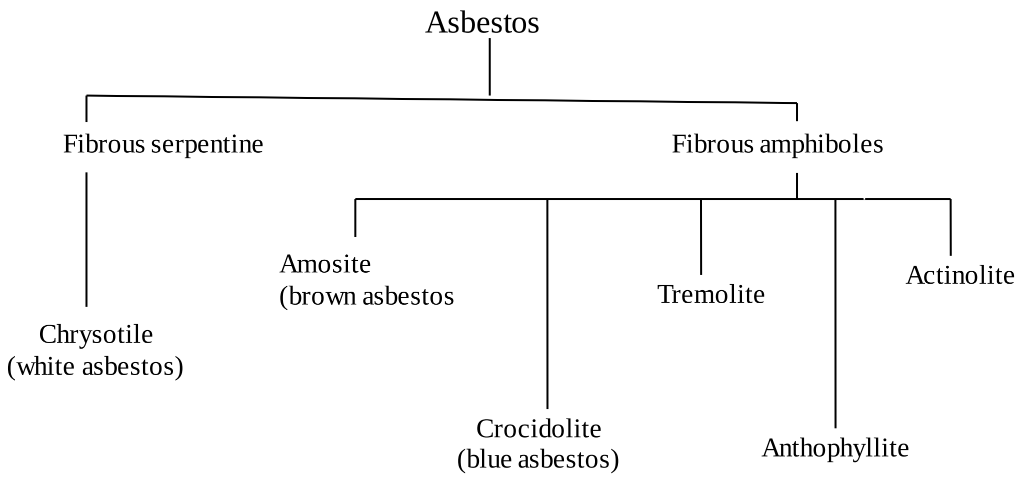
Other sources of information include database and literature searches and information obtained from national and overseas regulatory agencies and other relevant institutions.

2. Background

2.1 Classification of asbestiform materials

Asbestos is defined as the fibrous form of mineral silicates belonging to the serpentine and amphibole groups of rock-forming minerals. The most common asbestos types are chrysotile (white asbestos) a fibrous serpentine mineral and amosite (brown asbestos) and crocidolite (blue asbestos) which are amphiboles. Other forms of amphibole asbestos include actinolite, anthophyllite and tremolite.

ASBESTOS MINERALS



Asbestos has been used in a variety of capacities for centuries in many countries. Asbestos, including chrysotile, has been used in many applications because of its reinforcement, thermal (and electrical) insulation, and heat resistance properties. Some applications of asbestos only utilise one of these properties whereas other applications require several properties. Asbestos has also been used in yarns and textiles due to its flexibility and strength. It is elastically compressible, and therefore, suitable for use in packings, jointings and seals.

In the past, Australia has mined and imported asbestos fibre. Asbestos fibre was used to manufacture asbestos products, such as asbestos cement articles, asbestos yarn cord and fabric, asbestos joint and millboard, asbestos friction materials and gaskets. These products were also imported into Australia as finished articles. Asbestos mining (crocidolite and chrysotile) ceased altogether in Australia in 1983.

2.2 Trends in asbestos use worldwide

Although significant amounts of amphibole asbestos were used in the past, chrysotile is the major type used in the world today, with amphiboles comprising less that 3% of total asbestos usage. Countries that account for the majority of the world production of chrysotile are Brazil, Canada, China, Kazakhstan, Russia, South Africa and Zimbabwe (Pigg, 1994; Lemen & Bingham, 1994).

Lemen & Bingham (1994) reported that world production and consumption of asbestos peaked in 1976 and declined only slightly during the early 1980s. World production was 4.5 million tons in 1985, dropped to 4.2 million tons in 1988, and was projected to be 4.4 million tons in 1990.

Some of the commercial applications for asbestos in the world today (Lemen & Bingham, 1994) are:

Asbestos cement products	70%
Vinyl asbestos flooring	10%
Friction products	7%
Asbestos paper & felt	5%
Gaskets & packings	3%
Paints, roof coatings, caulks, etc	2%
Filter media	2%
Asbestos textile products	1%
All other uses	< 1%

Over the last few years, asbestos consumption has declined worldwide, especially in North America and European markets. For example in the United States during the period of 1977-1991, there has been a large decline in asbestos use. This decline is shown in Table 1.

Table 1 - US demand pattern (x 10^3 tonnes)

Product	1977	1991
Asbestos-cement pipe	115	4
Asbestos-cement sheet	27	2
Coating and compounds	36	1
Flooring products	150	-
Friction products	57	10
Installation: electrical	4	1
Installation: thermal	17	-
Packing and gaskets	28	3
Paper products	7	-
Plastics	8	-
Roofing products	70	15
Textiles	10	-
Other	143	1
Total*	672	34

(Adapted from Pigg,1994)
*Data does not add up to totals shown because of independent rounding.

Use of asbestos is increasing in some countries. For example asbestos-cement production continues to grow in South America, Southeast Asia, the Middle East and Eastern Europe. Japan, Thailand, Malaysia, Korea and Taiwan imported 430,000 tonnes in 1989, that is, well over 30% of worldwide asbestos (Pigg, 1994). In developing countries the principle use of asbestos is as building material for dwellings and potable water piping.

2.3 Trends in asbestos use in Australia

Chrysotile was mined in Australia for over 100 years with production gradually increasing until cessation in 1983. The main Australian centres of asbestos mining were the crocidolite deposits of the Hamersley Ranges in Western Australia, and chrysotile deposits at Baryulgil and Woods Reef in New South Wales, and Lionel and Nunyerrie in Western Australia (Commonwealth of Australia - Department of National Development Bureau of Mineral Resources, 1965).

Amosite has never been mined in Australia (Hughes, 1977).

Crocidolite dominated asbestos production until the closure of the Wittenoom mine in 1966. The highest and final quantity of crocidolite production was between1960-1969 and was 86,566 tonnes.

In Australia the mining of chrysotile peaked during the 1970s in which period a total of 400,000 tonnes was produced. Mining of chrysotile ceased in 1983, at which time approximately 55,000 tonnes per year of chrysotile was being produced in Australia and approximately 20,000 tonnes imported. The importation of chrysotile has dropped significantly since this period to approximately 2000 tonnes per annum.

Raw chrysotile continues to be imported into Australia. Articles also containing chrysotile are both locally produced and imported. The raw chrysotile is used for the manufacture of friction materials such as brake disc pads, brake linings and brake blocks and in the manufacture of gaskets. Gaskets are widely used in the industrial sector for high temperature and pressure applications. Similar chrysotile products are also imported.

There are many asbestos products that were used in the past that are still present in the community. These are known as fixed uses. Areas where fixed use of asbestos may be found are insulation, cement materials (pipe and building materials), vinyl floor tiles and sealants.

Asbestos use is extensively regulated in Australia. However, in each jurisdiction more severe restrictions exist in relation to particular forms of asbestos other than chrysotile (generally amosite and crocidolite). This is discussed further in Section 10 (Risk Management).

3. Chemical and Physical Properties

3.1 Chemical name

Chrysotile is listed on the Australian Inventory of Chemical Substances (AICS).

CAS number	12001-29-5
EC number	650-013-00-6
RTECS number	GC2625000

3.2 Other names

Asbestos

Serpentine asbestos

White asbestos

3.3 Trade names

7-45 Asbestos

Avibest

Avibest C

Calidria RG 100

Calidria RG 144

Calidria RG 600

Cassiar AK

K 6-30

NCI C61223A

5RO4

3.4 Molecular formula and structure

Molecular formula: $Mg_3Si_2O_5(OH)_4$

The crystal structure of chrysotile is layered or sheeted similarly to the kaolinite group. It is based on an infinite silica sheet (Si_2O_5) in which all the silica tetrahedra point one way. On one side of the sheet structure, and joining the silica tetrahedra, is a layer of brucite, $Mg(OH)_2$. The result is a layered structure.

3.5 Molecular weight

283

3.6 Chemical composition

Chemical analysis shows that chrysotile typically consists of the following range of major constituents (%) (IPCS, 1986):

SiO_2	38 - 42
MgO	38 - 42
N_2O^+	11.5 - 13
Fe_2O_3	0 - 5
FeO	0 - 3
Al_2O_3	0 - 2
CaO	0 - 2
Na_2O	0 - 1

3.7 Impurities

Impurities that are present in chrysotile may be part of the crystal structure or due to associated minerals. The most common impurities are iron and aluminium. Other impurities associated with chrysotile in lesser amounts are calcium, chromium, nickel, manganese, sodium and potassium.

Common mineral impurities found in commercial grades of chrysotile from various locations include magnetite, chromite, brucite, calcite, dolomite and awaruite. Within the chrysotile lattice, nickel and iron can occur as minor isomorphic substitutions for magnesium.

Chrysotile is frequently contaminated by small amounts of other fibrous minerals such as tremolite (HSDB, 1998).

3.8 Physical properties

Chrysotile is an odourless white, grey, green, yellowish fibrous (flexible) solid material with a soft, 'soapy' texture at standard temperature and pressure (HSDB, 1998).

Table 2 - Physical properties

Property	Value	Reference
Boiling point	Not applicable	
Melting point/decomposition temperature	800-850°C	(US Department Of Health & Human Services, 1995)
Tensile strength	31,000kg/sq cm	HSDB (1998)
Specific gravity	2.55	HSDB (1998)
Vapour pressure	Not applicable, expected to be low	
Partition coefficient	Not applicable in view of expected insolubility of this inorganic compound in octanol.	
Isoelectric point	11.8	(US Department Of Health & Human Services, 1995)
pH	Approximately 10 (in aqueous slurry)	(Budavari et al., 1989)
Electrical charge at neutral pH*	Positive	(US Department Of Health & Human Services, 1995)
Flammability limits	Non-flammable	(US Department Of Health & Human Services, 1995)

* Chrysotile is isoelectric (zero charge) over the pH range ~10.0 to 12.0, and tends to have a positive charge at physiological pH.

3.8.1 Solubility

Chrysotile is insoluble in water (pH 7) and organic solvents. The solubility of chrysotile is both pH and temperature dependent, for example acidic conditions and high temperatures will cause chrysotile fibres to dissolve rapidly (Schreir, 1989). While other forms of asbestos fibres are stated as fairly resistant to acids, chrysotile is described as soluble in acid (Kirk-Othmer, 1985), with a 56.0% weight loss (due to loss of counter-ions; silicate structure remains intact). However, only around 1% dissolution is seen under basic conditions (US Department Of Health & Human Services, 1995).

Solubility under acidic conditions is to be expected from the chemical structure of chrysotile. Serpentine chrysotile has a structure composed of layers of silicate tetrahedrons linked into sheets. Between the silicate layers are layers of magnesium hydroxide (brucite layers). In most serpentines, the silicate and brucite layers are more mixed and produce convoluted sheets. In the asbestos varieties, the brucite and silicate layers bend into tubes that produce the fibres (Amethyst Galleries Inc., 1996a). Magnesium hydroxide is practically insoluble in water, but is soluble in dilute acids (Budavari et al., 1989).

3.8.2 Thermal degradation

Chrysotile is subject to thermal decomposition at elevated temperatures. This thermal decomposition is a two stage reaction consisting first of a dehydroxylation phase and then a structure phase change. Dehydroxylation or the loss of water occurs at 600-780°C. At 800-850°C (see Table 2) the anhydride breaks down to forsterite* and silica. These reactions are irreversible (HSDB, 1998).

*Forsterite is a member of the olivine series of iron magnesium silicates, and is non-fibrous. It is magnesium rich with a formula approximating Mg_2SiO_4 (Amethyst Galleries Inc, 1996).

4. Methods of Detection and Analysis

4.1 Qualitative analysis

Several methods are available, either singly or in combination, for the qualitative analysis of asbestos. For specificity in identification of asbestos minerals, the ranking is electron microscopy, optical microscopy, X-ray diffraction and infra-red spectophotometry.

4.2 Determination of asbestos in air

The determination of asbestos (including chrysotile) in air entails two steps, sampling and analysis. Sampling typically involves drawing a measured volume of air through a filter mounted in a holder. When sampling for occupational exposure, the holder is located in the breathing zone (personal sampler) of the worker. Static sampling involves taking samples at fixed locations and provides information on asbestos concentrations in the general area. Asbestos fibres are collected on the filter which is removed for analysis at the end of the sampling period.

Analytical methods usually determine the fibre number concentration of asbestos in air. Some analytical methods also enable characterisation of the fibres. The standard analytical method for counting fibres is the membrane filter method using phase contrast light microscopy (PCM). Electron microscopy techniques, scanning electron microscopy (SEM) and transmission electron microscopy (TEM), have also been used for counting, especially for low fibre concentrations and environmental sampling. Accessories to the electron microscope such as Selected Area Electron Diffraction (SAED) and Spectrum Analysis (EDXA) have further enabled identification of fibres.

4.2.1 Membrane filter method (using phase contrast microscopy)

The membrane filter method using phase contrast microscopy (MFM/PCM) has been used for many years, both internationally and in Australia, as the standard method for the determination of asbestos in air in the occupational environment. Although the methodology may vary slightly between the various published methods and between testing authorities, the basic principles are similar.

In Australia, the National Occupational Health and Safety Commission (NOHSC) has published the *Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Dust* (MFM Guidance Note) in: *Asbestos: Code of Practice and Guidance Notes* (NOHSC, 1988). The methodology is generally referred to as the MFM method and is used as the standard for regulatory monitoring in Australia. Laboratory accreditation for this method is provided by the National Association of Testing Authorities (NATA).

In the MFM method, air is drawn via a sampling pump through an opaque membrane filter (mixed esters of cellulose or cellulose nitrate), which is later transformed into a transparent, optically homogeneous specimen. The fibres collected on the filter are then sized and counted using a phase contrast microscope and eyepiece graticule. For the purposes of determination of asbestos in air by the MFM method, a fibre is defined as having a length greater than 5 µm, a width less than 3 µm, and a length/width ratio greater than 3:1. The result is expressed as fibres per millilitre of air (f/mL), calculated from the number of fibres on the filter and the volume of air sampled. For occupational exposures, results are determined as a time-weighted average (TWA) with sampling over a 4-hour minimum period for comparison to the occupational exposure standard.

The main advantage of the MFM method is it is relatively quick and inexpensive. Although used as the standard method, it has several limitations (mainly associated fibre counting of fibres rather than sampling), which are discussed further in the MFM Guidance Note and highlighted by several authors (Corn, 1994; Lippmann, 1994; Kohyama & Kurimori, 1996). Limitations include:

- the method is not fibre specific and cannot discriminate between the various types of asbestos, or between asbestos and other types of fibres, e.g., wool, cotton, cellulose and fibre glass;
- the method has limited resolution and cannot detect very thin fibres (lower limit of optical resolution for PCM is 0.2-0.3 µm), and it may be difficult to quantify fibre size;
- artifact "fibres" sometimes form on the filters during mounting for microscopy, which may give rise to false (high) readings if not recognised.

These limitations may lead to problems such as high background counts and inaccurate results due to the failure to detect artifacts or some smaller airborne respirable fibres. In dusty occupations background dust levels may be high and sampling times may need to be reduced to minimise the particulate or fibre load on the filter, so consecutive samples must be taken to make up the required sampling time in order to increase the limit of detection. Consequently, the method is most useful for analysis of samples that contain a significant amount of asbestos and where there is not a significant fraction of fibres that are too fine to be counted.

The NOHSC MFM Guidance Note states that the practical lower detection limit for occupational sampling is 0.05-0.1 f/mL for a 100 L sample and a minimum fibre loading of 10 fibres/100 graticule areas (NOHSC, 1988). The limits are based on the assumption that blank filters contain a few countable fibres. In practice, the limit of detection may be higher if the conditions above are not met, for example, lower sample volumes and high blank counts. Suggested changes to the methodology have been recommended in the NOHSC draft public discussion paper (proposed National Exposure Standard) on chrysotile (NOHSC, 1995a).

4.2.2 Transmission Electron Microscopy (TEM)

Transmission Electron Microscopy (TEM) has developed as a viable technique for the determination of asbestos in air. The US National Institute for Occupational Safety and Health (NIOSH, 1990) Analytical Method 7402 for asbestos fibres employs TEM which has a detection limit of <0.01 f/mL (in atmospheres free from interference). The latest analytical methodology for asbestos fibres using TEM is prescribed in ISO Standard 10312 (ISO, 1993). This method has a detection limit of 0.002 f/mL (in ambient air).

The higher magnification and resolution of the TEM method allow an examination of shorter and finer asbestos fibres, not permitted by PCM. TEM equiped with high resolution x-ray spectra (fitted with a tilt and rotate specimen holder) and selected area electron diffraction patterns (SAED), enables reliable discrimination between asbestos and non-asbestos fibres and also the ability to distinguish between different types of asbestos fibres. It has been reported that TEM can resolve fibres down to 0.02 µm[1] in diameter (Kohyama & Kurimori, 1996), which makes it the only viable technique for analysis of chrysotile fibres. TEM, not only requires considerable capital expenditure, but is time consuming. In occupational exposure monitoring TEM is only used to confirm results obtained by MFM/PCM. TEM is the preferred method for monitoring asbestos in the general environment, where fibre sizes and fibre concentrations are usually much lower than in occupational situations (Rogers, 1998).

A number of different methods of sample preparation have been used with TEM and are broadly divided into 'direct' and 'indirect' transfer methods. The fibres are basically unaltered in direct transfer methods. With indirect methods, some mechanical breakdown to smaller fibres often occurs, particularly if sonification is used (Corn, 1994). As chrysotile fibres are more susceptible to breakdown through sonification than other asbestos fibres (Breysse, 1991). Due to the probability of fibre breakdown, results by TEM 'indirect' methods are often quoted in mg/m^3 rather than f/mL. Direct TEM methods, such as ISO 10312 are preferred since they do not change fibre size distributions on the collected sample (Rogers, 1998).

Attempts have been made to adapt TEM analysis into asbestos removal guidelines. Due to the considerable analytical variability found at such low fibre concentrations, TEM monitoring has been found to be impractical and routine clearance monitoring has reverted to MFM/PCM (Rogers, 1998).

4.2.3 Scanning Electron Microscopy (SEM)

Scanning Electron Microscopy (SEM) permits the sizing of small fibres and with x-ray spectral attachments most fibres can be identified. The resolution of SEM is not as good as TEM and is similar to the PCM, such that it is possible to distinguish non-asbestos fibres and most common types of asbestos down to a fibre diameter of about 0.2 µm using x-ray spectral attachments. However, only the elemental ratio for fibre composition is obtained and this is somewhat insufficient in positively identifying fibres, as it is often necessary to determine the internal crystalline structures (National Board of Occupational Safety and Health, 1982). The principal fibres identified by the SEM are amphiboles such as amosite, crocidolite and anthophyllite asbestos.

Although there are routine analytical methods using SEM, this method is less favoured than TEM (in the determination of asbestos fibres in air) due to the lower analytical resolution and possibility of missidentification of fibres using this technique (Roberson et al., 1992; AIA, 1984).

[1] Higher resolution (down to 0.005 µm) may be achieved with some contemporary computer controlled instrumentation.

4.3. Comparison of methods

Several papers comparing the various methods have been published in the open literature. Some have compared PCM and TEM (Marconi et al., 1984; Dement & Wallingford, 1990; Snyder et al., 1987), SEM and TEM (Roberson et al., 1992), and PCM, SEM and TEM (Cherrie et al., 1989; Kohyama & Kurimori, 1996).

In general, the electron microscopic methods give higher total counts (of fibres > 5 μm in length) than PCM because the latter cannot detect very thin fibres. In a comprehensive comparison using similar filter sizes, the total chrysotile fibre count using TEM by the direct transfer method was approximately four times that obtained by PCM, with the count for fibres of length > 5 μm approximately three times higher (Kohyama & Kurimori, 1996). For the purposes of comparison, some study authors have advocated the use of multiplication factors which vary depending on the process to convert results from one method to the other (Snyder et al., 1987; Cherrie et al., 1989). In the identification of fibres in the comparison between SEM and TEM (Roberson et al., 1992), TEM was the favoured method for chrysotile whereas SEM was favoured for amosite. In the NICNAS survey a good agreement was found between the TEM and PCM methods after adjustment for differences in fibre size observations (see Section 6.2.1).

The consensus appears to be towards the use of the MFM and PCM for routine analyses and use of TEM for low level and identification work and situations where the fibre size and identification are important. The reasons for this approach are that PCM is simple, cheaper and has been used over a long period (about 30 years). Most health risk assessments have been based on data derived from the standard MFM/PCM method. However, with the need to improve the MFM to detect low fibre concentrations, TEM methods are being used more widely. Use of TEM or improvement in the MFM would be required to support any lowering of exposure standards for asbestos below 0.1 f/mL. One possibility would be to upgrade the MFM/PCM so as to utilise the optimum techniques that are available in optical microscopy.

5. Manufacture and Use

This section covers importation of raw chrysotile; manufacture of chrysotile products in Australia; importation of chrysotile products and end-use and export of chrysotile products.

There are numerous types of chrysotile products which were used in the past and are still present in the general community, which include: asbestos-containing sprayed insulation materials in buildings and other structures; lagging, asbestos cement sheets, piping and moulded products in building construction, vinyl asbestos flooring, sealants, textiles (used in heat resistant clothing), conveyor belts, boards (marine and soft building boards), felts (roofing), pipe and electrical coverings and insulating ropes and paper, asbestos yarn for packing, asbestos gloves and headgear.

Consistent with the objectives of this assessment, use of asbestos is defined as those uses that are currently being introduced, either by import and/or manufacture, into Australia. Information on use was collated from data provided by the Australian Bureau of Statistics (ABS), Australian Customs Service (ACS) and applicants and from surveys of importers and end-users of chrysotile products (see Appendices 1 and 2 for details).

5.1 Historical overview of importation and mining of chrysotile in Australia

Figure 1 shows the production of raw chrysotile in Australia from 1890 to 1983 and for comparison the importation of chrysotile from 1950 to 1983. Mining of chrysotile peaked dramatically during the 1970s, with new mines such as Wood Reef mine coming into operation in the early part of the decade. A total of 400,000 tonnes was produced during the 1970s. In 1981 there was a decrease in the production of chrysotile due to a drop in world demand and the increased operating costs at the Wood Reef mine. Mining finally ceased in 1983 as the Wood Reef mine could not meet dust control regulations. At the time mining of chrysotile ceased (1983), approximately 55,000 tonnes per year was being produced in Australia and approximately 20,000 tonnes per year of chrysotile was being imported (Leigh, 1994). Importation of chrysotile has dropped significantly since this time to approximately 2000 tonnes per annum.

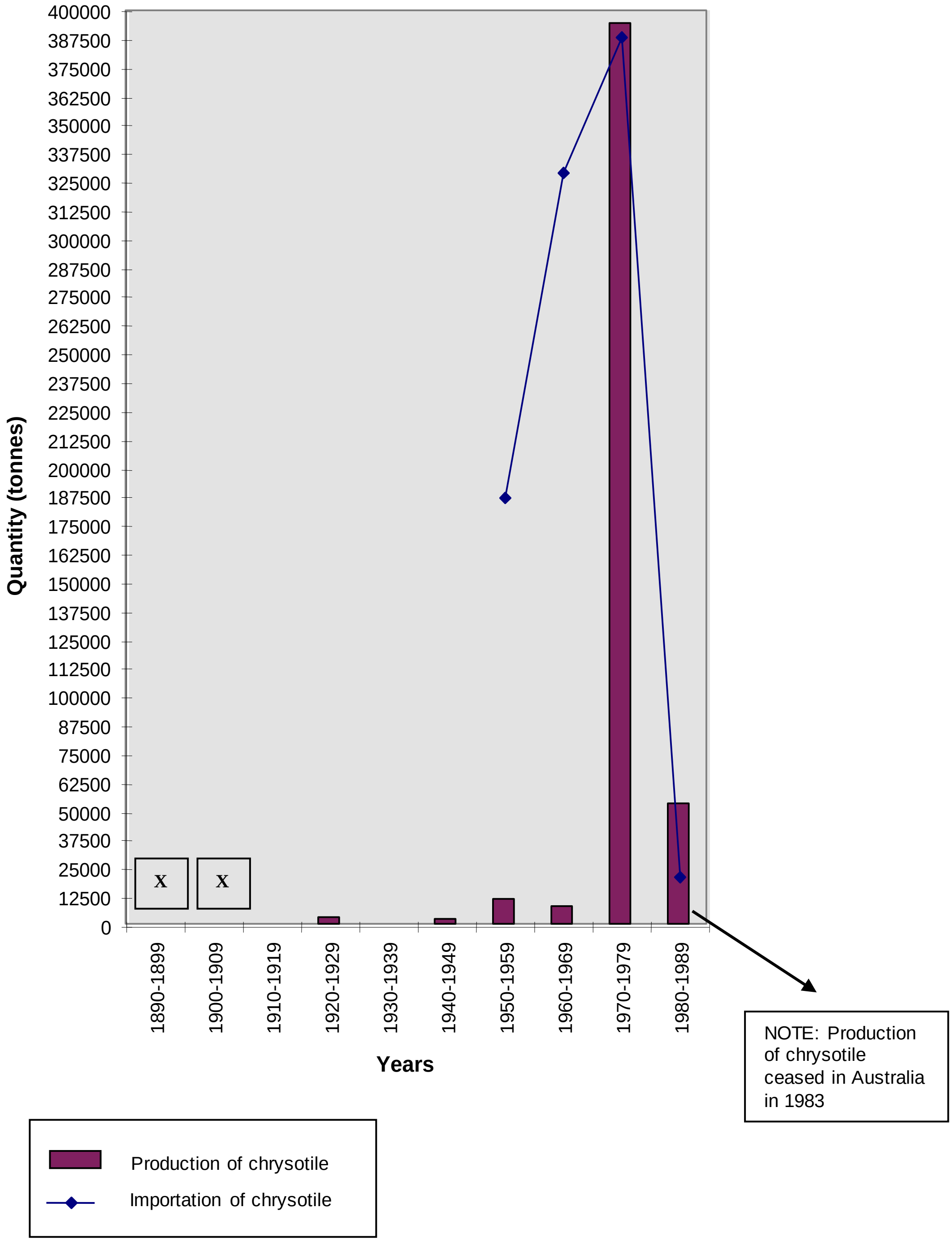
5.2 Current importation of chrysotile and asbestos products

5.2.1 Australian Customs data

Appendix 2 details sources of information and import data for chrysotile, which is briefly summarised below.

There are four major customs tariff categories, including subcategories, relating to the importation of asbestos and asbestos products. The customs categories, product types and quantities imported in 1997 are given in Appendix 3, figures 1A-1D.

Figure 1 – Production and importation of chrysotile in Australia, 1890 to 1990



x Chrysotile production did occur between 1890 and 1909, however, the amounts were small and therefore not identifiable in the graph.

The four customs categories include 1) asbestos (white asbestos and other asbestos), 2) articles of asbestos-cement, of cellulose fibre-cement or the like, 3) asbestos products (including gaskets) other than fibre cement products and friction materials and articles thereof.

When analysing the Australian Customs data to identify the current uses of asbestos products, the following issues arose:

- only one subcategory (2524.00.00.01) specifically includes chrysotile;
- no differentiation exists between asbestos and non-asbestos products for some categories. For example, Customs data did not distinguish between asbestos and non-asbestos brake pads as they all fell under the category "May or may not contain asbestos";
- only one subcategory exists for asbestos gaskets with no subcategory for non-asbestos gaskets;
- most Customs tariff classifications have changed over time and are different for import and export, making historical comparisons of trends difficult;
- some importers (or their agents) unintentionally misclassify asbestos and asbestos products.

These findings support those of a 1990 inquiry into usage, substitutes and alternatives of asbestos in Victoria (Victorian Occupational Health and Safety Commission, 1990). The inquiry found that the current ACS tariff classification system makes the collection of reliable data on asbestos imports into Victoria difficult. The report of the inquiry also commented that there is a need for the customs requirements to be reviewed so that asbestos imports can be more readily identified and quantified.

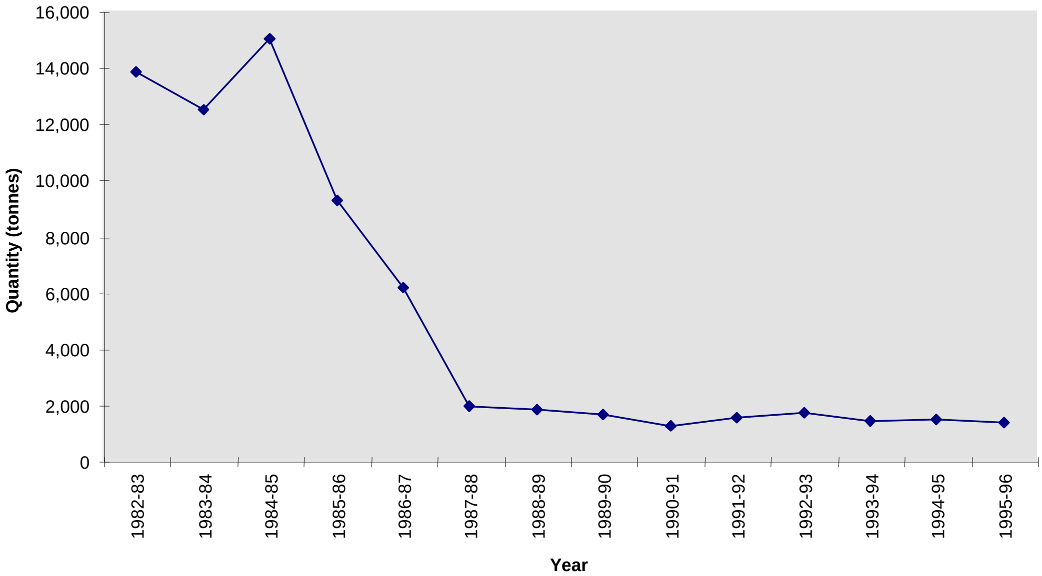
Bendix Mintex have commented that in attempts to use customs data in the past (to determine market penetration of imports) they found that for certain periods, the data (in terms of number of articles) were impossible to reconcile with their estimations (based upon known information on vehicle population and usage of friction materials per vehicle) of total market size. Bendix Mintex have also identified errors at the Customs level with regard to the correct identification/recording of imported articles.

5.2.2 Imports of raw chrysotile

The quantity of raw chrysotile imported into Australia for the period 1982 to 1996 is shown in Figure 2. In the mid 1980s the importation of chrysotile rapidly declined. In the last decade, the amount of chrysotile imported into Australia has been relatively constant, between 1000 and 2000 tonnes being imported per annum.

The customs category for 'asbestos' (2524.00.00) contains two subcategories: chrysotile (white) and 'other asbestos' (see Appendix 3, Fig.1A). Customs data for 1997 showed that approximately 735 tonnes of 'other asbestos' was imported into Australia. If this figure is correct it would be a concern due to prohibitions existing under State and Territory legislation for other forms of asbestos such as crocidolite and amosite. However, on further investigations and discussions with importers in relation to this category for 1994 data, it was found that errors had occurred in tariff coding and that all of the asbestos imported under this subcategory was chrysotile. It is therefore likely that all asbestos being imported into Australia is chrysotile, however the ACS has been asked to provide further data for the 1997 figures so that this can be investigated.

Figure 2 – Australian importation of raw chrysotile, 1982 to 1996*



*Data for figure 2 was retrieved from the Australian Bureau of Statistics

Customs data for 1997 indicated that approximately 1500 tonnes of chrysotile was imported (all sourced from Canada), the majority of which was imported by Bendix Mintex Pty Ltd and Richard Klinger Pty Ltd with Vivacity Engineering importing much smaller amounts (approximately 16 tonnes/year). These companies have also stated that they imported similar amounts in 1994, 1995 and 1996. Vivacity Engineering stated that they intended phasing out use of chrysotile during 1997, however phase out had not been achieved when last contacted in August 1998.

Current use of raw chrysotile is therefore between 1-2 thousand tonnes per year and would seem to show no sign of declining in the immediate future although work is proceeding for alternatives to chrysotile in some industry sectors (see Section 11 on Asbestos Alternatives). Bendix Mintex have estimated that their use of chrysotile (as percentage of total sales) will decrease by about 5% per annum over the next 5 years.

5.2.3 Imports of chrysotile/asbestos products

ABS data for 1997 indicates that chrysotile is imported in a wide range and high number of products. The ABS data show that the most highly imported asbestos products are brake linings (category 6813), which numbered approximately

860,000[2] articles, gaskets (category 6812) numbering approximately 200,000 and clutch facings numbering 6000 articles. Detailed information on the customs tariff codes for product categories that may contain asbestos (according to product type, volume, and number of companies importing, is provided in Appendix 3, Figs 1B,C,and D).

NICNAS surveys of importers

Surveys were conducted by NICNAS in 1995 (see also section 5.4) to determine the accuracy and representitiveness of the 1994 customs data (see Appendix 2 for details of the surveys conducted). A total of 843 companies ranging from shipping, building, timber, marine, engineering, aircraft, industrial equipment and machinery, vehicle importers and manufacturers and automotive spare parts suppliers were surveyed throughout all States and Territories in Australia.

Of the 843 companies, approximately 766 companies used products in the categories for friction materials and articles thereof and gaskets. The results of the survey of these companies are discussed in Appendix 4.

Of the remaining 77 companies, 37 imported fibre-cement products (which may or may not contain asbestos) and 40 imported 'asbestos products not otherwise specified'.

Customs data indicated that there were two categories (6811 and 6812) which comprised products other than friction materials. The survey of importers of fibre-cement products in this customs category (6811) showed that asbestos containing fibre cement products are unlikely to be imported into Australia. All 15 companies surveyed in this category confirmed this. The remaining 6 companies were unable to be contacted.

For category 6812 (asbestos products other than goods in 6811 and 6813) the survey of importers showed that the major import was gaskets. The survey showed that asbestos and non-asbestos gaskets are being used in both the automotive industry and for industrial applications and that a greater numbers of non-asbestos gaskets were used in industrial applications.

Other uses of asbestos identified (other than in friction material and gaskets) were: blades in high vacuum pumps, asbestos yarn for packing, asbestos gloves and asbestos washers for miners oil flame safety lamps. It should be noted that these were all one-off imports (refer to Appendix 4 for a breakdown of survey responses).

Trends in importation of brake linings and gaskets (Customs data)

Due to changes in Customs categories or lack of identification within a category, trends could only be followed for brake linings and gaskets since 1994. Table 3 provides figures for the importation of brake linings and gaskets for calendar years 1994 to 1997, together with the first 8 months data for 1998.

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[2] This figure does not include brake pads "that may contain asbestos" under Customs code 6813.10.10.45, which totaled approximately 100,000 articles in 1997.

Table 3 - Importation of asbestos and non-asbestos brake linings and asbestos gaskets for the period 1994-1998[1]

Product and Customs category	Number of articles[2]				
	1994	1995	1996	1997	1998[3] (Jan – Aug)
Asbestos brake linings for passenger cars 6813.10.10.41 6813.10.10.42	492,295	47,735	43,087	771,182	(548,692)
Non-asbestos brake linings for passenger cars 6813.10.10.43 6813.10.10.44	70,109	321,472	485,812	2,084,963	(4,057,143)
May or may not contain a*sbestos* - brake linings for passenger cars 6813.10.10.45	218,033	65,849	35,041	104,261	(76,876)
Asbestos brake linings for industrial use 6813.10.90.46 6813.10.90.47	103,087	79,443	22,922	90,926	(87,994)
Non-asbestos brake linings for industrial use 6813.10.90.48 6813.10.90.49	308,864	557,167	371,381	1,889,537	(203,259)
Asbestos gaskets for passenger cars 6812.90.10.57	45,682	49,519	52,707	59,811	(46,478)
Asbestos gaskets for industrial use 6812.90.90.59	110,003	176,159	196,254	139,745	(87,386)

[1]Data provided by Australian Bureau of Statistics (ABS)
[2]For friction products, industry have advised that, for brake linings/pads, the number of articles should be multiplied by 4 (i.e., no. of articles per pack), in order to obtain the actual number of linings/pads.
[3]Data for 1998, are for 8 month period only.

Passenger cars

When comparing the use of asbestos and non-asbestos brake linings, the figures indicate that since 1994 significantly more (up to 10 fold) non-asbestos than asbestos brake linings have been imported for use in passenger cars.

A sharp decrease in the use of asbestos brake linings in passenger cars was seen in 1995 and 1996, which correlated with increased imports of non-asbestos linings. However 1997 and 1998 saw large increases in importation of both asbestos and non-asbestos linings (up to 10 fold), compared to 1996 quantities. All asbestos brake linings imported between January and August 1998 were of the moulded type (category 6813.10.10.41).

The use of asbestos gaskets in passenger cars appears to have gradually increased (about 10% per annum) since 1994. There are no customs data for non-asbestos gaskets.

Customs data verification

In order to validate Customs data for passenger car brake linings, an ABS investigation (at the request of NICNAS) was carried out for 1998 import data for brake linings. Customs brokers were asked to verify the accuracy of records for the months March to August 1998. This process identified errors in the data classified to 6813.10.10.42 (amendments included in Table 3). No errors were found with regard to data classified to category 6813.10.10.41. Extrapolation of this data provides an estimated annual total of 800,000 articles (i.e. 3,000,000 brake linings/pads – see footnote to Table 3) imported for 1998, which is consistent with data for 1997. It was concluded that either, imports have risen significantly since 1995/96 or that the 1995/96 data is incomplete (industry sources have stated that import figures for category 6813.10.10.41 for 1995/96 appear to be underestimates). With regard to the latter possibility, miscoding was not evident from an analysis of other categories for asbestos and non-asbestos brake products, in particular, data for category 6813.10.10.45 (see Table 3).

Industrial applications

More than three times the amount of non-asbestos than asbestos brake linings was imported for industrial applications in 1994, the proportion of which has doubled annually, up to around twenty fold in 1997. Data for 1998, although incomplete, indicate a sharp decrease in non-asbestos imports.

As with passenger cars, a significant decrease in imports of asbestos linings for industrial applications was seen in 1996 and, also as seen for passenger vehicles, increased (around 4 fold) importation (see section 5.2.3 for qualification) of asbestos linings was seen in 1997 and 1998.

The use of asbestos gaskets in industrial applications has gradually increased (about 10% per annum) from 1994 to 1997. There is no Customs coding for non-asbestos gaskets.

5.3 Current manufacture of chrysotile products

Imported raw chrysotile is used by 3 companies in the manufacture of asbestos products (see Appendix 1 for details). Applicants provided the following information on current manufacture of chrysotile products in Australia.

5.3.1 Bendix Mintex Pty Ltd

Bendix Mintex uses raw chrysotile in the manufacture of disc brake pads, commercial vehicle blocks and linings and passenger car drum linings. Most of the sales volume is for passenger vehicles, with commercial vehicle blocks and linings comprising less than 10% of sales.

These products are supplied to:

- the Australian automotive aftermarket via automotive wholesalers, resellers, and brake specialists;
- the Australian car companies aftermarket service and distribution outlets; and
- export markets direct to distributors overseas.

Bendix Mintex also sell brake blocks and linings to Australian brake shoe re-manufacturers (bonders) and overseas distributors. Products are not sold directly to the public. Bendix Mintex no longer manufactures clutch facings. Brand names for Bendix asbestos-containing friction products are Bendix and Don.

5.3.2 Richard Klinger Pty Ltd

Richard Klinger Pty Ltd uses raw chrysotile in the manufacture of compressed asbestos fibre (CAF) sheeting. This product is sold in sheeting and cut gasket form and is used to make spiral wound gaskets that will resist pressure, temperature and aggressive media. Such gaskets are used by a broad range of industries which include: petrochemical, shipbuilding, petroleum refineries, pulp and paper mining, chemical processing and food processing.

5.3.3 Vivacity Engineering Pty Ltd

Vivacity Engineering use chrysotile as a 'non-sag' additive in epoxy resin adhesives used for affixing marble and granite panels to walls of buildings. The final product contains 2% by weight chrysotile.

5.4 NICNAS surveys on the use of chrysotile products

Because of the difficulties in distinguishing between asbestos or non-asbestos products from Customs data (see Section 5.2.1), a NICNAS survey (see also Section 5.2.3) of potential importers/users of asbestos products was carried out for the following product categories:

- 6811 - Fibre cement products;
- 6812 - Asbestos products other than goods of 6811 or 6813; and
- 6813 - Friction materials and articles thereof.

For full details of survey methodologies see Appendix 2.

5.4.1 Automotive industry

The major use of asbestos in the automotive industry is in friction materials (brake linings, disc brake pads, brake blocks and clutch facings) and gaskets.

Since 1994, the vast majority of brake linings being introduced into Australia are non-asbestos, the use of which is divided almost equally (between 1995 and 1997) between industrial and automotive applications (see Table 3). The 1994 survey indicated that the majority of disc brake pads (no Customs category) imported into Australia were non-asbestos for use in both automotive and industrial applications. Brake blocks (no Customs category) were still being used in the automotive industry but their use was minimal. Brake blocks (non-asbestos) were more commonly used for rail vehicles and other industrial applications.

The NICNAS survey confirmed that clutch facings are predominantly non-asbestos. The 1997 Customs data showed that the number of asbestos clutch facings imported into Australia were around 6,000 in contrast to 600,000 non-asbestos facings. According to ABS data, none of the asbestos clutch facings imported in 1997, were for use in passenger vehicles.

The survey also confirmed that alternatives are available for many applications. This is discussed in more detail in Section 11.

New vehicles

Out of 26 companies, 25 stated that they are using non-asbestos original equipment in all current models. One company (Ford Motor Australia) reported that they are still using asbestos parts in 2 current models: asbestos head gaskets for the Econovan and asbestos rear brake linings for the Ford Utility. Ford Australia introduced non-asbestos components for their most popular models (e.g. Laser, Falcon and Fairlane) between 1989 and 1995. Other current models manufactured by Ford have been asbestos-free since their introduction.

Asbestos parts are imported by 6 of the 26 companies (BMW, Ford, Mazda, Mitsubishi, Nissan and Toyota) with five companies using asbestos parts for superseded vehicles and one company (Ford Australia) using asbestos parts in superseded and current models. In response to the question whether asbestos parts in superseded models could be replaced with non-asbestos parts, companies stated that although this was possible for certain vehicles, the extent to which this was possible had not been investigated. This would require actual 'on-vehicle' testing or other suitable simulation in order to determine the adequacy of non-asbestos replacement parts.

The majority of the vehicle manufacturing companies stated that they have had policies in place in regard to not using asbestos components in new vehicles for the last 5 to 10 years.

To further supplement the survey, the use of asbestos and non-asbestos parts by companies importing commercial vehicles (trucks, buses and coaches) and not included above, was investigated. Four major companies namely Hino, Kenworth Trucks, Man Bus and Volvo Trucks were contacted with 3 companies responding. Responses indicated that the majority of current commercial vehicles have non-asbestos 'original' equipment. All 3 companies also reported that non-asbestos parts can replace asbestos parts in superseded vehicles and that use of non-asbestos parts was generally introduced in the late 1980s.

Automotive Aftermarket Survey

The small number of new cars manufactured in Australia compared to the number of imported (obtained from Customs data) and manufactured asbestos friction materials and gaskets, suggests that there must be significant use of asbestos products in the aftermarket industry.

NICNAS conducted an Automotive Aftermarket Survey in which service garages, brake bonders and gasket manufacturers were surveyed on the use of asbestos and non-asbestos products. For details of this survey see Appendix 2 and Section 6 (Occupational exposure).

