

GUIDELINE

Management of fibrous minerals in Western Australian mining operations



Government of Western Australia
Department of Mines and Petroleum
Resources Safety

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Reference

The recommended reference for this publication is: Department of Mines and Petroleum, 2010, Management of fibrous minerals in Western Australian mining operations – guideline: Resources Safety, Department of Mines and Petroleum, Western Australia, 47 pp.

ISBN 978 1 92 116362 3

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Contents

Foreword	iv
1 Introduction	1
2 Nature of the hazard	2
3 Duty of care	6
4 Health risks from exposure to fibrous minerals	7
5 Exposure standard	10
6 Management process	11
7 General mining operations	15
8 Processing and earth-moving operations	20
9 Waste disposal	21
10 Information and training	24
11 Warning signs and labelling	24
12 Personal protective clothing and equipment	26
13 Assessing exposure to airborne fibres	26
14 Further information	28
Appendix 1 Legislative provisions	31
Appendix 2 Adjustment of exposure standards for extended work shifts	34
Appendix 3 Fibrous minerals management plan	36
Appendix 4 Incident response for uncovered fibrous minerals ...	39
Appendix 5 Risk assessment for mineral fibres	40
Appendix 6 Sampling method for contaminant fibrous minerals .	41
Appendix 7 Application of the membrane filter method to contaminant asbestos in mining operations	44
Appendix 8 Contaminant monitoring	46

Guidelines

A guideline is an explanatory document that provides more information on the requirements of legislation, details good practice, and may explain means of compliance with standards prescribed in the legislation. The government, unions or employer groups may issue guidance material.

Compliance with guidelines is not mandatory but they could have legal standing if it were demonstrated that the guideline is the industry norm.

Who should use this guideline?

This guideline should be used by anyone planning or conducting exploration or mining in areas where fibrous minerals are likely or have been encountered, particularly those responsible for the health of personnel.

Foreword

This guideline is issued by Resources Safety under the *Mines Safety and Inspection Act 1994*, and has been endorsed by the Mining Industry Advisory Committee.

The Act

The *Mines Safety and Inspection Act 1994* (the Act) sets objectives to promote and improve occupational safety and health standards within the minerals industry.

The Act sets out broad duties, and is supported by regulations, together with codes of practice and guidelines.

Regulations

The Mines Safety and Inspection Regulations 1995 (the regulations) provide more specific requirements for a range of activities. Like the Act, regulations are enforceable and breaches may result in prosecution, fines, or directions to cease operations and undertake remedial action.

Application

The provisions of this guideline apply to all mines as defined in section 4(1) of the Act.

1 Introduction

The presence of mineral fibres in mines is of great concern within the mining industry. It is well known that there are significant health risks associated with inhalation of airborne fibrous minerals.

Increasing demand for minerals has made mining and processing of previously uneconomic orebodies commercially viable. Consequently, fibrous minerals are now encountered in mining operations more frequently than in the past. This has necessitated updating information relevant to the management of these minerals at Western Australian mining operations.

Employers have a duty to ensure that the exposure of workers to airborne fibrous minerals is within regulatory standards and as low as reasonably practicable. Achieving this requires using appropriate strategies to recognise, evaluate and control such hazards to workers.

Another fundamental principle of occupational health and safety practice is that workers have a right to know about workplace hazards. Effective control strategies should include provision of relevant information to workers and targeted training programs.

The purpose of this guideline is to help the mining industry understand the hazards associated with exposure to airborne asbestiform mineral fibres and other common naturally occurring mineral fibres, and to identify, assess and control these hazards.

The guideline builds on Asbestos Management in Mining, published by the then-Department of Mineral and Petroleum Resources in 2001, and incorporates the risk assessment process documented in regulation 7.27 of the Mines Safety and Inspection Regulations 1995.

The specific legislative requirements applicable to these hazards are listed in Appendix 1.

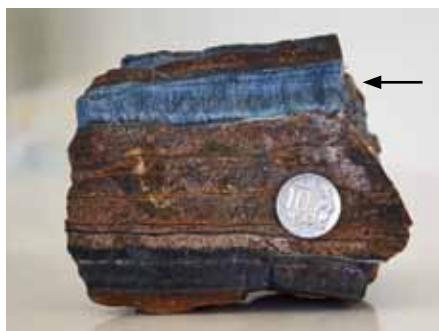


2 Nature of the hazard

2.1 Mineral fibres

Although many types of mineral fibres inhaled at low concentrations have little effect on human health, others are decidedly harmful to the respiratory system. These are the asbestiform fibrous hydrated silicate minerals, several of which occur naturally in both asbestiform and non-asbestiform forms. They can have identical chemical composition but different physical properties, morphology and health consequences. For example, riebeckite, a mineral commonly found in the Pilbara region (Miyano and Klein, 1983), is found in both forms (Figure 1).