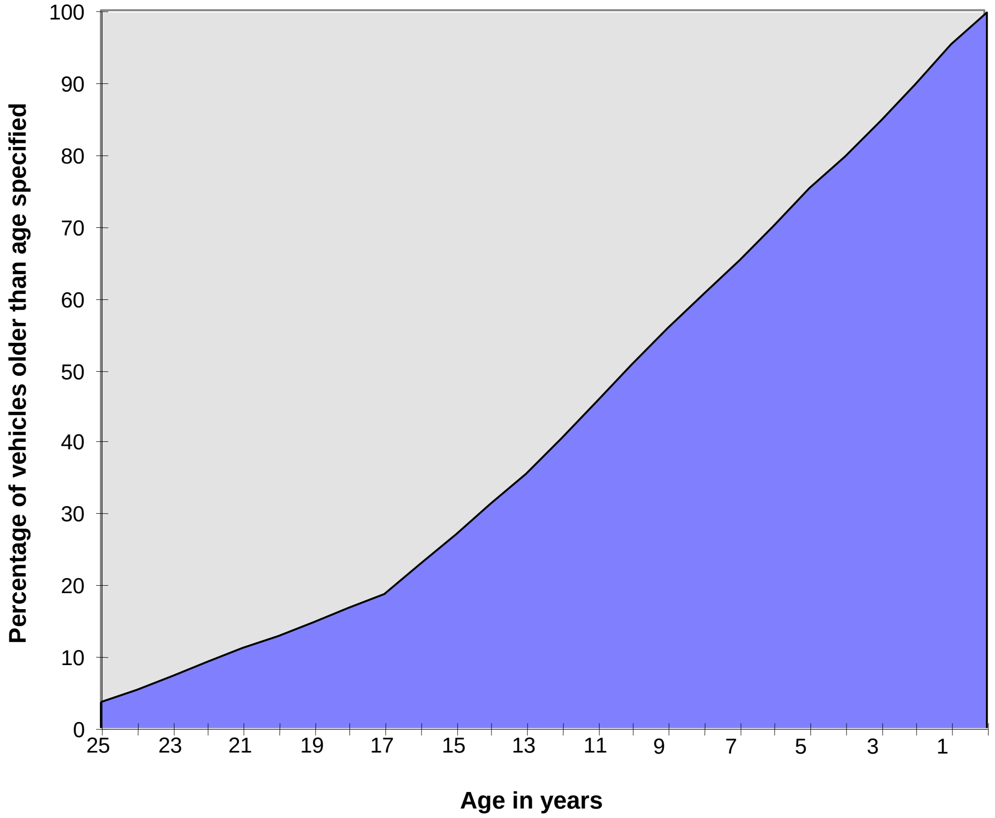
Results from these surveys indicated that a high proportion of the work with friction products (up to 90% in brake bonding workshops) involved the use of chrysotile products. However, the reported availability of new products (e.g. clutch kits and disc brake pads) which are already cut to size, limit the amount of machining (sanding, grinding and cutting) that is now required. In addition, workshops reported that the majority of clutches which come in kit-form are non-asbestos.

Currently, large quantities of asbestos friction materials are still used in asbestos and non-asbestos original equipment vehicles. The 'Automotive Aftermarket Survey' identified some of the reasons for the continued use of asbestos products in the automotive replacement aftermarket and these are discussed in detail in Section 11.

The continued 'aging' of the Australian vehicle fleet is considered to be the predominant factor in the sustained use of asbestos friction products. Recently (June 1997), a comprehensive national survey of motor vehicles published by the Australian Bureau of Statistics found that between 1971 and 1995, the average age of the vehicle fleet increased steadily from 6.1 years to 10.6 years. Also the proportion of cars that were at least a decade old rose sharply from less than a fifth to more than a half of total vehicles (Australian Bureau of Statistics, 1997).

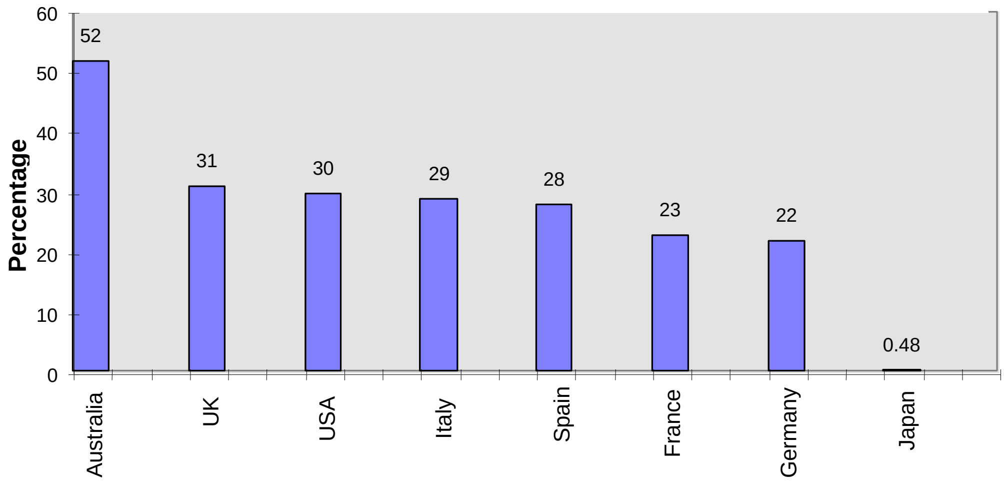
Figure 3 provides information on the age of vehicles in Australia in 1995. For comparison, information on the average age of cars in other countries is providing in Figure 4. It can be seen that in 1995, Australia had the highest percentage (52%) of cars older than 10 years, with Japan the lowest (<0.5%). Data for UK, USA, Italy and Spain were similar with percentages ranging from 28% to 31%, with France (23%) and Germany (22%) being slightly lower.

Figure 3 – Age of vehicles in Australia in 1995



Source: Australian Bureau of Statistics (1995)

Figure 4 – Proportion of cars older than 10 years in 1995, by country



Source: Federal Chamber of Automotive Industries (1977)

5.4.2 Aircraft industry

Surveys were sent to the two major Australian airlines, Ansett and Qantas. Only Qantas responded to the survey. The company stated that asbestos has special physical properties that are not currently available in alternative materials. Consequently most aircraft engines, particularly older designs, use parts containing asbestos. These parts are usually in the form of gaskets and seals and comprise asbestos in a composite or matrix of other materials. While extensive efforts worldwide have been made to retrofit many of these parts with non-asbestos materials, alternatives have not been found for several applications. Qantas supplied information on the current use of asbestos parts in two different aircraft (Boeing 767 and Boeing 747) and the information is summarised in Table 4.

Table 4 - Use of asbestos parts in aircraft (NICNAS Survey 1994)

Product	Use
Consumables e.g. sealing goop	For component flange interfaces in high temperature applications (contains 1-10% chrysotile).
Clamps	Metal clamps with polytetrafluoroethylene (PTFE) bound asbestos cushions are used in many locations on gas turbine engines, to insulate hydraulic tubes and fuel lines from the high temperatures cases to which these tubes and lines are secured. The metal clamps also protect tubes from vibration and chafing.
Gaskets and seals	Various flange interface surfaces are assembled with asbestos-containing seals.
Rub pads & blocks	Asbestos bound into a matrix is used in some aircraft applications to prevent metal to metal contact between parts, usually in high temperature and high vibration areas.
Heat shields & shrouds	Insulating shrouds are used around gas turbine to protect vulnerable components (such as electrical components and fuel systems) from the very high temperature combustion and turbine section.

5.4.3 Industrial equipment and machinery

To determine whether asbestos friction parts and gaskets are continuing to be used in industrial equipment and machinery e.g. forklift, cranes used in mining, miniloader, tractors, hoisting equipment, diesel engines and diggers surveys of 15 companies were carried out. Fourteen companies stated that they are using non-asbestos parts in all current models. These companies also stated that they are replacing asbestos parts with non-asbestos parts in superseded models. Most of the companies stopped using asbestos parts in the late 1980s.

One company reported that they are still using asbestos gaskets in diesel engines due to the lack of an effective substitute. One manufacturer of asbestos gaskets reported that their business consisted of 25% asbestos and 75% non-asbestos gaskets, respectively. This company supplied asbestos gaskets to industries which use gaskets in special applications e.g. high temperature and high pressure applications in oil refineries and chemical plant or when specially requested by customers.

The NICNAS Survey (1994) also identified the use of asbestos brakes in draglines[3] used in the coal industry. Although it is possible that there are some asbestos brakes still in use in older draglines, mining companies have generally replaced these with non-asbestos parts (since the late 1980s).

5.5 Current exports of asbestos and asbestos products

Export of raw asbestos from Australia ceased in 1984. A total of 22 tonnes of raw asbestos was exported during 1984.

Customs export data for asbestos products from 1990 to 1997 were analysed. Specific information on exports for this period, such as product category, quantity and cost are presented in Appendix 8. Customs coding for asbestos exports is not as detailed as that for imports.

Only one category in the export data, "articles of asbestos", which includes gaskets, differentiates between asbestos and non-asbestos articles. The other three categories; brake linings and pads, transmission linings and friction materials for clutches do not distinguish between asbestos and non-asbestos products. The export data were found to be variable and no trends could be established. The export and import Customs categories did not correlate, hence direct comparisons could not be made.

Bendix Mintex stated that friction products, including friction material mixes containing chrysotile, are exported to friction material suppliers and manufacturers in the Asia Pacific Region. Details requested, including quantities were not provided by Bendix Mintex, although they have indicated that such exports represent some 20-30% of total asbestos market volume.

Richard Klinger manufacture both asbestos and non-asbestos sheeting and spiral wound gaskets for export. Of the total asbestos and non-asbestos products manufactured in Australia, 78% and 36% are exported, respectively.

Vivacity Engineering report that virtually all of their chrysotile-containing product is exported.

5.6 Summary

Raw chrysotile is no longer mined nor exported in Australia and is imported at approximately 1000 – 2000 tonnes per year. This level has been stable since 1989 and shows no sign of decline/increase.

The current major uses of raw chrysotile imported into Australia are for the manufacture of friction materials and CAF sheeting for gasket production for both industrial and automotive applications. Although a significant proportion of asbestos braking components and gaskets are still used for these applications, the majority are asbestos free.

A small quantity of raw chrysotile is used in the manufacture of a 'non-sag' additive in epoxy resin adhesives. The manufacturer reports that this product is being phased out and currently is virtually all exported.

[3] A dragline is a type of excavating equipment used in mining which casts a rope-hung bucket for collection and deposition of excavated material.

A small number of 'one-off' uses for asbestos products exist and these include blades in high vacuum pumps, asbestos yarn in packing, asbestos gloves and asbestos washers for miners oil flame safety lamps. Investigations confirmed that chrysotile is no longer imported for a range of other past applications, such as pipes, textiles etc. Investigations have confirmed that the importation of asbestos fibre cement products is unlikely.

Chrysotile brake linings/pads and clutch facings continue to be imported into Australia for use in passenger motor vehicles and industrial applications. The use of brake blocks in Australia is declining with the predominant use in industrial applications (e.g. railway industry and mining equipment). The majority of these imports are non-asbestos.

For new vehicles, only one company is using asbestos 'original' parts in just two of their current models. New vehicles include passenger cars, trucks, light trucks and heavy trucks. The majority of new vehicle companies have policies in place regarding transition to asbestos substitutes. Approximately 20% of the Australian new vehicle manufacturing/importing companies import asbestos products for superseded models. Although a sharp decrease in imports of asbestos brake linings for passenger cars was seen in 1995 and 1996, a marked increase was apparent (see section 5.2.3 for qualification) in 1997 and 1998. The reason(s) for this trend is unclear, but may reflect either:

- increased use in the domestic market;
- miscoding of products by importers for 1995/96; and/or
- transcription errors in customs data for 1995/96.

Imports of non-asbestos brake linings for passenger cars have also increased significantly, from around 100,000 in 1994 to 4 million in the first 8 months of 1998.

Asbestos friction materials are extensively used in the vehicle aftermarket. This, together with the fact that Australia has a significantly high proportion of 'old' vehicles (compared to other developed countries), is the predominant factor in the sustained manufacture and import of asbestos brake linings.

It is not possible to determine the proportion of asbestos versus non-asbestos gaskets in use from Australian Customs categories. A significant number of non-asbestos gaskets are used for industrial applications, however, investigations indicate that there continues to be a large number of asbestos gaskets in use for both industrial applications and passenger cars. The importation of asbestos gaskets for industrial applications averaged at around 150,000 per annum for 1994 to 1997, but shows an increasing trend (about 10% per annum) for passenger cars during this period.

The majority of industrial equipment and machinery (e.g. agricultural machinery), has non-asbestos original parts. A significant number of companies use non-asbestos in both superseded and new equipment and machinery and most stopped using asbestos parts in the late 1980s.

In the airline industry asbestos parts are still being used in new and older aircraft e.g., gaskets and seals. However, as with other industries there is a continued effort towards the identification of possible substitutes.

Australian export of raw asbestos ceased in 1984. As several customs export categories include articles which 'may or may not contain asbestos' and since the customs tariff classifications for imports and exports are different, the amount of export trade in specific asbestos products has proved difficult to determine. Export data for certain brake linings and pads and transmission linings for the period 1991-1998 can be found in Appendix 8. Detailed export data (quantities) were not provided by any of the applicants. However, Bendix Mintex, Richard Klinger and Vivacity Engineering, reported that exports constituted up to 30%, 80% and 'nearly all', respectively, of their manufactured chrysotile products.

6. Occupational Exposure

Workers may be exposed to chrysotile during warehousing and distribution, manufacture, processing and end-use of products containing chrysotile. The major route of worker exposure is inhalation, with oral exposure likely to be a very minor route. Consistent with the objectives of this assessment, this section covers those uses currently being introduced either by import or manufacture. However, there are sources of data relating to other exposures which would need to be included in any consideration of these other scenarios. This includes Australian data on worker exposure in some asbestos contaminated Australian mines (Rogers et al. 1997).

6.1. Exposure to chrysotile during Australian manufacturing processes

This section covers the following: manufacture of friction materials (brake disc pads, brake linings, brake blocks and clutches), manufacture of asbestos fibre (CAF) and processing (of CAF) in the production of gaskets and manufacture of epoxy resin adhesive. Information in this section was provided by Bendix Mintex, Richard Klinger and Vivacity Engineering.

6.1.1 Manufacture of friction materials

Chrysotile friction materials are now manufactured at only one workplace, Bendix Mintex Pty Ltd, Ballarat, Victoria in Australia.

Manufacturing processes are as follows. Prior to mixing, 50 kg plastic bags of raw chrysotile are transferred to the pre-weigh department with other ingredients required to make up a product mix. Following the transfer of other ingredients to the mixer, bags of raw chrysotile are placed in the mixer and opened (by knife) under dust extraction. The empty chrysotile bag is pushed through a chute in the mixer and delivered into a plastic bag attached to the mixer. When full, this plastic bag is sealed and eventually taken to a controlled disposal site. Mixing is a closed process.

After mixing, the product is emptied under extraction into large bins. These bins are placed in enclosures prior to decanting into smaller mix buckets for weighing and use in moulding and finishing processes. The mix is weighed (manually) under dust extraction and placed into a die for moulding. The moulding of asbestos product is a hot process. When this process is complete, the moulded product undergoes finishing processes, which include grinding, grooving and drilling. All of these processes are conducted under dust extraction.

The finished products, disc pads and commercial vehicle brake blocks and linings, are wrapped and packed into sealed containers.

Potential for exposure

Potential for exposure exists during the following operations:

- opening and emptying bags of chrysotile into the mixer;
- during the moulding and finishing processes;

- during maintenance of processing equipment; and
- handling of damaged bags containing raw chrysotile.

According to Bendix Mintex around 700 workers are employed at the plant. Approximate numbers of workers and typical exposure times for the various groups of workers are summarised in Table 5.

Table 5 - Number of workers and duration and frequency of exposure

Category of workers	No. of workers	Maximum exposure per employee (h/day/year)
Management-supervisory - non-factory	29	minimal
Management- factory	4	1 h/100 days/year
Supervisory - factory	16	3.6 h/230 days/year
Professional - non-factory	6	minimal
Professional - factory	10	1 h/30 days/year
Trades/skilled - non-factory	44	minimal
Trades/skilled - factory	26	3.8 h/115 days/year
Engineering/technical	55	3.8 h/115 days/year
Clerical and related	40	minimal
Sales	6	minimal
Plant operating	1	minimal
Process and related	501	7.6 h/ 230 days/year

Production support staff, who include maintenance, engineering and quality assurance workers, have various levels of involvement in the production process. Office employees (management, clerical, sales) have minimal involvement in the production process except on occasions when they work in the factory, for example, during peak production times. Bendix Mintex has stated that this has occurred only on rare occasions and is not expected in the future.

Atmospheric monitoring

The monitoring of worker exposure to chrysotile at Bendix Mintex is performed in accordance with the standard membrane filter method (MFM), as outlined in the *Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Dust* (NOHSC, 1988). Primarily personal monitoring is conducted, however static monitoring is also performed on a limited basis.

Personal monitoring data provided by Bendix Mintex (Ballarat site) for 1992 to 1997 is summarised in Table 6 and in Figure 5. Approximately 84% of the 461 samples taken between 1992 and 1997 were <0.1f/mL; 10% were ≥0.1 - <0.2 f/mL, 6% were ≥0.2 - <0.5 f/ml and <1% were ≥0.5 f/mL. There was no trend in the data over time.

For all activities, over this period, between 54 and 97% of all samples were <0.1 f/mL. Weighing and drilling operations recorded a higher percentage of results > 0.1 f/mL, which was to be expected as these activities are more likely to release chrysotile fibres. Only during weighing[4] were exposures (2 samples) recorded >0.5 f/mL, with the highest result being 1.02 f/mL.

[4] Respiratory protection is used in the weighing area

Apart from 2 samples in 1996 (3% of total samples), all were below 0.5 f/mL for other years (see Table 6).

Table 6 – Personal air monitoring data for airborne fibres* (1992 to 1997) at Bendix Mintex plant

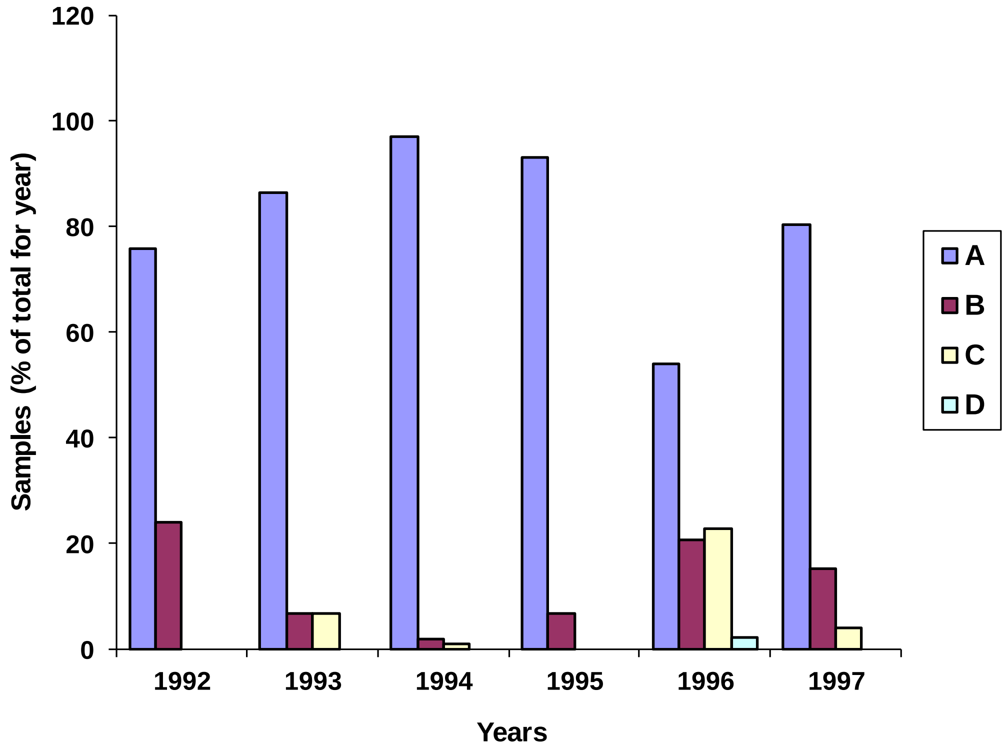
Year	Total no. of samples	Results: Range (f/mL)	Sample Groupings: Fibre range (f/mL)	Sample Groupings: No. of samples	Summary
1992	29	0.00 – 0.09	<0.1 ≥ 0.1 - < 0.2 ≥ 0.2 - < 0.5	22 7 0	100% of samples < 0.5 f/mL 76% of samples < 0.1 f/mL
1993	59	0.01 – 0.43	<0.1 ≥ 0.1 - < 0.2 ≥ 0.2 - < 0.5	51 4 4	100% of samples < 0.5 f/mL 86% of samples < 0.1 f/mL
1994	111	0.01 – 0.27	<0.1 ≥ 0.1 - < 0.2 ≥ 0.2 - < 0.5	108 2 1	100% of samples < 0.5 f/mL 97% of samples < 0.1 f/mL
1995	103	0.01 – 0.16	<0.1 ≥ 0.1 - < 0.2 ≥ 0.2 - < 0.5	96 7 0	100% of samples < 0.5 f/mL 93% of samples < 0.1 f/mL
1996	87	0.01 – 1.02	<0.1 ≥ 0.1 - < 0.2 ≥ 0.2 - < 0.5 > 0.5	47 18 20 2	97% of samples < 0.5 f/mL 54% of samples < 0.1 f/mL
1997	72	0.00 – 0.28	<0.1 ≥ 0.1 - < 0.2 ≥ 0.2 - < 0.5	58 11 3	100% of samples < 0.5 f/mL 81% of samples < 0.1 f/mL

* Monitoring and analysis method (MFM/PCM) does not enable differentiation between chrysotile and other fibres

Sampling carried out using SKC portable programmable pumps (0.5 L/min) with cellulose membrane filter.

Data provided by Bendix Mintex.

Figure 5 – Personal air monitoring data (1992 to 1997) at Bendix Mintex plant.



A <0.1 f/ml
B ≥0.1 - <0.2 f/ml
C ≥0.2 f/ml - <0.5 f/ml
D ≥0.5 f/ml

6.1.2 Manufacture of compressed asbestos fibre sheeting (CAF) and gaskets

Compressed asbestos fibre (CAF) sheeting, using raw chrysotile, is manufactured in Australia by Richard Klinger Pty Ltd at Booragoon, Perth, Western Australia. The majority of the CAF sheeting is then exported and the remainder processed into finished cut gaskets (for use in industrial applications) at both their Melbourne and Perth (post 1996) sites.

At Booragoon, the bags of raw chrysotile are inspected to ensure there are no broken bags. If broken, the bags are sealed by operators and immediately consumed in the manufacturing process. Where necessary, the surrounding area is vacuumed using high efficiency cleaners. The polyethylene bag is removed from the raw chrysotile using a debagging machine, which is enclosed and under negative pressure. The machine disposes of the chrysotile containing bag automatically into a fresh sealed plastic bag. The sealed bag is then removed from the machine manually.

The production of CAF sheets is a closed process. The chrysotile fibres are transferred under negative pressure through conduits attached to the bagging machine to the hammer mill, where the fibres are milled and introduced into a mixing machine via a closed loop system. The fibres are then encapsulated by combining with various grades of rubber to form a wet mash, which is then passed through a calendering machine to form CAF sheets.

The CAF sheets are then printed and trimmed using knife action tooling, for example, a guillotine. The CAF sheets are cut to size using knife bladed tools. For spiral wound gasket production, imported rolls of asbestos filler material are slit using a rotary die block. The slit material is then wound between alternate layers of stainless steel. The finished goods are stored prior to packing for distribution to customers.

Gasket off-cuts also undergo secondary manufacturing at the Perth site. These off-cuts are recycled for further use.

Gasket cutting from CAF is also carried out by other workshops and this is discussed under end-use in section 6.2.

Potential for exposure

There is potential for worker exposure during the following operations:

- when damaged bags are encountered during raw material preparation;
- when removing plastic bag from debagging machine;
- during the maintenance of processing equipment;
- during finishing processes and gasket cutting operations; and
- when the rolls of asbestos filler are slit for spiral wound gasket production.

Workers at Richard Klinger wear cotton overalls, half face mask respirators (with class M cartridges) and leather gloves when handling chrysotile or conducting equipment maintenance operations. The number of workers, maximum duration and frequency of exposure at the Perth and Melbourne plants are summarised in Table 7.

Laboratory staff conduct a number of destructive and non-destructive tests (Perth site) on gasket material. The only destructive test used where there is a potential for release of fibres is the tensile test. Tensile tests are infrequently performed on samples of compressed asbestos fibre sheeting. A maximum of 5 samples are tested per week with a test time of approximately 1.5 minutes per each sample. Control measures in place include the use of disposable masks appropriate for asbestos fibres and wipe down (with damp cloth) of testing equipment.

Atmospheric monitoring

Both personal and static monitoring are conducted at Richard Klinger sites. At the Perth site, air monitoring is carried out weekly at various testing sites, including the raw material preparation area and the calendering and guillotining process areas. At the Melbourne site, air monitoring is carried out every 2 years. All testing is performed according to the NOHSC *Asbestos Code of Practice* (NOHSC, 1988), with the sampling period between 5 and 8 hours. Air monitoring data provided by Richard Klinger is summarised in Table 8 (Melbourne site) and Table 9 (Perth site). At the Melbourne site, where raw chrysotile is *not* handled, all personal samples were <0.5 f/mL. Although data were only provided for a few workers at each location, Richard Klinger have stated that locations monitored represent the highest CAF usage areas.

Table 7 - Worker exposure at Richard Klinger sites

Category of workers	No. of workers	Max. exposure/employee (h/day/year)
Booragoon, Perth, WA - CAF production		
Raw material preparation	6	4 h/231 days/year
Calendering	10	4 h/231 days/year
Finishing	4	4 h/231 days/year
Stores	5	1 h/231 days/year
Gasket cutting	3	3 h/231 days/year
Maintenance personnel	5	1 h/231 days/year
Laboratory staff	1	0.75 h/231 days/year
Melbourne, VIC - Gasket production		
Gasket cutting	16	6 h/231 days/year
Spiral wounding	10	6 h/231 days/year
Stores	6	3 h/231 days/year

data provided by Richard Klinger

Table 8 - Asbestos air monitoring data (1989 - 1996) at Richard Klinger, (Melbourne plant).*

Year	Location	Sampling type	No. samples	Concentration (f/mL)
1989	Spiral wound gasket area	na	na	0.04
1991	Industrial cutting shop	personal	2	below limit of detection
		static	2	< 0.01, 0.01
	Handcut area	personal	1	below limit of detection
		static	1	< 0.01
	Stores	personal	1	below limit of detection
	Spiral Wound area	personal	2	below limit of detection
		static	2	0.01
1993	Cutting shop	na	na	0.04
1995	Handcut area	personal	1	< 0.05
	Press	personal	3	<0.05
	Press	static	2	0.01
	Small guillotine	static	1	< 0.01
	Packing area	static	1	< 0.01

na = not available

* data provided by Richard Klinger

Table 9 - Asbestos air monitoring data (1991 - 1996) at Richard Klinger (Perth plant)

Year	Process	No. of samples	Sample type	Results			Comments
				Range (f/mL)	Sample groupings		
1991	Assembling of spiral wound gaskets (no raw material preparation)	4	Personal	<0.05	4 samples	<0.05	
1991	Assembling of spiral wound gaskets (no raw material preparation)	4	Static	<0.01 - 0.02	4 samples	<0.05	
1992	Raw material preparation	48	Personal	<0.05 - 0.3	16 samples 14 samples 7 samples 10 samples	<0.05 ≥0.05 - <0.1 ≥0.1 - <0.2 ≥ 0.2	1 sample: filter overloaded.
1993	Raw material preparation	48	Personal	<0.05 - 0.27	16 samples 22 samples 6 samples 3 samples	<0.05 ≥0.05 - <0.1 ≥0.1 - <0.2 ≥0.2	1 sample: filter overloaded.
1994	Raw material preparation	47	Personal	<0.05 - 0.38	6 samples 5 samples 13 samples 15 samples	<0.05 ≥0.05 - <0.1 ≥0.1 - <0.2 ≥0.2	8 samples: filter overloaded
1995	Raw material preparation	39	Personal	0.01 - 0.8	5 samples 17 samples 6 samples 10 samples 1 sample	<0.05 ≥0.05 - <0.1 ≥0.1 - <0.2 ≥0.2 - <0.5 ≥0.5	

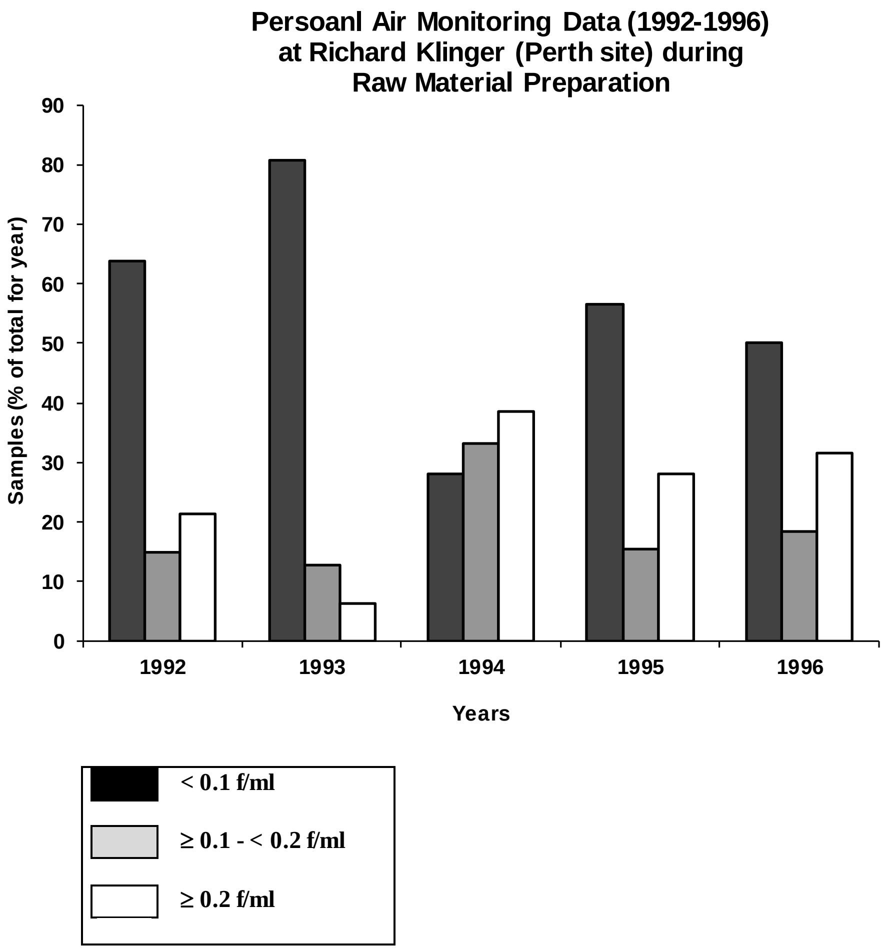
Table 9 - Asbestos air monitoring data (1991 - 1996) at Richard Klinger (Perth plant) (Cont.)

Year	Process	No. of samples	Sample type	Results			Comments
				Range (f/mL)	Sample groupings		
1996	Raw material preparation	46	Personal	< 0.05 - 0.3	15 samples 5 samples 7 samples 12 samples	< 0.05 ≥0.05 - <0.1 ≥0.1 - <0.2 ≥0.2	3 samples: filters overloaded; 4 samples: damaged
1995	Calender/Trimmer	23	Static	<0.01 - 0.05	22 samples 1 samples	<0.01 ≥0.01 - <0.05	
1996	Calender/Trimmer	23	Static	<0.01 - 0.01	22 samples 1 sample	<0.01 >0.01	
1995	Guillotine	21	Static	<0.01 - 0.02	19 samples 2 samples	< 0.01 ≥ 0.01 - <0.05	
1996	Guillotine	23	Static	<0.01	22 samples	<0.01	1 sample: filter overload

< 0.05 is limit of detection for personal sampling
< 0.01 is limit of detection for static sampling
data provided by Richard Klinger

A total of 232 personal samples (including 17 overloaded or damaged filters) were taken during raw material preparation at the Richard Klinger Perth site between 1991 and 1996. Of the personal samples, 58% were <0.1 f/mL, 18% were ≥0.1 - <0.2 f/mL, 23% were ≥0.2 - <0.5 f/mL and 1 sample was ≥0.5 f/mL (i.e. 0.8 f/mL). The personal monitoring data for 1992 to 1996 is presented according to year in Figure 5. There appears to be no trend in measurements over time. Static samples (94) were recorded during guillotine and calender/trimming activities at the Perth site. All samples were ≤0.05 f/mL.

Figure 6



6.1.3 Manufacture of epoxy resin adhesive

Vivacity Engineering (New South Wales) use chrysotile as a 'non-sag' additive in the formulation of an epoxy resin adhesive for affixing marble and granite panels to the walls of buildings.

Chrysotile is imported in compressed form in 15 kg paper bags, wrapped in plastic. Approximately 500 bags are imported in a shipping container which is stored on site.

The liquid ingredients are first added to the mixer. Bags containing chrysotile are manually opened, the chrysotile weighed and then added to the mixing vessel. A lid is placed on the vessel which is exhaust ventilated. Mixing takes approximately one hour. The product is a thick paste and is mechanically forced out of the vessel using a plunger. The product is produced in batches for approximately 50% of the year. It is packaged in 2, 4 or 20 litre plastic buckets.

Any spills or loose asbestos released during cutting are collected during vacuuming and waste is disposed of in drums to a licensed contractor.

At the time of the survey, 17 workers were employed at the site, around half of which were engaged on the factory floor and storage areas. Workers wear 3M 8710 respirators when handling and weighing asbestos. Gloves are worn by all factory floor workers.

Potential for exposure

Exposure to chrysotile may occur during the following operations:

- when damaged bags are encountered during storage and raw material preparation;
- when manually opening chrysotile bags and adding chrysotile to the mixing vessel;
- during general clean-up and disposal.

Atmospheric monitoring

Vivacity Engineering advised that no air monitoring has been conducted at this site.

6.2 Exposure during end-use in Australian industries

The main end-uses for chrysotile products are friction materials (brake disc pads, brake linings, clutch facings and brake blocks) and gaskets in the automotive aftermarket and for industrial applications. Worker exposure may occur during the removal and replacement of worn parts. Wear and tear of parts may result in production of friable chrysotile (dust) which may be easily disturbed and become airborne during repair and removal. In addition, modification of parts, such as by cutting, grinding, sanding and drilling may release fibres.

It has been estimated that up to 10,000[5] workers are intermittently exposed to chrysotile during end-use. These workers are found in the construction industry, automotive brake and clutch repair, gasket cutting and brake bonding workshops and other service industries (NOHSC, 1995a).

There is limited occupational exposure data available for end-use. Australian data include:

- a survey (carried out by NICNAS) of the automotive aftermarket (this also included a gasket cutting workshop) see Appendix 2;
- data from Western Australia for service garages;
- data on gasket removal and installation at a single company; and
- data on preparation of gaskets (for use in engineering applications).

Potential exposure to chrysotile for end-users exists when fibres are released, such as in the following situations:

Gasket workshops

- during fabrication of CAF sheeting to produce gaskets - this may involve cutting, sawing and drilling.

Brake bonding industry

- when worn brake pads and clutch facings are stripped from their metal supports; and
- during assembly of disc brakes and clutches - this may involve grinding (grinding generates high volumes of dust and very fine fibres).

Garage service workshops

- during changing of worn brake disc pads, brake shoes and clutch facings.

6.2.1 End-use monitoring data

NICNAS Automotive Aftermarket Survey (Sydney, NSW)

A small survey (carried out by NICNAS) in 1996 of the Automotive Aftermarket industry was conducted to gauge the relative usage of both asbestos and non-asbestos products in garages and workshops and to assess occupational exposure to chrysotile in the workplaces. Detailed information on the methodology of this survey can be found in Appendix 2.

Control measures used in the workshops were also investigated and this information is summarised in Table 10.

The automotive aftermarket survey found that:

- In service garages, exposure to asbestos may occur during brake changes and clutch repair, with the number of hours per day/week varying from garage to garage. The service garages surveyed indicated that they rarely undertook cutting, grinding or sanding of asbestos products.

[5] The Victorian Asbestos Diseases Society are of the opinion that this figure is likely to be a significant underestimate, based on assumptions derived from ABS statistics for the numbers of workers reported (55,000 at September 1997) under the category 'automotive repair and services'.

- In brake bonding the work normally consists of removal and replacement of worn brake pads and clutch facings. Worn pads and facings are stripped from their metal backing by abrasive action. Once the metal has been cleaned new linings are glued into place, cured in an oven, and then ground to size. Some cutting of new linings is carried out, but in most cases, the brake and clutch material comes precut.
- In gasket workshops cutting and stamping (by machine) takes place. Sawing and drilling are sometimes performed in the finishing process. The average exposure time was 5 h/week however, the number of hours was dependent on customer orders and hence varied considerably.

Personal and static monitoring was also conducted (using MFM) at all workshops surveyed and results are summarised in Table 11. The TEM results and corresponding MFM results are provided in Table 12.

The light microscopy monitoring results indicate that exposure to chrysotile was greatest during the cutting and grinding of brake shoes. The only results >0.05 f/mL were obtained in brake bonding workshops, with the highest personal monitoring result being 0.2 f/mL. However, the sampling duration was less than the preferable minimum of 4 hour and therefore the results cannot be directly compared with the TWA exposure standard. The results indicate that exposure to chrysotile on a task basis was less than 0.05 f/mL (the detection limit of the MFM), during repair work in service garages. As this is the detection limit of the method, the exposure on a 4 hr basis would be the same i.e. <0.05 f/mL. Background fibre concentrations (static monitoring) were all less than 0.03 f/mL.

Results of TEM analysis, which are summarised in Table 13 show that chrysotile fibres were found in all 3 brake bonding workshops and the gasket workshop but only in one service garage,. The highest number of chrysotile fibres (using TEM) was found in brake bonding workshops where up to 100% of sampled fibres were identified as chrysotile.

Lower numbers of chrysotile fibres were found in samples from the gasket workshop.

No chrysotile fibres were detected in the samples taken from 4 of the 5 service garage workshops. This may indicate that no asbestos was present in the atmosphere during sampling or that it was present at concentrations less than the detection limit of the method. These samples were taken during removal and replacement of asbestos parts e.g., changing drum and disc brakes. All mineral fibres that were identified in the service garage for buses were amorphous silica and forsterite which are products from heat affected chrysotile.

The results show that the TEM (asbestos) count was significantly higher than that measured under light microscopy in 3 samples. This is due to the finer diameter fibres counted using TEM, which are presumably caused by greater mechanical breakage such as cutting and grinding. When diameter differences are taken into account there is reasonable agreement between adjusted TEM counts and light microscopy counts in nearly all samples.

Table 10 - Worker exposure to asbestos by work practice – NICNAS Automotive Aftermarket Survey*

Workshop	No. of workers	Work done	Exposure duration & frequency	Cutting, sanding or grinding	Comments
Service garages					
1	1	brake change clutch repair	0.5-1.5 h/day 4-6 h/day	No	Good general ventilation.
2	2	brake changes	1-5 h/2-3 days/wk	No	Use aerosol brake cleaner for dust control & degreasing.
3	1	brake change clutch repair	2h/2-3 days/wk 3-5 h/2-3 days/wk	No	Use squirt bottle to wash & compressed air to dry brake assembly; good natural ventilation.
4	1	brake change clutch repair	1-1.5 h 4 h (brake work 12h/week and clutch work 3h/ week)	No	General ventilation good.
5 (bus)	5	brake change clutch repair	1-1.5 h/1-2 days/wk 4.5-5 h/1-2 days/wk	No	Brake dust removed by scalpel then dry wiping; general ventilation good; workers wore disposable mask.
Brake bonding					
1	10	brake grinding & clutch work	5 h/wk	Yes	Worker wore disposable mask; general ventilation fair; worker undergoes regular health surveillance.
2	2	bonding brake shoes	5 h/wk	Yes	Flexible hose LEV and disposable mask used during cutting and grinding; general ventilation fair; 1 worker has annual chest x-ray.
3	7	brake grinding and sanding; some cutting	5 h/wk	Yes	General ventilation good.
Gasket workshop					
	3	cutting and stamping gaskets	5 h/wk	Yes	General ventilation fair.

*including one gasket workshop

Table 11 - Personal and static monitoring results using MFM – NICNAS Automotive Aftermarket Survey

Workplace	Activity	Personal Monitoring: No. samples	Personal Monitoring: Sampling time (hr)*	Personal Monitoring: Conc. (f/mL)	Static Monitoring: No. samples	Static Monitoring: Sampling time (hr)	Static Monitoring: Conc. (f/mL)
Service garages							
1	Changing drum and disc brakes	1	1.3	< 0.05	5	1.3	< 0.03
2	Changing disc brakes, checking drum brakes	1	1.3	< 0.05	6	1.3	< 0.03
3	Changing drum & disc brakes	1	2.2	< 0.05	6	2.2	< 0.02
4	Changing clutch	1	2.1	< 0.05	7	2.1	< 0.02
5	Changing rear drum brakes on coach	1	1.3	< 0.05	7	1.3	< 0.03
Brake bonding workshops							
1	Bonding, baking & grinding brake shoes; static monitoring in radius grinding area under LEV	1	0.3	< 0.1	3	0.25	< 0.2
		1	1.2	< 0.05	5	1.2	< 0.03 - <0.04
2	Cutting (0.5 h), bonding and baking.	1	2.1	0.2			
	Grinding (0.5-0.7 h), then packing brake shoes	1	2.3	0.07			
	Grinding/cutting area				4	2.1 - 2.5	< 0.02-0.04
	Packing area and background				2	2.1	< 0.02
3	Packing and unpacking brake shoes	1	2.1	< 0.05			
	Cutting, sanding & grinding	1	2.0	n/r	2	2.0	0.04, 0.05
	Cutting area				3	2.0	n/r, 0.04, 0.07
	Storage area				1	2.0	0.03
Gasket workshop							
1	Planning and cutting gaskets with hand-held electric saw.	2	1.8	< 0.05	3	1.7	< 0.02
	Stamping gaskets (by machine).	1	1.7	< 0.05	3	1.8	< 0.02

n/r = no result (filter overloaded with dust)
*Sampling duration was less than the prerequisite minimum of 4 hours
Limit of detection=0.05 f/mL

Table 12 - TEM fibre types and fibre counts – NICNAS Automotive Aftermarket Survey

WORK-PLACE	SAMPLE TYPE	ACTIVITY	FIBRE TYPE No. of respirable fibres / EWBGA*				FIBRE CONCENTRATION (Fibres / mL of air)		
			CHRYSOTILE (% of total fibres)	MINERAL	ORGANIC	TOTAL No. FIBRES	Light Microscopy MFM	TEM MFM Equivalent Asbestos	TEM MFM Equivalent Total
Service garages									
1	Personal	Changing drum & disc brakes	0/96 (0%)	1/96	3/96	4/96	<0.05	<0.01	0.01
2	Personal	Changing disc brakes, checking drum brakes	0/96 (0%)	0/96	1/96	1/96	<0.05	<0.01	<0.01
3	Personal	Changing drum & disc brakes	3/96 (50%)	1/96	2/96	6/96	<0.05	<0.01	0.01
	Static	Changing drum & disc brakes	0/96 (0%)	1/96	4/96	5/96	<0.02	<0.01	0.01
4	Personal	Changing clutch	0/96 (0%)	1/96	1/96	2/96	<0.05	<0.01	<0.01
5	Personal	Changing drum brakes on bus	0/96 (0%)	38/96	0/96	38/96	<0.05	<0.01	0.09
	Static	Changing drum brakes on bus	0/96 (0%)	35/96	4/96	39/96	<0.03	<0.01	0.13
Brake bonding workshops									
1	Personal	Radius grinding	0/96 (0%)	0/96	1/96	1/96	<0.1	<0.04	<0.04
	Personal	Radius grinding	7/96 (63%)	1/96	3/96	11/96	<0.05	0.02	0.03
2	Static	Cutting area	15/96 (94%)	0/96	1/96	16/96	0.04	0.02	0.02
	Personal	Cutting, bonding, baking	85/96 (90%)	0/96	9/96	94/96	0.2	0.13	0.15
	Personal	Radius grinding, packing	62.5/96 (94%)	0/96	4/96	66.5/96	0.07	0.12	0.14
3	Static	Cutting, sanding, grinding	25.5/96 (84%)	1/96	4/96	30.5/96	0.05	0.04	0.05
	Static	Cutting area	97.5/96 (100%)	0/96	0/96	97.5/96	0.07	0.16	0.16
Gasket workshop									
1	Personal	Planing & cutting gaskets with hand-held electrical saw	5/96 (71%)	0/96	2/96	7/96	<0.05	0.01	0.01
	Personal	Stamping asbestos/non-asbestos gaskets	4.5/96 (70%)	0/96	2/96	6.5/96	<0.05	0.01	0.01
	Static	Planing & cutting with hand-held electrical saw	28/96 (93%)	0/96	2/96	30/96	<0.02	0.05	0.06

*EWBGA - Equivalent Walton Beckett Graticule Area

Note: The results for TEM fibre concentrations are based upon the theoretical detection limit of 4 fibres in the analysis based on a Poisson distribution. The results for light microscopy are based on a practical detection limit of 10 fibres as indicated in the NOHSC MFM. These values have been used to calculate the less than values and also indicate for some samples that no asbestos fibres were detected in the analysis unless otherwise stated.

Other Australian monitoring data

Atmospheric levels of asbestos have been monitored in several service garages by occupational health and safety authorities in Western Australia (Table 13). In all cases, the MFM method, including phase contrast light microscopy was used for counting. Little information was provided on sampling details such as sampling time and nature of the work being carried out. The majority of fibre concentrations were $\leq$ 1.0 fibres/mL, and all the most recent (1986-89) analyses were <0.1 f/mL.

The data suggests that exposure levels have decreased over time. This may be a result of the introduction of new work practices such as increased use of pre-ground, ready-to-install parts, non-blowing methods of brake removal and use of exhaust local ventilation.

Monitoring data were available from an Australian oil refinery for the removal and replacement of asbestos gaskets. The standard NOHSC MFM method was used except for sampling time. Sampling time was considerably less than 4 hours for several samples. These results are tabulated in Table 14 at the 4 locations designated as A, B, C and D. The results were $\leq$ 0.1 fibres/mL in all cases.

Data were also available (provided by Richard Klinger Pty Ltd) from a limited 'test situation' study on airborne asbestos fibre concentrations during the preparation of asbestos gaskets for use in typical engineering applications (i.e. pipe flange sealing). Extensive work was conducted on the CAF sheeting including cutting, hammering, drilling. Three gaskets were completed in the hour test period. Personal exposures were < 0.05 f/mL (the detection limit) and a static sample taken close to the work-piece was < 0.01 f/mL.

Table 13 - Monitoring results for service garages, Western Australia*

Date	Location	Work done	Sampling type	No. tests	Concentration (f/mL)	Comments
Dec 1979	service garage*	belt grinding radius grinding	static	1 1	0.4 <0.1	Sampling duration 10 min. Sampling duration 10 min.
Jun 1981	5 service garages	brake maintenance	(not stated)	5	<0.2, 0.2, 0.6, 0.6, 1.3	
May 1982	4 service garages		static	4	<0.3, <0.4, <0.5, 10	
Sep 1983	service garage**		personal	3	0.7, < 0.1	Sampling time approx. 3 hrs. 1 sample not analysed due to overloading of filter.
Apr 1986	service garage**	brake maintenance	personal static	1 1	< 0.01 < 0.01	
Jun 1987	service garage		static	5	< 0.1	
Sep 1987	service garage	brake maintenance	personal	4	≤ 0.1	Sampling time 175-185 min.
Dec 1987	service garage	brake maintenance	personal static	1 1	< 0.1 < 0.1	
Mar 1988	service garage	grinding brake discs and linings	personal	1	<0.1	
Jan 1989	brake bonders		static	2	0.1	

* data supplied by Worksafe (Western Australia)
** same service garage

Table 14 - Air monitoring results during processing of asbestos gaskets

Location / Operation		No. of workers	Sampling time (min)	Conc. (f/mL)	Comments
Personal monitoring					
A.	handling CAF gaskets	4	250	< 0.01	
B.	cutting gaskets		60	0.08	45 min. cutting with a ball peen hammer, 5 min. with hand cutters, remainder cleaning up.
C.	(i) scraping gaskets (ii) cutting gaskets (iii) cleaning up	1 1 1	13 37 12	0.07 0.07 0.1	3 successive operations by one worker
D.	removal and replacement of gaskets	5	240	< 0.01	Actual time working with gaskets was significantly less than 4 hours.
Static monitoring					
C.	at 3 locations 2-3 m from cutting area		124	< 0.01	
D.	near cutting area		60	< 0.01	

Note: Data for a limited test situation study on airborne asbestos fibre concentrations while preparing asbestos gaskets for use in typical engineering applications, was provided by Richard Klinger.

6.3 International exposure/monitoring data

6.3.1 Manufacture of asbestos products

Limited monitoring data for sites manufacturing friction materials and gaskets is available in the literature. Information published in 1986 in the OSHA Report on Occupational Exposure to Asbestos (Environmental Protection Agency, 1986) is summarised in Table 15.

Table 15 - Atmospheric monitoring data for overseas manufacturing sites

Product	Activity	Atmospheric Concentration (f/mL)	Comments
Friction products (monitoring at 1 plant)	introducing raw chrysotile	0.03 - 0.21	Monitoring of 15 employees
	involved in wet mechanical operations	n.d. - 0.3	Monitoring of 28 employees. Most results were < 0.2 f/mL.
	involved in dry mechanical operations (e.g. grinding and machining)	0.07 - 1.7	One third of workers were regularly exposed to levels > 0.2 f/mL.
Gaskets (monitoring at 3 plants)	introducing raw chrysotile	0.2	2 plants reported levels in excess of 0.75 f/mL.
	involved in wet and dry mechanical operations	< 0.2	

6.3.2 Exposure to asbestos in end-use products

Results from a number of air monitoring studies of garage workshops are available in the scientific literature. Air monitoring studies were also available for gasket modification and installation at oil refineries and chemical plants.

Removal and installation of friction materials

Monitoring data for atmospheric levels of asbestos in garage workshops are summarised in the Table 16.

Table 16 - Overseas monitoring data for atmospheric levels of asbestos in garage workshops

Country (Reference)	Operation	Sampling type (and method)	No. samples	Sampling time (min)	Concentration (fibres/mL)	Comments
USA	Brake drum service - comparison of 5 different methods for controlling brake dust during maintenance:	Personal (MFM, NIOSH 7400 B)	83	120	< 0.004 - 0.016	Little differences in range of exposures between brake drum service methods.
(Sheehy et al., 1989)	2 commercial enclosed devices with ventilation; 1 enclosed device without ventilation, 1 wet brush/recycle system, 1 aerosol spray to wet brakes.	Personal (TEM)	59	120	0.010 - 0.139	TEM results higher than by PCM. Wet brush/recycle method gave lowest results.
		Static (TEM)	74	120	< 0.003 - 0.166	Samples taken near dust control device.
	Bulk samples of brake dust analysed.	na	48	na	na	Brake dust contained ≤ 1% asbestos. <3% of fibres were > 5μm in length.
USA	Brake servicing using wet spray and manual wet brush dust control methods.	Personal (MFM/PCM) TEM	10	120-180	mean 0.006 range < 0.004-0.016 mean 0.213, range 0.013-0.894	One brake job on a large vehicle (brake drums > 4.7 cm) gave much higher TEM results (mean 0.882 f/mL) than the other 5 brake jobs (all < 0.079).
(Cooper et al., 1988)	Brake service area: - near fender and near axle - background (indoors) - outdoors	Static (MFM/PCM)	8 10 10	< 4 hr	< 0.002 < 0.002 < 0.001 - < 0.004	TEM results < 0.002 - 0.166 (highest reading near fender).
	Bulk samples of brake dust analysed.	na	6	na	na	Brake dust contained < 1% asbestos. 1-15% of asbestos fibres >5μm in length.

Table 16 - Overseas monitoring data for atmospheric levels of asbestos in garage workshops (Cont.)

Country (Reference)	Operation	Sampling type (and method)	No. samples	Sampling time (min)	Concentration (fibres/mL)	Comments
Finland	Brake repair work of trucks and buses	Personal (MFM/PCM)	176	1-60	range < 0.1-125	Only results > 2f/mL (mean 56 f/mL) were for machine grinding of brake linings without exhaust. Operations where mean concns were between 1 and 2 f/mL were brake brushing or cleaning with wet cloth, compressed air blowing & grinding brake linings. Static background samples <0.1 f/mL.
(Kauppinen & Korhonen, 1987)	Brake repair work of passenger cars	Personal (MFM/PCM)	36	1-38	range < 0.01-8.2	Only results > 1f/mL (mean 1.5 f/mL) were for cleaning of drum brakes with air jet. Static background samples <0.1 f/mL.
Federal Republic of Germany	Brake service in car repair shops:	Personal (MFM)		30-60	mean values	Sampling time short, thus total fibre count higher than a TWA and precision of measurements low. Static background samples (by EM) was <0.03 f/mL for fibres >5µm.
	- blowing out dust from drum brakes		4		0.10	
	- dry brushing drum brakes		4		0.09	
	- hand grinding of drum brake linings		7		0.12	
	- machine grinding brake linings		5		0.06	
	- combination of tasks		11		0.04	
(Rodelsperger et al., 1986)	Brake service in bus and truck garages:					Using EM, observed a low occurrence of chrysotile fibres > 5µm in brake drum dust and a large number of short, thin fibres.
	- blowing out dust from drum brakes		4		0.05	
	- dry brushing drum brakes		1		0.15	
	- riveting		7		0.10	
	- machine grinding brake linings		1		0.39	
	- turning brake linings		18		0.08	
	- combination of tasks		5		0.08	

Table 16 - Overseas monitoring data for atmospheric levels of asbestos in garage workshops (Cont.)

Country (Reference)	Operation	Sampling type (and method)	No. samples	Sampling time (min)	Concentration (fibres/mL)	Comments
Hong Kong	Car and bus brake servicing:	Personal (MFM)		10		Survey of 12 garages of varying size.
	- brake cleaned by air jet		25		mean 0.13	
	- brake cleaned by air jet		16		- range 0.01-0.28	
	- brake cleaned by brushing		6		- range 0.01-0.12	
	- brake pad machining		3		- range 0.04-0.83	
(Cheng, 1986)	Car and bus brake servicing:	Static (MFM)	46	240	mean 0.05	Samples taken at breathing level within 5 metres of the work activity.
	- brake cleaned by air jet		22		- range 0.01-0.09	
	- brake cleaned by brushing		14		- range 0.01-0.03	
	- brake pad machining		9		- range 0.02-0.54	
USA	Automotive brake & clutch remanufacture:					
	- OSHA data	Personal	23	8 hr	mean 0.12	Results based on OSHA data 1979-1984.
	- RTI survey		112		mean 0.05	Results for 7 workshops surveyed in 1984 by Research Triangle Institute, USA
(Environmental Protection Agency, 1986)	Automotive brake and clutch repair	Personal	47	8 hr	mean 0.03	Results based on OSHA data 1979-1984.
USA	Car repair shops: - blowing dust from brake drums with air jet	Personal (MFM)	9	not stated	mean peak concn at 1-1.5 m was 15.0 f/mL, (range 0.3-29)	Static samples of 0.2 f/mL (5 min. after air jet blowing)
(Rohl et al., 1977)						

Table 16 - Overseas monitoring data for atmospheric levels of asbestos in garage workshops (Cont.)

Country (Reference)	Operation	Sampling type (and method)	No. samples	Sampling time (min)	Concentration (fibres/mL)	Comments
USA	Truck repair shops: - renewing used brake linings by grinding	Personal (MFM)	10	not stated	mean peak values 4.8 f/mL at 1-1.5 m (range 1.7-7.0)	Static samples of 0.2 - 1.7 f/mL
	- bevelling new brake linings by grinding		4		37.3 f/mL (range 24-72)	Static samples of 0.3 - 0.6 f/mL
(Rohl et al., 1977)	Car repair shops in USA, Europe, Australia - analysis of brake drum dust	na	39	na	na	Chrysotile found in 29/39 samples by PCM, and in all by TEM. Mean weight % of chrysotile in dust samples was 2.4%. TEM results indicated that about 80% of chrysotile was in free fibril form with fibre length < 0.4 µm. Morphology of most chrysotile was unaltered. Presence of forsterite not confirmed.
USA	Blowing dust out of drum brakes with air jet (cars)	Personal (MFM)	4 3 2	2-10	mean 15.9 range 6.6-29.4 (at 3-5 ft) 2.0-4.2 (at 5-10 ft) 0.4-4.8 (at 10-20 ft)	Static background monitoring 0.1-0.8 f/mL. EM examination of brake-drum dust indicated that: most fibres showed little alteration in the typical chrysotile fibre; about 20% (by weight) was chrysotile and over 80% was <0.4 µm and so not visible by optical microscope.
(Lorimer, 1976)	Renewing used brake linings by grinding (truck)	Personal (MFM)	10	2-10	mean 3.8 (range 1.7-7.0)	Static background monitoring 0.2 - 1.7 f/mL.
	Bevelling new linings (truck)	Personal (MFM)	5	2-10	mean 37.5 (range 23.7-72.0)	Static background monitoring 0.3 - 0.6 f/mL
UK	Car brake service during blow out	Static (MFM) Personal (MFM)	2 6	45+45 whole shift	1.25, 2.55 mean 0.68 (range 0.2-1.1)	
(Hickish & Knight, 1970)	Truck brake service during blow out	Static (MFM)	3	180	0.17 - 0.28	

Table 16 - Overseas monitoring data for atmospheric levels of asbestos in garage workshops (Cont.)

Country (Reference)	Operation	Sampling type (and method)	No. samples	Sampling time (min)	Concentration (fibres/mL)	Comments
UK	Truck brake service	Personal (MFM)		whole shift		Brake and clutch cleaning was carried out during the first part of the shift (1.5-2 h), when peak fibre concentrations were higher (for brake cleaning, 7.1; for clutch repair, 2.25).
	- brake cleaning				1.75	
	- clutch repair				0.79	
(Hickish & Knight, 1970)	Bulk samples of drum dust	na		na	na	Drum dust contained <1% chrysotile and very little forsterite. Mainly contained amorphous magnesium silicate (non-fibrous).

na = not applicable; MFM=Membrane filter method; TEM=Transmission electron microscopy; PCM=Phase contrast microscopy

The monitoring data includes results from studies conducted up to 25 years ago, so these data may not be representative of current exposures in brake service garages. However, the results provide some insight into the influence that control measures have had on personal exposure. Higher results generally occurred in the older studies during blowing and grinding operations. The more recent studies (Sheehy et al., 1989 and Cooper et al., 1988) indicated lower exposures. The MFM/PCM results indicate that exposure levels are generally <0.2 f/mL (no grinding). In these studies control measures included enclosed devices or wet cleaning.

In most cases monitoring was conducted only during the maintenance operation, that is, only during the often very short period when fibres may be released. These results are generally higher and not representative of exposure during 8 hr shift or standard work periods. Therefore, the results should not be compared to the occupational TWA exposure standard, where a minimum sampling duration of 4 hours is required.

Several bulk samples of brake dust contained < 1% asbestos.

Removal and installation/modification of gaskets

The results of 3 studies carried out primarily to investigate the removal and installation of gaskets are summarised in Table 17. The MFM results were generally below 0.06 f/mL for monitoring of full workshifts during wet removal of gaskets. Cheng and McDermott (1991) compared different methods of removal of gaskets and found that the results were much higher during dry removal of gaskets using a power sander (up to 1.4 f/mL). This study also included monitoring during fabrication (cutting) of sheet gaskets (CAF), where the maximum time-weighted average exposure was 0.017 f/mL.

6.4 Summary

Workers may be exposed to chrysotile during the manufacture and use of chrysotile products. Exposure is most likely to occur during the handling of raw chrysotile during manufacture and installation/modification and replacement of the products in the aftermarket.

Air monitoring data were analysed from various sources including, applicants (Bendix Mintex, Richard Klinger), the automotive aftermarket survey (carried out by NICNAS), air monitoring in service garages in Western Australia and international exposure data in garage workshops and industries involved in the removal and replacement of asbestos friction products and gaskets. Results from these studies indicate that over the past 10 years, samples were less than 1 f/mL (NOHSC national exposure standard for chrysotile[6]).

Raw chrysotile is used by Bendix Mintex in the manufacture of friction products. Air monitoring data was provided for the period 1992 to 1997. During this period more than 80% of personal samples (all fibres) were < 0.1 f/mL and only two samples were > 0.5 f/mL. There are no other manufacturers of asbestos friction

[6] Where exposure to other asbestos fibres is possible, the NOHSC exposure standard is 0.1 f/mL (NOHSC 1995d).

Table 17 - Exposure during gasket removal and installation

Country / Study type / (Reference)	Operation	Sampling type (and method)	No of samples	Sampling time (min)	Concentration (fibres/mL)	Comments
USA	Removal of gaskets from old valves	Personal (MFM)	23	Approx. 30 min	mean 0.16 (range 0.05-0.44)	
Simulated study		Personal (TEM)	26		mean 4.58 (range 0.86-18.45)	
	Installation of gaskets in old valves	Personal (MFM)	12		mean 0.20 (range 0.13-0.29)	
(McKinnery & Moore, 1992)		Personal (TEM)	12		mean 2.97 (range 0.40-74.32)	
Netherlands	*Group A* - gaskets easily removed without breaking (spiral wound gaskets)	Personal (MFM)	11	400-435	0.04-0.24	Wetting agent used during gasket removal.
Study of chemical plant		Personal (TEM)	"	"	<0.0008	In the only sample containing asbestos >0.06f/mL, TEM confirmed high level of non-asbestos fibres.
	Group B - removal of remaining gaskets (asbestos plate gaskets)	Personal (MFM)	10	69-156	below detection limit - 0.02	
(Spence & Rocchi, 1996)		Personal (TEM)	"	"	below detection limit - 0.004	
USA	Replacement of spiral wound gaskets	Not stated	2	short duration	<0.06	Activities include lifting and disposal of old gaskets, wire brushing surfaces of flanges and installing new gaskets.
Study of oil refineries and chemical plants	Fabrication (cutting) of sheet gaskets	Personal	7	330-490	0.001-0.017	Activities include cutting and hammer punching with various types of tools.
			4	30-55	0.33-0.49	Monitoring during peak action period
			3	19-55	11-0.33	
			1	25	1.4	
	Replacing sheet gaskets		2	15-30	<0.06	Dry removal of gasket; surface cleaning with scraper and wire brush.
(Cheng, 1986)						Dry removal of gasket; polishing flanges with power sander.
	Storage of gaskets	Personal		480	0.037-0.058	Wet removal of gasket

products in Australia, however information available to NICNAS indicates that at least 10 other companies import asbestos friction products.

At Richard Klinger (Perth site), raw chrysotile is used in the manufacture of CAF sheets for production of gaskets. Air monitoring data (between 1991 to 1996) showed that during raw material handling, approximately 60% of personal samples (all fibres) were <0.1 f/mL and only one sample was > 0.5 f/mL (i.e. 0.8 f/mL). Richard Klinger is the only gasket manufacturer in Australia using raw chrysotile, however there are a number (at least 5 companies) of manufacturers/processors (using CAF sheeting starting material) of asbestos gaskets.

At Richard Klinger (Melbourne site), processing (cutting and stamping) of gaskets is undertaken, however no sanding or grinding occurs. Air monitoring samples for both personal and static samples for the years 1989, 1991, 1993 and 1995 were < 0.05 f/mL. Although only a few samples were undertaken at specified locations, Richard Klinger indicate that they represent highest exposure potential to CAF sheeting. In addition, Richard Klinger have stated that it would be incorrect to assume that this data is representative of other manufacturers of CAF gaskets as potential chrysotile exposure levels are related to the grade of CAF (i.e., degree of fibre encapsulation in the CAF matrix and amount of a free surface layer asbestos[7]).

The third applicant, Vivacity Engineering stated that they had not conducted any air monitoring studies and that they intended phasing out all use of chrysotile during 1997, although this had not occurred as at August 1998.

Asbestos fibres may be released during replacement of friction products and gaskets in vehicles. Many service garages around Australia carry out brake and clutch repair work and therefore workers may be exposed to friable asbestos. Results of the NICNAS air monitoring studies in an automotive aftermarket industry indicate that personal and static short-term exposures were < 0.05 and < 0.03 f/mL respectively. These levels may have been lower if the sampling duration was longer. For comparison with TWA occupational exposure standards, the preferable minimum total sampling duration is 4hr.

Monitoring data from Western Australia service garages carried out in the last 10 years indicate exposures to be < 0.1 f/mL. These results also show that recent exposure levels appear to be lower than in the past.

International monitoring results in service garages indicate that exposure levels are generally < 0.2 f/mL (no grinding). The data includes studies conducted up to 25 years ago and indicates that exposure levels have decreased over time. Decreases in exposure levels are likely to be due to implementation of better engineering controls and good work practices (e.g., use of compressed air to blow dust from brake parts is prohibited and the use of grinders has diminished) during brake and clutch servicing.

In the brake bonding industry worn brake pads and clutch facings are stripped from their metal supports and replaced with new pads and linings. The NICNAS automotive aftermarket survey indicated that exposure to chrysotile was highest

[7] Richard Klinger have indicated that the CAF sheeting they manufacture is a high grade product (i.e., maximum encapsulation and low dust residue).

during grinding of brake shoes and cutting of brake linings. The highest personal monitoring result obtained was 0.16 f/mL, during cutting of brake shoes. This exposure level could be reduced with improved local exhaust ventilation.

In the gasket industry, CAF sheeting is cut to size and is modified by stamping, sawing and drilling at several workshops in Australia. Limited monitoring data is available in this area. Results of short-term monitoring data in 3 Australian studies indicate that personal exposures were $\leq$ 0.08 f/mL and static exposures < 0.01 f/mL. Personal exposure in an overseas study was < 0.02 f/mL (TWA) during cutting of CAF.

A review of 3 international studies on occupational exposure to asbestos during removal and installation of gaskets showed that the highest exposure levels were during dry removal of gaskets (up to 1.4 f/mL). During wet removal of gaskets exposure levels were below 0.06 f/mL.

7. Health Effects and Risk Characterisation

The human health effects from exposure to asbestos, including chrysotile, are well documented. There are many reviews available that give detailed information on the pathology and/or epidemiology of asbestos-related diseases. These include: Doll and Peto (1985); International Programme on Chemical Safety (IPCS) Environmental Health Criteria 53 (1986); IPCS Environmental Health Criteria 203 (1998); Mossman and Gee (1989); Roggli (1990); Selikoff (1990); Hughes and Weill (1991); McDonald and McDonald (1991); Liddell (1991 & 1997); Stayner et al (1996); Smith and Wright (1996). The data presented here is not intended to be a detailed review of the literature, but is a summary of the pertinent data on the health effects and risk estimates for exposures to asbestos/chrysotile. In addition, controversial issues and uncertainties associated with the assessment of hazard and risk are highlighted.

7.1 Historical overview

Since the turn of the century, asbestos has been recognised as an occupational health hazard. All forms of asbestos have been linked with asbestosis, lung cancer and mesothelioma in humans. Other malignancies (including gastrointestinal cancer) have also been associated with asbestos exposure, however, the epidemiological evidence is inconclusive.

Mining and industrial use of asbestos goes back to the late 19th century. Asbestosis was first identified in the 1920s. Public awareness that lung tumours were causally related to asbestos was first noted in an epidemiological study of chrysotile textile workers in Rochdale, UK in 1955 (Doll, 1955). Malignant mesotheliomas were first described in the northwestern Cape region of South Africa in miners exposed to crocidolite (Wagner et al., 1960).

7.1.1 Classification of health effects

All forms of asbestos, including chrysotile, are classified by regulatory authorities as carcinogenic to humans.

The International Agency for Research on Cancer (IARC) classify all forms of asbestos under carcinogen Category 1 (IARC, 1987). NOHSC classify chrysotile as a Category 1 carcinogen (Risk phrase 45) . This classification is consistent with that of the EU (EEC Council Directive 67/548/EEC). In addition, according to NOHSC (NOHSC, 1994c), chrysotile products containing > 0.1% chrysotile should also be classified as carcinogenic (Category 1).

7.2 Human health effects from exposure to asbestos

7.2.1 Asbestosis

All forms of asbestos may cause asbestosis. Asbestosis was the first asbestos-related lung disease to be recognised. It is defined as diffuse interstitial fibrosis of the lungs resulting from exposure to asbestos dust. It is this scarring of the lungs which reduces their elasticity and function resulting in breathlessness. It can appear and progress many years after the termination of exposure. Epidemiological data indicate that the disease incidence rate increases and becomes more severe with increasing dust levels and duration of exposure (Weill, 1994).

7.2.2 Lung cancer

Lung cancer has been shown to be caused by all types of asbestos fibre. Lung cancer has been responsible for the largest number of deaths attributable to occupational exposure to all principal commercial asbestos forms i.e. chrysotile, amosite and crocidolite. An increased incidence of lung cancer has been documented among workers involved in asbestos mining and milling and in the manufacturing and use of a variety of asbestos products. The average latency period of the disease (from the first exposure to asbestos) ranges from 20 to 30 years.

Combined exposure to asbestos and cigarette smoke increases the risk of lung cancer. Together they act synergistically and the combined risk is much greater than the individual risks for exposure to asbestos or for smoking (IPCS, 1996). Lung cancers caused by asbestos are clinically indistinguishable from those caused by cigarette smoking.

IPCS (1998) concluded that based on available data in miners and millers, there is an interaction between tobacco smoke and chrysotile in the induction of lung cancer which appears to be less than multiplicative.

The question of whether asbestos-induced lung cancer can develop in the absence of asbestosis has been the subject of intense debate. The issue has been discussed in detail in several reviews including Becklake (1991); HEI-AR (1991) and Meldrum (1996).

Autopsy investigations in some workers have shown that asbestos-induced lung cancer is seen in association with pulmonary fibrosis (Newhouse et al., 1985; Kipen et al., 1987; Wagner et al., 1988). Hughes and Weill (1991) also reported excess risk of lung cancer being restricted to workers with x-ray film evidence of asbestosis. Meldrum (1996) states that there is sufficient evidence to demonstrate an association between asbestosis and lung cancer. Evidence includes similarities in dose-response relationships, latency periods for development and similar dependencies on fibre length and type. These findings are consistent with the view that asbestos is a lung carcinogen by virtue of its fibrogenicity.

On the other hand, a number of studies have suggested that lung cancer may be caused by asbestos in the absence of asbestosis (Anttila et al., 1993; Hillerdal, 1994; Wilkinson et al., 1995; Egilman & Reinert, 1996).

Abraham (1994) and Roggli et al. (1994) argue that there is insufficient evidence to determine the association between these two diseases. Should there be a causal relationship between asbestosis and asbestos-induced lung cancer, this would support a 'threshold for effect' hypothesis for asbestos induced lung cancer.

7.2.3 Mesothelioma

Pulmonary mesothelioma is a primary malignant tumour of the mesothelial surfaces, generally affecting the pleura and less commonly the peritoneum. Mesothelioma has been associated with occupational exposure to chrysotile, amosite and crocidolite. The latency period is generally between 35 and 40 years. In almost all cases prognosis is extremely poor, with the survival rate generally being less than 2 years following diagnosis.

IPCS (1996) reports that although up to 90% of pleural mesothelioma cases have been attributed to asbestos, no evidence has been advanced to delineate the effects of smoking on this disease.

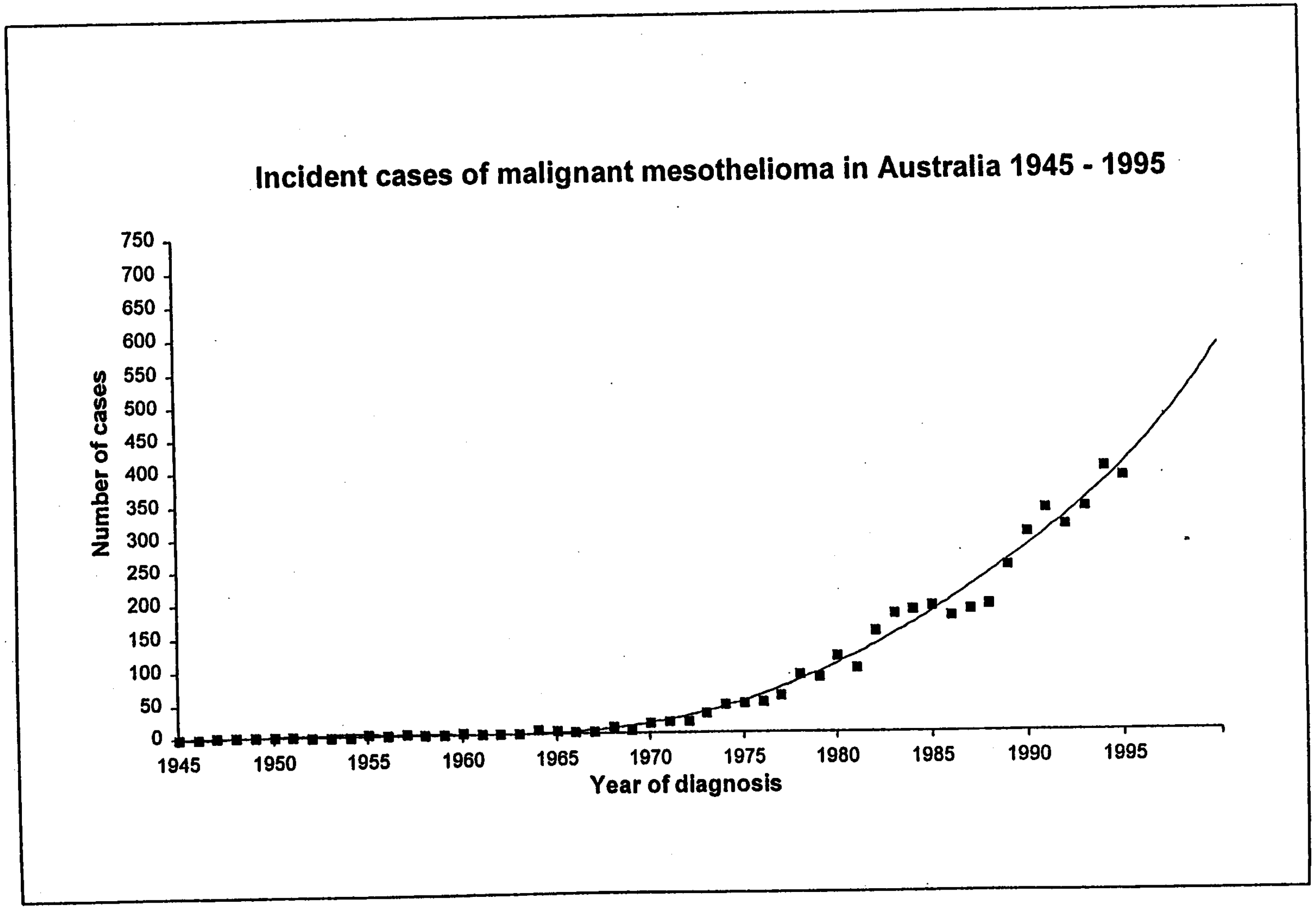
The Australia Mesothelioma Surveillance (AMS) Program

The AMS Program began on 1 January 1980, to monitor the incidence of the disease and to explore occupational and other associations with mesothelioma. A system of formal voluntary notifications of mesothelioma cases was introduced. Information collected included full occupational and environmental history, diagnosis by a pathology panel and assessment of lung fibre content.

From January 1986, a less detailed notification system has operated, the Australian Mesothelioma Register, and is a continuation of the AMS Program (Leigh et al., 1997). This includes a short questionnaire history, followed up by mail. Only histologically confirmed cases are accepted but there is no confirmation of the diagnosis by a pathology panel. Incident cases from 1945 to end 1996 totaled 4585 notifications and a continuing upward trend over time is clearly evident (Figure 6). There has been an increase in both male and female rates of mesothelioma cases, however the male rate is over 7 times the female rate. Leigh et al. (1997) reports that these are the highest reported rates in the world and that incidence is now similar to Hodgkins lymphoma or liver cancer and the mortality greater than that of cervical cancer.

Occupation/industry classification of the mesothelioma cases on the register are based on the Australian Bureau of Statistics 'Industry and Occupation Codes'. The percentage of overall cases of mesothelioma (January 1986 to March 1995) according to exposure category are; repair and maintenance of asbestos materials (13%), shipbuilding (3%), asbestos cement production (4%), railways (3%), power stations (3%), boilermaking (3%), mining (Wittenoom) (5%), wharf labour (2%), para-occupational, hobby, environmental (4%), carpentry (4%), building (6%), navy (3%), plumbing (2%), brake linings (manufacture/repair) (2%) and combinations of the above (multiple) (12%) (Leigh et al., 1997). Leigh (1994) reported that the pattern of exposure is shifting away from the older traditional industries towards product, domestic and environmental exposure. An analysis of 16 years data in 1996 by Yeung et al (1997) showed more cases (on a number of cases basis) in more recent years in the asbestos user industries and from occupations such as plumbers, carpenters, machinists and car mechanics.

Figure 7 – Incident cases of malignant mesothelioma in Australia 1945-95 (reproduced from the Australian Mesothelioma Register Report 1998)



N.B- Prior to the publication of this report, the 1998 edition of the Australian Mesothelioma report became available. This report contains more complete data for notification in recent years and as such the figure which appeared in the draft PEC report has been amended to reflect this (as above).

In the AMS Program, the potency for mesothelioma for different asbestos types has been investigated. Analysis of some 1,000 cases indicated that appoximately one third of cases were primary asbestos workers, while a further third came into contact with asbestos in the coarse of their work and for the remaining third, there was either no available information or they did not have a history of occupational exposure to asbestos. Almost all of the occupationally exposed cases had been exposed to mixed asbestos types (combinations of crocidolite, amosite or chrysotile) with the exception being those from Wittenoom (crocidolite only), but these cases only contributed 7 % of all cases in Australia (Ferguson et al., 1987).

Data were analysed on a case-referent basis, to relate relative risks of mesothelioma to dose of fibre, as measured both by lung content and estimated airborne exposure. Multivariate analysis of Australian cases found a dose response relationship for lung fibre content of crocidolite, amosite and chrysotile and the development of mesothelioma. Either a multiplicative or additive model could be used to fit the relative risk/dose coefficients for the various asbestos types. A progressive increase in relative risk with increasing fibre content was reported for all fibres (Rogers et al, 1991; Leigh, 1994). Tests for trend were highly significant in all cases.

Further review of the information contained in the case histories, provided evidence that the effects of increased lung clearance of chrysotile (see section 7.5) reduced considerably the relative risk of mesothelioma compared with the risk associated with amphiboles. Using an additive risk model adjusting in terms of relative airborne exposure levels, the risk coefficients[8] for each fibre type were 9.1 for crocidolite, 5.2 for amosite and 0.013-0.006 for chrysotile (Rogers et al., 1994). It was concluded that although the evidence shows that crocidolite, amosite and chrysotile can all cause mesothelioma, chrysotile is less potent in this regard (Leigh, 1994). A review of this work and a comparison of findings from other epidemiological studies was presented to NOHSC (Rogers and Leigh, 1991).

7.2.4 Other malignancies

In some cohorts of workers occupationally exposed to asbestos (Hillerdal et al., 1983; Doll & Peto, 1987) cancer of the larynx, oropharynx, and upper and lower digestive tract have been reported to be increased. The excess risk for these tumour types appears to be small.

7.3 Human health effects from exposure to chrysotile

Chrysotile can cause asbestosis, lung cancer and mesothelioma. In most groups of workers, lung cancer is the predominant cause of death related to chrysotile exposure. There is increasing consensus that the hazards of the different forms of asbestos are different, with chrysotile less hazardous than amphiboles (see section 7.5). Therefore, the data on chrysotile needs to be considered in isolation to, and in conjunction with, data on other forms of asbestos. In addition, it has been argued that fibre size also impacts on the degree of hazard.

[8] This figure is based on lung fibre levels in humans, whereas the relative potency estimate reported in section 7.5 of this report was based on clearance data obtained from animal studies. Both estimates have been critiqued.

The major heat degradation product of chrysotile (of relevance to applications where chrysotile may be heated to high temperatures i.e., in its use in friction products) is forsterite. Forsterite or other 'olivine' minerals have been shown to be non fibrogenic and non-carcinogenic in animal studies and do not appear to cause fibrosis/silicosis in humans (Anderson 1995; Jones et al., 1996).

7.3.1 Asbestosis

Chrysotile has been shown to cause asbestosis. There is some evidence indicating that chrysotile is less potent than amphiboles in causing asbestosis (Wagner et al., 1988; Becklake, 1991). There is also evidence to suggest that fibre size may influence the degree of hazard. For example, the rate of radiologic asbestosis in Quebec textile plant workers was greater than in Quebec miners and millers, possibly due to differences in fibre size.

7.3.2 Lung cancer

Exposure to chrysotile is associated with an excess risk of lung cancer. Table 18 summarises the results for mortality from lung cancer (and mesothelioma) from a recent update of cohorts predominantly exposed to chrysotile.

In all but one study, mortality from lung cancer was greater than expected, however this was only statistically significant in 50% of studies. In the studies that included information on tobacco habits, the observed excesses of lung cancer mortality did not appear to be related to differences in cigarette consumption. Studies indicate that there are marked differences in the levels of risk for the various industries i.e., greater risk in textile manufacturing compared to mining, milling and friction product manufacture. The most common reason suggested for these differences is fibre size, as longer fibres were generally used in the textile industry (Doll & Peto, 1985).

The carcinogenic potency of chrysotile compared to the amphiboles has been increasingly debated in the literature. Several authors have also concluded that there is sufficient epidemiological evidence to show that chrysotile, at comparable exposures, is less potent than amphiboles in the induction of lung cancer. Across-study comparisons have been conducted to examine the relationship of fibre type and risk of lung cancer. However, such comparisons are limited as exposure levels and other differences cannot be taken into account and most occupational scenarios involve exposure to mixed asbestos fibres. Therefore, the comparative risks for different fibre types cannot be quantified. Table 19 is a summary of lung cancer risk in industrial cohorts by industry segment and fibre type.

The studies and results are discussed in more detail by (Hughes, 1991), where references for individual studies are provided. Hughes concluded that the above epidemiological studies demonstrate increased lung cancer risk among past asbestos-exposed workers. The studies indicate that lung cancer risk associated with chrysotile exposure is likely to be lower than from exposure to amphiboles or mixed fibres, except in the textile industry. The information also indicates that where exposure is primarily to chrysotile, the potential risk is related to industry type.

In contrast, Stayner et al. (1996) stated that the results of the textile industry do not support the theory that chrysotile is less potent than amphiboles in inducing lung cancer. They concluded that variations in risk are more related to industry type rather than fibre type and that there is little evidence to indicate a lower risk of lung cancer from exposure to chrysotile. From the available human and animal data, Nicholson and Landrigan (1994) concluded that chrysotile is as potent a lung carcinogen as any other variety of asbestos.

Table 18 - Summary of epidemiological cohort studies of workers exposed predominantly to chrysotile

Industry	Lung cancer deaths		Mesothelioma cases		Study
	Observed	Expected	Observed No.	Deaths %	
Gas masks	6	4.8[a]	1	0.6	(Acheson et al., 1982)
Textiles, friction materials and cement	21	6.7*	2	0	(Cheng & Kong, 1992)
Textiles	126	64.0*	2	0.2	(Dement et al., 1994)
Electrical conduit pipe	6	3.7	1	1.0	(Finkelstein, 1989)
Automotive	11	7.9	1-2[b]	1.0-1.9	(Finkelstein, 1989)
Cement manufacturing[c]	70	53.2	1	...	(Hughes et al., 1987)
8 asbestos factories	65	15.6[a]*	2	0.4	(Huilan & Zhiming, 1993)
Friction products	73	49.1*	0	0	(McDonald et al., 1984)
Mining and milling[d]	518	389.7*	28	0.4	(McDonald et al., 1980) and (McDonald et al., 1993)[d]
Mining	22	19.9	2	0.5	(Piolatto et al., 1990)
Paper and millboard	4	4.3	0	0	(Weiss, 1977)
TOTAL	922	618.9	41	0.3=	

Table adapted from (Stayner et al., 1996)

[a] Expected number for cancer of the lung and pleura combined.

[b] One or two cases of mesothelioma were reported. Only one was included in the totals.

[c] Results are for workers exposed only to chrysotile from one of two plants studied. The total number of deaths was not reported: thus the percentage of mesothelioma deaths could not be estimated.

[d] Observed and expected numbers exclude observations from the asbestos factory.

* Significantly different from the observed number, P<.05 (two tailed).

= This percentage is for all studies combined.

Table 19 - Lung cancer risk by industry segment and fibre type

	Chrysotile[a]			Mixed			Amphiboles		
Industry Segment	**Obs**	**Exp**	**Obs/ Exp**	**Obs**	**Exp**	**Obs/ Exp**	**Ob s**	**Exp**	**Obs/ Exp**
Mining/milling	239	192.7	1.24				91	34.5	2.64
Gas mask manufacturing	6	4.8	1.25				33	15.8	2.09
Friction products[b]	161	131.4	1.23						
Insulation				397	93.7	4.24	84	17.5	4.80
Assorted manufacturing	4	4.3	0.93	77	72.4	2.71			
Asbestos cement	58	56.3	1.03	351	225.1	1.56			
Textiles	94	55.6	1.69	342	188.9	1.81			
Total	562	445.1	1.26	1167	536.1	2.18	208	67.8	3.07

Table source: Hughes (1991)
Obs = Observed
Exp = Expected
[a] exclusively or predominantly chrysotile
[b] combined results from studies by McDonald et al. (1983) and Newhouse and Sullivan (1989)

7.3.3 Mesothelioma

Chrysotile has been shown to be associated with an increased risk of mesothelioma in humans. It is not possible to compare the number of observed to expected cases as mesothelioma is such a rare disease in the general population. Stayner et al. (1996) compared the percentage of deaths due to mesothelioma to the background percentages in the United States to demonstrate the association between chrysotile and mesothelioma (see Table 18).

Based on epidemiological evidence some investigators are of the opinion that for a given exposure, the risk of developing mesothelioma is greater with amphiboles (primarily crocidolite) than chrysotile (Hughes & Weill, 1986; Leigh, 1994; Rogers et al 1994; Meldrum, 1996; Stayner et al., 1996).

In contrast, other investigators have concluded that chrysotile is a major cause of mesothelioma in humans and has a similar potency to amphiboles. The US EPA (US EPA, 1989), in its quantitative assessment of mesothelioma risk, concluded that epidemiological and animal evidence did not conclusively establish differences in mesothelioma hazard for the various asbestos fibre types and as such all asbestos fibres should be regarded as exhibiting similar carcinogenic potency. Smith & Wright (1996) reviewed the data from the asbestos cohorts ranked according to the ratio of pleural mesotheliomas per 1,000 deaths, and found chrysotile to be the primary asbestos type for at least 2 of the 10 top-ranking cohorts. The authors concluded that chrysotile is of similar potency to amphiboles. Similarly, Huncharek (1994) concluded that for mesothelioma (as for lung cancer) the differences for carcinogenic potential appear to be more related to fibre size than fibre type. In support of this were findings in an Australian study, where a significant dose-response effect for short chrysotile fibres was independent of the presence of long amosite and long crocidolite fibres, based on lung fibre content (Leigh, 1994).

7.3.4 Epidemiological studies on friction product manufacture

There are 3 major studies relating to the mortality and cancer incidence of employees working in the manufacture of chrysotile friction products (Berry & Newhouse, 1983; McDonald et al., 1984; Finkelstein, 1989).

The mortality of over 13,000 workers at a UK factory producing friction products has been reported. The initial study analysed mortality data for the period 1941-1979 (Berry & Newhouse, 1983). The study was then extended to include data to1986 (Newhouse & Sullivan, 1989). During this period only chrysotile was used in the factory, with the exception of 2 periods before 1945 when crocidolite was used. The study found that there was no detectable excess of deaths due to lung cancer, gastrointestinal cancer or other cancers. There were 13 mesothelioma cases, however, eleven of these subjects had known contact with crocidolite. Of the 2 remaining mesothelioma cases, diagnosis was uncertain for one case and the occupational history was not well established for the other. From 1931-1950 exposures were 5-20 f/mL in certain areas, after 1950 they were <5 f/mL and since 1970 levels were <1 f/mL (Newhouse & Sullivan, 1989). The SMR was 106, but was not considered statistically significant (Berry & Newhouse, 1983).

A study by McDonald et al. (1984) investigated mortality due to lung cancer, mesothelioma and asbestosis in three US factories manufacturing friction products and packings. The cohort comprised 3641 men employed between 1938-1958. During the 1930s exposures for most processes were 1-5 mpcf (millions of particles per cubic foot) and >10 mpcf during dry mould mixing. By the 1960s most exposures were <0.5 mpcf. A significant excess of deaths (reference was to mortality rates for Connecticut) due to respiratory cancer was observed however this was not related to duration of employment. No cases of mesothelioma were reported. There was limited evidence of an increase in risk of lung cancer with increasing exposure. However the SMR for lung cancer was noted in workers with less than one year of service.

A study by Finkelstein, (1989) investigated mortality rates among 1657 employees at two Ontario factories manufacturing chrysotile friction materials. The study population consisted of workers employed for at least 12 months after 1 January 1950. The study showed a significant increase in mortality from laryngeal cancer and lung cancer. No increase in mortality was noted from gastrointestinal cancer or from non-malignant respiratory disease. One or two deaths may have been due to pleural mesothelioma. Case-control analysis demonstrated a lack of association between the risk of death from laryngeal or lung cancer and the duration of employment or employment in departments where chrysotile had been used. The author also notes that cigarette smoking is a risk factor for laryngeal cancer and lung cancer, and therefore, increased risk may be in part attributable to differences in smoking habits.