Some other natural mineral fibres that are potentially hazardous because of their physical and chemical properties are erionite, wollastonite, attapulgite and sepiolite (International Programme on Chemical Safety, 1986).



Asbestiform riebeckite (Crocidolite)



Non-asbestiform riebeckite

Figure 1 Two forms of riebeckite



2.2 Asbestos

“Asbestos” is a commercial term referring to six types of naturally occurring silicate mineral fibres that can be separated into two broad categories: amphibole and serpentine minerals (Figures 2 and 3). These minerals are hydrated silicates with varying metal compositions and are known as *asbestiform minerals*.

Asbestiform minerals have the following properties:

- fibrous morphology;
- flexible fibres;
- durable;
- heat and corrosion resistant;
- high tensile strength; and
- low electrical conductivity.

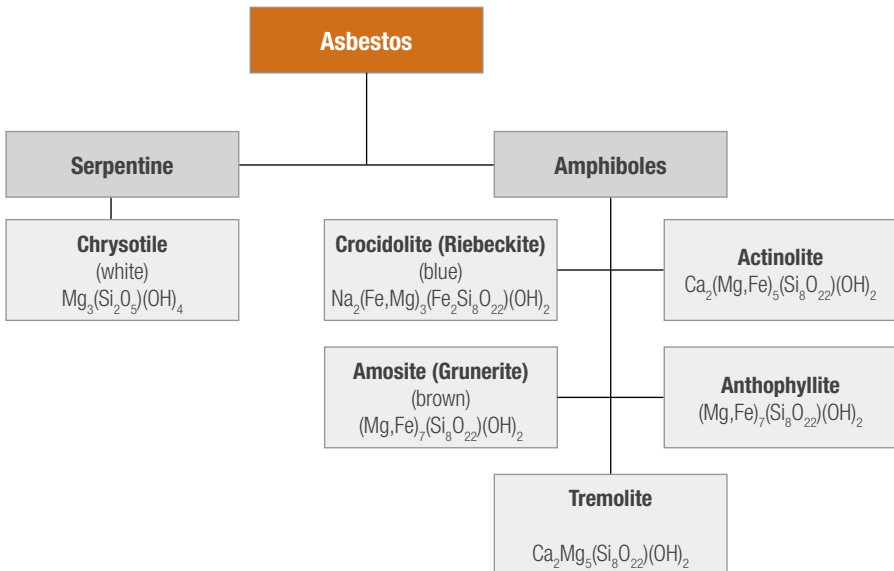
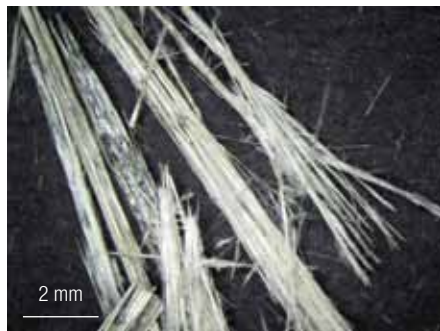


Figure 2 Naturally occurring asbestiform minerals (Osinubi et al., 2000)