In reviewing the above studies, Berry (1994) concluded that the risk from working in the manufacture of chrysotile friction materials are small compared to risks associated with working with chrysotile in the textile industry.

7.3.5 Case reports of mesothelioma in car mechanics

In Germany, Woitowitz and Rodelsperger (1991) reported that out of 174 identified cases of mesothelioma, 14 were in car mechanics. Eleven of these cases were workers who moved from this occupation to others where asbestos exposure was known. Only 3 had remained as car mechanics for the duration of their working life. The authors concluded that there was an increased incidence of mesothelioma among car mechanics. This finding was refuted by Wong (1992) in a letter to the Editor, which provided further statistical interpretation of these results together with a review of similar studies carried out in the US, which indicated no increased mesothelioma risk for garage mechanics. In response, the authors conducted a further study on a larger group of mesothelioma cases (324 cases), which included 16 cases listed as car mechanics. On detailed examination, only 6 cases had definate exposure to asbestos (during brake repair) and the authors concluded that there was no evidence that car mechanics are exposed to an increased risk of mesothelioma, even if they are involved in brake repair work (Woitowitz and Rodelsperger, 1994).

Of 413 cases of mesothelioma notified to the UK Mesothelioma Register during the period 1967 to 1968, only 1 case was listed as a motor mechanic (Greenburg and Davies 1974). A review of the period 1967 – 1992 from the UK register, indicated a total of 11,492 cases, in which there was no mention of garage or motor mechanics as being in groups with an increased incidence of mesothelioma (Rogers 1998). A more detailed analysis of the occupations associated with these cases (reported at the Inhaled Particles Conference in Oxford, UK in 1996) reported that during this period, motor mechanics had a mesothelioma incidence rate of approximately 50% of the general (background) UK population (Rogers 1998).

An analysis of the Australian Mesothelioma Surveillance Programme (AMS) and Register for the period 1979-1985 indicated that 7 cases out of a total of 858 cases were recorded in car mechanics who had handled asbestos friction products (Ferguson et al., 1987). Out of 2119 mesothelioma cases registered (with a response to history) for the period 1986-1995, 46 cases were listed for the category 'brake lining - manufacture/repair', 40 of which were recorded in car mechanics, of which 37 were exposed to asbestos in this occupation only[9] (Leigh et al., 1997; Rogers et al. 1997). Overall the numbers indicate a slight increase of around 1-2 cases per year, which is roughly proportional to the growth rate of all mesothelioma cases in Australia (Rogers, 1998).

7.4 Animal data

Results from animal studies reflect the known human health effects of asbestos. IARC (1987) reports that asbestos has been tested for carcinogenicity by inhalation in rats, by intrapleural administration in rats and hamsters, by intraperitoneal injection in mice, rats and hamsters and by oral administration in rats and hamsters. Chrysotile, crocidolite, amosite, anthophyllite and tremolite produced mesotheliomas and lung carcinomas in rats after inhalation and mesotheliomas following intrapleural administration. Chrysotile, crocidolite,

[9] Bendix Mintex have questioned this job description, as they state that most brake work is carried out by mechanics who may be exposed to asbestos in other (non-friction material) products e.g. gaskets, body fillers and historically, tremolite talc (used in puncture repair).

amosite and anthophyllite induced mesotheliomas in hamsters following intrapleural administration. Intraperitoneal administration of chrysotile, crocidolite and amosite induced peritoneal tumours, including mesotheliomas, in mice and rats and abdominal tumours in rats (administered crocidolite).

Animal studies have been useful in studying the association between lung cancer and asbestosis and the time course of disease development following exposure. Studies have shown that fibre-induced lung cancer is preceded by the development of pulmonary fibrosis and that exposures which are insufficient to cause asbestosis do not lead to an increase in lung tumour incidence (Meldrum, 1996, Davis and Cowie, 1990). However, available inhalation studies are considered inadequate for investigating dose-response relationships and no study has clearly identified a NOAEL (no adverse effect level) for any of the endpoints.

7.5 The relationship between fibre type and size to carcinogenicity

Although all forms of asbestos are hazardous and have been shown to cause asbestosis, lung cancer and mesothelioma, there is accumulating evidence to indicate that the degree of hazard (pathogenicity) is intrinsically related to:

- fibre type; and
- fibre size distribution.

Several authors have concluded that there is sufficient evidence to demonstrate that chrysotile is less hazardous than amphiboles (McDonald & McDonald, 1987; Hughes, 1991; Churg, 1994; Meldrum, 1996). With respect to mesothelioma, Leigh (1994) concluded that chrysotile is some 14 times less potent in this regard.*

As commercial chrysotile may contain low levels of tremolite, it has been suggested that tremolite may be the cause of mesotheliomas in populations exposed primarily to chrysotile (Churg & Harley, 1984; Weill & Hughes, 1988; McConnochie et al., 1989). However, Begin et al. (1992) reported that in Quebec, mesothelioma rates are as high in the 'Asbestos region' as the 'Thetford mines region', despite much lower tremolite contamination of chrysotile in the former region. In addition, mesotheliomas have been reported in animal studies from exposure to 'pure' chrysotile (Wagner et al., 1974; Frank et al., 1997). In conclusion, the tremolite issue is largely unresolved and has been considered by many as academic, in that tremolite is an impurity in most commercial chrysotile samples.

IPCS concludes that dose-response information is needed for animal studies for various asbestos fibre types in order to evaluate the differential risks from different fibre types (IPCS, 1998).

The predominant reason proposed for a lower potency for chrysotile, compared to other asbestos fibres, is the shorter residence time of chrysotile fibres in the lung. This could be a result of:

- chrysotile being chemically unstable in the lung and the leaching of magnesium, eventually leading to dissolution of the fibre; and

*This figure is based on clearance data obtained from animal studies, whereas the relative potency estimates reported in section 7.2.3 of this report were based on human lung fibre levels. Both estimates have been critiqued.

- chrysotile rapidly fragmenting into very short fibrils that are easily phagocytised and removed from the lung (Churg, 1994).

It has also been postulated that due to their shape, inhaled chrysotile fibres do not reach the parenchyma but instead are trapped at large airway bifurcations, whereas amphiboles (due to their straight shape) are carried in the airstream into the periphery of the lung (Mossman & Gee, 1989; Churg, 1994). However, animal studies have shown extensive chrysotile deposition in the lungs and some reports have concluded that deposition fractions of amphiboles and chrysotile fibres are similar (Churg, 1994).

There has been intense debate about which property (fibre type or fibre size) has the greatest impact on potency. For example, Nicholson & Landrigan (1994) and Smith & Wright (1996) examined the evidence from epidemiological and animal studies published in the literature and concluded that, in general, the differences between studies using the same fibre type exceed those that exist between using different fibres. There is however good evidence to indicate that long fibres are more hazardous than short fibres (Stanton et al., 1981; Smith & Wright, 1996). Relative risks for mesothelioma, in particular, have been shown to be statistically higher for chrysotile, crocidolite and total amphibole fibres > 10 µm than for risks associated with fibres < 10 µm (Leigh, 1994).

It is generally accepted that the fibre dimensions that correlate most strongly with increased lung tumour incidence are fibres that measure > 5 µm long (length) and < 3 µm wide (diameter) (Spurney 1995). However high correlations have been seen in other size ranges, such as > 8µm long and <0.25 wide and > 4 µm long and < 1.5 µm wide (Stanton et al. 1981). Dimensions of asbestos and non-asbestos fibres can be found in Table 35 (Section 11). In addition, it is generally assumed that the carcinogenic effect of fibres decreases rapidly when the ratio of length to diameter (aspect ratio) falls below 3 (EC, 1997).

IPCS (1998) concluded that the significance of physical and chemical properties (e.g. fibre dimension, surface properties) of fibres and their biopersistence in the lung in relation to their biological and pathogenic effects needs further elucidation.

7.6 Characterisation of lung cancer risk from asbestos exposure

Several risk estimates for occupational exposure to chrysotile have been published in the literature. Because lung cancer is the overriding risk from chrysotile exposure, most estimates are based on this effect. Table 20 summarises estimates of lung cancer risk by industry and fibre type for different cohort studies (Stayner et al., 1996). These risk estimates have been based on a linear, non-threshold model, where the slope of the linear dose-response relationship (expressed as the excess relative risk of lung cancer per unit of cumulative exposure (fibre.year/mLs) is indicative of the level of risk.

The risk estimates indicate that there is an increased risk with increasing exposure in all industries. The rate at which the risk of lung cancer increases with cumulative exposure (the slope of the line) appears to vary significantly for different industries. Textile manufacture produces the highest risk of lung cancer, with lower risks for production of cement products, friction materials and

Table 20 - Estimates of lung cancer risk from exposure to chrysotile in different industries

Study	Industry	Fibre type	Excess relative risk per fibre.year/mL
Dement et al., 1994	Textiles	Chrysotile	0.031
McDonald et al., 1983	Mainly textiles	Chrysotile, amosite, & crocidolite	0.017[a]
Peto et al., 1985	Textiles	Chrysotile & crocidolite	0.015[b]
McDonald et al., 1993	Mining and milling	Chrysotile	0.0006[a,c]
Hughes et al., 1987	Cement products	Chrysotile Chrysotile & crocidolite	0.0071[a] 0.0076[b]
Berry & Newhouse, 1983	Friction products	Chrysotile	0.00058
McDonald et al., 1984	Friction products	Chrysotile	0.00053[a]

Table adapted from Stayner et al., (1996)

[a] A conversion factor of 3 fibres/cc being equivalent to 1 million particles per cubic foot was assumed.

[b] Data are based on results for workers employed after 1951.

[c] Slope was estimated by fitting a linear relative risk Poisson regression model to the standardised mortality ratio results reported by (McDonald et al., 1986).

chrysotile mining. The reasons for the variation in risk between industries are not clear, however, it has been postulated that differences may be partly attributable to differences in the airborne fibre size distributions in the industries, and also to inaccuracies in the reported exposure estimates (Meldrum, 1996). A study of fibre morphology by (Dement & Wallingford, 1990) indicated that airborne asbestos fibres in the textile industry were longer than in the cement pipe or friction products industries. Another possible explanation is that the processing of chrysotile could change fibre sizes and morphology.

Based on the weight of evidence, different forms of asbestos appear to possess different degrees of hazard (see section 7.5). Several investigators have also concluded that there is sufficient evidence to show that the level of risk of lung cancer for chrysotile exposure varies between industry sectors (Doll & Peto, 1985; Nicholson, 1991; Meldrum, 1996).

7.6.1 Risks in the friction product industry

The industry of most relevance to chrysotile usage in Australia is the manufacture of friction products. Risk estimates for this industry are available from two studies (Berry & Newhouse, 1983 and McDonald et al., 1984). Similar risk estimates (based on a linear extrapolation methodology) of approximately 0.0006 (excess relative risk per fibre.year/mL) were obtained for these studies (see Table 20).

NOHSC reviewed the available epidemiological data on the risk of lung cancer associated with chrysotile (NOHSC, 1995a). It was decided that risk estimates in Australia should be based on data from mining and friction product manufacturing industries. For this purpose the UK/US OSHA additive relative risk model (RR = 1 + excess relative risk) was used. Using the excess relative risk[10] (0.0006 fibre.year/mL) obtained from McDonald et al (1993) and Berry & Newhouse (1983) data, estimates were derived for lung cancer risk at different chrysotile exposure levels (see Table 21).

Table 21 - Estimated risk of lung cancer at various levels of exposure to chrysotile

Exposure (yearly average fibre/mL)	**Excess risk[1]** (per 100,000 persons exposed)		
	NOHSC	**US OSHA**	**US NIOSH**
1	173	2880	5760
0.5	86	1440	2880
0.1	17	288	576

[1]Excess risk = Risk coefficient x lifetime exposure (yrs) x average exposure level (f/mL) x background risk*
[*A cumulative background risk for lung cancer in the male population was used in these calculations (i.e., 7,200/100,000 assuming mixed smoking habits)].

NOHSC estimated that the number of lung cancers per 1000 workers lifetime (assuming mixed smoking habits and 40 years continuous exposure) expected in the Australian friction products industry is 1-2 cases at 1 f/mL, 1 case at 0.5 f/mL and 0.2 case at 0.1 f/mL (NOHSC, 1995a).

There has been some debate over the choice of the risk coefficient for the calculation of excess risk. The US OSHA lifetime excess risk from exposure to chrysotile is considerably higher (28.8/1000) than the NOHSC estimate and was based on a coefficient of 0.01 obtained from epidemiological studies on textile workers. More recently, US NIOSH studies put this coefficient at closer to 0.02 (Stayner et al. 1997) – see Table 21. According to Lash (1997), a meta-analysis of all chrysotile cohorts (with dose-response data), suggests a lower coefficient of 0.0025.

None of the above estimates include mesothelioma (due to the lack of adequate dose-response data) and therefore may understate the overall incremental cancer risk.

7.6.2 Uncertainties in chrysotile risk estimates

The risk estimates used in the calculations in Table 21 were derived from past exposures to relatively high levels of chrysotile. Current levels of exposure are much lower than the levels estimated in the cohort studies (presented in Table 20) and as such risk extrapolations in Table 21 may be an overestimate.

There are several other reasons why there is a great deal of uncertainty regarding these risk estimates, which include:

1. Past occupational exposures have generally involved exposure to a mixture of asbestos fibres. As it appears likely that different types of asbestos have different degrees of hazard, it is difficult to determine the risk attributable to chrysotile *per se*. In addition, commercial chrysotile often has low levels of tremolite contamination.

[10] Known also as the risk coefficient

2. Fibre size, such as difference in fibre size between different chrysotile industries, probably influences the degree of hazard and/or potency.
3. There is a long latency between exposure to asbestos and development of lung cancer. Hence, it is not possible to state definitively what fibre type and level of exposure caused the disease. Consequently, risk estimates are related more to duration of employment rather than intensity of exposure.
4. A linear, non-threshold model may not be an appropriate model as there is some evidence suggesting that lung cancer due to chrysotile exposure may have a threshold for effect.
5. Past exposure estimates (both quantitative and qualitative) are subject to considerable error. For example, conversion of historical results in mpcf units to fibres/mL has inherent uncertainties.
6. There is a high background level of lung cancer in the general population due to smoking. Cases of lung cancer attributable to asbestos cannot be distinguished from those due to smoking. Attribution can only be assessed in terms of excess of lung cancers above a control population, hence the choice of control population is critical.
7. The identification of the disease is dependent on medical diagnosis, however autopsies are not always conducted.

The impact of some of these uncertainties can be accounted for to some extent. For example, it is considered that (1) and (2) are largely accounted for by basing risk estimates on epidemiological studies where exposure was only to chrysotile in the most relevant industry.

For the remainder of the above uncertainties it is unclear what influence they have on the risk estimates and how they should be accounted for. For example, recently there has been some debate in the literature as to whether a threshold or non-threshold model should be used when predicting risk due to chrysotile exposure. Meldrum (1996) states that based on balance of toxicological evidence, the linear no-threshold model for chrysotile-induced lung cancer may not be appropriate. An association between pulmonary fibrosis and lung cancer is evident in that both diseases show a similar dose-response relationship with respect to asbestos exposure, similar latent periods for development, similar dependence on fibre type and size, and both diseases originate from the same underlying chronic inflammatory condition. This suggests that asbestos-induced lung cancer, like fibrosis, is a threshold phenomenon. Epidemiological data alone are not able to clearly distinguish between the possibility of a threshold or a non-threshold model due to the relatively high background rate of lung cancer in the human population. There is at present no consensus with respect to a threshold level of exposure for chrysotile below which there is no risk of disease.

7.7 Conclusions

Chrysotile, like all other asbestos forms, causes asbestosis, lung cancer and mesothelioma in humans and animals and has been shown to cause these diseases with a dose-response relationship. Chrysotile is classified as a known human carcinogen (IARC, 1987; NOHSC, 1994c). It has been shown that smoking and asbestos act in a synergistic manner, increasing the overall risk of lung cancer.

There is continuing debate over the potency of chrysotile, particularly in relation to the amphiboles; crocidolite and amosite. There is accumulating evidence to indicate that chrysotile is less potent in causing asbestosis, lung cancer and mesothelioma, although this issue has not been conclusively resolved.

Risk estimates are based on the incidence of lung cancer, as this is the overriding risk from asbestos exposure and insufficient dose-response data exist to estimate risks of mesothelioma. Risk estimates have assumed a linear, non-threshold approach and are extrapolated from high to low doses. Although risk estimates for chrysotile exhibit a dose-response relationship, the degree of risk appears to be dependent on the type of industry. The most relevant industry in Australia is the friction product manufacturing industry. NOHSC have estimated the risk of lung cancer in Australia based on the estimated risk in overseas friction product industries (NOHSC, 1995a). Analysis of other cohorts by US agencies provide higher risk estimates (up to 30 fold).

There are many problems associated with low-dose risk extrapolation, such as the assumption of a linear relationship. However as insufficient data exists to indicate a threshold exposure for effect, the linear extrapolation methodology provides a conservative worst-case scenario estimate of risk. Other confounding factors in estimating risks from epidemiological data are possible contamination by other fibre types and inaccurate estimates of historical exposures.

Although the hazards of chrysotile (asbestosis, lung cancer and mesothelioma) have been researched and discussed in great detail, there are still many uncertainties regarding the level of risk associated with its use. Therefore, any estimate of risk should be used with caution.

8. Public Health Assessment

There is the potential for public exposure during the transport, storage and disposal of raw chrysotile, emissions from manufacture and from end-use of products containing chrysotile, particularly friction products.

8.1 Public exposure

8.1.1 Manufacture

In Australia, raw chrysotile is currently fabricated in friction materials and gasket sheeting in 3 locations and into epoxy resin adhesive at another site.

Detailed information on the manufacturing processes and dust emission control measures can be found in Section 6 (Occupational Exposure) and Section 10 (Risk Management), respectively.

In general, manufacturing processes are carried out in enclosed systems and dust levels are controlled by dust extraction with automatic plant shutdown when dust levels exceed prescribed limits. Monitoring of manufacturing and processing activities has revealed personal exposure levels generally < 0.1 f/mL with most samples ≤ 0.05 f/mL. Significant exposure of the public to chrysotile fibres from these manufacturing processes is therefore unlikely.

8.1.2 End-use

Automotive applications are likely to be the major source of public exposure to chrysotile dusts. Chrysotile friction materials contain between 40 and 60% chrysotile. A proportion of the end-use products containing chrysotile may be sold directly to the public, particularly automotive friction products and gaskets.

In the home mechanic situation, little if any personal protective equipment is likely to be worn when replacing brake pads and shoes, clutch plates or engine gaskets. In the case of gaskets, generation of significant quantities of dust is unlikely as the chrysotile is bound into the matrix of the gasket. Similarly dusts created from clutch facings tend to be enclosed in the transmission of the vehicle and most replacement clutch facings do not contain chrysotile. During the changing of brake pads and drum shoes, however, significant exposure is possible. In commercial operations compressed air is generally no longer used to remove excess dust and improved housekeeping practices has reduced exposure levels occupationally and as a consequence, has reduced the likelihood of public exposure from this source. The home mechanic however, may have significant intermittent exposure during the changing of brake pads and shoes.

Generation of chrysotile dusts at busy traffic intersections, by braking vehicles, is a known source of public exposure. Studies (Jaffrey, 1990) on the levels of chrysotile fibres at two busy (approximately 2000 vehicles/hr) London intersections found total asbestos levels of between 5.5×10^{-4} to 6.2×10^{-3} f/mL. Of the fibres detected, less than 10% had dimensions within the peak hazard range (>5 µm long by < 3 µm wide) prescribed by WHO (Spurney 1995). Another study carried out in Australia found airborne asbestos levels to be very low (0.5 particles/mL) in the immediate vicinity of the intersection braking area of the Tullamarine (SE exit) freeway (Alste et al 1976). The particles consisted of small bundles of fibres and the number of fibres in the bundle was not determined. The majority of fibres had a maximum dimension of ≤ 2 µm and the crystal structure of the fibres was unchanged. At a different location (30 metres from the nearest traffic), levels were below the limits of detection (Alste et al. 1976). Therefore, exposure from this source is likely to be highly localised and intermittent for most people.

The use of chrysotile in industrial gaskets, such as in petrochemical plants, is unlikely to yield significant public exposures. Similarly, the use of 'sag resistant' epoxy resins (containing approximately 2% chrysotile) in building and construction work, is unlikely to lead to significant public exposure as the chrysotile is bound into the adhesive matrix. These applications are generally limited to large industrial complexes or commercial buildings, utilise relatively small volumes of chrysotile at any one location, are likely to enclose the material between metal or masonry surfaces, and would not generally be expected to produce significant quantities of free chrysotile fibres.

8.1.3 Transport and storage

Imported raw chrysotile is landed in 50 kg polyethylene woven bags within a sealed sea going container which is shipped, intact, to manufacturing sites. The nature and construction of these containers is such that, other than in extraordinary circumstances, a transport accident is unlikely to release significant quantities of raw chrysotile. The shipment of bulk raw chrysotile in non-contained cardboard boxes could pose a significant public hazard in the event of a transport accident, however this would be localised and could be ameliorated by vacuum removal of dispersed material. Finished products containing chrysotile bind the fibres into the matrix of the product. Shipment of the types of products currently manufactured in Australia is unlikely to result in significant public exposure to chrysotile fibres.

8.1.4 Disposal

Waste chrysotile, the polyethylene bags in which it is supplied, and chrysotile containing materials from the manufacturing process, are disposed to landfill by licensed disposal contractors. As chrysotile fibres are unlikely to be mobile in the soil or water table, landfill is not inappropriate from a public health perspective.

8.2 Public health risks

The health effects of chrysotile are described in detail in Section 7.

Chrysotile is unequivocally a human carcinogen, however the risk to the public associated with its continued use is dependent on the nature of the material to which the public is exposed and the level, frequency and duration of exposure.

The most prevalent chrysotile induced disease is lung cancer, hence an assessment of the likely risk to the public of this hazard, from current sources of public exposure, will provide a qualitative indication of the likely risks for mesothelioma. At the levels of exposure likely to be encountered by the public the risk of asbestosis, which follows a dose response relationship, is essentially zero (IPCS, 1986).

As the major source of public exposure to chrysotile is that generated from brake linings in commercial and private vehicles, exposure is likely to be widespread with exposure via oral, dermal and inhalation routes, predominantly by inhalation and dermal contact.

Levels of exposure will vary widely, with rural residents expected to have the lowest exposure levels and those living or working adjacent to busy intersections having the highest exposures. As the levels of exposure at peak generation points such as traffic intersections remains low in absolute terms, and the levels tail off rapidly as measurements are taken further from the point of generation, cumulative exposures for the bulk of the population are expected to be low.

In assessing the risk to the public from exposures likely to be encountered in the worst case scenario, by a newspaper seller on the corner of a major traffic intersection for example, the most relevant epidemiological data available comes from studies on workers in friction material manufacturing plants. NOHSC have estimated that the number of lung cancers per 1000 workers lifetimes (assuming mixed smoking habits and 40 years of continual exposure) expected in the Australian friction industry to be 1 to 2 cases from exposure to 1 f/mL, 1 case at 0.5 f/mL and 0.2 case at 0.1 f/mL (NOHSC, 1995a). Because of the process of derivation of this figure, particularly the no threshold assumption with low dose linearity and the level of exposure, it is considered a conservative estimate of the risk.

As the nature of the dusts generated from milling, cutting and grinding of chrysotile-based friction materials in manufacturing plants is likely to be either similar to, or considerably more hazardous than, that produced by automotive traffic, the conclusion that the risk to the public from exposure to dusts generated by commercial and private vehicles is likely to be low, is reasonable. There is also some evidence to suggest that the fibres generated by vehicles may be less hazardous. Chrysotile fibres in the debris from brake shoes and clutch linings measured in automotive workshops tend to be relatively short with a large proportion < 1 µm and 84% < 0.4 µm in length (Plato et al., 1995). These figures are consistent with those obtained at busy traffic intersections discussed above. As these fibres are smaller than the peak hazard dimensions (see Section 8.1.2), the risk from exposure to them will be lower than to exposure to the raw chrysotile prior to fabrication.

In the home mechanic setting, a risk of substantial intermittent exposure to chrysotile dusts exists. The degree of exposure and the risks associated with this are largely unquantifiable, nevertheless a warning to avoid inhalation of brake housing dusts during exchange of brake pads/shoes should be carried on or included in their packaging. In a study of automotive mechanics in Sweden (Plato et al., 1995), time weighted exposures in the 1960s were given as 0.11-0.41 f/mL falling to 0.003-0.08 f/mL in 1985. The 'Automotive Aftermarket Survey', conducted during this assessment, found exposure levels were less than 0.03 f/mL during the replacement of friction products in vehicles. Earlier studies where dusts were blown out of the brake housing with compressed air exposures of up to 40 f/mL were recorded. Although the home mechanic is less likely to employ the precautions likely to be used at automotive repair centres, their less frequent exposure to friction material dusts is likely to yield lower time weighted exposures. Based on the NOHSC risk estimates, the maximal exposures reported for mechanics, if applied to home mechanics, would yield approximately one additional lung cancer case per 1000 lifetimes in home mechanics. As discussed above, this is likely to be an overestimate of the risk.

The majority of new cars manufactured and imported into Australia no longer include asbestos containing components. As a consequence, the generation of chrysotile-containing dusts from this source will gradually decline as the proportion of chrysotile-free vehicles increases. The general decline in use of chrysotile containing parts is assisted by the trend away from drum brakes towards disc brakes. A high proportion of vehicles may be fitted with chrysotile-containing brake pads or shoes in the automotive aftermarket and in home car maintenance, due to the lower cost of chrysotile components. However, the overall use of chrysotile-containing brake parts is unlikely to rise because of the increased use of non-asbestos brakes in most new vehicles.

In general, as exposures experienced by the public will normally be considerably lower and less frequent than those experienced in the industrial environment, the expected lung cancer incidence in the public due to exposure to chrysotile will be lower than those estimated for workers. Based on the NOHSC risk estimates for the industrial setting, the risk to the public, even in the worst case situation, is considered to be low. Should a threshold model for chrysotile induced lung cancer prove to be more accurate, then the current NOHSC risk estimates will tend to overstate the actual risk and the risk to the public will be even lower.

The International Programme on Chemical Safety (IPCS) in assessing the risk to the public from asbestos exposure concluded that “the risks of mesothelioma and lung cancer cannot be quantified reliably and are probably undetectably low” and that “the risk of asbestosis is virtually zero” (IPCS, 1986). The conclusions of the IPCS, although referring to a broader range of mineral fibres than chrysotile alone, are consistent with the conclusions drawn from the discussion above.

8.3 Conclusions

Chrysotile is a known human carcinogen, however the risks associated with its use are dependent on the nature of the application and of the product utilised.

Based on the data available, the continued use of chrysotile on friction surfaces, gaskets, and in seals for critical industrial applications is not expected to present a significant hazard to public health. As such there are no objections to the continued use of chrysotile in these applications, however, continued progress towards a phase out of this material in favour of less hazardous materials is supported, where this phase out does not introduce greater risks through the lesser performance of substitute materials.

9. Environmental Assessment

9.1 Environmental fate and exposure

9.1.1. Release from manufacture

In Australia, raw chrysotile emissions/release may arise from the manufacture of friction products, CAF sheets for production of gaskets and the manufacture of 'non-sag' epoxy resin. Detailed information on manufacturing processes can be found in Section 6 (Occupational Exposure).

At the Bendix Mintex site mixing, moulding and finishing processes during manufacture of friction products are carried out under dust extraction. The bag filters used to filter extracted air from the plant are a potential release point. Dust waste disposal quantities for 1994 from Bendix Mintex Pty Ltd, i.e. the amount of chrysotile wastes collected in the fabric filter dust collector, was estimated at 1085 kg per day. Imports of chrysotile imported in this year were 947 tonnes. Assuming 260 days per annum where production occurs, losses collected through the fabric filter dust collector account for almost 30% of the imported chrysotile.

Solid friction material scrap containing chrysotile landfilled as part of the companies solid scrap was estimated at 320 kg per day. Car brakes and clutches contain between 40 and 60% asbestos (Bendix Mintex) and assuming the maximum ratio, up to 190 kg per day will be released with solid friction material scrap. This accounts for a further 5% of the imported chrysotile.

Another use of raw chrysotile in Australia is the manufacture of CAF sheeting for gasket production (carried out by Richard Klinger Pty Ltd). Manufacturing of the raw material is carried out in Perth, while gasket processing (e.g. cutting) is performed at both Perth and Melbourne factories. Richard Klinger estimates that a maximum of 600 tonnes of CAF (510 tonnes of chrysotile) is produced in any one year. The volume of waste generated and sent to landfill is estimated at 35 tonnes per year, with an additional 30 tonnes recycled within the processing plant. Further, the plant's dust extraction system collects approximately 25 kg of general dust per week, of which a fraction is asbestos fibre, all of which is then recycled through the system.

Waste disposal

It is known that Bendix Mintex disposes of its waste to specifically engineered landfills. Richard Klinger bags their waste in polyethylene containing an asbestos warning. These are sealed and placed in an asbestos waste collection bin for disposal by a licensed waste contractor. This process is in accordance with the disposal methods recommended by the Asbestos Institute for friable waste (The Asbestos Institute & Quebec Asbestos Mining Association, 1993). With regard to disposal of empty bags in which chrysotile is imported, Bendix Mintex seal (in plastic bags) these bags immediately they are emptied into the mixer. As with chrysotile waste, these bags are disposed of to a controlled disposal site.

9.1.2 Release from end-uses

Major uses (of both processed raw chrysotile and imported products containing chrysotile) is for friction material and gaskets. The major release expected from these uses will be when used parts are sent to landfill. This will result in diffuse release around the country.

Release of chrysotile from brake linings during use appears limited. A study conducted in the Greater London Area over two busy intersections stated that the levels of asbestos fibres generated by the high traffic density was low. The combined results of all samples collected at these sites show the levels of all sized fibres to range from 5.5×10^{-4} to 6.2×10^{-3} f/mL (Jaffrey, 1990). It is difficult to find ambient air concentrations for asbestos in the Australian environment. However, Environment Australia believes that, unless asbestos is used or occurs naturally in the area, the background concentrations will be negligible. The levels measured by Jaffrey, (1990) are certainly lower than the current NOHSC occupational exposure standard (TWA) concentration for chrysotile of 1 f/mL[11].

It is claimed that the amount of asbestos found in the dust arising from braking is rarely more than 1%[12] of the wear product (Asbestos Information Committee, 1975). It is not known what quantity of chrysotile is imported in brake linings and other friction materials, but ABS data indicates in excess of 750,000 articles (brake linings, pads and clutch facings) being imported in 1997 containing asbestos and therefore possibly containing chrysotile. Assuming each unit weighs 200 g and contains 50% chrysotile, this equates to around 150 tonnes of chrysotile per annum. Assuming a further 1000 tonnes of chrysotile present in friction products manufactured in Australia, it is estimated that (assuming a worst case scenario of 1% release per annum, i.e., all products are completely worn in one year[13]) around 11.5 tonnes of chrysotile will be released per annum countrywide or 32 kg per day spread all around the country. It is acknowledged that this figure may be an overestimate, as studies have shown that some of the chrysotile is degraded to magnesium silicates and forsterite (section 9.1.3). In addition, some of the debris will be retained in the brake system and removed and disposed of under controlled conditions.

The remainder of the chrysotile, as used friction or gasket products is likely to be disposed of to landfill.

9.1.3 Fate

Terrestrial fate

The majority of waste chrysotile from manufacturing (i.e. from dust extracted and caught in fabric filters, or as off cuts from end products) is expected to be disposed of to landfill. This waste will be secured in landfill through containment

[11] Where exposure to other asbestos fibres is possible, the NOHSC exposure standard is 0.1 f/mL (NOHSC 1995d).

[12] This figure was questioned (as being an underestimate) during the variation phase of this report. However, it was concluded from further assessment of the literature that this figure is representative of the best quality data available.

[13] This does not imply that every vehicle will have brake linings replaced on an annual basis, but reflects the annual import/manufacture quantities and hence the amount of chrysotile used per annum.

in plastic bags. It is known that at least one of the manufacturers sends such waste to a specifically engineered landfill.

Waste from use (i.e. used linings and gaskets) will be disposed of to unsecured landfill, and would not be readily available for transport by wind or water as it would be encapsulated in end articles, and possibly bagged. Due to temperature decomposition during use it is possible that these worn articles will contain more forsterite[14] than chrysotile with overall chrysotile levels reduced even more.

Normal use of motorised vehicles is associated with wear of the brake and clutch linings, which will liberate a small amount of chrysotile to the terrestrial environment. Of the material dislodged in this manner, it is stated that in cars, 81.6% of the wear material was deposited on the ground (where it will be available for transport by wind and water), 14.4% retained in the brake housing and 3% emitted to the atmosphere (Jaffrey, 1990). During end use as friction materials or in gaskets, the chrysotile will be exposed to high temperatures. It appears that at temperatures of 500-600^{0}C chrysotile decomposes rapidly by loss of water to form non-fibrous magnesium silicates and forsterite although there is some question as to whether although there is some question as to whether braking during town driving generates enough heat to effect this change.

Aquatic fate

It can reasonably be expected that chrysotile fibres from end use will reach aquatic systems arising from dust generated during brake wear and to a lesser extent, from disposal to unsecured landfill. Where present as a result of the above activities, fibres could be transported to nearby water bodies through wind or runoff to stormwater drains as a result of their small size.

Degradation

Chrysotile is not expected to degrade in aquatic systems although some degradation may occur under acidic conditions. One literature reference claims asbestos fibres are highly persistent in water, with a half-life greater than 200 days (University of Virginia, 1996), although methods of testing are not known.

Soil/groundwater

Asbestos fibres have very small dimensions, hence they can be quite mobile. Water turbulence may suspend and transport fibres over long distances in surface waters. Leaching potential for asbestos in soils is not well understood, especially with regard to concerns over drinking water quality (Pennsylvania State University, 1994).

9.2 Environmental effects

There is a paucity of data available as to the effects of asbestos in the environment.

Environmental effects are more likely to be of a physical rather than chemical nature as a result of the fibrous nature of asbestos. Data are insufficient to

[14] Forsterite is a member of the olivine series of iron magnesium silicates, and is non-fibrous. It is magnesium rich with a formula approximating Mg_2SiO_4 (Amethyst Galleries Inc, 1996).

determine if asbestos poses any acute or chronic toxicity hazard to plants birds or land animals. It is possible that birds or land animals may develop cancers or other long-term effects from inhalation of asbestos fibres (Asbestos Information Committee, 1975), although it is improbable animals will suffer chronic exposure as they are unlikely to remain for long periods of time in areas where high concentrations of fibres are expected (e.g., road intersections).

A study of the effects of chrysotile was carried out by Belanger and co-workers on all life stages of the cyprinodontid fish, the Japanese medaka (*Oryzial latipes*), including egg hatchability and survival, larval to juvenile growth and survival, histopathology and asbestos bioaccumulation and adult reproduction. Studies demonstrated that larval and juvenile fish were the most sensitive with significant growth reductions occurring at 10^6 to 10^8 f/L. At 10^{10}f/L, 100% mortality was recorded in 56 days of exposure (Belanger et al., 1990).

Direct evidence of chrysotile accumulation was present with concomitant epidermal lesions. A small percentage (5%) of fish at 10^{10} f/L developed ventral non-invasive epidermal hyperplastic plaques (Belanger et al., 1990.

Reproduction tests resulted in 33% spawning frequency from 10^4 and 10^5 f/L compared to control populations and 25% more viable eggs (Belanger et al., 1990).

The study concluded that chrysotile may represent a significant environmental hazard, especially to juvenile fish and that asbestos should receive greater attention than it has historically. Environment Australia considers the hazard will be low as it is unlikely that fibre concentrations in water will approach those tested above. Ambient levels of asbestos in water are not known, however, assuming ambience in water similar to that for air, a concentration of chrysotile of 10^{-9} f/L would be a good approximation.

9.3 Environmental risk assessment

Anthropogenic releases outlined above, if managed in the manners described, are unlikely to be of concern to terrestrial species from inhalation due to the disperse nature of fibres entering the atmosphere.

Bearing in mind the outcomes of the fish toxicity study cited above, it is possible to derive a predicted environmental concentration (PEC) to determine the likelihood of a hazard existing.

Extrapolation of the upper concentration of 0.0062 f/mL (results from the study by (Jaffrey, 1990) on asbestos fibres release from vehicular traffic in London) by assuming a direct correlation from the top 1 mL above ground, provides an area measurement of 0.0062 f/mm^2. Assuming roadways cover 10% of a hectare, this equates to 2.6 x 10^6 fibres per hectare (every 4 hours). Assuming this is a constant rate and there is no loss of fibres through wind movement, then after a week, 2.6 x 10^8 fibres will be present per hectare. If rain washes these fibres into a standing body of water, 1 hectare in area and the rain fills the body of water to 15 cm depth, this quantity of fibres will result in a concentration of around 174 f/L. This is four orders of magnitude lower than the 10^6 f/L shown to cause growth reduction in Japanese medaka fish, and suggests a low environmental hazard.

Risk is further mitigated when accounting for dispersal of fibres through wind, and further dilution in flowing water and coastal areas.

9.4 Conclusions

Based on available data for Australia, it can be predicted that the use of chrysotile (including manufacturing) when used in the manners outlined in this report, will result in a low hazard to the environment.

When chrysotile is encapsulated in end use products such as brake linings and epoxyresin adhesives, it is unlikely fibres will be in a form where an environmental hazard is posed. Therefore, disposal of used parts to standard municipal landfills is acceptable.

10. Risk Management

In this section, measures currently employed in the management of human health risks from potential exposure to chrysotile and other asbestos fibres are discussed. All uses are covered, as background for consideration of approaches which may be appropriate for those uses of chrysotile which fall within the scope of this assessment.

The information reviewed includes national and international standards, together with relevant guidance material, MSDS and labels. Where appropriate, measures for managing risks from exposure to asbestos are dealt with separately for specific workplace scenarios.

In addition to the provision of relevant information by manufacturers (applicants) and users of chrysotile products, data were also obtained from site visits, surveys and questionnaires and a commissioned consultancy project to survey current national and international regulatory controls for chrysotile and other asbestos products.

In Australia and overseas, legislation is currently in place that restricts or controls activities which involve exposure to asbestos.

General legislative measures currently taken for the control of asbestos include:

- restricting use through prohibition (often subject to exemptions) of imports and sale, manufacturing or use and/or by licensing certain activities such as import and waste disposal;
- regulating its use in the workplace through specific restrictions on the method or standard of carrying out an activity, such as prohibitions against exceeding prescribed exposure standards;
- labelling requirements for asbestos and asbestos-containing products; and
- controls on methods for packing and transportation.

Controls are generally imposed by legislation or regulations (or their equivalent) on specific activities, and enforced under occupational health and safety or environmental legislation, or both.

Legislation commonly includes ‘chrysotile’ in the definition of asbestos, and as such chrysotile is usually regulated under regulations pertaining to asbestos. The focus of most legislation is on asbestos manufacturing activities and exposure to asbestos in construction and demolition work. Regulation tends to be “risk based”, focussing on high risk activities (such as spraying of asbestos containing substances) and prevention of risk to employees. With the exception of construction activities, regulation is not generally directed at industry specific risks.

10.1 Regulation of asbestos in Australia

During the preparation of this report, chrysotile was regulated as a Priority Existing Chemical (PEC) under the Commonwealth *Industrial Chemicals (Notification and Assessment) Act* 1989.

Chrysotile is regulated in Australia through various State and Territory legislation relating to occupational health and safety, dangerous goods and to a limited extent through environmental protection. In some cases a national framework or model is in place to enable uniformity.

10.1.1 Workplace regulation

NOHSC has declared several national standards under s.38(1) of the *National Occupational Health and Safety Commission Act* 1985 (Cwlth) which address risks associated with asbestos and prescribe actions to be taken to address such risks. National standards, which may take the form of national model regulations, are instruments of advisory nature only, except where a law other than the NOHSC Act , or an instrument under such a law, makes them mandatory. The expectation is that national standards will be suitable for adoption by Commonwealth, State and Territory governments. Table 22 provides information on NOHSC Standards and Codes relevant to the regulation of asbestos in the workplace, together with the current status of adoption in State/Territory OHS regulations.

Also of relevance to the regulation of asbestos/chrysotile are the following documents[15], called up under the Hazardous Substances Standard and Code:

- List of Designated Hazardous Substances (NOHSC, 1994c)*
- National Code of Practice for the Labelling of Workplace Hazardous Substances (NOHSC, 1994d)
- National Code of Practice for the Preparation of Material Safety Data Sheets (NOHSC, 1994e)]
- Guidelines for Health Surveillance (Asbestos) (NOHSC, 1995c)*
- Guide to the Control of Asbestos Hazards in Buildings and Structures (NOHSC, 1988)*
- Australian Code for the Transport of Dangerous Goods by Road and Rail (FORS,1998)*

The key elements in the management of occupational risks from chrysotile are:

- workplace control measures;
- hazard communication and training; and
- workplace monitoring (air monitoring and health surveillance).

[15] Documents marked with an asterisk (*) contain requirements specific to chrysotile.

Table 22 – Status of implementation in Australian jurisdictions of NOHSC Standards and Codes relevant to asbestos/chrysotile

Standard/Code	NSW	VIC	QLD	SA	WA	TAS	ACT	NT	CWLTH
Hazardous Substances - Standard and Code[1]	A	A	A	A	A	A	A	A	A
Asbestos (1988) - Code and Guidance Note[2]	A	A	A	A	A	A	A	A	A
Carcinogens (1994) - Standard and Code[3]	A	A	C	Y	A	A	A	A	A
Exposure Standards (1990) - Standard[4]	A	A	A	A	A	A	A	A	-

A = Adopted or committed to adopt
C = Under consideration
Y = Yet to be considered (standard recently declared or standard to be first reviewed by state advisory body)

[1] Refers to *National Model Regulations for the Control of Workplace Hazardous Substances and National Code of Practice for the Control of Workplace Hazardous Substances* (NOHSC, 1994b).

[2] Refers to *Code of Practice for the Safe Removal of Asbestos and Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Dust* (NOHSC, 1988).

[3] Refers to *National Model Regulations for the Control of Scheduled Carcinogenic Substances and National Code of Practice for the Control of Scheduled Carcinogenic Substances* (NOHSC, 1995b).

[4] Refers to *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* (NOHSC, 1995d).

OHS control measures

According to the NOHSC *National Model Regulations for the Control of Workplace Hazardous Substances* (NOHSC, 1994b), exposure to hazardous substances should be prevented or, where that is not practicable, adequately controlled so as to minimise risks to health. The NOHSC *National Code of Practice for the Control of Workplace Hazardous Substances* (NOHSC, 1994b) provides further guidance in the form of a hierarchy of control strategies, namely:

- elimination;
- substitution;
- isolation;
- engineering controls;
- safe work practices; and
- personal protective equipment.

The following sections provide a summary of information on control measures relevant to the manufacture of chrysotile products and their end-use. Information on the manufacture of chrysotile products was provided by applicants. Information on end-use was obtained from a survey of automotive garages and gasket workshops, previously described as the ‘Automotive Aftermarket Survey’ (see Appendix 2). Control measures for the maintenance or removal of asbestos from past uses, such as asbestos sheeting, are not covered in this report and further information can be obtained from the *Guide to the Control of Asbestos Hazards in Buildings and Structures and Code of Practice for the Safe Removal of Asbestos* (NOHSC, 1988).

Elimination and substitution

Where an activity involves the use of a hazardous substance that is not essential for that use, the hazardous substance should be eliminated wherever practicable. Elimination is defined as the complete removal of a chemical from a process or product. Brake pads and gaskets of some material are an essential requirement and therefore total elimination of such is not possible. Where elimination is not practicable, substitution of the chemical should be considered. Substitution includes substituting with a less hazardous substance (alternative), the same substance in a less hazardous form or process.

An asbestos alternative is any material that replaces asbestos in a commercial product. The development of chrysotile substitutes has been vigorously pursued for many years due to the health risks posed by the release of asbestos fibres during manufacture, use, repair and disposal of asbestos-containing products. Currently there is no one substitute material available for all uses that exhibits all the advantageous properties of chrysotile. Since no single alternative material is available, manufacturers use blends of different types of material to produce the final product. The use, availability and health effects of asbestos alternatives are discussed in detail in Section 11.

Isolation

Isolation involves separation of the process from people by distance or the use of barriers to prevent exposure. For Bendix Mintex and Richard Klinger, handling of raw chrysotile takes place in a separate area and away from workers involved in other manufacturing operations.

Engineering controls

Engineering controls are plant construction or processes which minimise exposure to hazardous substances such as ventilation, enclosure (closed process) and automation.

The three manufacturers of chrysotile products in Australia have various engineering controls in place at their manufacturing sites. These controls include:

- dust extraction systems which operate during different stages of the manufacturing process;
- automated process for the opening and removal of the woven polyethylene bag which contains the raw chrysotile and disposal of the bag;
- mixing vessels enclosed and operated under negative pressure;
- automated decanting of asbestos mixes and machining of final product
- localised automated dust extraction; and
- centrally ducted vacuum systems.

Detailed information on the manufacturing processes can be found in Section 6 - Occupational Exposure.

Engineering controls in place at five service garages, three brake bonding workshops and one gasket workshop, surveyed as part of an investigation of the automotive aftermarket, included the following:

Service garages:

- natural ventilation (considered adequate in 4 of the 5 workshops)

Brake bonders:

- local exhaust ventilation

Gasket workshop:

- use of machines to cut gaskets

Safe work practices

Safe work practices are administrative practices that require people to work in safer ways. For the companies manufacturing chrysotile products the following safe practices are in place:

- all work areas are vacuumed before leaving work area and vacuuming any spills or loose chrysotile fibres;
- exposed areas of skin are washed before eating and drinking;
- clothes are cleaned by vacuuming before leaving work areas;
- portable high efficiency vacuum cleaners in place for housekeeping;
- processes that create dust are not permitted;
- processes (such as die cutting and winding) which do not create dust when cutting CAF sheets are used;
- preventive maintenance program in place for plant, equipment and extraction systems;
- damaged bags of chrysotile are sealed immediately and surrounding area vacuumed;
- damaged chrysotile bags are consumed immediately in the manufacturing process;
- all waste chrysotile or materials containing chrysotile are collected into polyethylene bags. Bags are printed with an asbestos warning and sealed with a bag tie and placed in an asbestos waste collection bin for collection; and
- disposal of waste drums by licensed disposal contractor.

Safe work practices adopted by end-users of chrysotile products included:

Service garages

- wet rag used to transfer dust into plastic bag;
- wet brushing and an aerosol spray for dusty jobs;

- aerosol water spray for back drum brakes (disc brakes not dusty);
- watering of brakes if dusty;
- aerosol can (containing 48% dichloromethane and 12% isopropanol) used for dust control and as a degreasing agent;
- no cutting and grinding of brake linings for brake drums and brake disc pads (these are sent to brake bonders for bonding); and
- vacuum for cleaning workshop area.

Brake bonders

- wet brushing

Gasket workshops

- No special precautions were taken at a gasket workshop visited as very little dust released.

Personal protective equipment

In general, the use of personal protective equipment (PPE) as a control measure should be limited to situations where other control measures are not practicable or where it is used in conjunction with other measures to increase protection.

PPE used by chrysotile product manufacturers in Australia include:

- respiratory protection (e.g. half-face mask respirators with class M cartridges or 3M 8710 respirators);
- safety glasses or goggles in designated eye protection areas or on designated machines (e.g. grinders);
- cotton overalls; and
- gloves for handling of materials.

In most service garages and gasket and brake bonding workshops, overalls were worn by all employees. All brake bonding shops and one service garage reported that respiratory protection was used during times of potential exposure to asbestos. During site visits it was observed that a 3M 8710 mask was used during cutting and grinding of brake linings (in brake bonding) and during the changing of brake linings (service garage).

NSW WorkCover has published a guidance document on the use of personal protective equipment (NSW WorkCover, 1996). Personal protective equipment should be selected according to manufacturers/suppliers recommendations, usually available in the MSDS. Personal protective equipment should also meet the appropriate Australian Standards (see information contained in sample MSDS at Appendix 6).

Hazard communication and training

Material Safety Data Sheets (MSDS)

MSDS are the primary source of information needed to handle chemicals safety. In accordance with the NOHSC National Model Regulations for the Control of Workplace Hazardous Substances (NOHSC 1994b) and corresponding State and Territory legislation, suppliers are obliged to provide MSDS to their customers for all hazardous substances.

An MSDS (prepared by the Asbestos Institute) submitted by Richard Klinger, was the only MSDS for *raw chrysotile* available for assessment. Assessment against the NOHSC National Code of Practice for the Preparation of MSDS (NOHSC 1994e) indicated it did not contain the following information:

- statement of hazardous nature;
- Australian occupational exposure standard for chrysotile; and
- contact details of the company.

Further, the health effects information is both inadequate and inaccurate. Terminology, such as ‘overexposure’ is not defined (essential, given the carcinogenic nature of chrysotile). Information on preventive measures was also considered inadequate and referred to ILO or US regulations rather than the respective Australian regulations. In addition, the MSDS did not specify the type of personal protective equipment to be worn and in particular there is no mention of respirator use.

For *chrysotile products*, a number of MSDS were obtained from the NICNAS survey, from Bendix Mintex (friction products) and Richard Klinger (CAF sheeting/gasket products). In general these MSDS provided adequate information, particularly in the following areas: ingredient listing and quantities, health hazard, Australian exposure standard, PPE, safe handling statements and contact details for further information.

A sample MSDS for chrysotile, prepared in accordance with the MSDS Code, is provided in this report in Appendix 6. This sample MSDS is for guidance purposes only. Under the National Model Regulations, manufacturers and importers have the responsibility to prepare their own MSDS and ensure that the information is up-to-date and accurate.

Labelling

Under the NOHSC *National Model Regulations and Code of Practice for the Control of Workplace Hazardous Substances* (Model Regulations) (NOHSC, 1994b) and the corresponding State and Territory legislation, suppliers of hazardous substances are obliged to provide labels in accordance with the NOHSC *Code of Practice for the Labelling of Hazardous Substances* (Labelling Code) (NOHSC, 1994d).

In accordance with the NOHSC *National Code of Practice* (NOHSC, 1994b), articles which give rise to hazardous substances during use, should be appropriately labelled and indicate the conditions of use leading to the generation of hazardous substance(s). As such, for the purpose of labelling asbestos-containing articles, items such as brake parts, clutches, gaskets and CAF sheets should be labelled in accordance with NOHSC requirements.

In addition to NOHSC labelling requirements, requirements for labelling of asbestos-containing wastes and construction materials should comply with the NOHSC *Asbestos Code of Practice* (NOHSC, 1988) and the ADG Code for labelling of chrysotile containing materials for the purposes of transport by road/rail (see section 10.1.2).

NOHSC requirements for labelling of asbestos and asbestos products

Chrysotile is listed in the NOHSC *List of Designated Hazardous Substances* (the List) (NOHSC, 1994c) and is classified as follows:

Concentration* of chrysotile	**Risk phrases**
≥10%	R45; R48/23
≥1% to <10%	R45; R48/20
0.1 to <1%	R45

* Refers to concentration of chrysotile (w/w basis) in a mixture. Raw chrysotile should be classified as R45; R48/23.

R45 = May cause cancer (carcinogen category 1)

R48 = Danger of serious damage to health by prolonged exposure (R20 and R23 indicate the critical route of exposure is inhalation)

The provision for inclusion of the Risk phrase R48 is to provide warning of the potential for the non-carcinogenic effects of asbestos, primarily asbestosis. The use of this Risk phrase in combination with R20 or R23 is to denote the critical route of exposure for such effects (i.e., inhalation).

The List (NOHSC, 1994c) also recommends the use of the following Safety phrases:

S22 = Do not breath dust;

S44 = If you feel unwell, contact a doctor or Poisons Information Centre immediately (show label where possible); and

S53 = Avoid exposure - obtain special instructions before use.

Although the inclusion of Risk and Safety phrases is a requirement of the Labelling Code, the Model Regulations stipulate only, that containers of hazardous substances are appropriately labelled. As such the above risk and safety phrases are not mandatory, provided adequate hazard and safety data are included.

According to The List all substances (including hazardous articles) containing chrysotile at and above 0.1% should be classified as 'Toxic'. The Labelling Code provisions permit the use of the (signal) word 'Hazardous' as an alternative and/or the ADG Code Class label 9 (Class 9).

Other information to be included on labels (for chrysotile/asbestos) as prescribed by the Model Regulations and/or the Labelling Code are:

- Disclosure of the chemical name (e.g., chrysotile) - under the provisions for Type I ingredients;

- UN number;
- Proportion of ingredients;
- Directions for use;
- Contact details of the Australian supplier; and
- Reference to an appropriate MSDS for further directions (on use and handling etc.,).

Labels for raw chrysotile

Raw chrysotile should be labelled in accordance with the NOHSC Labelling Code, the minimum requirements of which should include product/chemical name; details of supplier; hazard category/signal word and/or ADG Code[16] Class; risk and safety phrase information and reference to the MSDS.

Labels for raw chrysotile were supplied by Bendix Mintex Pty Ltd, Richard Klinger Pty Ltd and Vivacity Engineering. Labels provided appear to be based on labelling guidelines produced by NHMRC (National Health and Medical Research Council, 1982), in addition to relevant provisions of EEC Directive 76/769 (Anon, 1983). None of the labels complied completely with NOHSC requirements. Bendix and Klinger labels, although containing warning of potential hazards and safe handling instructions, did not contain the NOHSC recommended hazard category/signal word or ADG Code classification and class information. The label provided by Vivacity, although containing ADG Code classification and class information, did not contain the NOHSC recommended hazard category/signal word or adequate data on potential hazards and safe handling.

None of the labels provided risk and safety phrases or a reference to the appropriate MSDS.

It was pointed out by one applicant that some of the above information was present in the Emergency Procedure Guide (EPG)[17], provided by the freight forwarding company, however, the EPG provided for assessment had not been updated for over 10 years and was deficient with respect to hazard category/signal word, ADG Code classification/class information, risk and safety phrases or reference to the MSDS. In addition, it was considered (by NICNAS) unlikely that EPGs would be provided to workers handling bags of raw chrysotile.

It should be noted that raw chrysotile is imported and that apart from affixing the standard (as recommended by EEC) label for asbestos and asbestos products (i.e. '**a**' – WARNING/ CAUTION CONTAINS ASBESTOS), the above companies do not appear to re-label the imported containers/bags.

Labels for chrysotile products

A total of 14 labels for chrysotile products were obtained from the following sources:

[16] Additional information e.g. Hazchem Code (2X) and Packaging Group (III) are required by this Code for the purpose of transportation by road/rail.
[17] Emergency Procedure Guide 9B7 - White Asbestos - (AS 1678, March 1988).

- a survey of the automotive aftermarket (see Survey 3 in Appendix 2) (5 labels);
- a survey of importers of chrysotile products (see Survey 1 in Appendix 2) (7 labels); and
- applicants (2 labels).

Labels were provided for chrysotile friction materials (brake blocks, brake disc pads and brake linings), gaskets and CAF sheeting. No labels were provided for clutch facings and automotive transmission discs. More than 5 labels were sighted during the automotive aftermarket survey, however only 5 (representing one for each product type) were analysed for this assessment. Bendix Mintex Pty Ltd provided a label which it was claimed appears on the packaging of all chrysotile containing products that they manufacture, as did Richard Klinger Pty Ltd.

Table 23 presents a comparison of the information on the labels provided, with some of the safety and health hazard information recommended by NOHSC.

Table 23 - Comparison of information contained on labels supplied for chrysotile friction products and gaskets with information recommended by NOHSC.

Recommended information	Brake blocks	Disc brake pads	Drum brake linings[1]	Gaskets/ CAF sheeting
Total number of labels	**1**	**5**	**3**	**5**
Hazard category/Signal word:				
'Toxic' or 'Hazardous'	0/1	0/5	0/3	0/5
Recommended safety phrases and directions:				
Do not breath dust	0/1	0/5	0/3	0/5
If you feel unwell, contact a doctor or Poisons Information Centre immediately (show label where possible)	0/1	0/5	0/3	0/5
Avoid exposure – obtain special instructions before use	0/1	0/5	0/3	0/5
Refer to MSDS for further directions	0/1	0/5	0/3	0/5
Recommended health hazard/risk information:[2]				
May cause cancer	0/1	2/5	2/3	3/5
Danger of serious damage to health by prolonged exposure	1/1	5/5	3/3	5/5
Toxic by inhalation [3]	0/1	5/5	3/3	5/5

[1] Includes the Bendix Mintex generic label

[2] actual phrases used on labels sometimes differed in wording, but were counted as complying where the meaning was the same

[3] No labels contained this phrase, however all except one indicated that inhalation was the critical route of exposure by such wording as 'Breathing asbestos dust may cause serious damage to health.'

All labels had a general statement about the risk of serious damage to health , however only half the labels contained a reference to the risk of cancer. None contained the relevant signal word/hazard classification.

The labels, as supplied, were deficient in the recommended safety phrases and directions. Some labels for brake pads and linings did contain important safety directions, specifically, instruction to use a damp cloth when handling the product and to not use an airline or brush to remove dust from brake drums (3/8). Most labels also contained a direction to avoid creating dust or to keep dust down (9/14).

It was noted that all of the labels contained a symbol for asbestos recommended to be placed on labels by the EEC, in part 1 to Annex II of Directive 76/769/69/EEC (white '**a**' on black background). Four of the labels followed the full EEC recommendations concerning this particular label, namely, the above symbol together with the words: *'Warning Contains Asbestos. Breathing Asbestos Dust is Dangerous to Health. Follow Safety Instructions'.* However, no safety instructions were provided. It was observed during the automotive aftermarket survey that safety directions are sometimes enclosed within the packaging in the form of a pamphlet. A potential problem arising from this form of labelling is unintentional discarding of safety directions with the packaging.

It was also noted that six of the labels were labelled in accordance with NH&MRC guidelines issued in 1981, which recommended the following words: '*Caution. Contains asbestos fiber. Avoid Creating Dust. Breathing asbestos may cause serious damage to health, including cancer. Smoking greatly increases the risk.'*

Some workers interviewed during the automotive aftermarket survey claimed that there were some product labels for asbestos-containing friction products that did not identify the presence of asbestos. These products originated from overseas (e.g. India, Taiwan and Thailand) and the workers claimed they were able to tell from appearance that the products contained asbestos.

Education and training

Guidelines for the induction and training of workers potentially exposed to hazardous substances are provided in the NOHSC Model Regulations (NOHSC, 1994b).

All new employees of Bendix Mintex attend an induction program. They receive information and training in regard to safe working with chrysotile. The induction program covers health risks, potential routes of exposure, workplace control mechanisms, safe work practices, personal protective equipment and specific information on handling of chrysotile. Employees working in areas where there is a mandatory requirement to wear respiratory protection are given training and information on the correct use and selection of appropriate respirators.

Similarly, Richard Klinger employees involved in the handling of raw chrysotile and chrysotile products are provided with a training program at the commencement of employment. Employees required to wear respirators are given training on how to use and maintain the respirators. Each employee is supervised and receives "on the job training" regularly.

Additionally Richard Klinger employees involved in the production of gaskets receive training on safe working practices. All employees also receive training on how to operate each item of plant or equipment.

From the responses to the questionnaire for end-users of chrysotile products, (see Appendix 2) few workers received formal training on the hazards of asbestos and precautions to be taken for safe handling. Most learnt about the health and safety issues from 'on the job' experience. In some workshops, it was reported that workers, particularly younger workers, were educated in these issues during their technical college training. One workshop reported that information was obtained from industry magazines.

With regard to technical college training, NSW Technical and Further Education (TAFE), Transport Industry Training Division provides training in their course on *Automotive Workplace Safety, Tools, Equipment and Practice*. This course covers light and heavy vehicle, motorcycle, marine and plant mechanics and provides instruction and practical experience to enable workers to correctly use and maintain automotive tools and equipment. The course provides an understanding of automotive workshop procedures/practices including occupational health and safety issues, which include those related to working with asbestos.

Scheduled Carcinogenic Substances

The NOHSC *Model Regulations for the Control of Scheduled Carcinogenic Substances* (NOHSC, 1995b) impose requirements over and above the provisions of the NOHSC Model Regulations (NOHSC, 1994b) for certain carcinogenic substances.

Chrysotile is a scheduled carcinogenic substance under these regulations, listed in Schedule 2, as a notifiable carcinogenic substance when used for the manufacture of asbestos products. Schedule 2 carcinogens are substances that have specific limitations on their usage. Requirements of the regulations include:

- notification to the relevant public authority of any proposed use of chrysotile for manufacturing products;
- a work assessment, including an assessment of potential exposure, to be carried out prior to its use;
- the keeping of records of employees likely to be exposed;
- the reporting of exposure incidents to the relevant public authority; and
- advising employees of any accidental exposure.

Amosite and crocidolite are listed in Schedule 1 of the regulations as prohibited substances, except for removal and disposal purposes and situations where they occur naturally and are not to be used for any new purpose.

Monitoring and exposure standards

Air monitoring

Air monitoring is required for asbestos (including chrysotile) under the specified provision of the NOHSC *Model Regulations for the Control of Scheduled Carcinogenic Substances* (NOHSC, 1995b). Details of the methodologies currently employed in the sampling and analysis of asbestos fibres (in air) are provided in Section 4. Results from air monitoring studies (for asbestos) in different Australian industry sectors are provided in Tables 8,9,11,13 and 14.

Australian exposure standard

The current national exposure standard (TWA) for chrysotile is 1 f/mL (NOHSC, 1988). This standard has been under review by the National Commission since 1993, following information (on the levels of lung cancer risk in various industries) in a report presented by Rogers and Leigh, (1993). A public discussion paper issued in December 1995 called for comment on three proposed exposure standards; 1 f/mL, 0.5 f/mL, and 0.1 f/mL (NOHSC, 1995a), currently adopted in different States/Territories. Public comment received for the draft *Proposed National Exposure Standard for the Occupational Environment for chrysotile* is currently being reviewed by NOHSC.

State/Territory exposure standards

National exposure standards are declared by the National Commission and serve only as guidance. They have no legal status unless they are specifically incorporated into Commonwealth, State or Territory legislation. The current national exposure standard (1 f/ml TWA) has *not* been uniformly adopted by State and Territories.

Table 24 - Current Australian State and Territory exposure standards for chrysotile.

State/Territory	Exposure limit
Australian Capital Territory	0.1 f/mL
Victoria	0.5 f/mL
New South Wales	0.5 f/mL (interim)*
All other States/Territories	1 f/mL

* pending review of the exposure standard by the National Commission.

Currently the lowest exposure standard for chrysotile is in the Australian Capital Territory. Documentation for this standard (which has been in force since 1991) was not available for this assessment, however it would appear (from available transcripts of the Asbestos Advisory Committee) that the rationale for adopting this level is related to the fact that the MFM for analysis of fibres does not distinguish between chrysotile and other asbestos fibres (ACT Workcover, 1998). As such a level of 0.1 f/mL, would protect against co-exposure to other forms of asbestos (e.g., amosite, crocidolite) which have a national exposure standard of 0.1 f/mL. International exposure limits for chrysotile can be found in Section 10.2.2.

Health surveillance

Health surveillance is prescribed for asbestos (including chrysotile) under provisions of the NOHSC *Model Regulations for the Control of Scheduled Carcinogenic Substances* (NOHSC, 1995b) and Schedule 3 of the NOHSC Model Regulations (NOHSC, 1994b).

Health surveillance is required for employees who have been identified in the workplace assessment process as having a significant risk to health from being exposed to asbestos.

NOHSC has published guidelines for health surveillance for asbestos (NOHSC, 1995c), which sets out the minimum requirements, which comprise a medical examination (at least every 2 years); and an occupational and medical history. Respiratory function tests, chest x-ray and physical examination are not required unless indications are present.

Bendix Mintex provides health surveillance for all relevant employees engaged in the manufacture of asbestos products and associated support operations. This program includes chest x-rays, pulmonary function tests (spirometry) and physical examinations by a qualified medical practitioner.

At Richard Klinger, employees handling raw chrysotile are given a medical examination after commencement of employment. Medical examinations include chest x-ray and lung capacity tests (spirometry). Medical examinations are conducted on a regular basis at intervals not exceeding three years.

Workshops involved in the end-use of friction materials and gaskets were not specifically asked whether their workers were sent for regular medical check-ups. However, two workshops indicated that their workers underwent a regular check, including an x-ray and a lung function test.

10.1.2 Transportation regulation

Chrysotile (white asbestos), is classified in the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (the ADG Code) (FORS, 1988) in Class 9. This category comprises miscellaneous substances that present a danger but which are not covered by other classes. Under the ADG Code, chrysotile is assigned to packaging group III.

The ADG Code sets out various requirements for the labelling, packaging and surface transport of dangerous goods. With regard to chrysotile, it specifies the marking of packages (of > 2 kg) with the shipping name 'White Asbestos', Class label 9, UN Number (UN 2590) and name and address in Australia of manufacturer, agent or consignor of the goods. Freight containers containing chrysotile must be marked with the UN Number and Class label and road vehicles must be marked with Class label, unless more than one dangerous good is present, in which case the mixed Class label is required (see ADG Code for further details).

Dangerous Goods legislation, which makes reference to the ADG Code, has been enacted in all States and Territories.

10.1.3 Environmental regulation

Environmental legislation in Australia relates primarily to asbestos waste and is outside the scope of this report. There is no obligation on the original manufacturer of an asbestos product to take back the product, however legislation such as the *Environmentally Hazardous Chemicals Act 1985* (NSW) obligates workers using or removing asbestos and asbestos containing materials to dispose of waste in accordance with prescribed requirements. Further information on the safe removal of asbestos and control of asbestos hazards in buildings is available in the NOHSC Code of Practice and Guidance Notes on Asbestos (NOHSC 1988).

10.1.4 Details of regulation in Australia

Regulation of chrysotile is complex, implemented in over 30 statutes and regulations and involving at least sixteen occupational health and safety and environment authorities (see Table 25). In addition, various local government bodies may have specific requirements for particular activities (e.g., building and construction works).

Although legislation does not generally distinguish chrysotile from other forms of asbestos specific restrictions are sometimes imposed. For instance, the use of amosite and crocidolite is prohibited in most jurisdictions, however the use of chrysotile is not (see Table 26).

There is a difficulty with current legislation in that definitions of asbestos 'processes' vary between jurisdictions and it is sometimes unclear as to the extent to which the use of manufactured articles is regulated as distinct from the process of manufacture. This has particular importance when considering certain work processes specific to chrysotile. For example, the definitions of "asbestos process" and "asbestos material" in *Western Australia* are:

Asbestos process *means:*

Any manufacturing process involving the use or handling of asbestos or any substance containing asbestos including:

a) the sawing, cutting and sanding of asbestos materials;

b) the repair, maintenance and replacement of asbestos surfaces;

c) the cleaning and disposal of asbestos material; and

d) the mixing and application of asbestos shorts, cement, grouts, putties and similar compounds.

Asbestos material *means:*

a) loose asbestos fibre;

b) any material containing loose asbestos fibre for use in an asbestos process; and

c) waste material containing asbestos fibre that has been collected in a work place.

From these definitions it would appear that the installation (during vehicle maintenance) and the use of a friction product (e.g., brake pad) containing chrysotile would not be regulated as either an 'asbestos process' or 'asbestos material'. The concept of 'manufacturing' does not generally extend to installation and replacement processes. The definition of 'asbestos material' only incorporates loose asbestos or waste material containing asbestos and does not extend to products containing asbestos in a bound matrix.

A different definition of 'asbestos process' is found in The *Victorian* Occupational Health and Safety (Asbestos) Regulation 1992, which provides that:

Asbestos process *means:*

a) the removal of asbestos containing material from a building, structure or ship; or

b) the handling of raw asbestos or dry mixtures containing raw asbestos, including storage, mixing, sieving, crushing and milling; or

c) the manufacture of articles containing asbestos cloth; or

d) all processes in the manufacture of articles containing asbestos including guillotining, grinding, blanking, finishing and dispatch; or

e) a process which is likely to create airborne asbestos fibres in excess of 50% of the exposure standard; or

f) the maintenance of plant, including dust extraction equipment, used in any of the processes listed in items (a) to (e) above; or

g) laundering of asbestos-contaminated personal protective equipment including respiratory protective equipment and personal protective clothing

This definition would not extend to replacement of chrysotile articles (e.g., friction materials or gaskets) in equipment unless that could be described as a process likely to cause airborne fibres in excess of 50% of the exposure standard.

Table 25 - Main legislative instruments in Australian States and Territories for the control of asbestos

State/ Territory	Legislation
Australian Capital Territory	Building Act 1972 Dangerous Goods Act 1984 Occupational Health & Safety Act 1989
New South Wales	Mines Inspection Act 1901 Construction Safety Regulations 1950 Factories, Shops and Industries Act 1962 Dangerous Goods Act 1975 Dangerous Goods Regulations 1978 Factories (Health and Safety - Asbestos Processes) Regulation 1984 Environmentally Hazardous Chemicals (Chemical Control Order for Asbestos Waste) Act 1985 Occupational Health and Safety (Carcinogenic Substances) (Transitional) Regulation 1994 Waste Minimisation and Management Act 1995 Occupational Health and Safety (Asbestos Removal Work) Regulation 1996 Occupational Health and Safety (Hazardous Substances) Regulation 1996 Occupational Health and Safety (Hazardous Substances) Amendment (Carcinogenic Substances) Regulation 1997
Northern Territory	Dangerous Goods Act 1980 Work Health (Occupational Health and Safety) Regulations 1996 Dangerous Goods Regulations (draft) 1998
Queensland	Environmental Protection Act 1994 Transport Operations (Road Use Management) Act 1995 Workplace Health and Safety Act 1995 Workplace Health and Safety Regulations 1997, Part 11 - Specified Dangerous Goods, and Part 13 – Hazardous Substances
South Australia	Dangerous Substances Act 1979 Dangerous Substances Regulation 1981 Environment Protection Act 1993 Occupational Health and Safety Regulations 1995, Part 4 - Hazardous Substances
Tasmania	Dangerous Goods Act 1976 Industrial Safety, Health and Welfare (Administration and General) Regulations 1979 Dangerous Goods Regulation 1994
Victoria	Occupational Health and Safety Act 1985 Road Transport (Dangerous Goods) Act 1995 Road Transport Reform (Dangerous Goods) Act 1995 (Commonwealth) Road Transport Reform (Dangerous Goods) Regulations 1997 (Commonwealth) Dangerous Goods (Transport) (Amendment) Regulations 1998
Western Australia	Explosives and Dangerous Goods Act 1961 Health Act 1971 Occupational Safety and Health Regulations 1988 Health (Asbestos) Regulations 1992
Commonwealth	Hazardous Waste (Regulation of Exports and Imports) Act 1989 Road Transport Reform (Dangerous Goods) Act 1995 (Cmwlth) Road Transport Reform (Dangerous Goods) Regulations 1997 (Cmwlth)

Table 26 - Prohibitions (absolute) on asbestos use in Australia

State/ Territory	Prohibitions	Legislation
New South Wales	Amosite and crocidolite in a factory manufacturing process. All uses of amosite, crocidolite, , fibrous anthophyllite, tremolite and actinolite, except for the purposes of sampling or analysis, maintenance, removal, disposal, encapsulation or enclosure.	*Factories (Health and Safety - Asbestos Process) Regulations* 1984 – under *Factories, Shops and Industries Act* 1962. *Occupational Health and Safety (Hazardous Substances) Regulation* 1996 - under *Occupational Health and Safety Act* 1983.
Northern Territory	New applications of amosite, crocidolite, actinolite, anthophyllite, tremolite. Chrysotile must not be reused or used in a 'spray' process.	*Work Health (Occupational Health and Safety) Regulations* 1996 - under *Work Health Act* 1996.
Queensland	All uses of amosite crocidolite, fibrous anthophyllite, tremolite and actinolite (except sampling, removal, disposal etc). Supply of second-hand asbestos product for use in the workplace. Chrysotile use in 'spraying'. Using a power tool or high pressure water process to clean an asbestos product. Using compressed air to clean a surface where asbestos is used.	*Workplace Health and Safety Regulation* 1997 – under *Workplace Health and Safety Act* 1995.
South Australia	Use of product containing asbestos 'other than chrysotile' prohibited**,** subject to certain exceptions. Not to be installed as insulation.	*Occupational Health Safety and Welfare Regulation* 1995 (Part 4) – under *Occupational Health Safety and Welfare Act* 1986.
Tasmania	Crocidolite must not be used in a manufacturing/work process.	*Industrial Safety Health and Welfare (Administrative and General) Regulation* 1979 (Regulation 241).
Victoria	All amphiboles – specifies amosite, crocidolite, actinolite, anthophyllite and tremolite – must not be used in a work process (specifies textiles (spinning or weaving); spraying and production) except for sealing, encapsulation, enclosure or removal.	*Occupational Health and Safety (Asbestos) Regulation* 1992 (Regs 12.13,16) – under the *Occupational Health and Safety Act* 1985
Western Australia	Crocidolite or amosite or products containing them must not be used in a manufacturing/work process. Not to be installed as insulation. Chrysotile must not be used in a 'spray' process.	*Occupational Health Safety and Welfare Regulation* 1988 (Reg 808). *Health (Asbestos) Regulations* 1992 – under *Health Act* 1991
Common-wealth	Crocidolite or amosite must not be used in a manufacturing/work process.	*Industrial Safety Health and Welfare (Administrative and General) Regulation* 1979 (Regulation 241).

10.2 International and overseas regulation of asbestos

10.2.1 International initiatives

International Labour Organisation (ILO) Convention 162

ILO Convention 162 *'Safety in the Use of Asbestos'*, adopted in 1986, was endorsed by government, industry and union representatives from over 125 countries in July 1986. This Convention provides for a hierarchy of preventative and control measures which include:

- the prescription of adequate engineering controls;
- the prescription of special rules and procedures for the use of asbestos (or certain types of asbestos or products containing asbestos) for certain work process;
- to protect the health of workers and where technically practicable, to replace asbestos (or certain types of asbestos) by other materials or use alternative technology, scientifically evaluated by the competent authorities as harmless or less harmful; and
- total or partial prohibition of the use of asbestos or of certain types of asbestos in certain work processes.

The Convention only calls for two specific prohibitions for i) crocidolite and all products containing crocidolite, and ii) spray-on applications of asbestos. At least 18 countries have ratified this Convention, including Brazil, Bolivia, Canada, Chile, Germany, Spain, Sweden and Uganda (The Asbestos Institute & Quebec Asbestos Mining Association, 1993).

In Australia, South Australia and Queensland agreed to ratification in February and April 1991 respectively. However, although gaining acceptance by the Australian Labour Ministers Council (in October 1992) and the National Labour Consultative Council (in September 1994), Australia has not as yet ratified this Convention (Department of Industrial Relations, 1994).

European Union Directives

EEC Directive 83/477 on the protection of workers from the risks related to exposure to asbestos at work (as amended by EEC Directive 91/382) prohibits the application of asbestos by spraying and procedures involving low-density insulating or sound-proofing material containing asbestos.

EEC Directive 91/659, adapting to technical progress *Annex 1 to EEC Directive 76/769 on the approximation of the laws, regulations and administrative procedures of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations* prohibits the marketing/use of amphiboles (crocidolite, amosite, anthophyllite, actinolite and tremolite) and amphibole-containing products, and the placing on the market and use of certain products containing chrysotile, including toys, paints and varnishes, catalytic filter and insulation devices (for incorporation into catalytic heaters using liquefied gas).

EEC Directive 98/12, of 27 January 1998 adopting to technical progress Council Directive 71/320/EEC on the approximation of the laws of member states relating to the braking devices of certain categories of motor vehicles and their trailers, prohibits the use of all types of asbestos in brake linings for vehicles under 3.5 tons This prohibition does not include disc brake pads, clutches or gaskets.

A number of EU countries take the view that prohibitions on the marketing and use of asbestos should be based on agreements within the European Commission. The European Commission is currently working on a total ban of asbestos and expects there to be a qualified majority in support of such a ban for the supply of chrysotile (with exemptions for essential uses).

Information on asbestos substitutes (alternatives) has been submitted to the EU Scientific Committee (CSTEE) on Asbestos by member countries for decision on the proposed ban. The proposed ban does not recommend the *removal* of asbestos materials already in place e.g., building insulation and industrial gaskets, provided that such materials are in 'good condition'.

Helsinki report[18]

In January 1997, an international expert meeting was held in Finland (Helsinki) to develop recommended policies for recognition, attributability and screening of asbestos related disease. A major outcome of this meeting was a consensus on attribution and screening guidelines for mesothelioma, lung cancer and asbestosis, which included the following (Anon, 1997):

- brief, low level exposure was regarded as sufficient to cause mesothelioma;
- all fibres can cause mesothelioma, but amphiboles are more potent carcinogens for the mesothelium;
- cumulative exposure to 25 fibre-years (fibres.year/mL)[19] is sufficient to cause lung cancer;
- asbestosis is not a necessary prerequisite for lung cancer;
- for asbestosis, uniform standards of pathology based on the US CAP-NIOSH system could be adopted;
- diagnosis should be based on radiology according to the ILO standards (category 1/0 minimum);
- high resolution CT scanning should only be performed in selected cases; and
- screening programs are justified in selected groups as early detection can now significantly improve the prognosis of lung cancer.

In Australia, State/Territory jurisdictions are actively considering whether these criteria would prove useful for adoption nationally (Labour Ministers Council, 1998).

10.2.2 Country specific regulations

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[18] Public comment received on the draft report indicated criticism of the Helsinki report (criteria) on the basis of a number of issues including lack of representation of the broader scientific community and the evaluation of available epidemiological data.

[19] Equivalent to an average exposure of 1 fibre per mL (in air) for 25 years.

The majority of countries regulate asbestos by controlling its use, although several countries have implemented bans or partial bans on asbestos and asbestos-based products.

Details of relevant legislation (relating to restrictions on asbestos) in Austria, , Denmark, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom and United States were obtained from the appropriate authorities. An analysis of this legislation (by country) is provided in Appendix 7.

Prohibitions

From the information available, no countries have implemented an absolute ban on the use of chrysotile (or chrysotile products), as current regulations contain either specific exemptions (for specific applications) or a general exemption provision (requiring permission from relevant authorities) or licensing requirements for import and/or sale.

Prohibitions generally relate to 'asbestos and asbestos-containing products' (preparations or articles) in one or more of the following categories/activities[20]:

- use;
- placing on the market;
- sale;
- manufacture; and
- import/export.

For the purpose of prohibition, chrysotile is generally included in the legal definitions of asbestos, although in some countries, the amphibole group (crocidolite, amosite, anthophyllite, actinolite and tremolite) is subject to specific regulation. This is the situation in Austria, which bans the manufacture, placing on the market and use of asbestos and asbestos products of the amphibole group, and 17 classes of products containing chrysotile. By contrast, countries that have included chrysotile in general bans on asbestos and asbestos-containing products include Germany, Norway, France and Switzerland.

Other countries, the UK in particular, take the view that prohibitions on the marketing and use of asbestos should be based on agreements with the EU. The Asbestos (Prohibitions) Regulations 1992, implements Directive 91/659/EEC and prohibits the importation and use of many forms of asbestos. Under this regulation, chrysotile is still permitted for any use other than those listed in the Schedule to this regulation. As a result of this, friction materials and gaskets made from chrysotile are still allowed in the UK. Since 1992, the UK policy has been to work with the EU to seek to ban supply of chrysotile, with exceptions for genuinely essential uses where safe and effective alternatives cannot be found.

[20] France also includes on its list of prohibited activities 'possession for the purpose of sale' and 'all manner of transfer'.

In the United States the responsibility for preventive actions to reduce human exposure to asbestos is held by the Environmental Protection Agency, and in particular its program Office of Pollution Prevention and Toxics (OPPT). Asbestos, including chrysotile, is controlled through various regulations issued by the EPA and other government agencies.

The US EPA Asbestos Ban and Phase-Out Rule (and Court decision)

The EPA promulgated the Asbestos Ban and Phase Out Rule on July 12, 1989, under section 6 of the Toxic Substances and Control Act (TSCA). This rule imposed phased bans on the manufacture, importation, processing and distribution in commerce of almost all asbestos products, and required labelling of those products still in commerce as the phase out progressed. Friction products, most gaskets, clutch facings, brake linings and disc brake pads for light and medium weight vehicles were included in the bans. New uses of asbestos were also banned [54 FR 29460; 40 CFR part 763].

In 1991 the US Court of Appeals (fifth hearing) voided[21] most of the Rule on the basis that the EPA had failed to comply with certain conditions of rulemaking under TSCA, in particular, that they had failed to show that the products banned by the Rule presented an unreasonable risk and that a less burdensome regulation would not adequately protect against that risk. In particular the Court stated that the EPA has failed to evaluate the harm that may result from increased use of substitute products, many of which contained carcinogens. The Court also noted that EPA had failed to study the effect of non-asbestos brakes on automotive safety and mentioned the credible evidence that non-asbestos brakes could significantly increase the number of highway fatalities. A clarification subsequently issued by the Court established that asbestos-containing products that were not being manufactured, imported or processed at the time of the Rule continued to be subject to the Rule. It was subsequently determined that six classifications of asbestos products fell into this category: corrugated paper, rollboard, commercial paper, specialty paper, flooring felt, and new uses of asbestos (58 FR 58964; 40 CFR part 763; Asbestos Institute Home Page, 1988). Actions taken by the OPPT to reduce sources of asbestos since then include regulatory and non-regulatory initiatives. For example, the EPA drafted a voluntary agreement with 44 motor vehicle manufacturing companies to phase out and discontinue use of asbestos-containing parts in the production of new motor vehicles, however an issue as to whether the agreement would be permissible under anti-trust laws meant the agreement did not go ahead. Subsequently the EPA conducted a survey of the same companies which indicated that most motor vehicle manufacturers either had already or expected to phase out the use of asbestos altogether by 1999 (Cestone & US EPA, 1996).

Exemptions

Countries that have banned asbestos with exemptions include; Belgium, Denmark, France, Germany, Holland, Italy, Norway, Poland, Sweden, Switzerland and USA. Exemptions usually take the form of an annex or appendix, which lists those classes of products which are exempt. In some cases, there is also a non-specific clause allowing for a government authority to grant exemptions on application.

[21] The US Court of Appeals decision was based on the statutory "unreasonable risk" test.

Chrysotile products are the most common exemptions from the bans. In some cases, the exemptions are time-limited, with a phase-out date specified, and often further qualified, for example, applying only to devices for heavy industrial equipment.

Friction materials and gaskets are the most common class of product exempted. The exemption for these materials is usually qualified by a provision that no suitable (i.e., less harmful and capable of assuring equivalent technical safety) alternative material is available. Table 27 lists the current status of prohibitions relating to asbestos/chrysotile containing friction products and gaskets in the countries assessed in Appendix 7.

Other classes of chrysotile products exempted under various legislation include: replacement parts for maintenance purposes; diaphragms for electrolytic processes; sewage and pressure pipes; well casings for drainage in mining; porous compounds for acetylene bottles; protective clothing for handling molten masses of >1000 deg C; thermal isolation devices used in industry when dealing with temperatures >600 deg C; seals and linings used for watertightness in industrial processes when circulation of water at high temperature or pressure poses two of the following risks: fire, corrosion, toxicity.

Table 27 – Current status of prohibition of asbestos-containing friction materials and gaskets (by country)

Country	Product	Prohibition/exemptions	Comments
Austria	Asbestos brake and clutch linings for vehicles	Prohibited from being placed on the market (incl. manufacture & use), if the technology and road laws allow the use of linings without asbestos and if such linings are available.	Government issues list of vehicle types, for which non-asbestos parts are available. Information provided by the Publication of this list has apparently ceased as there are no cars needing brakes or clutches made with asbestos. Legislation enacted in 1990
Denmark	Friction materials (containing max 70% asbestos)	Prohibited for use in: (a) motor vehicles, trailers and technical equipment fitted with non-asbestos original equipment. (b) all new cars (from 1988). (c) motor vehicles, trailers and technical equipment where suitable alternatives are available (from 30 June 1988).	Criteria for (c) are a manufacturer's declaration or a test report from an approved testing laboratory. In 1993 a list of 'old' cars which may still be equipped with asbestos-free linings was issued.

Table 27 – Current status of prohibition of asbestos-containing friction materials and gaskets (by country) (cont.)

Country	Product	Prohibition/exemptions	Comments
Denmark (cont.)	Asbestos-containing friction materials for lifts.	Prohibition date: 30 June 1989.	
	Asbestos or asbestos-containing (except crocidolite and amosite) bonded gasket materials	Exemption ('until further notice') for manufacture, import or use. Prohibited for gaskets used for water systems with a temperature of under 110 deg C.	
France	Friction linings for heavy industrial equipment and installations, certain machines and heavy vehicles. Friction components for compressors and vacuum pumps with pallets.	Exemption until 1 January 1999.	Exemptions to be reviewed annually. Importer/introducer must make annual declaration to the Minister for Employment in relation to activities involving listed exempt articles.
	Second hand vehicles or specified vehicles in place at 1996	Exemption until 31 Dec 2001.	
	Friction linings for aircraft and seals and linings used in industrial processes of high temperature or pressure.	Exemption until 1 January 2002.	
Germany	Clutch linings for vehicles.	Prohibition date: 31 December 1992 - except where no asbestos-free alternatives are available from a safety perspective.	Prohibitions do not apply to asbestos preparations and products manufactured before 14 October 1993.
	Brake shoe inserts for rail vehicles and friction pads for industrial applications.	Prohibition date: 31 December 1994 - except where no asbestos-free alternatives are approved under transport legislation.	Legislation enacted in 1986
	Cylinder head gaskets for vehicles and industrial use.	Exemption for brake linings in old lifts and lorries (no time constraint)	
Italy	Friction gaskets for motor vehicles, industrial machines and plant.	Prohibition date: 27 March 1994	

Table 27 – Current status of prohibition of asbestos-containing friction materials and gaskets (by country) (cont.)

Country	Product	Prohibition/exemptions	Comments
Italy (cont.)	Friction gaskets, spare parts for railway vehicles, industrial machines and plant with special technical characteristics. Gasket heads for older type motor vehicles. Dynamic gaskets for stress components.	Prohibition date: 27 March 1995.	
Netherlands	Asbestos, (except blue asbestos) containing friction materials (production, application and supply) for heavy (>3500 kg) motor vehicles (velocity < 50 km/hr), and for vehicles <3500 kg with velocity > 50 km/hr.	General exemption where for such vehicles, no asbestos-free friction materials are available. General exemption where these vehicles were introduced onto the market before October 1 1985.	As a result of an inquiry into the availability of asbestos-free friction materials for vehicles, the government is considering extending the ban to include heavy vehicles. Legislation enacted in 1991.
Norway	Friction components and gaskets.	Prohibited where it is impossible to manufacture or use products of this kind with a content less harmful to health.	The government has also indicated that most vehicles, both new and older models, are now fitted with asbestos free friction linings. A list of vehicles in which may use friction linings containing asbestos was published by the Norwegian National Association of Car Importers in 1993.
Sweden	Asbestos-containing friction linings and gaskets.	Prohibits for friction materials (when offered for sale or transfer) in: (a) passenger cars and motor cycles classed as 1988 or subsequent models for registration; (b) lorries and buses classed as 1989 or subsequent models for registration inspection or type inspection; (c) other motor-powered vehicles and trailers manufactured from 1st July 1988 onwards. Exemptions: Brake linings and other frictional elements containing asbestos may be used, machined/processed	A special statutory instrument lists vehicles manufactured prior to these dates for which asbestos-free friction linings are available. Asbestos and material containing asbestos may be used by permission of the National Board of Occupational Safety and Health if it is not possible for less deleterious material to be used. Exemptions do not apply to crocidolite and materials containing crocidolite

Table 27 – Current status of prohibition of asbestos-containing friction materials and gaskets (by country) (cont.)

Country	Product	Prohibition/exemptions	Comments
Sweden (cont.)		and treated if no acceptable products of less deleterious material are available. Gaskets may be fitted to engines manufactured before 1987 if no acceptable products of less deleterious material are available.	Frictional elements must be handled so that the emission of asbestos dust is prevented
Switzerland	Friction linings for motor vehicles, machines and industrial plants. Spare friction linings for motor vehicles, rail vehicles, machines and industrial plants with particular design conditions; cylinder head gaskets for older types of engine. Gaskets and other parts in new motor vehicles.	Prohibition date: 1 January 1992 (replacement parts & new vehicles) Prohibition date: 1 January 1995 Spare parts containing asbestos may continue to be exchanged for spares also containing asbestos in vehicles with “special construction conditions” Prohibition date: 1 January 1995 (gaskets) and Jan 1990 (other).	Legislation enacted in 1986. Special construction conditions are defined as cases where replacing a part containing asbestos by an asbestos-free spare part would involve making alterations to other components of the system concerned as regards dimensioning or materials.
UK	Friction materials such as brake and clutch linings, and gaskets.	All amphibole asbestos containing products are prohibited. Chrysotile-containing products not prohibited under current legislation. In relation to chrysotile, the current prohibition does not apply to the use of any product which was in use before 1 January 1993 unless it was subject to prohibition by the Asbestos (Prohibitions) Regulation of 1985.	The UK Health and Safety Commission has submitted (Sept 98) a recommendation to the Secretary of State to extend the scope of the existing UK legislation (1992) on asbestos to cover all uses (including marketing and supply) of chrysotile, except for a limited number of essential uses where there are no satisfactory alternatives available. Legislation enacted in 1992.
USA	Friction materials and gaskets.	Not prohibited under current legislation.	Legislation (ABPO rule) enacted in 1989. Intended to phase-out asbestos products by 1996. Court voided much of the ABPO Rule in October 1991, leaving only certain items as banned.