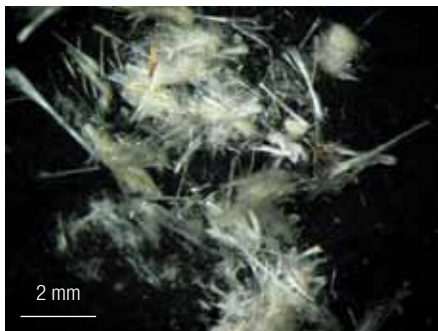




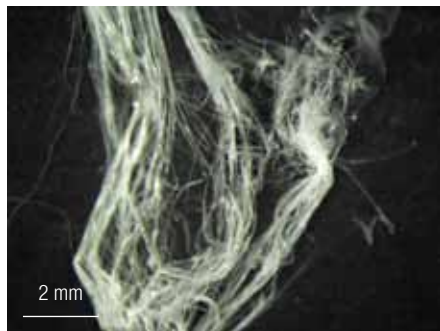
Actinolite



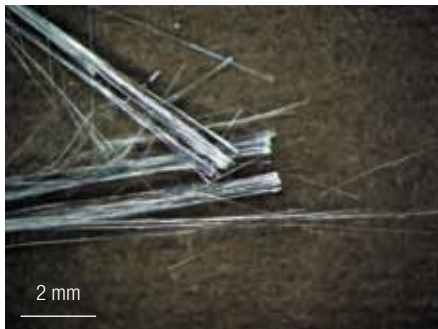
Amosite



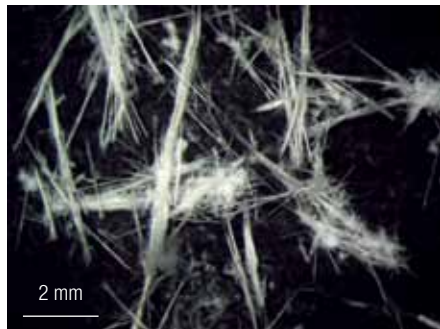
Anthophyllite



Chrysotile



Crocidolite



Tremolite

Figure 3 Six types of naturally occurring asbestiform minerals



2.3 Distribution of asbestiform minerals in Western Australia

Asbestiform minerals are widely distributed in Western Australia. Amphibole and serpentine minerals are major components of mafic and ultramafic rocks found in Western Australia's "greenstone belts", which contain the State's major gold and base metal deposits. Amphibole minerals may also be encountered in the banded iron formations of the Hamersley Basin (Ayres, 1972; Klein and Gole, 1981).

Asbestiform minerals are commonly found in veins, many of which are lens shaped. They may be covered by deep soil or a thick layer of weathered rock and are often small and isolated. Therefore, they may be present but unnoticed. Asbestiform minerals can be weathered to produce harmless secondary minerals (e.g. talc, chlorite, clay, iron oxides and hydroxides, and various silicates). Consequently, even if there is no near-surface evidence of asbestiform mineralisation, the probability of encountering asbestiform minerals in a mine increases with depth.



3 Duty of care

Where there is potential for workers to be exposed to fibrous minerals at a mine, the employer has a responsibility to:

- identify the potential occurrence of fibrous minerals at the workplace;
- assess the nature and degree of worker exposure; and
- develop and implement controls to reduce such exposures.

Where an asbestos or other fibrous mineral hazard exists, a risk-based approach to manage the hazard should be developed in consultation with employees and include:

- written procedures for the identification, assessment and control of fibrous minerals; and
- guidelines for the provision of information, instruction, training and supervision to employees.

Employees also have responsibilities for the safe and effective management of fibrous minerals. They must:

- comply with work procedures related to fibrous minerals and follow instructions given to them for their own safety and health and that of others;
- cooperate with their employer in the identification, assessment and control of fibrous minerals; and
- report immediately to their supervisor any hazard related to the presence of suspected fibrous minerals.

Regular assessments of the risk of exposure to airborne contaminants are recommended during each phase of all mining operations, including exploration, construction, mining (surface and underground), processing, shutdown, and care and maintenance and rehabilitation activities. More information on managing occupational health and safety using a risk management approach can be found in Australian Standard AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines*.



4 Health risks from exposure to fibrous minerals

4.1 Asbestiform fibrous minerals

Fibrous minerals present a hazard only if fibres of respirable size become airborne. The danger from airborne asbestos fibres is not immediately obvious because the fibres are too small to be seen with the naked eye. Also, there is often a long period between exposure and the onset of disease.

Asbestos-related diseases are most commonly found in workers who have been exposed to high concentrations of asbestos fibres in the work environment. In the past, such exposures were typically to concentrations one hundred (or more) times greater than present occupational exposure standards.

Most fibres are removed from the respiratory system by the body's natural defences (e.g. coughing). However, fibres that remain in the lungs can cause several health problems.

- *Asbestosis* – progressive and irreversible scarring of lung tissue that typically occurs five to 15 years after continued exposure to high fibre concentrations.
- *Lung cancer* – cancer of the bronchial lining or lung tissue that occurs 20 or more years after first exposure and is nearly always associated with heavy exposure to asbestos (amphibole and chrysotile). The risk of contracting lung cancer is greatly increased among smokers who are exposed to asbestos.
- *Mesothelioma* – cancer of the lining of the chest cavity (pleura) occurs 20 to 50 years after first exposure and is invariably fatal. The rate of occurrence of mesothelioma increases with greater exposure to amphibole asbestos and time since first exposure, but is unrelated to smoking. Exposure to amphibole (primarily crocidolite) is thought to be the main cause of mesothelioma in asbestos workers.
- *Pleural plaques* – patches of thickening in the lining of the chest cavity. The presence of plaques can indicate occupational exposure to asbestos without causing significant disability.