Source of data: Appendix 7

International exposure limits for chrysotile

Occupational exposure limits adopted by other OECD countries and other international organisations are listed in Table 28.

Table 28 - International exposure limits for chrysotile

Country	Exposure limit (f/mL)
Austria[2]	0.25
Belgium[2]	0.5
Canada[2]	2.0
Denmark[2]	0.3
Finland[2]	0.5
France[2]	0.6
Germany[1]	No MAK value established because chrysotile is classified as a Group A1 carcinogen
Greece[2]	1.0
Ireland[2]	0.6
Italy[2]	1.0 (8-hour TWA)
Japan[1]	0.5 (8-hour TWA)
Mexico[2]	2.0
Netherlands[2]	1.0
New Zealand[2]	1.0 (4-hour TWA) 6.0 (maximum concentration over 10 minute period)
Portugal[2]	1.0
Spain[2]	0.6
Sweden[1]	0.2 (8-hour TWA)[3]
Switzerland[2]	1.0
Turkey[2]	5.0 (processing industry) 2.0 (mining)
UK[1]	0.5 MEL (4-hour TWA) 1.5 STEL (10 minutes)
US[1]	0.1 (8-hour TWA)[4]
European Community[1]	0.6 (8-hour TWA)
ACGIH[1]	2.0 (8-hour TWA)

[1]overseas limits for which documentation is available.
[2]source: Asbestos International Association, United States (May 1994).
[3]all forms of asbestos except crocidolite.
[4]includes all asbestos fibres.

10.3 Compliance issues

NICNAS sought information from a number of other countries on their experience with phase-out of asbestos products. This was in response to industry raising the issue of the compliance measures needed to control illegal import. To date Germany, Switzerland, Norway and Denmark have responded.

Switzerland indicated that non-compliance may occur in rare circumstances (e.g. direct import of roof-sheets) and is not a major problem. Illegal importers risk a fine and in some instances may be brought to trial.

Germany has no information on this issue but stated that illegal import is highly unlikely to occur as all new vehicles in Germany now have asbestos-free components.

Norway advised of some (minor) problems regarding the illegal sales of asbestos containing friction linings. In 1993 and 1994 the Norwegian Government controlled this problem in certain retail groups.

Danish authorities advised that various elements in their existing regulations would impede a trend to illegal imports of asbestos, notably the labelling provisions of the EC Directive. Furthermore, it was believed that generally, there is a keen interest in asbestos related issues and worker representatives on safety councils are aware of this issue (illegal import).

While this information is indicative of the countries' experience, clearly the effectiveness of any controls is dependent on the implementation of the necessary appropriate compliance and enforcement measures.

11. Asbestos Alternatives

11.1 Background

The past decade has seen considerable activity in the development of alternatives for asbestos containing products and there are a number of substitutes in current use. Alternatives may be inorganic or organic, fibrous or non-fibrous and natural or synthetic. The majority of asbestos substitutes are mixtures of materials that exhibit similar characteristics to chrysotile under specific conditions of use (Virta, 1992).

There are a number of issues surrounding the development and use of alternatives to asbestos products, which include performance, cost and safety. The main issues of concern with respect to regulatory mechanisms are potential health and environmental risks and quality and performance assurance of alternative materials.

The following sections of the report review available information on asbestos alternative materials in current use overseas and in Australia, together with the known health effects of some of these alternatives. In addition, pertinent safety and regulatory issues associated with the use of non-asbestos alternatives are considered.

It is beyond the scope of this report to assess the suitability (with respect to performance and/or health effects) of specific alternative materials. Selection of alternatives for a particular use is the responsibility of manufacturers and importers/suppliers and should be carried out in accordance with existing State/Territory regulation and relevant guidelines/standards.

11.2 Use of alternatives overseas

Asbestos alternatives are used in many products overseas, including; beater-add gaskets, sheet gaskets, roofing felt, cement pipe, cement sheeting and shingles, friction materials (e.g. brake linings, disc brake pads, brake blocks, clutch facings), millboard and roof coatings. Alternatives in place for these uses include; aramid, para-aramid, moulded aramid, fibreglass, polytetrafluoroethylene (PTFE), polyethylene, polyvinylchloride (PVC) and vinyl compositions, semi-metallics, steel fibres, ductile iron, aluminium siding, carbon/graphite, cellulose, refractory ceramic fibres, phoshate, asphalt, tile, mica, wollastonite, fibreglass and other mineral fibres (Environmental Protection Agency, 1989; Virta 1992).

11.3 Use of alternatives in Australia

Alternatives have been developed for most uses of chrysotile in Australia. Based on known past uses of asbestos and NICNAS surveys of current uses, it was evident that alternatives have replaced chrysotile to a large extent in the following products in Australia:

Products where chrysotile has been completely replaced:

- cement sheeting, tubes and piping

- roofing tiles
- textiles
- fibre insulation
- railway brake blocks
- brake disc pads in new automotive vehicles (only 1 new vehicle model was identified as being supplied with asbestos pads in Australia)

Products where a major proportion of chrysotile use has been replaced:

- clutch facings (in automotive vehicles and industrial machinery e.g. tractors, centrifuge drives)
- brake disc pads (in older taxi and courier vehicles, and industrial machinery)
- gaskets, such as spiral wound and head gaskets
- washers
- packing material
- rotor blades (e.g. in high vacuum pumps)

Investigations show similar trends in other developed countries.

Some industries have replaced asbestos totally. For example, Futuris Industrial Products, who supply non-asbestos products to the railway industry indicated that alternatives already in place include: cotton, cellulose, wollastonite, aramid (kevlar) fibres, steel, carbon and glass and mineral fibre (personal communication, 1995). Futuris also reported that nearly all manufacturers in the railway industry have now converted to asbestos-free parts.

Other industries have chosen to redesign their equipment. For example, NSW State Railway have eliminated the use of asbestos in certain railway applications by redesign of certain equipment/structures e.g., the elimination of friction material in the bogie.

11.4 Friction material alternatives

Friction products comprise brake linings, brake disc pads, brake blocks[22] and clutch facings.

The most important physical properties that chrysotile imparts to these products are:

- heat resistance;
- low heat conductivity;
- durability; and
- high friction coefficient

[22] Brake blocks were commonly used in heavy vehicles and the railway industry.

Therefore, alternative materials should possess these properties to the level required for efficacy/performance, in addition to presenting a lower level of risk to human health. In considering replacements, cost will also be a consideration. Chrysotile is relatively low in cost, however, with the increased volume and availability of non-asbestos alternatives, it is envisaged that cost differentials will eventually be reduced.

ASME lists four types of non-asbestos materials most commonly used in friction materials (ASME, 1988). These are:

- non-asbestos organic (NAO);
- resin-bonded metallic (semi-metallic);
- sintered metallic; and
- carbon.

International research into alternatives for asbestos friction products has led to the development of a number of alternative materials that are claimed to exhibit equal or higher performance standards to chrysotile. There are currently no universal alternatives suitable for all applications and in many cases, particularly brake parts, they are only suitable for the specific braking system for which they were developed (ASME 1988; Anderson 1995). However, Baker (1992) reports that there are alternatives available for most applications (i.e., disc brake pads, drum brakes and clutch facings for cars and commercial vehicles,) which either match or exceed both physical and friction properties of their asbestos-based counterparts.

Table 29 provides further details on some alternative materials reported in the literature. Table 30 provides detailed information on the advantages and disadvantages (for use in friction products) for some of these materials reported by Hodgson et al. (1989). A more recent source of this type of information was not available.

Table 29 - Composition of alternative (non-asbestos) friction materials and uses

Material	Composition	Use
Non-asbestos organic (NAO) friction materials (utilise a combination of fibres and other ingredients in an organic binder resin)	Aramid(Kevlar), fibreglass, mineral wool, wollastonite, steel wool and processed mineral fibre	Used in brake linings for passenger cars and light trucks and brake blocks on heavy trucks. Also used in brake disc pads.
Semimetallic NAOs	Steel wool, iron powder (up to 70% wt % of NAO material), graphite, binder resin, and various other constituents in their formulations	Used in disc brake pads on passenger cars and light trucks
Sintered metallic friction materials	Iron or copper base generally containing inorganic filler and friction modifiers as minor constituents	Used in commercial vehicles and aircraft disc brake applications. Sintered copper-based friction materials are used in heavy-duty brakes and clutches. Sintered bronze friction materials are used for aircraft disc brake pads and heavy-duty truck/tractor clutches.
Carbon-carbon (graphite) friction materials	Composites of carbon fibre, held in a matrix of amorphous carbon	Used in disc brake pads for military aircraft, racing cars and some commercial aircraft.

Table adapted from ASME (1988)

Table 30 - Advantages and disadvantages of some non- asbestos alternatives in friction products

Material	Advantages	Disadvantages
Glass fibre	Good reinforcing properties	Temperature limits 250-400 °C; poor wear resistance; erratic friction; rotor wear; fibres clump together in mixing processes; fibres cause 'spring-back' in performing process.
Alumino silicates	Good reinforcing properties, very high temperature resistance	Poor wear resistance, abrasive, mixing and processing problems as for glass fibre
Mica	Good friction	Poor reinforcement, surface 'tear-out', rotor wear
Wollastonite	Good reinforcing properties, low wear	Rotor wear, surface 'tear-out', 'in-stop' fade
Steel fibres	Good reinforcing properties, good temperature resistance	High density, corrosion noise, high thermal conductivity, fibres clump together in mixing processes, fibres cause 'spring-back' in performing process
Aramid (Kevlar) fibres	Very good reinforcing properties, low wear rate, low density	Temperature limits 200-350 °C mixing and machining problems, less suitable in linings
Other synthetic organic fibres	Good reinforcing properties	Low melting point
Carbon fibres	Very good reinforcing properties, high thermal stability	Mixing problems; high cost
Semi-metallic products	Good all round performance in heavy duty applications	Suitable for disc pads only; cannot be formed as linings; high wear rates, high thermal conductivity; noise
Carbon composites	High-temperature, high performance properties	Less suited to motor vehicle use in present form, unless diluted with glass or steel fibres
Ceramics	High-temperature, high-performance products	Less suited to motor vehicle use than RCFs

Table adapted from Hodgson et al. (1989)

11.4.1 Road safety issues associated with replacement of chrysotile with non-asbestos materials in friction products

Excepting the considerable amount of work being carried out on the health effects of asbestos alternatives (see Section 11.7), little research appears in the literature regarding road safety issues in relation to replacement of chrysotile with non-asbestos friction products.

A study carried out on behalf of the US EPA in 1988 by ASME Centre for Research and Technology Development (ASME 1988) looked at the feasibility of replacing asbestos with alternative materials in automobile and truck braking systems, which included an assessment of the impact on road safety. The main finding of this study was that substitution of non-asbestos material in either vehicle disc pads or drum linings may have an adverse effect on vehicle brake balance and controllability, and that drum brakes in particular may exhibit significant differences in effectiveness.

It was concluded that mandating an industry wide substitution of non asbestos friction materials for aftermarket vehicles, originally equipped with asbestos-based linings, could lead to a potentially serious safety risk *unless stringent friction material qualification/specification tests were first undertaken*. Further studies were recommended, however it is not known whether these took place. It was proposed to first conduct a study to determine aftermarket vehicle classes and brake system designs, with the aim of identifying the major vehicle populations with respect to the key properties (for purposes of replacement of friction materials) of weight range, brake design, and front-to-rear braking balance. Dynamometer tests and vehicle performance tests of non-asbestos materials (to determine friction product effectiveness under vehicle service conditions, and compliance with existing vehicle performance standards) could then be targeted at the most common classes of vehicles identified (Fletcher et al., 1990).

According to the Australian Federal Office of Road Safety (FORS), no studies have been carried out on the feasibility and/or impact on road safety of replacing asbestos with alternative friction materials in Australia. (FORS, 1998). However, FORS in conjunction with the National Road Transport Council have developed safety standards (e.g., ADRs) that have been adopted as national standards under the Federal *Motor Vehicle Standards Act 1989* (see Section 11.5). General road safety issues associated with the aging Australian vehicle fleet has also been the subject of recent research (see Section 11.5.3), which would require consideration in any impact study.

11.4.2 Use of alternative materials in friction products in Australia

Bendix Mintex are the largest manufacturers of friction products in Australia producing both asbestos and non-asbestos products. Some of the alternative materials used by Bendix Mintex for friction materials are aramid fibres, fibreglass, semi-metallic, mineral wool, steel wool, wollastonite, and refractory ceramic fibres (RCF).

Investigations through industry surveys showed there are many alternatives in place for friction materials. For example in the railway industry asbestos brake blocks have been replaced with glass fibre pads. In the automotive industry, for motorcycles the alternatives in place for brake disc pads, brake shoes and clutch facings include aramid fibre, stainless steel, paper and cork. For automotive vehicles the alternatives in place for brake disc pads and clutch facings include aramid fibres, fibreglass, carbon/graphite, semi-metallic, mineral wool, steel wool, wollastonite, cellulose (A/T), refractory ceramic fibres and titanate fibres.

Investigations have shown that most of the clutch facings now come in a kit form, the majority of which are non-asbestos. No information was provided on the types of non-asbestos material(s) used in clutch facings.

New vehicle industry

All but one new vehicle model (Ford Utility with asbestos rear brake lining) on the Australian market have all non-asbestos friction components (see Section 5). Details of a NICNAS survey of companies importing/manufacturing new vehicles can be found in Appendix 2. Data indicates that the Ford Utility comprises <1% of total vehicle sales for the year 1996.

Most companies have manufactured and imported asbestos-free (including friction products and gaskets) vehicles for several years. Table 31 gives details of when the top 10 companies in Australia converted to using non-asbestos components in their new vehicles.

Table 31 - Introduction of non-asbestos components by top 10 importers/manufacturers in Australia.

Company	Year in which company converted to non-asbestos components
Ford	Laser: Brakes 1989 Clutch 1990 Mondeo: asbestos free from introduction in 1995 Falcon/Fairlane: 1994 - 1995 Louisville: asbestos free from 1992 onwards Probe: asbestos free from introduction in 1996
Holden	All current models are asbestos free, year of conversion not specified.
Toyota Australia	Introduced non-asbestos products into new vehicles 4-5 years ago.
Mitsubishi Motors Australia	Introduced asbestos-free from late 1980s to early 1990s. Production of vehicles requiring asbestos gaskets concluded in December 1996.
Hyundai	Always asbestos-free. Company started importing vehicles in 1994.
Nissan Motor Company	Started using non-asbestos components in 1991
Mazda Australia	First implemented non-asbestos components in 1986 for specific uses and came into full effect gradually in 1990.
Honda	Took action to discontinue usage of asbestos in its products in April 1991. Conversion to non-asbestos products was completed in July 1994.
Daewoo	Always asbestos free. Daewoo started operation in Australia in September 1994.
Subaru	Converted to non-asbestos components in 1989.

Vehicle aftermarket

As stated above, most new vehicles are now manufactured with non-asbestos original parts, and therefore, there are non-asbestos replacement parts available for these vehicles.

Several companies in Australia also manufacture/import non-asbestos products for the aftermarket. A NICNAS survey indicated that non-asbestos replacement friction products are available for around 90% automotive models.

For the specialised use of friction products in the aftermarket, several catalogues are available to assist service garages to identify correct parts. Bendix Mintex produces a catalogue which lists specific models of cars and the type of products available (e.g. asbestos, or non-asbestos brake disc pads or brake linings) (Bendix Mintex Pty Ltd, 1996/97). The catalogue is used by garage mechanics to identify suitable product for a particular vehicle type.

According to Bendix Mintex, the catalogue accounts for approximately 90% of vehicle models present in Australia and lists non-asbestos alternatives for most vehicles manufactured in the last 20 years. Bendix Mintex also provided NICNAS with a listing of vehicle models not covered in their product range and indicated that manufacture/import of suitable friction products for these models may have ceased due to the company policy of deleting ‘low volume’ parts from their product range.

Bendix Mintex manufacture two types of non-asbestos disc brake pads:

- semi-metallic (Brand names: Metal King Plus, Taxi Pack)
- low metal (Brand name: Ultimate).

The semi-metallic disc brake pads are particularly suitable for taxis, couriers , 4WD, front wheel drive and large passenger cars. They are recommended for active and frequent braking driving styles. Low metal disc brake pads are available for a more limited range of vehicles, in particular sports, performance and prestige vehicles.

The catalogue also includes a cross-reference section which provides information about parts from overseas suppliers and corresponding products available from Bendix Mintex. Also contained in the catalogue are data sheets which detail the driving style best suited to each material.

Similar catalogues are also available from other companies, such as National Brake and Clutch Pty Ltd (NBC). NBC only manufacture semi-metallic friction products.

Although non-asbestos products are available for most vehicle types, they are often not used in the aftermarket. Asbestos products continue to be used in vehicles with non-asbestos original equipment. The ‘Automotive Aftermarket Survey’ identified some of the reasons for the continued use of asbestos products in the replacement aftermarket (see Appendix 2). Some of the reasons stated in the survey were:

- Poor quality and performance of non-asbestos products e.g. Bendix Mintex reported deficiencies in a number of imported non-Japanese Asian products, where test results (under normal braking conditions) included delamination and cracking/crumbling of friction material; insufficient stopping distances and failure of fade tests;

- Alternatives not available for some applications because market too small to manufacture non-asbestos products for some applications;
- Non-asbestos friction products are not as durable (wear faster) as chrysotile products;
- Non-asbestos pads smell and are noisy when braking and produce a lot of dust;
- Non-asbestos products are more expensive;
- In buses, alternatives not used because of vehicle specification e.g. old buses manufactured only to take chrysotile products; and
- Lack of regulation of the aftermarket industry.

11.5 Safety assurance/regulation of friction products

11.5.1 New vehicle market

The *Motor Vehicle Standards Act 1989* provides for uniform national vehicle safety, emissions and noise standards for vehicles entering the Australian market for the first time. Under this Act, Australian Design Rules (ADRs) have been endorsed as national standards. ADRs were initially developed under the auspices of the Australian Transport Advisory Council between February 1983 and December 1986, and are periodically added to and amended, by the Federal Office of Road Safety in conjunction with the National Road Transport Commission, vehicle manufacturers, operators, consumer groups and road safety experts. There are a number of ADRs relating to brake systems - in passenger cars (ADR 31/00), motorcycles and mopeds (ADR 34/00), commercial vehicles (ADR 35/01), and trailer brake systems (ADR38/02). These ADRs prescribe performance tests designed to test the overall safety of the braking system as a whole, and do not specifically address safety aspects of individual components.

11.5.2 Vehicle aftermarket

A draft Australian Standard for testing aftermarket disc pads for passenger vehicles was released by Standards Australia for public comment in October 1997 (Standards Australia, 1997). The final standard, *AS 3839-1998 Evaluation of aftermarket disc pads for passenger vehicles and their derivatives*, was due for publication in September 1998.

The draft standard sets out the recommended minimum requirements for the quality and performance of disc pads sold in the Australian aftermarket. It specifies the tests required and the equipment to be used in performing the tests.

The objective of the standard is to ensure that the product is suitable for:

- fit;
- function; and
- performance for each application of the aftermarket disc pads.

According to the draft standard, two types of tests should be conducted: a bond plane shear test and a dynamometer performance test, the latter to be in accordance with recommended practice contained in the Society of Automotive Engineers' (SAE) standard J1652. Where the same disc brake pad is intended to suit different vehicles, it is proposed that all vehicle configurations be tested. The draft also draws attention to the fact that it is the responsibility of the manufacturers/importers/supplier of the brake pads to ensure the suitability of the product.

No Australian Standard(s) exist for other brake components (e.g., drum brake linings).

Bendix Mintex report that all brake products are tested for each vehicle type before being listed in their catalogue, except for some vehicle models where braking systems are virtually the same and therefore do not require testing. Testing carried out by Bendix Mintex include dynamometer and computerised 'in vehicle' data acquisition system testing. Field tests are carried out and in most cases the test product is given to garages, taxi companies and rental car companies for trialing. After the product has been tested by these companies they provide feedback to Bendix Mintex via a formal performance report.

NBC report that testing and re-testing are key procedures in each stage of manufacture. This testing is measured against tolerances which ensure complete conformance to standards and performance characteristics. This applies to both the raw materials received from suppliers and products produced.

Field and laboratory testing is undertaken on all the NBC product range. NBC has also undertaken and gained accreditation from two industry-recognised test procedures:

- Australian ADR 31 design rules; and
- US Vehicle Equipment Safety Commission V-3 regulations.

NBC report that the main difficulties with regard to testing products are the lack of standards to test against in the aftermarket. Although car manufacturers have to meet ADR 31 prior to placing a car on the market, the nature of the testing requirements (e.g. use of dynamometer) for ADR 31 is such, that compliance with this standard in the aftermarket is not readily assessable and as such is considered unlikely to be enforced.

11.5.3 General safety and other issues of aging car fleet

Recent research has highlighted some of the safety aspects of an aging car fleet. Two recent studies by CSIRO and Monash University Accident Research Centre found a direct relationship between vehicle age and mortality/morbidity rates and accident potential. More details of these studies can be found in Appendix 9.

The Australian Automotive Association cites road safety, emissions performance, fuel consumption and vehicle theft as the main issues of relevance to the aging car fleet. The AAA maintain that policies which encourage the updating of the car fleet and recycling of older vehicles will have substantial safety and economic benefits and have recommended a number of possible initiatives in this regard (AAA, 1998).

It was noted that a number of countries have stringent vehicle inspection and retirement regulations in place to control the extent of the aging car fleet.

11.6 Gasket material alternatives

Gaskets are used to seal one compartment of a device from another (such as engine and exhaust manifolds). The following properties are important when selecting materials for use in gaskets:

- flexibility;
- heat resistance;
- resistance to pressure;
- chemical resistance;
- low thermal conductivity;
- tear resistance; and
- resistance to crushing.

Asbestos is widely used for flange seals for pipelines and for gaskets in compressors, turbine castings and motor vehicle. Gasket and jointing materials that are considered as suitable substitutes for asbestos fall into a number of categories depending on cost, material and application. Table 32 outlines the properties of asbestos and some alternatives for use in gaskets (Hodgson et al., 1989). A more recent source for this type of information was not available.

Semi-metallic spiral wound gaskets and solid metal gaskets are another category of articles in this area. These gaskets have specialised applications. Semi-metallic gaskets consist of alternate layers of v-section metal strips and non-metallic fillers. Solid metal gaskets are stamped out of sheet metal, or are machined from cast or forged steel rings. These types of gaskets are used in petrochemical and oil-producing industries and in nuclear power installations where high temperatures and extremely high operating pressures prevail.

Table 32 - Properties of asbestos and some alternatives for use in gaskets

Material	Service temperature (°C)	Chemical resistance (pH range)	Advantages	Limitations
Asbestos/ graphite	425	3-14	Better than asbestos in packings	
Asbestos/ PTFE	250	3-14	Better than asbestos in packings	
Glass fibres	450	5-11	Good general-purpose jointing	Limited chemical resistance
Aramid fibres	250	3-11	Strong fibre, long service life	Difficult processing characteristics limited chemical resistance
Graphite/ PTFE	250	1-14	Non-abrasive, good heat dissipation, excellent chemical resistance, long service life	High price
PTFE	250	1-14	Low friction, excellent chemical resistance	Thermal expansion, low shaft speed in gland packings, high price
Carbon	650	1-14	Good heat dissipation, high shaft speed in packings, excellent chemical resistance	Brittle, not resistant to oxidising agents, high price
Graphite	650 (inert conditions eg. steam), 3000 (non-oxidising conditions)	1-14	Good heat dissipation, very high shaft speed in gland packings, excellent chemical resistance	Brittle, not resistant to oxidising agents, high price
Vegetable fibres, cork composites	100	5-10	Inexpensive	Limited applications, non-chemical resistant, for low pressure use

Source: Hodgson et al. (1989)

11.6.1 Use of alternative materials in gaskets in Australia

Investigations from industry surveys have shown that the use of non-asbestos gaskets are increasing in proportion in Australia. The NICNAS vehicle aftermarket survey found that only one company (Ford Australia) still use asbestos head gaskets in new vehicles, and in only one model (Ford Econovan).

Richard Klinger is the only manufacturer of compressed fibre (CF) sheeting (asbestos and non-asbestos) for gasket manufacture in Australia, although there are at least two other manufacturers of gaskets plus a large number of processors of gaskets from CF sheeting. Richard Klinger states that currently, 55% of 'all gaskets' and 70% of 'compressed fibre gaskets' in Australia are non-asbestos and that these proportions are increasing due to industry preference for non-asbestos products.

Richard Klinger manufactures two major types of non-asbestos products: compressed non-asbestos fibre jointing and non-asbestos spiral wound gaskets. These non-asbestos products are used in a broad range of industrial applications including sealing solutions for steam, oil, fuel gases, acids and alkalis. Alternative materials used by Richard Klinger are graphite, carbon, glass, aramid and ceramics. Technical advantages and disadvantages of these materials in regard to use in gaskets are outlined in Table 33.

Asbestos seals tend to be better than non-asbestos due to the superior performance of asbestos fibres in relation to temperature, pressure and chemical compatibilities. However, Richard Klinger states that non-asbestos products can be used in all applications where asbestos products are currently used, provided that careful consideration is given to installation techniques and equipment condition. For example, equipment which is of poor design or in poor condition may not be suitable for direct replacement of asbestos with non-asbestos products. Petroleum refineries were cited as an example, where such substitution often requires upgrading of equipment. Many sealing products are used within industry to contain volatile and/or toxic media and hence their reliability is critical. In the experience of Richard Klinger, some high temperature, high pressure type applications cannot be readily used with non-asbestos sealing products without consideration of equipment redesign, which also carries a cost consideration. However, Richard Klinger also reports that the proportion of applications where changeover would be difficult is quite small compared to the overall value of sealing products sold.

NICNAS investigations showed that there are alternatives in place in Australia for gaskets, these are listed in Table 34.

Table 33 - Advantages and disadvantages of alternative materials used for gaskets according to Richard Klinger Pty Ltd.

Property	Effect
Aramid Fibres	
Advantages:	
Will not melt:	Stability through a wide temperature range (to 400°C)
Will not break down at elevated temperatures:	Gradual carbonisation into a carbon fibre skeleton preventing crushing under heat and pressure
Good chemical resistance:	Suitable for the mixing and calendering process and for a wide application range in the finished material
Disadvantages:	
Limited resistance to caustic solutions:	Not recommended for applications exceeding pH 11-12
Hydrolysis if exposed to wet steam above 180°C:	Breakdown of fibre causes gasket brittleness and subsequent failure
Glass Fibres	
Advantages:	
Heat resistance:	Can be used in high temperature applications without fibre breakdown
Excellent chemical stability:	Essential in the calendering process where some fibres are prone to shrinkage. Can be used in general purpose applications.
Resists hydrolysis:	Ideal in medium pressure steam jointing materials
Disadvantages:	
Limited resistance to higher strength alkalis:	Limits the ability to handle strong caustic flushes or strong caustic service applications (over pH 12)
Poor adhesion to binders in virgin state:	Low load capabilities without correct formulation for calendering process
Carbon Fibres	
Advantages:	
Heat resistance:	Enables use in higher temperature ranges approaching that of asbestos fibres
Chemical resistance:	Can be used for a wide range of chemicals and is to be used over the full pH scale (0-14)
Resists hydrolysis:	Can be used in materials required to seal medium pressure steam
Disadvantages:	
Cost:	Initial outlay high, but offset by longer serviceability and safer sealing
Lower adhesion to binders compared to compressed asbestos fibres (CAF):	Without correct formulation with support fibres and other ingredients, stress relaxation problems may arise

Table 34 - Alternatives for gaskets in use in Australia

Use	Alternative
Industrial:	
Cylinder head gaskets	paper (cellulose) gaskets
Exhaust manifold gaskets	"
Gaskets for petrochemical and package boiler industry	graphite sheets
Gaskets for sealing and rotating equipment and associated equipment	graphite and mineral fibre
Insulation for industrial machinery	ceramic fibre
Pipeline/flanges for petroleum industry	nitrile/glass and graphite laminate
Automotive:	
Head, manifold and exhaust pipe gaskets	carbon fibre, aramid, stainless steel, cellulose/glass fibre, copper, aramid fibre, cellulose, rubber coated steel, cellulose, cellulose/aramid fibre
Insulator for automobiles	vegetable fibres
Outboard Engine:	
Cylinder head gaskets	aramid fibres
Cylinder head cover gaskets	"
Exhaust plate gaskets	"
Exhaust manifold gaskets	"
Water pump gasket	"

11.7 Health effects of alternative materials

Any substitution of chrysotile should be with a less hazardous substance. There has been ongoing debate regarding the health effects of alternatives, such as synthetic mineral fibres (SMF), natural organic fibres and synthetic organic fibres.

In general, less data on health effects of alternative materials (in comparison to asbestiform fibres) are available and because of this, it is difficult to make an assessment of the pathogenicity and potential carcinogenicity of many substitutes.

Although not the only determinant of potential pathogenicity, fibre dimensions (length, width and aspect ratio) are considered to be one of the most important factors associated with carcinogenic (lung cancer and mesothelioma) potential (EC, 1997). Table 35 presents data on fibre size for both asbestiform fibres and a number of alternatives[23]. This table was compiled from a review of the literature and the data may not be representative of all potential particle/fibre dimensions for a particular material. The commonly accepted 'peak hazard' dimensions, as discussed in Section 7.3.5 of this report are >5µm long (length) and <3µm wide (diameter).

The most commonly used alternatives in Australia (and overseas) for friction materials are aramid fibres, attapulgite, fibreglass, refractory ceramic fibres (RCF), semi-metallics, mineral wool, steel wool, cellulose, titanate fibres and wollastonite, and for gaskets are glass fibre, carbon fibre and aramid fibre.

It is not within the scope of this report to assess the health effects of these alternatives, however recent (peer reviewed) evaluations are presented for these materials in Table 36, together with supporting reference material. It should also be noted that, although Table 36 considers different fibres in distinct groups, it is often misleading to do so, as differences in fibre length, diameter and surface properties may lead to entirely different toxicological profiles.

A recent report by EC concludes that the available data are generally supportive of the conclusion that PVA, cellulose, p-aramid, glass wool and slag wool are likely to be safer in use than chrysotile. However, RCFs are the subject of ongoing concern (EC, 1997).

A summary of a recent review (unreferenced summary report only available for assessment – full report not available for review) by the French Medical Research Council (INSERM expert panel), made the following conclusions: that inhalation studies in animals show a statistically significant increase in the number of tumours with certain ceramic fibres, but not with either glass (excluding continuous filaments) or rock wool fibres. However a non statistically significant increase in tumour incidence was found in animals exposed to fibre glass. No conclusions could be drawn for slag wool, continuous glass fibres, para-aramid or cellulose fibres due to lack of data. Radiological studies in workers did not yield any firm conclusions about a relationship between exposure to glass, rock or slag wool or woolastonite and benign pleural lesions or pulmonary fibrosis. However there is a possible relationship between exposure to refractory ceramic fibres and pleural plaques. No information is available for assessing the risks of pleural or

[23] Not all the listed non-asbestos fibres are used in friction products or gaskets.

parenchymatous lesions associated with exposure to continuous glass fibres, para-aramid or cellulose fibres in humans (INSERM, 1998).

Table 35 – Dimensions of asbestos fibres and alternative (non-asbestiform) materials

Fibre type	Fibre length (µm)	Fibre diameter (µm)	DF_{50}(µm)
Asbestiform Fibres:			
Amosite	5 - 30[2]	0.05 - 0.5[2]	0.15
Anthophyllite	5 - 30[2]	0.05 - 2[2]	0.5[2]
Chrysotile	0.4[4]* - >0.5[13]	0.25	0.03[5] - 0.07[2]
Crocidolite	5 - 30[2]	0.05[2] - 0.4[7]	0.17
Erionite (Zeolite)	NA	NA	0.005
Tremolite	NA	NA	NA
Alternatives:			
Alumina fibre (refractory)	1 - 10[1]	2 - 3[1]	NA
Aramid(Kevlar/Twaron)	**2.5 - 30[12]	<1 - 20[12]	1 - 2.5[12]
Attapulgite (palygorskite)	NA	NA	NA
Carbon (graphite) fibre	20 - 60[9]	5 -15[1]	NA
Cellulose fibres	>5[14]	12-40[13]	NA
Ceramic fibre (RCF)	2 - 500[2]	0.2 - 6[2]	1.5
Silicon carbide			
whiskers	18.1 - 19[7]	0.8 - 1.5[7]	NA
fibres	1 - 2 [14]	3 - 30[14]	NA
Ceramic fibres (other):			
Cera blanket	NA	1 - 20[1]	NA
Cera felt	NA	0.75 - 10[1]	NA
Cera fibre (bulk)	NA	0.75 - 20[1]	NA
Cera form	NA	2 - 10[1]	NA
Cera paper	NA	1 - 6[1]	NA
Fibrefrax	305[10]	0.5 - 15[1]	NA
Kaolin wool	NA	0.3 - 20[1]	NA
Kerlane	NA	0.2 - 25[1]	NA
Zirlane	NA	0.3 - 18[1]	NA
Dawsonite	NA	NA	NA
Glass fibres:	**45.2[11]	0.3 - 18[1]	8.25[11]
E-glass	3 - 6[5]	10 - 15[1]	NA
Textile	NA	10 - 20[1]	NA
Mineral Wools:	200 - 800[5]	4[5]	NA
Glass Wool (fibreglass)	1 - 25[1]	0.3 - 20[1]	0.38 - 3.5
Rock Wool/Stone Wool	<5 - 22	0.3 - 10[1]	NA
Slag Wool	<5 - 22	2 - 6[6]	4.8
Polyacrylonitrile (PAN)	**227[11]	10 - 20[12]	31.6[11]
Polypropylene	**254[11]	10 - 20[12]	34.4[11]
Polyvinyl alcohol (PVA)	>5[13]	9.3 - 16.5[8]	NA
Silicate fibre	NA	8 - 10[1]	NA
Steel Wool	NA	NA	NA
Titanate fibre	10 - 20[5]	0.2 - 0.5[5]	NA
Wollastonite	5[1] - 25[5]	1 - 500[1]	1.2 - 1.3[11]

Data sources: NIOH (1994)[1]; Rogers and Fornasari (1988)[2]; Stanton et al (1981)[3]; Plato, (1995)[4]; Anderson (1996)[5]; CEPA[6]; Vaughan et al (1993)[7]; EC (1997)[8]; Owen et al (1986)[9]; unpublished source (various)[10]; Cambelova & Juck (1994)[11]; ECETOC (1996)[12]; UK HSE (1998)[13]; Lockey (1996)[14]
* majority of chrysotile fibres in the debris from friction linings measured in automotive workshops were less than this figure.
**geometric mean.
DF_{50} = 50% abundance diameter of fibres (from Spurney (1995), unless otherwise referenced.
NA = not available for assessment.

Table 36 - Health effects of alternative materials used in friction products and gaskets

Alternative material	Health Effects	Comment
Aramid (also known as Para-aramid, Kevlar, Nomex Twaron)	Lung fibrosis and cystic keratinising squamous cell carcinoma (CKSCC) in rats following inhalation exposure[1, 2] Induction of alveolar macrophages, granulomas and alveolar bronchiolarisation. Deaths due to obliterative bronchiolitis and centriacinar emphysema in rats following inhalation exposure[2, 3] Similar cytotoxic potential to crocidolite and chrysotile asbestos in hamster trachael epithelial cells and rat lung fibroblast cells[4] Skin irritation but no evidence of sensitisation from human 'patch testing'[3]	IPCS concluded that (1) on the basis of the limited available data, a potential for fibrogenic and carcinogenic effects may exist, and (2) exposures to aramid fibres should be controlled to the same degree as that required for asbestos fibres, until data indicating that less stringent controls are available[11] IARC Carcinogen group 3 - cannot be classified as to its carcinogenicity in humans[12] Report by EC suggests that para-aramid fibres are likely to pose a lower risk of pulmonary fibrosis, lung cancer and mesothelioma than chrysotile[24]
Attapulgite (magnesium aluminium silicates)	Causes mesothelioma and sarcomas in abdominal cavity of rats following i.p. administration[22] No increased incidence in tumours seen in epidemiological studies[23]	IARC Carcinogen group 3 - cannot be classified as to its carcinogenicity in humans[27]
Carbon/graphite fibres	Pulmonary inflammatory response (reversible) in rat. Epithelial cell hyperplasia but no lung fibrosis observed[6, 7] Evidence of effects on lung function and dermal effects in exposed workers[1, 8]	IPCS concluded that "the potential health risk associated with exposure to carbon fibres is unknown at this time, but is likely to be very low"[11]. Information on chronic toxicity/carcinogenicity was not available[11].

Table 36 - Health effects of alternative materials used in friction products and gaskets (cont.)

Alternative material	Health Effects	Comment
Cellulose	Evidence of lung cancer, and lymphatic and haematopoietic malignancies seen in workers exposed to cellulose in the paper and pulp industry[24] Evidence of fibrogenicity (including thickening of alveola septa) in rats following inhalation exposure[24]	NOHSC exposure standard (for cellulose paper fibre) = 10 mg/m3[25] Most cellulose fibre is derived from wood and wood dust is a known nasal carcinogen in humans Report by EC suggests that cellulose fibres are likely to pose a lower risk of pulmonary fibrosis and lung cancer than asbestos[24]
Fibreglass (glass wool)	Increased incidence of lung cancers in workers involved in glass wool production[9] Epidemiological studies have shown no evidence of pulmonary fibrosis, lung cancer or pleural disease in the Australian glass and rock wool industry[24]	IARC Carcinogen group 2B – possibly carcinogenic to humans[13] EU Carcinogen category 3 (EU Commission Directive 97/69/EC) – substances regarded as if they are carcinogenic to humans. This classification does not apply to fibres with a geometric mean diameter >6μm[14] Report by EC suggests that glass wool fibres are likely to pose a lower risk of pulmonary fibrosis, lung cancer and mesothelioma than chrysotile[24] NOHSC exposure standard = 0.5 f/mL[25] NOHSC Code of Practice available (NOHSC, 1990)
Glass fibre	Causes mesothelioma in experimental animals[22] Carcinogenic potency of glass fibres and asbestos fibres in humans has been reported to be similar[10]	IARC Carcinogen group 3 (glass filaments)- cannot be classified as to its carcinogenicity in humans[27] NOHSC exposure standard for superfine glass fibre = 0.5 f/mL[25]

Table 36 - Health effects of alternative materials used in friction products and gaskets (cont.)

Alternative material	Health Effects	Comment
Mineral (rock/slag) wool	Excess cancers of trachea, bronchus and lung detected among (rock/slag wool) production workers[9]	IARC Carcinogen group 2B – possibly carcinogenic to humans[13]
	No excess lung tumour incidence in a study of thermal insulation manufacturers[19]	EU Carcinogen category 3 (EU Commission Directive 97/69/EC) – substances regarded as if they are carcinogenic to humans[14]. This classification does not apply to fibres with a geometric mean diameter>6μm.
	Comparative (between rock wool and chrysotile) carcinogenicity studies in rats indicated chrysotile to be a much more potent tumourigen[17]	Epidemiological studies have shown no evidence of pulmonary fibrosis, lung cancer or pleural disease in the Australian glass and rock wool industry[24]
	Intraperitoneal administration of German slag wool and German and Swedish rockwools produced tumours in rats[18]	NOHSC exposure standard = 0.5 f/mL[25]
	No mesotheliomas or significant increase in lung tumours seen in rats exposed to rock wool[7]	NOHSC Code of Practice available (NOHSC 1990)
Refractory ceramic fibres (RCFs)	Evidence of fibrogenicity and carcinogenicity (including mesothelioma in rats only) in rats and hamsters following inhalation exposure to MMVF and RCF-1 fibre types[15, 16]	IARC Carcinogen group 2B – possibly carcinogenic to humans[13]
(Inorganic fibres based on silicon, alumina, zirconia and boron)	No evidence of fibrosis or other adverse lung conditions in Australian RCF manufacturing plants[29]	EU Carcinogen category 2 (EU Commission Directive 97/69/EC) – substances regarded as if they are carcinogenic to humans[14]. This classification does not apply to fibres with a geometric mean diameter >6μm.
		NOHSC exposure standard = 0.5 f/mL[25]
		NOHSC Code of Practice available (NOHSC 1990)

Table 36 - Health effects of alternative materials used in friction products and gaskets (cont.)

Alternative material	Health Effects	Comment
Titanates (commercial forms are: potassium titanate; octatitanate and hexatitanate)	Evidence (limited) of tumourigenicity in rats and hamsters from inhalation of potassium octatitanate[21] Potassium titanate induced mesothelioma in hamsters but not in guinea pigs[24]	IARC Carcinogen group 3 (for TiO_2) - cannot be classified as to its carcinogenicity in humans[27] NOHSC exposure standard for TiO_2 particles = 10 mg/m^3 [25] Studies have shown that titanium dioxide acts synergistically with chrysotile fibres in the induction of lung tumours and pleural mesothelioma[7] US EPA have currently imposed a 'usage consent order' on hexatitanate fibres
Wollastonite (hard crystalline form of calcium silicate)	Evidence of lung fibrosis, pleural thickening and chronic bronchitis in humans[20] Fibrogenic in rat studies. Similar potency to crocidolite[26] Induction of pleural sarcomas in implantation study[27]. Effects on lung macrophages and erythrolytic effects in animal studies[26]	IARC Carcinogen group 3 - cannot be classified as to its carcinogenicity in humans[27] Radiological examinations have suggested that inhaled wollastonite in miners may cause pleural findings similar to those induced by asbestos but to a lesser extent[28]. NOHSC exposure standard for SiO_2 (respirable quartz) = 0.2mg/m^3

[1]ILO (1989); [2]Lee et al., (1988); [3]Reinhardt (1980); [4]Marsh et al., (1994); [5]Owen et al., 1986;
[7]Warheit et al; (1994 and 1995); [8]Troitskaya (1988); [9]Saracci et al., (1984); [10]Infante et al., (1994); [11]IPCS (1993); [12]IARC (1997);
[13]IARC (1988); [14]EU (1997); [15]Rutten et al. (1994); [16]Davis et al (1983); [17] Le Bouffant et al., (1984) & Wagner et al., (1984);
[18]Pott et al (1987); [19]Bunn et al (1993) & Rossiter (1994); [20]Huuskonen et al. (1983); [21]Lee et al., (1985); [22]Pott et al., (1987); [23]Hodgson et al (1989); [24]EC (1997); [25]NOHSC (1995d);
[26]Cambelova and Juck (1994); [27]IARC (1987); [28]Huuskonen (1995); [29]Rogers and Fornasari (1988)

12. Secondary Notification

Under Section 65 of the Act, the secondary notification of chrysotile may be required where an applicant or other introducer (importer) of chrysotile and/or chrysotile-containing products, becomes aware of any circumstances which may warrant a reassessment of its hazards and risks. Specific circumstances include:

a) the application/function of chrysotile or chrysotile-containing products has changed or is likely to change. In this regard, notice should be paid to section 14.2.(c) of this report;

b) the usage and/or the amount of chrysotile or chrysotile-containing products introduced into Australia has increased or is likely to increase, significantly;

c) the conditions of use are varied, in such a way that greater exposure (to workers or general public) to chrysotile fibres may occur; and

d) additional information has become available to the applicant/notifier as to the adverse health and/or environmental effects of chrysotile.

The Director must be notified within 28 days of the applicant/notifier becoming aware of any of the above circumstances.

13. Discussion and Conclusions

13.1 Scope of the assessment

This report has focused on: the occupational, public health and environmental risks associated with current uses and applications of chrysotile in Australia.

In particular, the assessment has focused on the importation of chrysotile for manufacture of friction products and gaskets together with the use of these products in a variety of 'down stream' industrial/occupational sectors. Also assessed was the use of chrysotile as an additive in a specialty epoxy resin adhesive.

Assessment information was obtained from a number of sources. Information on imports/exports of raw asbestos/chrysotile and products were obtained from Australian Customs Service (ACS) and Australian Bureau of Statistics (ABS). Data (including exposure monitoring, production process details, risk management strategies and copies of labels and MSDS) were provided by Applicants (i.e., manufacturers of chrysotile products) and end users (in particular the Automotive and Aircraft industries). Much of the information on end use of friction products and gaskets and substitute (alternative) products was obtained from a NICNAS 'Automotive Aftermarket Survey' which incorporated an exposure monitoring study carried out by NOHSC. Information on Australian and overseas regulation/legislation was obtained through a NICNAS commissioned consultancy, which included an evaluation of mechanisms for restricting uses and importation of chrysotile-containing products.

13.2 Current use in Australia

Over the past 15-20 years, asbestos consumption worldwide has generally declined, especially in the US and European markets.

In Australia, the mining of asbestos (all forms) ceased in 1983. Asbestos (all forms) has not been exported from Australia since 1984. Chrysotile is the only form of raw asbestos being imported into Australia (by 3 companies) and has remained at approximately 1-2 thousand tonnes per year over the past decade, Canada being the sole source of these imports. Despite the increased importation of non-asbestos products over the past few years, imports of asbestos (assumed to be mainly chrysotile) products, particularly friction products and gaskets, do not appear (see section 5.2.3 for qualification) to be declining.

Asbestos is still present in the general Australian community from a range of past uses, which have been carried out for substantial periods of time. However, assessment of exposure from past uses was considered outside the scope of this PEC Report as they are adequately dealt with by local government authorities and under existing regulation and controls. Examples of some of these past uses are provided in Section 5 of this report.

In Australia imports of raw chrysotile are used mainly in the manufacture of friction materials and CAF sheeting for gasket production with a small quantity being used in the manufacture of a ‘non-sag’ additive in an epoxy resin adhesive. All these uses, according to manufacturers, are being phased out**.**

Brake linings and gaskets were found to be the main asbestos products imported for use in Australia. Most clutch facings (approximately 99%) for both automotive and industrial applications are now asbestos free. Chrysotile brake linings are imported for industrial applications and use in passenger motor vehicles, although most linings imported for these applications are non-asbestos. The use of brake blocks in Australia is declining; the predominant use of which was found to be for industrial applications (e.g. railway industry and mining equipment). A significant percentage of these brake blocks are non-asbestos. Customs data do not permit differentiation between asbestos and non-asbestos gaskets. Investigations indicated that a significant number of non-asbestos gaskets are being used for industrial applications, however there continues to be large numbers of asbestos gaskets still used.

A small number of ‘one-off’ uses for asbestos products were also identified. These products include blades in high vacuum pumps, asbestos yarn in packing, asbestos gloves and asbestos washers for oil flame safety lamps (used by miners). Investigations indicate that importation of asbestos fibre cement products is very unlikely.

In the new vehicle importing and manufacturing industries only one company reported the use of asbestos ‘original’ equipment (in two of their current models). The remaining companies surveyed, used non-asbestos original equipment. The majority of these companies reported that they have policies in place regarding not using asbestos products.

The majority of industrial equipment and machinery, such as agricultural machinery, have non-asbestos original equipment. A significant number of these companies use non-asbestos parts in both superseded and new equipment and machinery. Most of these companies stopped using asbestos parts in the late 1980s.

In the aircraft industry, asbestos parts are still being used in new and older aircraft (e.g., gaskets and seals). However, in this industry there is a continued effort towards the identification of possible substitutes.

13.3 Effects of concern

Chrysotile is a known human carcinogen and has been classified as such by NOHSC. As with other forms of asbestos, chrysotile can cause asbestosis, lung cancer and mesothelioma in humans and animals in a dose related manner. The Australia Mesothelioma Program reports that Australia has the highest incidence of mesothelioma in the world (Leigh et al., 1997).

Controversy exists over the potency of chrysotile in relation to other forms of asbestos (crocidolite, amosite and tremolite) and whether asbestosis is a prerequisite for cancer and hence, whether a level of exposure for chrysotile exists, below which there would be no risk to human health (i.e., an exposure threshold for carcinogenic effects). As such, linear extrapolation methodology has been used to provide a conservative estimate of risk.

Risk estimates for lung cancer in workers appear to be dependent on both cumulative exposure and the type of industry where exposure has occurred. NOHSC (NOHSC, 1995a) has estimated the lifetime risk of lung cancer, based on the best available epidemiological data (from friction products industries overseas) as up to 173 additional cancers per 100,000 workers exposed to a daily average of 1 chrysotile fibre per mL. Extrapolation for lower exposures provides lifetime risk estimates (per 100,000 population) of 86 and 17 for exposure to 0.5 and 0.1 f/mL, respectively, although estimates by US NIOSH and OSHA are between 4 and 30 times higher (Lash, 1997; Stayner et al 1997). There are many confounding factors surrounding risk estimates for chrysotile exposure, the most important of which are; the possibility of a threshold effect, possible co-exposure to other fibre types, inaccurate estimates of historical exposures and the influence of tobacco smoking.

Conclusions by scientific experts in a recent consensus report (see section 10.2.1) were: that all asbestos fibres can cause mesothelioma, but amphiboles are more potent carcinogens for the mesothelium; that low level exposure to asbestos is sufficient to cause mesothelioma; that cumulative exposure to 25 fibre-years (fibre.year/mL) is sufficient to cause lung cancer and that asbestosis is not a necessary prerequisite for lung cancer.

13.4 Exposures arising from current use

13.4.1 Occupational

Exposures of most concern are those where friable chrysotile may be generated. Occupational exposure may arise from the manufacture of CAF sheeting and other products (mainly friction products) and during processing and end-use (replacement) of these products, where public exposure may also occur. The major route of exposure is inhalation.

Air monitoring data were provided by two producers of chrysotile products, Bendix Mintex and Richard Klinger. Data for the period 1992 to 1997 (for Bendix Mintex), indicated that more than 80% of personal samples were less than 0.1 f/mL. Only 2 samples during this period exceeded 0.5 f/mL. Monitoring data (1991-96) at Richard Klinger (Perth site, where raw chrysotile is handled), indicated that approximately 60% of the personal air samples were less than 0.1 f/mL, with only one sample exceeding 0.5 f/mL. Personal and static samples for the years 1989, 1991, 1993 and 1995 at Richard Klinger (Melbourne site, where production of gaskets takes place) were all less than 0.05 f/mL (static exposures below 0.01 f/mL). Air monitoring data from other sources were also assessed, which included an automotive aftermarket survey of service garages in Western Australia where exposure levels were found to be less than 0.1 f/mL.

Vivacity Engineering, who manufacture an epoxy resin adhesive containing chrysotile, has not conducted air monitoring during manufacturing processes. However, once in place, the hardened adhesive is not considered to be of concern.

The NICNAS Automotive Aftermarket Survey showed that exposure to friable asbestos is highest in the brake bonding industry during grinding of brake shoes and cutting of brake linings. The highest personal monitoring result obtained was 0.16 f/mL, during machining of brake shoes. Work in the brake bonding industry is declining due to the availability of brake pad and clutch kits (preformed to standard sizes) which do not require modification before installation. However it was reported that 90% of current activities in this industry sector involve asbestos-containing material.

International monitoring results in service garages indicated exposure levels were generally below 0.2 f/mL. Data for personal and static short-term sampling in workshops involved in the removal (wet) and replacement of asbestos gaskets were <0.05 and <0.03 f/mL respectively. However, higher exposure levels were noted during the 'dry' removal of gaskets (up to 1.4 f/mL).

Both national and international data indicate that present exposure levels are lower than in the past. Reduced exposure levels could be due to increased awareness of the hazardous effects of chrysotile among workers and/or due to implementation of regulatory controls and better work practices (e.g. prohibition of use of compressed air to blow asbestos dust and diminished use of grinders) during brake and clutch servicing.

Monitoring results also indicate that over the past decade, the majority of exposures were below the current NOHSC national exposure standard (1 f/mL) for chrysotile (this standard is under review - see section 13.5). However, it should be noted that this standard relates to exposures where chrysotile is the only asbestos fibre present. Where other forms of asbestos (e.g., amosite or crocidolite) are present or where the composition is unknown, the NOHSC TWA exposure standard is 0.1 f/mL (NOHSC, 1995d).

13.4.2 Public

The major source of public exposure is from chrysotile dusts generated by vehicle braking, although the level of exposure is very low. Overseas and Australian studies showed very low air levels of chrysotile fibres at busy intersections (less than 0.01 f/mL) or freeway exits (0.5 particles/mL), generated by braking vehicles. At a location of 30 metres from the nearest traffic, air levels were below the limit of detection. There are no data on exposure of home mechanics during the changing of brake pads and shoes. However, the time-weighted exposure of home mechanics is unlikely to be higher than that of workers in automotive brake service centres.

13.4.3 Environment

When chrysotile is encapsulated in end use products such as brake linings and epoxy-resin adhesives, it is unlikely that fibres will be in a form where an environmental hazard is posed. Based on available data for Australia, it can be predicted that the manner of use of chrysotile (including release from driving and wastes from manufacturing) as outlined in this report, will result in a low exposure and hazard to the environment.

13.5 Current regulation and risk management

13.5.1 Australia

In Australia, legislation is currently in place that restricts or controls activities involving use of asbestos. Chrysotile is regulated (usually under the definition of asbestos) through various State/Territory regulations relating to dangerous goods (transport), OHS and the environment. In addition, local governments have specific requirements for building and construction work involving asbestos.

Current prohibitions on use/importation of asbestos and products relate solely to other asbestos types (mainly amphiboles), and in some cases specifically exclude chrysotile. In addition, the extent to which asbestos products (articles) are regulated under current legislation is often unclear due to differences in definitions (e.g., asbestos material, and asbestos process).

Chrysotile is regulated in the workplace under hazardous substances legislation enacted by the Commonwealth, States and Territories. This is based on the NOHSC *Hazardous Substances Model Regulations*, which address issues/requirements such as control measures, labeling, MSDS, exposure standards, classification and scheduling and health surveillance.

The NOHSC national exposure standard for chrysotile is 1 f/mL, however the States and Territories have not uniformly adopted this. In March 1993, NOHSC noted information in a report on the levels of lung cancer risk presented by chrysotile and its application to various industries. Since this time the national exposure standard for chrysotile has been under review[24] (with public comment sought on proposed standards of 1 f/mL, 0. 5 f/mL and 0.1 f/mL).

From the exposure data gathered, it can be concluded that OHS control measures are available to control exposure to below current national and State/Territory exposure standards. In the majority of workplaces studied, measured exposures were at or below 0.1 f/mL[25].

Deficiencies were noted in MSDS and labels (for both raw chrysotile and products) with regard to NOHSC requirements, particularly in regard to labeling of imported products, where in some cases labels did not state that the product contained asbestos material. Induction training and health surveillance were also considered inadequate in some workplaces. With respect to health surveillance, new developments in diagnostic methods, as highlighted in the Helsinki criteria (Anon, 1997), need to be considered by NOHSC with respect to their current requirements (NOHSC, 1995c).

Other relevant NOHSC risk management activities include discussions with NHMRC in relation to prevention and treatment of asbestos-related diseases and the development of a strategy (in consultation with State/Territory jurisdictions) for dealing with asbestos-related diseases, which will include further research requirements (Labour Ministers Council, 1998).

[24] The NOHSC Hazardous Substances Sub Committee has agreed that this PEC report will supplement public comments in the review of the exposure standard for chrysotile.

[25] It should be noted that where exposure to other asbestos fibres is possible, the NOHSC exposure standard is 0.1 f/mL (NOHSC, 1995d).

With regard to road safety, regulations/standards are in place in a number of States and Territories (made under the Road Safety Act, 1986 and the Motor Vehicle Standards Act 1989) relating to the quality/testing of friction products. Examples are the Australian Design Rules, developed by the Federal Office of Road Safety (FORS) and the Australian Standard for the Evaluation of Aftermarket Disc Pads for Passenger Vehicles (Standards Australia, 1997).

13.5.2 Overseas

A number of initiatives have been undertaken at the international level to regulate asbestos use and exposure, the most notable of which are the EU Directives on the marketing and use of asbestos, which contain specific prohibitions on the use of certain chrysotile products and certain work practices. Other initiatives include the ILO Convention 162 and the Helsinki criteria that aim at providing a framework for policies to protect worker health and for recognition, attribution and screening for asbestos related diseases.

The majority of countries regulate use of asbestos and asbestos containing products. Current regulation/legislation was assessed from 13 countries. As with Australia, none of these countries have implemented absolute bans on chrysotile or chrysotile products, as relevant legislation in most countries contains either specific exemptions for certain classes/types of products or general exemptions whereby government authorities may grant exemptions on application.

In most countries assessed, vehicle manufacturers are using asbestos-free parts for new vehicles and use in older vehicles is subject to phase-out regulations. Chrysotile products are the most common exemptions in the regulations (on asbestos) assessed and friction products and gaskets are the most common class of product exempted. Most exemptions for these products are either for a prescribed period of time and/or are subject to the development/availability of suitable (i.e., safe performance and lower health hazard) alternative products for specific applications.

13.6 Alternatives

NICNAS surveys on the use of asbestos alternatives indicated that substitution is occurring in many industries and at a quickening pace. In Australia, chrysotile has been replaced for many uses, including railway blocks, cement sheeting, tubes and piping, roofing tiles, and fibre insulation/packing.

The NICNAS Aftermarket Survey found that the automotive industry is moving rapidly towards using non-asbestos products (friction products and gaskets) with almost all new vehicles now asbestos free. Replacement non-asbestos parts are reported to perform as efficiently or better than asbestos parts (Baker, 1992). However, Bendix Mintex has advised that their testing results indicate that a number of sub-standard alternative products are being introduced to the Australian market, mainly from non-Japanese Asian sources. Non-asbestos parts are also available for some superseded models and clutches. With respect to older vehicles fitted with 'asbestos original' equipment, the suitability and efficacy of using non-asbestos replacement parts was difficult to ascertain, due mainly to the fact that the testing of non-asbestos parts in most old vehicles is reportedly costly and hence limited. However, other countries would also have faced this issue during phase-out of chrysotile friction products, which should expedite the development of suitable alternatives.

Bendix Mintex indicate that they have a product range of non-asbestos brake linings which covers around 90 per cent of vehicle models in Australia, however the extent of coverage for the remaining market by other suppliers of alternative friction products was not ascertained. In order to evaluate current and future use of asbestos products in the aftermarket, an assessment of the age of vehicles in use in Australia compared to other countries was carried out. In a recently available survey it was found that Australia has the highest percentage of cars older than 10 years, which may account for the sustained importation and use of chrysotile products in the automotive industry. Other explanations for continued use (of asbestos products) are the cost differential between asbestos and non-asbestos products and the fact that there are no regulations aimed at preventing replacement of non-asbestos with asbestos parts in the aftermarket. Bendix Mintex also reports that preferences exist for asbestos products based on 'driver perception' of performance.

Investigations also revealed that in some industries, asbestos gaskets are still used, reportedly because no alternatives currently meet the use requirements. For example it is reported that no substitutes have been developed to withstand high temperature and high-pressure conditions for gasket use in the petrochemical industry. Therefore there is also a need for further research into substitutes for asbestos gaskets.

A considerable amount of information on alternatives was reviewed in this assessment. The International Programme on Chemical Safety (IPCS) and the European Union have also conducted reviews of alternative fibres. The reports of these bodies provide significant data on the safety of alternatives. There are alternatives that are considered to be safer than chrysotile. However there is a potential that alternative fibres which have similar physical properties (particularly fibre dimension) to chrysotile may exhibit similar toxicological profiles. Therefore further work is required to generate health effects data for proposed alternative materials.

Replacement of chrysotile with other substitute materials must take into consideration all available toxicological, physicochemical and performance data to ensure that the selected substitutes are likely to present lower health risks than chrysotile for each particular use, without compromising road safety.

14. Recommendations

14.1 Preamble

This section provides the recommendations arising from the PEC assessment of chrysotile. Recommendations are directed at regulatory and non-regulatory bodies and users of chrysotile products. In order to facilitate consideration of these recommendations, the following provides a summary of the critical issues to be weighed. These should form the basis of a balanced action plan.

- Chrysotile is a known human carcinogen.
- Prudent OHS policy and public health policy favors the elimination of chrysotile wherever possible and practicable.
- The main exposure to Australian workers arises from manufacture, processing and removal of friction products and gaskets. Home mechanics are also exposed during 'do-it-yourself' replacement of brake pads/shoes. Due to the friability of these products in certain applications, these exposures are of concern.
- While the majority of current workplace exposures are below the current national exposure standard for chrysotile of 1 f/mL[26], this standard is currently under review by NOHSC. This exposure standard applies to all chrysotile exposures, both from the uses within the scope of this assessment and arising from chrysotile *in situ* from past uses.
- While the level of the exposure standard, once revised, will apply to all uses and exposures, the fact that a standard exists to deal with exposures from past uses should not be seen as limiting the ability to eliminate exposures arising from current uses.
- Current overseas experience with the phasing out of chrysotile products indicates that a range of alternatives is available to suit the majority of uses. Good OHS practice dictates that use of chrysotile products should be restricted to those uses where suitable substitutes are not available, and alternatives should continue to be sought for remaining uses.
- Despite the introduction of non-asbestos parts for the new vehicle fleet, current import data indicate that the import of chrysotile products (mainly friction products and gaskets) is not decreasing.
- A phase-out of chrysotile would require an organised and collaborative approach between industry and government. This would need to take into account manufacture, import, processing, export and distribution in commerce of all chrysotile products. Consistent with experience in Australia and overseas, a 'staged' approach would be required, enabling limited exemptions where suitable alternatives are genuinely not yet available, and taking into account health and road safety issues. In general, the use of time frames for phase-out provide an essential incentive towards development of alternatives.

[26] It should be noted that where exposure to other asbestos fibres is possible, the NOHSC exposure standard is 0.1 f/mL (NOHSC 1995d).

- Worker exposure may also arise from removal of friction and gasket products fitted by members of the general public (e.g., during home car maintenance). Compliance difficulties would be expected if use sectors were not treated similarly with respect to access to chrysotile products. A phase-out of chrysotile would need to encompass both workplace and public use.
- Best practice must be implemented to minimise occupational and public exposure, and to minimise environmental impact, over the remaining period(s) of use.
- A risk reduction strategy using all available and appropriate measures is required to ensure that the risks posed by chrysotile are continually reduced and eliminated wherever possible.

14.2 Recommendations

Recommendation 1: Phase-out (importation and local manufacture)

It is recommended that the uses of chrysotile in Australia, including manufacture for the purpose of export, be phased out over time, with the period of phase out to be determined by the relevant regulatory authorities.

In achieving this it is further recommended that:

a) Specific phase-out periods should be set, with stages (over the shortest possible period of time) to encourage and reflect the availability and suitability of alternatives.

b) Action is taken in the immediate future to prohibit the replacement of worn non-chrysotile original equipment with chrysotile products, as alternatives are now available.

c) No new uses of chrysotile or chrysotile products should be introduced (i.e., an immediate prohibition on new uses).

d) Occupational health and safety authorities take the lead role in considering this recommendation and specific strategies to implement it as worker health is identified as the major concern. This role would require involvement of other relevant authorities, including road safety authorities.

e) That NOSHC consider use of the existing hazardous substances control framework in order to avoid adding to the numerous existing pieces of regulation for asbestos. This would enable controls over both supply and workplace use. It would also enable any necessary Regulatory Impact Statement (including road safety issues) to be undertaken. This mechanism would need to be supplemented by controls over supply for public use by the relevant authorities.

To facilitate any phase out it is further recommended that:

f) Substitution of chrysotile by less hazardous materials is facilitated by dissemination of information to industry, workers and the public about suitable alternatives for specific uses. In particular, it is recommended that data on performance testing be obtained by importers/distributors of alternative friction products prior to release of any new products into the

Australian marketplace. In this respect, industry bodies can make a significant contribution to the recommended phase-out.

g) The assistance of the Australian Customs Service and Australian Bureau of Statistics is sought to identify necessary changes required for compliance as currently, there are shortcomings in the customs coding of imported chrysotile products. This would include improvements to enable distinction between asbestos and non-asbestos materials, for all categories of products and to reduce the possibility of misclassification. Consideration should also be given to using similar tariff classifications/codes for exports and imports.

h) Activities are initiated to promote maximal use of non-asbestos friction materials where these have been specifically identified as substitutes. To facilitate this, guidance information should be made available for chrysotile original equipment vehicles (as with new vehicles) which should include details of suitable non-asbestos friction materials. Participation of the manufacturing and aftermarket industry, insurance companies and motoring organisations in such activities would lead to a more extensive penetration of the aftermarket.

Recommendation 2: NOHSC Hazardous Substances Framework

It is recommended that a number of areas of the NOHSC Hazardous Substances Framework, which includes the Model Regulations for the Control of Workplace Hazardous Substances, be considered for review and update, as follows:

a) ***Classification.*** Prior to publication of this report the EU updated its classification for chrysotile, replacing R45 (may cause cancer) by R49 (may cause cancer by inhalation). This revised classification is supported and its inclusion in the NOHSC List of Designated Hazardous Substances will need to be adopted by NOHSC according to the usual process.

b) ***Exposure standards***. It is recommended that NOHSC consider this report in the context of its current review of the exposure standard for chrysotile. In particular noting, (i) for health hazards, that there is considered to be no safe level of exposure to chrysotile, and (ii) the exposure data collected for this report from Australian workplaces.

Priority consideration should also be given to the development of standards for asbestos alternative materials that do not have a national exposure standard, and maintenance of exposure standards where they already exist. In particular, for alternative fibres that are currently being used in friction products and gaskets.

c) ***Methodology for fibre analysis***. In conjunction with consideration of the exposure standard, noting that the analytical methods differ in their level of detection of chrysotile, it is recommended that the adequacy of the current standard method of analysis should be considered. This may be required to support any change in the exposure standards for chrysotile and/or alternative fibres.

d) ***Health surveillance guidelines***. It is recommended that NOHSC review these guidelines to ensure they are up to date with current knowledge on detection of chrysotile-related health effects in workers.

e) ***Carcinogen regulations***. Consideration of any phase-out recommendation (see Recommendation 1) will require update and review of the current scheduling of chrysotile in Schedule 2 to the Model Carcinogenic Substances Regulations.

Recommendation 3: Implementation of Workplace controls

It is recommended that manufacturers, suppliers and users comply with the requirements of the NOHSC Hazardous Substance Model Regulations, as adopted by States/Territories, in particular:

a) ***Classification***. The review confirms the current classification of chrysotile as a carcinogen category 1 (R45), with danger of serious damage to health from prolonged exposure (R48), as listed in the NOHSC *List of Designated Hazardous Substances.* However note the foreshadowed change in Recommendation 2a) above.

b) ***MSDS***. Noting major inadequacies in some existing MSDS, MSDS should be updated and reviewed to comply with requirements. This should include ensuring that adequate information is provided on ingredients, health hazards, the Australian exposure standard, personal protective equipment, safe handling and disposal and contact details for further information. Where MSDS are not provided for chrysotile products, sufficient information on hazards, safe handling and precautions for use must be present on the label and/or supplementary information (e.g. information sheets) present in the product packaging. The latter approach would also ensure adequate information for use by the general public, where MSDS would not be required by legislation.

c) ***Labeling***. Noting the inadequacies of labeling identified in this assessment, labels should be reviewed and updated to ensure they comply with requirements. In accordance with the Model Regulations, this is a duty of the manufacturers and importers. In the workplace, if it is not clear whether a product is asbestos or non-asbestos, procedures must be in place to ensure that the product is handled as if it were asbestos and labeling solutions should be sought to assist identification of types of hazardous fibres present. This is particularly relevant for the aftermarket industry, due to the need to remove and dispose of worn parts and in some cases to further process replacement parts (e.g. brake bonding).

d) ***Exposure monitoring***. Should be continued to enable exposure to be reduced to the minimum feasible level and in accordance with the relevant exposure standard. This includes those applications of asbestos/chrysotile identified in this report where little if any exposure monitoring data were available. In conjunction with review of the NOHSC national exposure standard for chrysotile, it is recommended that relevant State/Territory and other Commonwealth regulatory authorities provide advice on the work situations were exposure monitoring is indicated. This will be dependent on the standard set, and should also take into account the representative exposure data provided in this report.

In addition, applications where workers are potentially exposed to alternative 'non-asbestos' fibres should also be monitored, with regard to compliance with exposure standards (NOHSC 1995d).

e) ***Engineering controls and safe work practices***. It is recommended that the current controls and practices in workplaces be reviewed and updated, in order to eliminate, wherever possible, exposure in the workplace.

f) ***Health surveillance***. It is recommended that health surveillance be carried out in accordance with the NOHSC Health Surveillance Guidelines for 'chrysotile'.

g) ***Training.*** It is recommended that those employees who are potentially exposed to chrysotile are provided with an adequate induction and training program, which should incorporate:

- safe work practices and procedures to be followed, including correct use and maintenance of control measures, disposal of asbestos containing waste and cleaning of overalls/clothing;
- proper use and fitting of personal protective equipment;
- provision of MSDS and explanation of information contained in MSDS and labels; and
- nature of health surveillance required.

Recommendation 4: Public health and safe disposal

a) Continued progress towards a phase-out of chrysotile in favour of less hazardous materials is supported. This phase out should be conducted with care so that greater risks to road safety are not introduced through inferior performance of substitute materials.

b) It is recommended that a warning be carried on the label/packaging of brake pads/shoes containing asbestos/chrysotile that are available to the public for 'do it yourself' repair and maintenance. A suggested wording is as follows:

Warning - this product contains asbestos. When exchanging brake pads/shoes, do not inhale brake-housing dusts. Do not blow or use compressed air to remove dusts from the housing, as repeated exposure to the dust may cause lung disease, including cancer.

c) Risk management options need to address disposal of used chrysotile containing products (e.g., provision of re-sealable bag - for disposal of old parts - could be enclosed with asbestos friction products available to consumers)**.**

Recommendation 5: Environmental disposal measures

a) Disposal of used asbestos parts to standard municipal landfills is acceptable. However it is recommended that all workplace asbestos waste be collected and disposed of by licensed hazardous waste contractors.

b) It is recommended that handling of chrysotile waste and disposal of used chrysotile packaging is in accordance with the following:

For friable asbestos/chrysotile collected under dust extraction techniques:

Waste collected under dust extraction methods should be put in properly labeled translucent bags (polyethylene) with a minimum thickness of 100 microns. Bags should be sealed immediately after filling, and stored in an area where they cannot be broken or otherwise disturbed. They should be collected and disposed of by a licensed hazardous waste contractor.

For waste bags of imported raw chrysotile:

Sacks or bags which contain loose asbestos fibres, or mixtures including loose asbestos fibres, should be deposited in a suitable receptacle, under a dust extraction hood immediately after being emptied. Where possible, the bags should be shredded and recycled in the process.

For disposal, bags should be sealed in an impermeable outer bag and deposited in an appropriate landfill. A further method of plastic bag disposal is melting. By melting the empty bags and wrappers, the asbestos residue becomes embedded in the melted plastic. Under no circumstance should bags be reused for packing or other purposes.

Recommendation 6: Public Information

It is recommended that appropriate measures are taken to disseminate information in order to provide information to the community with regard to issues addressed in Recommendations 1b, 3, 4 and 5. Suggestions on this issue in the public comment phase for the draft PEC report were that such measures could be addressed in a campaign facilitated by participation of unions, industry, motoring associations and health authorities. The type of activity required will be dependent on the risk management action to be implemented.

Recommendation 7: Secondary notification

The National *Industrial Chemical (Notification and Assessment) Act 1989* prescribes circumstances where secondary notification is required. Examples are provided in Section 12 of this report.

Recommendation 8: Data gaps and further studies/research requirements

In general, the following research is strongly supported:

a) It is recommended that research into alternatives to chrysotile should actively continue, taking into account the need to ensure that the relevant hazard information is generated to ensure that proposed alternatives present reduced risks to health and the environment.

b) At present it is not possible to identify a level of chrysotile exposure below which there would be no risk to human health. Further information on this, including full elucidation of the mechanism of action for chrysotile induced lung disease and mesothelioma, would assist regulatory decision-making.

APPENDIX 1

LIST OF APPLICANTS

Bendix Mintex Pty Ltd
Elizabeth Street
Ballarat
Vic 3353

Richard Klinger Pty Ltd
138-146 Browns Road
Noble Park
Melbourne
Vic 3174

Vivacity Engineering Pty Ltd
3 Sefton Road
Thornleigh
NSW 2120

APPENDIX 2

SOURCES OF INFORMATION

Information/data submitted by the applicants

- Quantities of 'raw' chrysotile imported into Australia;
- Uses of chrysotile by the applicant;
- Description of the persons to whom the applicant has supplied or intends to supply chrysotile and chrysotile products;
- Methods used or proposed to be used by the applicant in handling chrysotile and chrysotile products;
- Occupational exposure data;
- Occupational health monitoring – atmospheric monitoring and health surveillance
- Information on prevention of exposure to chrysotile;
- Release of chrysotile to environment;
- Transportation and storage;
- Disposal;
- Hazard communication – MSDS, labels etc.;
- Alternatives (substitutes) for chrysotile/asbestos, their composition and efficacy; and
- Reference papers from overseas sources relating to health effects of chrysotile, air monitoring, information on alternatives and the use of chrysotile products in the aftermarket.

Other sources of information

Other sources of information included:

- CD-ROM database searches;
- Australian regulatory agencies and institutions, including NOHSC, FORS, FCAI, ABS, ACS, AAA and Monash University;
- Overseas regulatory agencies, including UK Health and Safety Executive, USEPA, Ministry of Social Affairs and Health in Finland, National Institute of Health and Medical Research in France, Swedish National Chemicals Inspectorate; and
- Institutions such as The Asbestos Institute and the Asbestos International Association.

Australian Bureau of Statistics (ABS) and Australian Customs Services (ACS) data

Information on quantities of asbestos and asbestos products (import and export) was retrieved from the Australian Bureau of Statistics (ABS) and Australian Customs Service (ACS).

There are four major customs tariff categories, including subcategories, relating to the import of asbestos and asbestos products. The customs categories, product types and quantities imported in 1997 are provided in Appendix 3, figures 1A-1D. These four categories are:

- **2524 - Asbestos**
  category includes chrysotile (white asbestos) and other asbestos types (Appendix 3, Fig. 1A);

- **6811 - Articles of asbestos-cement, of cellulose fibre-cement or the like**
  may or may not contain asbestos (Appendix 3, Fig. 1B);

- **6812 - Asbestos products (including gaskets) other than fibre cement products and friction materials** (Appendix 3, Fig. 1C); and

- **6813 - Friction material and articles thereof** (Appendix 3, Fig. 1D).

ABS data is the main source of Australia's foreign trade statistics. ABS obtains data direct from ACS which is then analysed and collated (on a statistical month basis) according to tariff code (classification), month, port of import and country of export.

ACS receives documentation submitted by exporters and importers (or their agents), as required by the *Customs Act 1901*, Section 113 and Section 168. The documentation includes information about the type, quantity and value of goods being imported and exported. This includes names of importer, overseas suppliers and description of product being imported. Information provided in the documentation is used by ACS to assess and collect Customs duty and other revenue payable on imported and exported goods and to facilitate the monitoring and control of the movement of goods into and out of Australia. Non-confidential information is available to the public. Confidentiality restrictions are placed on the release of statistics for certain commodities to ensure the confidentiality of information relating to individual importers. These restrictions do not affect total export and import figures, but they can affect statistics at all levels in country, commodity State and port tables.

ACS and ABS classify information on imported and exported goods according to an international convention (World Customs Organisation's Harmonised Commodity Description and Coding System). This classification system cannot, of necessity, individually distinguish between every item of commerce and it is common for codes to include only the major sub-groupings of a particular type/group of product, such as chemicals. Australia collects more detail than is provided for at the international level by extending the 6-digit Tariff to a 10 digit description for imports.

Survey information (methodology)

Survey 1. Survey on importation of chrysotile products (6811, 6812, 6813)

Surveys of importers were conducted seeking information on the importation and use of asbestos products in Australia. Companies that were identified from the three customs categories for asbestos products (6811, 6812, 6813) using 1994 ACS data, were surveyed.

Investigation of the import levels and use of automotive friction materials (e.g. brake lining, brake disc pads, clutch facings and brake blocks) and gaskets in Australia was limited to New South Wales and Western Australia due to the large number of import companies identified for all of Australia.

Survey forms were sent to 263 companies who according to customs data, could have been importing asbestos containing products, and responses were received from 137 companies, a response rate of 52%. Appendix 4 provides a summary of the results of the surveys.

This information was supplemented by additional survey work in the automotive manufacturing and importing industry, the automotive aftermarket industry and by directly contacting companies that may be using chrysotile products in industrial equipment and machinery, aircraft industry and other industries (e.g. coal and mining industry).

Other uses of asbestos products in Australia (i.e. excluding friction materials and gaskets) were also investigated. Customs data indicated the ‘other products’ included fabricated asbestos fibres, yarn and thread, cords and string, woven or knitted fabric, clothing and accessories, footwear and headgear, paper, millboard and felt. This survey was carried out nationally.

These surveys sought information on:

- type of asbestos products being imported and end-use of the products;
- alternative (non-asbestos) products in use;
- modification of asbestos products and the processes involved;
- control measures in place when using asbestos products;
- disposal of asbestos materials; and
- company policies in regard to the use of asbestos.

New car manufacturers and importers listed in these customs categories (6811, 6812 & 6813) were surveyed separately (survey 2).

Survey 2. Survey of companies importing and manufacturing new vehicles

A survey of importers and manufacturers of new vehicles was carried out in collaboration with the Federal Chamber of Automotive Industries (FCAI). The aims of the survey were to:

- provide an overview of the current market applications of asbestos and non-asbestos products in the automotive industry for new vehicles;
- identify situations where alternatives are available;
- identify company policies regarding asbestos products.

This survey investigated a range of vehicle types including passenger cars, commercial trucks, buses, motorcycles, heavy trucks and coaches.

A total of 26 companies were surveyed, which included the top 10 car manufacturing and importing companies in Australia namely Ford, Holden, Toyota, Mitsubishi, Hyundai, Nissan, Mazda, Honda, Daewoo and Subaru (Federal Chamber of Automotive Industries, March 1997). All 26 companies responded to the survey and clarification of certain aspects of the survey was followed up by phone call. A list of the companies participating in this survey can be found in appendix 5. These companies import and manufacture a range of vehicles including passenger cars, trucks, light trucks and heavy trucks.

Survey 3. End-use aftermarket survey

A small survey of the automotive aftermarket industry was conducted to gauge the relative usage of both asbestos and non-asbestos products in garages and workshops and to assess occupational exposure to chrysotile in the workplaces. Each of the workplaces in the survey was visited. A questionnaire was completed at each workplace and air monitoring for exposure to asbestos was conducted. The workplaces surveyed in Sydney, NSW, were as follows: 5 service garages (4 car and 1 bus), 3 brake bonding workshops, and one gasket-processing workshop.

In response to the questionnaire, the employer and employees at each workshop provided information about potential exposure to chrysotile, type of work carried out, number of workers and estimated duration of exposure. Part of the survey concerned the management of risk, including control measures, training and disposal procedures. Each workshop was asked about engineering controls and safe work practices that have been implemented in the workplace to reduce exposure to asbestos.

At these workplaces, information was also sought on:

- usage of chrysotile and non-chrysotile products;
- labels and MSDS; and
- management policy and/or approach; and

Personal monitoring was conducted at all workshops using the method specified in the Asbestos Code of Practice (NOHSC, 1988), that is, membrane filter sampling (MFM) and phase-contrast optical microscopy (PCM). However, sampling was for less than the specified 4 hours as work was task orientated (therefore results were not expressed as a TWA). To supplement the personal monitoring results, a number of fixed point (static) samples were taken in the work areas. Static monitoring was also conducted in areas of the workplace away from the work areas to ascertain background fibre concentrations.

Some samples were analysed for mineral fibre types by Analytical Transmission Microscopy (ATEM) using the NIOHS/TEM/MFM1 and MFM2. The analysis was carried out using Phillips CM12 at a magnification of 8800X and fibrous minerals were analysed using Energy Dispersive x-ray analysis (EDAX) and selected area electron diffraction patterns (SAED). Fibre length and diameter were measured directly using the pre-calibrated measurement mode of the instrument. Only respirable fibres of any length were recorded i.e. those less than 3 µm diameter, including any adhering particles; all fibre lengths and diameters were recorded (NB This is different to the size of regulatory fibres, which are fibre length > 5µm and fibre diameters > 0.2 and < 3 µm).

APPENDIX 3

ANALYSIS OF 1997 AUSTRALIAN CUSTOMS DATA ON ASBESTOS AND ASBESTOS PRODUCTS

Figure 1A. Customs data for import of raw chrysotile during 1997

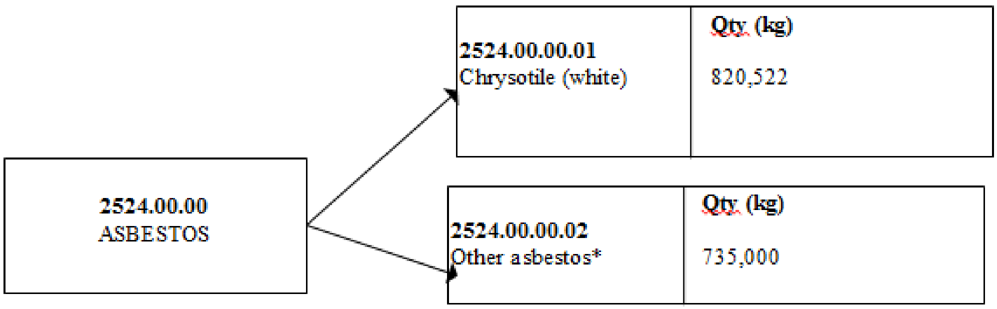


Figure 1B. Customs data for import of fibre-cement products during 1997

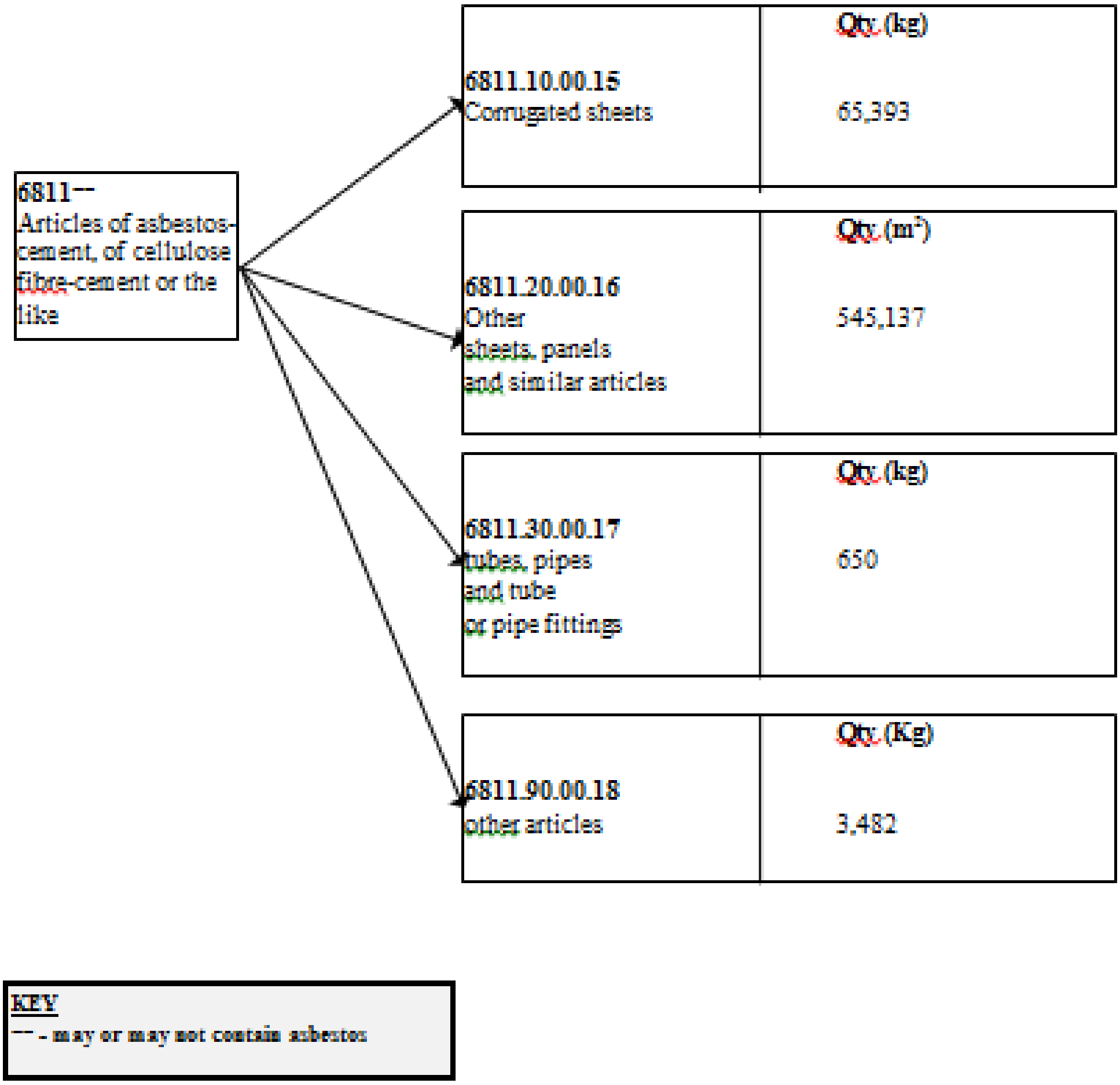


Figure 1C. Customs data for import of “other” products containing asbestos (including gaskets) during 1997

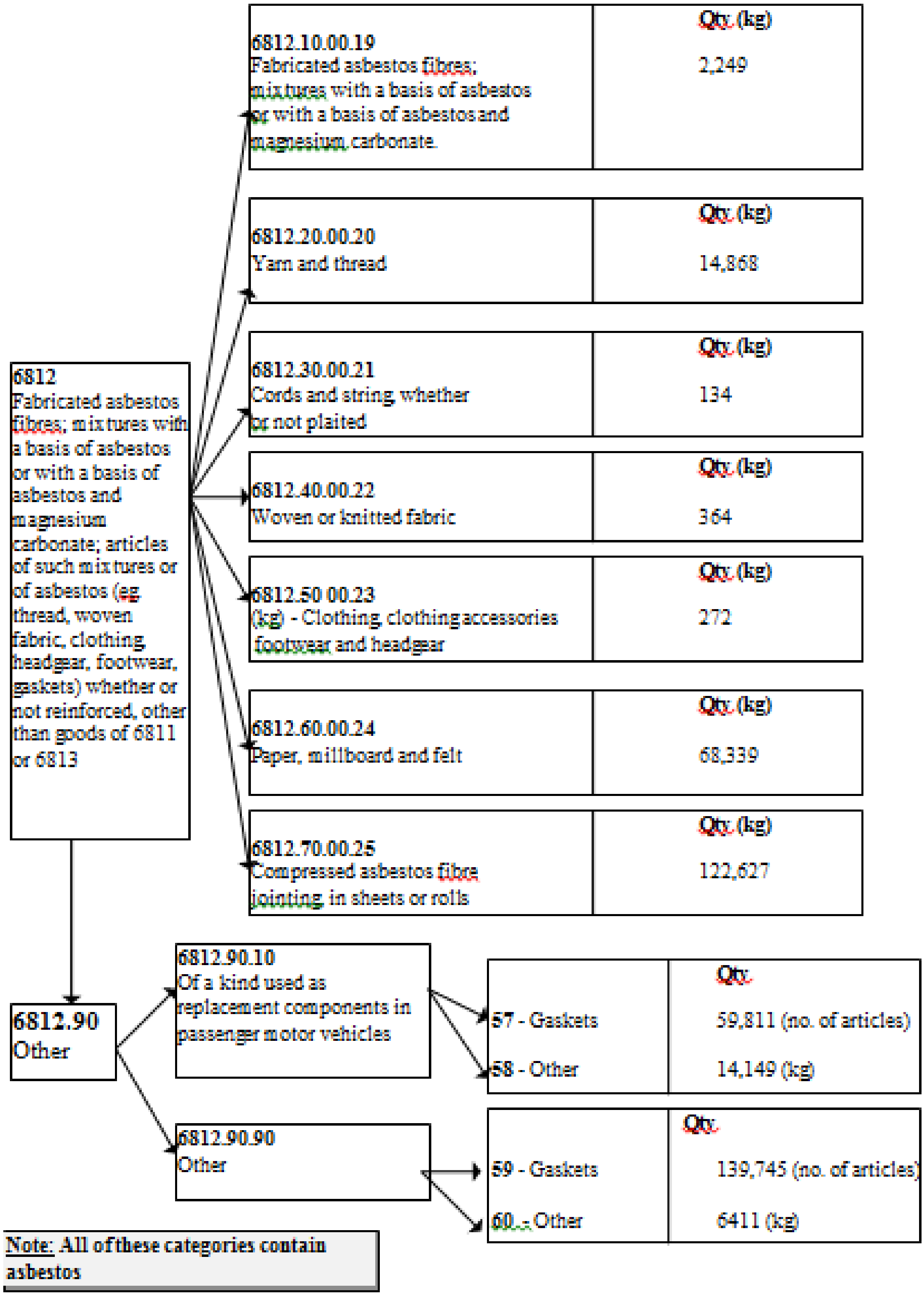
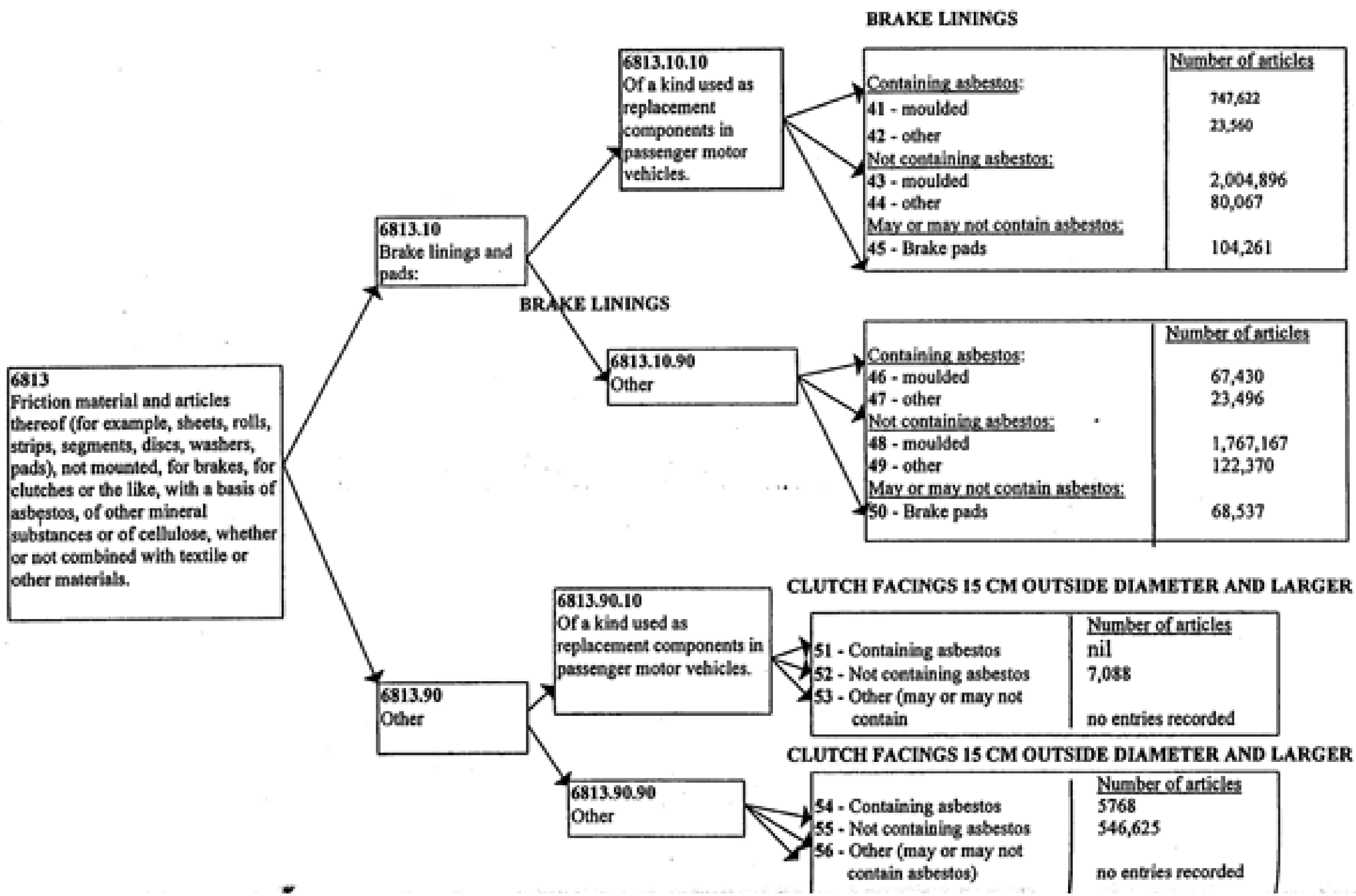


Figure 1D. Customs data for import of friction materials during 1997



Customs Tariff Code & Product type	Volume imported in 1994	Total companies	Results of survey
6812 Asbestos products other than goods of 6811 or 6813 (includes gaskets and CAF sheeting)			
6812.10.00.19 6812.20.00.20 6812.30.00.21 6812.40.00.22 6812.50.00.23 6812.60.00.24 6812.70.00.25	266,406 kg	3 3 4 4 6 4 16	• 27 surveys were sent out and 27 companies responded to the survey. Thirteen companies "not identified" • 13 companies confirmed that they imported asbestos articles. One company reported to importing asbestos yarn used in packing, one company reported to be using asbestos gloves for use with oven work in a repair workshop. The remaining companies confirmed to be importing CAF sheeting for manufacture of gaskets, for example, cylinder head gaskets, exhaust manifold gaskets and exhaust and inlet manifolds. • 2 companies were unsure of the asbestos status of their products, such as cord for model yachts and firing gloves. • 7 companies reported they were no longer using asbestos products • 5 companies reported not ever having used asbestos products. • Alternatives identified included fibre glass yarn and ceramic based woven cloth instead of asbestos yarn and non-asbestos paper and compressed non-asbestos fibre and graphite sheet instead of CAF.
Gaskets 6812.90.10.57 6812.90.90.59	155,685 (no. of articles)	131	33 surveys were sent out and only 10 companies responded. • The responses indicated that both asbestos and non-asbestos products are imported and are used in automotive and industrial applications. • At least 5 manufacturers of gaskets from CAF sheeting were identified from the survey. • Non-asbestos gaskets where found to be more common in industrial applications. • Industrial uses for non-asbestos gaskets include air tools, pipeline joints, power generation equipment, stationary diesel engines, gas diesel and gas engines, petroleum industry and waste heat boiler/power generation equipment. • Alternatives for asbestos include nitrile/glass, graphite laminate. • Customs data indicated that a significant number (~45,000) of asbestos gaskets were imported for use in passenger motor vehicles and even more (~110,000) asbestos gaskets for other uses.

Customs Tariff Code & Product type	Volume imported in 1994	Total companies	Results of survey
Other 6812.90.10.58 6812.90.90.60	24,545 kg	38	• A total of 6 surveys were sent out and 5 responses were received. 32 companies "not identified". • 1 company responded to using asbestos in washers for 'miners oil flame safety lamps'. • Remaining 4 companies reported to be importing CAF sheeting for gaskets.
6813 Friction materials and articles thereof			
Brake lining 6813.10.10.41 6813.10.10.42 6813.10.90.46 6813.10.90.47	595,382 no. of articles	78	• 16 surveys were sent out and 8 companies responded. • Survey indicated that majority of brake linings being imported are asbestos and used in the automotive industry. Most of the non-asbestos brake linings are used in industrial applications (e.g. agricultural and mining industry) and fewer in the automotive industry. • At least 10 importers of asbestos disc brake pads were identified from Customs data. Country sources for these imports include: Brazil, India, Malaysia, Taiwan, Thailand and USA.
Disc brake pads 6813.10.10.45 6813.10.90.50	266,437 no. of articles	311	• 81 surveys were sent out and 33 companies responded • ABS data did not identify whether the pads were asbestos or non-asbestos. • Survey indicated that there are more importers of non-asbestos disc brake pads than asbestos. • In the automotive industry there are similar numbers of importers of asbestos and non-asbestos products. A clear trend was evident towards the use of non-asbestos disc brake pads for industrial applications. • Industrial applications include mining equipment, hoisting equipment and agricultural tractors. • Substitutes reported was carbon fibres, aramid and semi-metallic materials.
Clutch disc (plate) 6813.90.10.51 6813.90.90.54	5350 no. of articles	5	• ABS indicated that more than 99% of imported clutch facings for use in vehicles and industrial applications are non-asbestos. • No surveys were sent out for this category, but other surveys on friction materials and articles thereof, identified the following industrial applications for non-asbestos clutch disc/plates - mining equipment and agricultural machinery.

Customs Tariff Code & Product type	Volume imported in 1994	Total companies	Results of survey
Brake blocks and other industrial friction materials 6813.90.90.56 6813.90.10.53	no entries recorded	203	• 77 surveys were sent out and 33 companies responded. • The ABS data did not indicate whether articles in this category are asbestos or non-asbestos. The survey responses indicated that the majority of brake blocks are non-asbestos and the dominant use being industrial applications e.g. railway industry. • A small number of asbestos brake blocks are still being imported for the automotive industry. • The survey also identified other industrial uses for non-asbestos friction materials e.g. friction paper, kiln feed segments for industrial kilns and clutch components for centrifugal machines.

APPENDIX 5

LIST OF COMPANIES INVOLVED IN THE 'NEW VEHICLE MANUFACTURING AND IMPORTING SURVEY'.

1. BMW Australia Ltd
2. Chrysler Jeep
3. Daewoo Automotive Australia
4. Diahatsu
5. Ford Motor Company Australia
6. General Motors - Holden
7. Honda Australia (Motorcycles and Power Equipment)
8. Honda Australia (Motor Vehicles)
9. Hyundai
10. International Trucks Australia Ltd
11. Jaguar Daimler
12. Kawasaki Motors Pty Ltd
13. Mack Trucks
14. Mazda Australia
15. Mercedes-Benz Australia
16. Mitsubishi
17. Nissan Australia
18. Rover Australia
19. Saab
20. Scania
21. Subaru
22. Suzuki Australia Pty Ltd
23. Toyota Australia
24. Volkswagen
25. Volvo Truck Australia
26. Yamaha Motor Australia

APPENDIX 6
Sample Material Safety Data Sheet for **Chrysotile (white asbestos)**

Date of issue	08 December 2003

Page	1	of Total	5

Chrysotile is classified as Hazardous according to the National Occupational health and Safety Commission's *Approved Criteria for Classifying Hazardous Substances* [NOHSC:1008(1994)].

Company details

Company name	
Address	
State	Postcode
Telephone number	Emergency telephone number
Facsimile number	Telex number

Identification

Product name	Chrysotile
Other names	White asbestos, Asbestos, Serpentine asbestos, Avibest C, Calidria RG, Cassiar AK, K6-30, Plastibest 20, Sylodex
Manufacturer's product code	
UN Number	2590
Dangerous goods class and subsidiary risk	Class 9 - Miscellaneous Dangerous Goods
Hazchem code	2X
Poisons Schedule number	None allocated
Use	Various

Physical description and properties

Appearance
Greyish-white, flexible fibres with a soft, "soapy" texture, odourless.

Boiling point
Not applicable

Freezing point
Not applicable

Vapour pressure
Not applicable

Specific Gravity
2.55

Flashpoint
Does not burn.

Flammability limits
Not applicable

Solubility in water
Not soluble

Other properties

Solubility in other liquids - Insoluble in organic solvents. May dissolve in strong mineral acids.

Stability - Very stable

Ingredients

Chemical entity	CAS Number	Proportion
Chrysotile	12001-29-5	

Health hazard information

Acute

Inhalation - High concentrations of chrysotile fibres may cause irritation of the nose and the throat.

Skin - Chrysotile is unlikely to cause irritation to the skin.

Eye - May cause irritation of the eyes.

Ingestion - Chrysotile is unlikely to cause any short-term effects on the gastrointestinal system.

Chronic

Systemic:

Prolonged exposure by inhalation may cause asbestosis (progressive scaring of lung tissue). The latency period for asbestos is usually >20 years. Symptoms begin with a gradual decrease in lung capacity.

Chrysotile is a known human carcinogen and is classified as a Category 1 carcinogen. Prolonged exposure by inhalation can cause lung cancer and mesothelioma (cancer of the chest lining or abdominal cavities). The latency period for these tumours is generally between 25 and 40 years.

Contraindications

Smoking combined with asbestos exposure results in an increased risk of lung cancer.

FIRST AID

Inhalation - Remove person from exposure - avoid becoming a casualty. Remove contaminated clothing and loosen remaining clothing. Keep patient comfortable and warm. Make sure airways are clear and monitor breathing. Contact a doctor or Poisons Information Centre immediately

Skin contact - Wash contaminated skin thoroughly with lots of water. Remove contaminated clothing and wash before re-use. Seek medical attention if irritation persists.

Eye contact - Hold the eyes open and irrigate with plenty of water for at least 15 minutes. Keep the eyelids open. Seek immediate medical attention if irritation persists.

Swallowed - Rinse mouth with water. Give plenty of water to drink. Contact a doctor or Poisons Information Centre immediately.

First aid facilities:

ADVICE TO DOCTOR - Treat symptomatically -

Precautions for use

EXPOSURE STANDARD

The NOHSC occupational standard for chrysotile is 1 f/mL and is currently under review. Chrysotile is also classified by NOHSC as a Category 1 carcinogen.

Lower exposure standards are currently in force in some States/Territories

ENGINEERING CONTROLS

Control airborne concentrations below the exposure standard.

Stringent control measures e.g. enclosure or isolation, may be necessary.

Use local exhaust ventilation system. Contaminated air should be filtered prior to exhausting to outside air.

Enclosed cutting/grinding machines to be used where relevant.

PERSONAL PROTECTION

Where engineering controls and work practices are insufficient in controlling exposure to chrysotile, then suitable personal protective equipment should be worn.

Ensure personal protective equipment complies with relevant Australian Standards (see Other Information)

Respiratory protection (at minimum a half face mask respirator) should be worn when handling raw chrysotile.

SCBA and complete protective clothing should be worn during spills.

Wear overalls to prevent accumulation of fibres on skin and clothes. Wash contaminated clothing or equipment before re-use or storage. Contaminated clothing should be washed at site (where possible).

Gloves should be worn when handling raw chrysotile or chrysotile-containing materials.

Ensure good personal hygiene.

No specific requirement for eye/face protection, but good working practice favours the wearing of protective glasses/goggles.

Safe handling information

STORAGE AND TRANSPORT

Store in sealed, correctly labelled containers (approved for asbestos storage).
Store in area where potential damage to containers is unlikely. Regular inspection for deficiencies in packaging requireed.
Storage area to be separate from populated work areas.
Restricted access to personnel to storage area.
Post appropriate warning signs.
Classified as a dangerous good and should be stored and transported in accordance with the ADG Code requirements.

Correct shipping name:	WHITE ASBESTOS
Packaging group:	III
Emergency Procedure Guide:	9B7
Special provision number:	168
Packaging method:	3.8.9

SPILLS AND DISPOSAL

In the event of a spill, restrict access to area until completion of cleanup. Ensure cleanup conducted by trained personnel. Wear appropriate protective equipment including SCBA (large spill) or half-face mask respirator (small spill). Wet down spilled material. An asbestos vacuum cleaner equipped with a high efficiency particulate aerosol (HEPA) filter may be used. Shovel into clean, dry labelled containers and seal. If polyethylene waste bags are used, they should be a minimum thickness of 100 microns and sealed in an impermeable outer bag. Where possible bags should be shredded and recycled in the process. Flush area with water. Dispose of spilled material and used asbestos parts/packaging in accordance with local and State/Territory regulations. Disposal should be carried out by a licensed hazardous waste contractor.

OTHER INFORMATION

Relevant Australian Standards:
Respiratory protection (including SCBA) – refer to AS 1319; AS 1715; AS 1716
Clothing/overalls – refer to AS 3765.1 and AS 3765.2
Gloves – refer to AS/ANZ 2161
Safety glasses – refer to AS 1336 and AS 1337
Further information:
Asbestos: Code of Practice and Guidance Notes (NOHSC 1988)
Guidelines for Health Surveillance: Asbestos (NOHSC 1995)
National Industrial Chemicals Notification and Assessment Scheme (NICNAS), Full Public Report – Priority Existing Chemical No. 9 – Chrysotile Asbestos (NOHSC 1999)
Australian Dangerous Goods (ADG) Code – 6th edition (FORS 1998)

Contact point

Contact name	Telephone number

Position title

Address

State | Postcode | Country

APPENDIX 7

ASBESTOS BANS/RESTRICTIONS IN SPECIFIC COUNTRIES

AUSTRIA

Legislation:

Ordinance of the Federal Minister of the Environment, Youth and the Family and of the Federal Minister of Labour and Social Affairs of April 10, 1990, Concerning Restrictions on the Placing on the Market, the Manufacture, Use and Labelling of Substances, Preparations and Finished Products which Contain Asbestos.

Prohibitions:

Manufacture, placing on the market and use of products containing substances, preparations or finished products of which asbestos of the amphibole group is a component (actinolite, amosite, anthophyllite, crocidolite and tremolite); and certain products containing substances, preparations or finished products of which asbestos of the chrysotile type is a component.

Seventeen classes of chrysotile product are listed as prohibited, including: toys; smoking articles, paints; putties, glues; catalytic screens and insulating means intended for us in connection with LPG-fuelled heating devices; pulverised substances and preparations in powder form dispensed by retailers; substances and preparations applied by spraying; fiber-reinforced polymers and asphalts; mortars and fillers; floor and road-surfacing materials; filters and auxiliary filter materials, except diaphragms used in electrolytic processes; light-weight construction panels (volume weight <1.0 g/cm^3); insulating materials or insulants (e.g. felts, papers, paper-boards) for fire protection, sound insulation, thermal insulation, cold insulation and moisture-proofing; thermal-protection clothing for temperature below 500 °C.

Seals and packing, and friction linings for machinery and industrial equipment are on the list, with the qualification that they may be subject to exemptions contained in the Ordinance (see below).

Brake and clutch linings for vehicles containing asbestos are prohibited from being placed on the market, if the technology and road laws allow the use of linings without asbestos of at least equivalent effectiveness, and if such linings are available. There is provision for the government to issue each year a list of vehicle types, for which linings not containing asbestos are available.

Exemptions:

Government may permit certain uses where it does not effect employee health and safety, and a where the manufacturer or importer has demonstrated by way of a State authorised expert opinion that no substitute substances are available which constitute a lower health hazard or no hazard at all, or that only asbestos-containing replacement parts can be used due to specific design conditions.

Comments:

Information provided by the Austrian government is that the publication of the list of vehicle types for which asbestos linings are permitted, has ceased to occur as there are almost no cars needing brakes or clutches made with asbestos.

Asbestos-cement products for building applications were banned from January 1994.

DENMARK

Legislation:

Order No. 660 of 24 September 1986, as amended by Order No. 984 of 11 December 1992, on Asbestos.

Prohibitions:

Prohibited to manufacture, import, use or work with asbestos or asbestos-containing material in any form.

Time limitations were implemented for the following:

1. *Until 31 December 1986*:

- manufacture of roofing and surface materials of asbestos cement for external use; use of same permitted until 30 June 1987.

2. *until 31 December 1987*:

- import of asbestos apart from crocidolite and amosite for external cement products (corrugated plates, hand-moulded goods for roofing), use of same permitted *until 30 June 1988*.

3. *until December 1989*:

- import and use of asbestos other than crocidolite or amosite in commutators.

4. *until 30 June 1989*:

- lifts with asbestos-containing friction materials.

Exemptions:

The following items were given indefinite exemption ('until further notice') from the ban:

1. manufacture, import or use of asbestos or asbestos-containing material, apart from crocidolite and amosite, for bonded gasket material (except for gaskets used for water systems with a temperature of under 110 deg C, which is prohibited);
2. closed metal asbestos packing (e.g. copper asbestos packing);
3. rubber asbestos packing and similar packing;
4. friction materials (containing max 70% asbestos); (also see comments below); and
5. bearings based on phenolic resin (containing max of 50% asbestos) for use on board ships in accordance with the requirements of the classification companies (this signifies that the use of these materials is very limited, mainly for propeller shaft bearings).

Comments:

Under Order No. 660, motor vehicles and trailers and technical equipment that are provided with asbestos-free friction linings by the manufacturer are required to use asbestos free linings when the originals are replaced. Furthermore, if other vehicles or technical equipment can be provided with asbestos-free linings according to a declaration from the manufacturer or a test report from an approved testing laboratory, then as of 30 June 1988 these were required to be used. In 1988, a regulation came into effect according to which all new cars had to be equipped with asbestos-free linings. In 1993 a list of 'old' cars which still may be equipped with asbestos-free linings was issued. A comment has been made by Danish authorities that a mandatory system of tests every second year for cars older than 4 years is being introduced and it is expected to eliminate many older cars still running on the roads.

Order No. 540 of 2 September 1982 on Substances and Materials, Section 19, applies the principle of substitution to the exemptions listed above. It states that a substance or material which may constitute a danger to or in any other way adversely affect safety or health shall not be used if it can be replaced by a harmless, less dangerous or less harmful substance or material.

Exemptions to the ban on asbestos may be granted by the Danish Arbejdstilsynet, however they have stated this happens rarely and only under limited time restraints.

FRANCE

Legislation:

Decree No. 96-1133 of 24 December 1996 Relating to the Banning of Asbestos.

Prohibitions:

Prohibits the manufacture, modification, sale, import, export, placement on the national market, possession for the purpose of sale, supply and transfer for any reason whatever, of all forms of asbestos and asbestos-containing products or devices.

Prohibitions do not apply to pre-existing materials and listed products or devices containing chrysotile, where an alternative cannot be found that could fulfil the same function as the chrysotile fibre, and that could:
(a) present, according to current scientific knowledge, a lesser risk than chrysotile to the worker dealing with these materials or devices; and
(b) fulfil all the technical safety criteria applied to the final product.

Exemptions:

1. *Until 31 December 2001:*

- The prohibition of possession with a view to selling, placing on the market and transfer for whatever reason, will not apply to second hand vehicles or to stipulated vehicles and agricultural and forestry machinery which were in circulation prior to the decree coming into force; and

Listed products:

1. *Until 1 January 1998:*

- Thermal isolation devices used in industry for temperatures between 600ºC and 1000ºC;

2. *Until 1 January 1999:*

- Friction linings for heavy industrial equipment and installations, certain machines and vehicles greater than 3.5 tonnes;
- Friction components for compressors and vacuum pumps with pallets.

3. *Until 1 January 2002:*

- Friction linings for aircraft;
- Seals and linings used for watertightness in industrial processes of high temperature or pressure;
- Diaphragms used in the production of chlorine and oxygen in nuclear submarines;
- Thermal isolation devices used in industry for temperatures above 1000ºC.

Comments:

Prohibitions do not relate to waste disposal.

List of exemptions to be reviewed annually.

Importer/introducer must make annual declaration to the Minister for Employment in relation to activities involving listed exempt articles. In practice, the list of derogations is very limited.

The French Government commissioned the Institute National de la Sante et de la Recherche Medicale (INSERM) Expert Panel on Asbestos to undertake a report (Effects on the Health of the Main Types of Asbestos, June 1996), the main finding of which, was that action is needed to reduce the burden of asbestos-related tumours in the French population. The findings of this report have been critised by a number of expert bodies, including the Royal Society of Canada, who claim that the INSERM report omits a number of key studies, uses an inappropriate risk model (overestimating risks from current exposures) and provides little new information.

GERMANY

Legislation:

Ordinance on Bans and Restrictions on the Placing on the Market of Dangerous Substances, Preparations and Products of 14 October 1993 - pursuant to the Chemicals Act.

Prohibition:

Specified substances and preparations may not be placed on the market. Chrysotile, together with other forms of asbestos, is subject to this prohibition with the following exemptions.

Exemptions:

1. Replacement parts containing chrysotile for maintenance purposes where no other suitable parts are available;
2. Renewed placing on the market of vehicles, devices and systems which contain asbestos products and were manufactured before 14 October 1993; and
3. Naturally occurring mineral raw materials containing free asbestos fibres in a concentration not exceeding 1% asbestos by weight.

At the time of the ban coming into force (14 October 1993), temporary exemptions were introduced for some categories of chrysotile-containing articles as follows:

1. *Until 20 April 1994:*

- Asbestos preparations and products manufactured before 14 October 1993, except for: toys, finished products in powder form for sale in retail outlets; smoker's articles; catalytic screens and insulating devices intended for or installed in heating equipment powered by liquid gas; coatings; substances or preparations for spraying; crocidolite and preparations and products containing crocidolite.

2. *Until 31 December 1994:*

- Clutch linings for vehicles, where no asbestos-free alternatives are available from a safety point of view;
- Brake shoe inserts for rail vehicles, where no asbestos-free alternatives are approved under transport legislation;
- Friction pads for industrial applications; and
- Static seals, dynamic seals, packings and cylinder head gaskets for vehicles and industrial use.

3. *Until 31 December 1999:*

- Diaphragms for electrolytic processes where asbestos free substitutes are not available on the market or their use gives rise to unreasonable hardship;

4. *Until 31 December 2010*

- Asbestos containing raw materials for the manufacture of chrysotile-containing diaphragms for chlor-alkali electrolysis in existing systems where asbestos free substitutes are not available on market or their use gives rise to unreasonable hardship.

Comments:

Ban does not apply to demolition or repair of buildings containing asbestos material or to waste disposal.

Information provided from the German government indicates that since the period of expiry for the temporary exemptions listed above, special permission is required from the Government in order to use these previously exempt articles. However only a few permissions have been granted, relating mainly to brake linings for old industrial lifts and lorries.

ITALY

Legislation:

Law 27 March 1992, n.257: Regulations relating to the cessation of the use of asbestos.

Prohibitions:

Extraction, import, export, marketing, manufacture of asbestos and products containing asbestos.

The regulation contained one or two year 'phase-in' dates for the prohibition to become effective for the following applications:

1. *until 27 March 1994:*

- Friction gaskets for motor vehicles, industrial machines and plants; and
- Filters and auxiliary means of filtration for production of beverages

2. *until 27 March 1995:*

- Large-sized asbestos sheets, flat or corrugated
- Tubes, piping and containers for transport and storage of fluids, for both industrial and public use
- Friction gaskets, spare parts for motor vehicles, railway vehicles, industrial machines and plants with special technical characteristics
- Gasket heads for older type motor vehicles
- Static plate joints and dynamic gaskets for components subject to strong stresses
- Ultrafine filters for sterilisation and production of beverages and medicinals
- Diaphragms for electrolysis processes

NETHERLANDS

Legislation:

Asbestos-Free Friction Materials Decree (19 September 1991) (no. 507); Asbestos Decree (Working Conditions Act)(1993) (no.136); Commodities Decree on Asbestos (15 August 1994).

Prohibitions:

Production, use, and supply of all types of asbestos and asbestos-containing products are prohibited.

Exemptions:

Exemptions to the prohibition on the production and use of asbestos and asbestos-containing products can only be given when it is impossible to produce or use asbestos-free products that are less dangerous than asbestos-containing products. Exemptions to the prohibition on supply can only be given when an exemption has been granted for the production and use of the products concerned.

Exemptions are divided into general exemptions and exemptions given to an individual company. General exemptions are:

1. Laboratory research on asbestos and asbestos containing products;
2. Storage of asbestos waste;
3. Supplying asbestos and asbestos containing products for conveying in transit to another member state of the EU;
4. Production, application and supply of asbestos (except blue asbestos) containing friction materials when these actions relate to motor vehicles on more than 3 wheels with a mass *greater than* 3500 kilograms or with a velocity *less than* 50 kilometers per hour;
5. Production, application and supplying of asbestos (except blue asbestos) containing friction materials when these actions relate to motor vehicles on more than 3 wheels with a mass *less than* 3500 kilograms and with a velocity *above* 50 kilometers per hour, when for these motor vehicles no asbestos-free friction materials are available or when these motor vehicles were introduced onto the market before October 1 1985;
6. *Until July1, 1998*:

- ❑ Application and supplying of asbestos containing packing in seals, intended to function under high temperatures and high pressure, which are put into use before July 1, 1995 and which can’t be replaced by asbestos-free products which are not or less dangerous; and

7. *Until July 1, 1988*:

- ❑ Use, filling and supplying of asbestos containing cylinders for the storage of acetylene gas, which are put into use before July 1, 1993.

Specific (temporary) exemptions given to individual companies up to the period ending January1 1997 were:

8. *Until September 30 1997*:

- Application of white asbestos containing seals in a production plant for liquid chlorine, and in relation to shipment and transport of fluid chlorine, as long as no asbestos- free alternative is available;

9. *Until December 31 1997*:

- Production, application and supplying of asbestos (except blue asbestos) used for the production of chlorine in a diaphram-electolysis plant, as long as no asbestos-free alternative is available;

10. Until January 1 1998:

- Application and supply of asbestos (except blue asbestos) containing packing for application in a desulphuring installation, as long as no asbestos-free alternative is available; and

11. *Until January 1 1999*:

- Application and supply of asbestos (except blue asbestos) containing packing for application in "Flexicoker" systems, as long as no asbestos-free alternative is available.

Comments:

Information provided from the Netherlands government is that a ban was introduced on spray-on asbestos and the use of blue asbestos in 1978. Since 1983 trade in asbestos has been limited exclusively to "tightly-bonded" asbestos products. As a result of an inquiry into the availability of asbestos-free friction materials for vehicles, the government is considering extending the ban to include vehicles with a mass above 3500 kilograms. Some problems with the use of asbestos-free friction materials in vehicles produced before October 1 1985 is anticipated.

NORWAY

Legislation:

Regulations laid down by the Ministry of Local Government and Labour 1991 under the Working Environment Act.

Prohibitions:

Prohibits the import, manufacture, sale, use, and other handling of asbestos or products containing asbestos (defined as the fibrous crystalline silicate materials chrysotile, crocidolite, amosite, anthophyllite, tremolite, and actinolite), unless an exemption is granted by the government or an exemption exists under Chapter 3 of the regulations, as follows:

Exemptions:

Under Chapter 3 of the regulations, there are exemptions for:

1. Use of friction components, gaskets and filling compounds, if it is impossible to manufacture or use products of this kind with a content less harmful to health;
2. Repair with asbestos of technical devices which contain asbestos or material containing asbestos (other than friction components and gaskets), when it is impossible to use a substance less harmful to health;
3. Demolition or repair of buildings or technical installations which include asbestos material; and
4. Mining and milling of rocks containing a maximum of 1% asbestos by weight.

Comments:

Information provided by the Norwegian government indicates that dispensation from the regulations, although possible, is rarely given.

The government has also indicated that most vehicles, both new and older models, are now fitted with asbestos free friction linings. A list of vehicles in Norway and Denmark which may use friction linings containing asbestos was published by the Norwegian National Association of Car Importers in 1993.

SWEDEN

Legislation:

Ordinance of the Swedish National Board of Occupational Safety and Health Containing Provisions on Asbestos, together with General Recommendations on the implementation of the Provisions (AFS 1992:2).

Ordinance Prohibiting Asbestos-Containing Friction Linings in Vehicles (SFS 1986:683 and 684).

Prohibitions:

AFS 1992:2 – prohibits the use, machining/processing or treatment of asbestos and materials containing asbestos, subject to certain exemptions indicated in sections 5-8 of the legislation (see below). Exemptions, however, do not apply to crocidolite and materials containing crocidolite.

SFS 1986:683/684 - prohibits the fitting of asbestos-containing friction linings in the following vehicles when offered for sale or transfer:

1. Passenger cars and motor cycles classed as 1988 or subsequent models for registration or type inspection;
2. Lorries and buses classes as 1989 or subsequent models for registration inspection or type inspection; and
3. Other motor-powered vehicles and trailers manufactured from 1st July 1988 onwards.

A special statutory instrument lists vehicles manufactured prior to the above dates for which asbestos-free friction linings are available. The selling or commercial transfer of asbestos friction linings for these vehicles is also prohibited.

Exemptions:

AFS 1992:2 - sections 5-8

1. Asbestos and material containing asbestos may be used by permission of the National Board of Occupational Safety and Health if it is not possible for less deleterious material to be used and the emission of asbestos-containing dust is prevented;
2. Brake linings and other frictional elements containing asbestos may be used, machined/processed and treated if no acceptable products of less deleterious material are available. Frictional elements must be handled so that the emission of asbestos dust is prevented;
3. Gaskets containing asbestos may be fitted to engines manufactured before 1987 if no acceptable products of less deleterious material are available;
4. Technical devices and structural parts which include asbestos or material containing asbestos (other than brake linings and frictional elements), may be used as long as the asbestos-containing material is not interfered with and if the emission of asbestos-containing dust is prevented;

5. Asbestos and asbestos-containing material may not be replaced with other such material in connection with repair or service without permission; and
6. Asbestos and material asbestos-containing material may be machined/processed and treated by permission of the Labour Inspectorate.

Comments:

Information from the Swedish National Board of Occupational Health and Safety indicates that it is very restrictive in the granting of permits for the use of asbestos gaskets. Permission is usually only granted in cases where the fitting of asbestos gaskets is a requirement for certification or official approval e.g. in aircraft. The trend is for a decline in the number of permits being issued. More than 100 were issued in 1987-88, whereas only 5 were issued from January to September 1997.

SWITZERLAND

Legislation:

Ordinance relating to Environmentally Hazardous Substances (Ordinance on Substances) of 9 June 1986.

Prohibitions:

Prohibits the use, supply and importation of asbestos and asbestos-containing products or articles as commercial goods from 1 March 1990. The following classes of asbestos-containing products or articles were prohibited from the dates specified:

1. *From 1 January 1991*:

- Large-size flat panels and corrugated sheets; pipes for house drainage; filters and filter aids for drink manufacture.

2. *From 1 January 1992*:

- Friction linings for motor vehicles, machines and industrial plants.

3. *From 1 January 1995:*

- Pressure and sewage pipes; spare friction linings for motor vehicles, rail vehicles, machines and industrial plants with particular design conditions; cylinder head gaskets for older types of engine; static flat packing and dynamic packing for high demand applications; very fine filters and de-germinating filters for the manufacture of drinks and pharmaceutical products; diaphragms for electrolysis processes.

Exemptions:

The government may grant permission for a manufacturer or trader to continue to supply certain of the products specified above after the dates laid down provided that:

1. according to the state of the art, there is no replacement substance for the asbestos and provided that no more than the minimum amount of asbestos necessary is employed for the desired purpose, or
2. only spare parts containing asbestos can be used because of particular design constraints,.

The use of chrysotile for motor vehicles is permitted insofar as it is permitted under the provisions of the EU Council Directive 76/769 (*Approximation of the Laws of Member States relating to Restrictions on the Putting into Circulations and Use of Certain Hazardous Substances and Preparations*).

Comments:

Notes on regulations made in connection with this Ordinance (Regulations Concerning Materials Harmful to the Environment) were supplied by the Swiss Government (Notice No. 20 May 1990). These notes clarify the situation regarding asbestos-containing vehicle parts in vehicles imported or manufactured in Switzerland, and asbestos-containing vehicle parts for use in the aftermarket. Briefly, seals and gaskets in new motor vehicles were prohibited from 1.10.95; friction linings from 1.10.92 and other parts from 1.10.90. Spare parts containing asbestos may continue to be exchanged for spares also containing asbestos in vehicles with "special construction conditions" (defined as cases where replacing a part containing asbestos by an asbestos-free spare part would involve making alterations to other components of the system concerned as regards dimensioning or materials). In the case of asbestos-containing replacement parts for vehicles without "special construction conditions", replacement friction linings, seals and gaskets were prohibited from 1.10.95 and other spare parts from 1.10.90.

UNITED KINGDOM

Legislation:

The Asbestos (Prohibitions) Regulations (1985, as amended in 1992).

Prohibitions:

The importation into the UK of crude fibre, flake, powder or waste amphibole asbestos (amphibole defined as crocidolite, amosite, fibrous actinolite, fibrous anthophyllite, fibrous tremolite and any mixture containing one or more of these minerals), the supply of amphibole asbestos or any product to which amphibole asbestos has been intentionally added, the use of amphibole asbestos or any product to which amphibole asbestos has intentionally been added in the manufacture or repair of any other product, the use of any product containing amphibole asbestos, asbestos spraying (asbestos defined as amphibole and chrysotile), and the supply and use of any product containing chrysotile listed in the Schedule to the Regulations.

Categories of chrysotile-containing products specified in the Schedule as prohibited are: materials or preparations intended to be supplied by spraying; paints or varnished; filters for liquids, except for filters for medical use until 31 December 1994; road surfacing material where the fibre content is more than 2%; mortars, protective coatings, fillers, sealants, jointing compounds, mastics, glues and decorative products in powder form and decorative finishes; insulating or soundproofing materials which when used in their intended form have a density of less than 1g/cm^3; air filters and filters used in the transport, distribution and utilisation of natural gas and town gas; underlays for plastic floor and wall coverings; textiles finished in the form intended to be supplied to the end user unless treated to avoid fibre release, except for diaphragms for electrolysis processes until after 31st December 1998; roofing felt after 1st July 1993.

Exemptions:

1. The Government may exempt any person or class of persons from all or any of the prohibitions by a certificate in writing from the Health and Safety Executive, subject to certain conditions, including that it is satisfied that the health or safety of persons likely to be affected by the exemption will not be prejudiced as consequence;
2. In relation to chrysotile, the prohibition does not apply to the use of any product which was in use before 1st January 1993 unless it was subject to prohibition by the Asbestos (Prohibitions) Regulation 1985, which this legislation revokes;
3. Prohibition does not include any activity in connection with the disposal of a chrysotile product; and
4. Chrysotile products not listed in the Schedule would be considered exempt, including brake linings, clutches and gaskets.

Comments:

These Regulations implement relevant EU Directives.

Prohibition does not apply to any chrysotile product not listed in the Schedule to the Regulation. As a result, friction materials such as brake and clutch linings, and gaskets containing chrysotile are *not* prohibited.

The UK Health and Safety Commission has submitted a recommendation to the Secretary of State to extend the scope of the existing EU ban on asbestos to cover all uses (including marketing and supply) of chrysotile, except for a limited number of essential uses where there are no satisfactory alternatives available. (HSE Press release - 17 February 1997).

Other UK legislation relevant to asbestos is: Control of Asbestos at Work (CAW) Regulations 1987; Asbestos (Licensing) Regulations (ASLIC) 1993. Recent proposals (by the HSC) to 'tighten' these regulations (HSE Press Release – 11 March 1998) include:

1. Extend licensable work;
2. Tighten the exposure limits for chrysotile asbestos;
3. Place a duty on employers to ensure that where respiratory protective equipment (ERP) is required, it is chosen to reduce exposures to as low a level as reasonably practicable and not just to the exposure limit;
4. Put a duty on employers to provide refresher training to workers;
5. All work liable to lead to asbestos exposure must comply with the requirements of CAW

HSC plans to issue a Consultative Document by mid-1998 on recommended changes to these regulations, which are scheduled to come into force in 1999 (HSE News Release February 1997).

UNITED STATES

Legislation:

Asbestos Ban and Phase Out (ABPO) Rule of 12 July 1989.

Prohibitions:

Asbestos (including chrysotile) containing substances not being manufactured, imported or processed at the time of promulgation of the Rule, namely: corrugated paper, rollboard, commercial paper, specialty paper, flooring felt, and new uses of asbestos.

Exemptions:

Products on the market prior to the promulgation of the rule, which include: disc brake pads, drum brake linings, clutch facings, gaskets, asbestos cement sheeting, shingles and piping, roofing felt, millboard, pipeline wrap, vinyl-asbestos tiles and asbestos clothing.

Comments:

The ABPO rule was intended to reduce exposure and health risks by imposing a phased ban (over 7 years) on asbestos products and requiring labelling on those products still in commerce as the phase out progressed.

The Fifth Circuit Court voided much of the ABPO Rule in October 1991, leaving only those items described above as banned.For further information on this court decision see Section 10.2.2

APPENDIX 8

EXPORT DATA ON CERTAIN PRODUCTS WHICH CONTAIN (OR MAY CONTAIN) ASBESTOS

Customs category	Period (yr)	Quantity (kg)	Cost ($A)
6812.90.00* Articles of asbestos or of mixtures with a basis of asbestos or with a basis of asbestos and $MgCO_3$ (this category should contain gaskets)	1990-1991 1991-1992 1992-1993 1993-1994 1994-1995 1995-1996 1996-1997 1997-1998	8,704 38,387 9,161 76,968 8,617 8,417 45,893 21,704	189,000 351,000 216,000 1,410,000 289,000 531,573 1,195,795 876,891
		Quantity (number)	
6813.10.00** Brake linings and pads, not mounted, with a basis of asbestos, of other mineral substances or of cellulose	1990-1991 1991-1992 1992-1993 1993-1994 1994-1995 1995-1996 1996-1997 1997-1998	204,994 210,601 240,775 351,463 256,610 215,027 161,714 120,503	574,000 502,000 1,261,000 1,508,000 1,633,000 1,463,289 956,320 1,148,140
6813.90.10** Transmission linings, not mounted, with a basis of asbestos, of other mineral substances or of cellulose	1990-1991 1991-1992 1992-1993 1993-1994 1994-1995 1995-1996 1996-1997 1997-1998	32,176 12,462 25,771 35,829 46,999 23,354 N/A 36,164	185,000 89,000 156,000 190,000 338,000 125,256 201,619 549,837
6813.90.90** Friction material and articles thereof, not mounted, for clutches or the like, with a basis of asbestos, of other mineral substances or of cellulose (excl. brake linings and pads or transmission linings)	1990-1991 1991-1992 1992-1993 1993-1994 1994-1995 1995-1996 1996-1997 1997-1998	no entries made	71,000 75,000 99,000 959,000 292,000 310,349 206,899 1,851,454

*all asbestos
**may or may not contain asbestos
N/A = data provided was incomplete due to a transcription error

APPENDIX 9

STUDIES ON THE RELATIONSHIP OF AGE TO SAFETY OF THE AUSTRALIAN CAR FLEET

CSIRO study

A 1996 study by the CSIRO (using ABS statistics and a subset of data on reported crashes in NSW over the period 1977-1993,) analysed the effect of an aging NSW car fleet on road safety. The study noted that the age of the Australian car fleet has increased steadily over the past 20 years, with the median vehicle age increasing from about 5.3 years in 1970 to about 8.5 years in 1993 (these figures are consistent with more recent ABS statistics on age of the car fleet, reported in Section 5.4.1). The study showed that cars, in which an occupant casualty or fatality was reported, tended to be older than the general population of registered cars, and that this age difference increased over the period studied. The study data was insufficient to determine whether the increased incidence of 'old vehicle' involvement in accidents was due to (i) the deterioration of vehicle systems in old cars, (ii) the continued use of old cars preventing new cars and their improved safety features from penetrating the market, or (iii) non-car effects, such as driver characteristics. However, it was concluded that reduction of the average age of cars in 1993 to that in 1977, would have resulted in a saving of 43 fatalities and 1,002 casualties (CSIRO, 1996).

Monash University Accident Research Centre study

The Monash University Accident Research Centre has also undertaken research into the relationship between 'crashworthiness' (the relative safety of vehicles in preventing injury in crashes) and year of vehicle manufacture. Using crash data from 1987-1996, the study measured the risk of the driver being killed or admitted to hospital as a result of involvement in a 'tow-away' crash. The study showed an improvement in crashworthiness over the period of study (vehicles manufactured from 1964 to 1996), with greatest gains over the years 1970-1979 and 1989-1996 (Newstead et al., 1998).

An associated project (Cameron, 1995) estimated the potential impact on total road trauma (deaths and hospital admissions) of replacing older cars with new cars. Estimates for the percentage reduction in road trauma, the number saved annually and social costs saved annually were made for two different scenarios for two periods. The results are shown in the following table.

Estimated savings from replacement of older cars involved in accidents with new cars (Cameron, 1995)

Saving in driver deaths and hospital admission costs	Pre-1970 cars replaced by new cars	Pre-1980 cars replaced by new cars
Estimated savings if new cars had replaced older cars crashing in 1987-92		
Percentage reduction	2.4%	16.4%
Number lives saved (per annum)	242	1652
Social costs saved (per annum)	$31 million	$207.5 million
Estimated savings if new cars had replaced older cars crashing in 1995		
Percentage reduction	0.43%	4.4%
Number lives saved (1995)	43	442

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