4.2 Non-asbestiform fibrous minerals

Research has shown that many non-asbestiform fibres of similar dimensions to asbestiform fibres can damage the lungs without necessarily causing cancer (Fubini and Otero Areal, 1999). However, there is also evidence that some non-asbestos fibrous minerals, such as erionite, may be carcinogenic (Donaldson et al., 1993). Amphiboles such as winchite and richterite are also considered to be potentially hazardous (Wylie and Verkouteren, 2000).

4.3 Comparative risks of exposure to asbestiform minerals

Asbestos fibres are widespread in the environment, arising principally from breakdown of materials containing asbestos (e.g. brake-linings, insulation, asbestos-cement products). Minor amounts may also be produced by geological weathering of asbestiform minerals. Measurements of airborne fibre concentrations in cities indicate that the average person inhales up to a million fibres every year (Berry et al., 1989). This finding clearly shows that inhalation of asbestos fibres does not necessarily mean illness and death as espoused by the commonly held belief that “one fibre can kill”.

The risk of contracting an asbestos-related disease depends on the:

- concentration of respirable fibres in the air;
- length of time of exposure;
- type of fibre (mineralogy);
- size and shape of the fibres; and
- persistence in the lung (Chung and Wright, 1994).

Provided exposures to airborne asbestos fibres are maintained within present mining industry standards, the risk of mine workers contracting an asbestos-related disease is very low, and certainly much lower than other risks associated with mining. If workers are exposed to asbestos for only short periods, or intermittently, the risk will be much lower than for workers who are continuously exposed.

Table 1 compares the risk of exposure to asbestos with some other well-known health risks.



Table 1 Predicted annual risk of death from various causes
(Department of Mineral and Petroleum Resources, 1999)

Cause	Risk rating	Average annual risk*
Smoking (20 cigarettes per day)	Extra high	3,500
Underground mining (1980–1991)	Extra high	1,750
Drinking alcohol (4 cans per day)	High	380
Surface mining (1980–1991)	Elevated	150
Motor vehicle travel	Elevated	150
Passive smoking	Low	30
Asbestos fibre exposure		
0.1 fibres per millilitre of air inhaled** for 1 year	Very low	2
0.1 fibres per millilitre of air inhaled** for 20 years	Low	30

* Average annual risk expressed as fatalities per million people exposed to the cause. Annual risks in excess of 1,000 per million are considered excessive; in excess of 100 per million are considered elevated; and below 10 in a million are considered very low.

** National Occupational Health and Safety Commission's exposure standard for airborne concentration (see Chapter 5)



5 Exposure standard

The National Occupational Health and Safety Commission (1995) specified that the occupational exposure standard (OES) should:

- be defined as the time-weighted average (TWA) asbestos fibre concentration of the air breathed by a worker during a working shift; and
- not exceed 0.1 fibres per millilitre (f/mL) for all forms or mixtures of asbestos.

The TWA is defined as the average concentration of a particular substance when calculated over a normal eight-hour working day, for a five-day working week.

Where the shift length is greater than eight hours, the occupational exposure standard should be adjusted in accordance with the 1999 guideline on adjusting exposure standards for extended workshifts (Department of Minerals and Energy, 1999). For example, a 12-hour shift has an adjusted exposure standard of 0.07 f/mL (Appendix 2).



6 Management process

6.1 Fibrous minerals management plan

If fibrous minerals such as asbestos exist on a mine site, a fibrous minerals management plan should be formulated. It should be made available to the Department of Mines and Petroleum upon request.

For new mine site approvals, it may be included with the general project management plan.

Appendix 3 lists recommended headings for a fibrous minerals management plan.

6.2 Management of risk – an overview

Exposure to fibrous minerals can be maintained at an acceptable level by implementing the following key control measures and working procedures.

- Dust and fibres should be suppressed at source using stringent engineering and procedural dust-control techniques (e.g. dust suppression, enclosure or isolation of dust areas, local exhaust ventilation, routing of underground airflows).
- Workplaces contaminated with asbestos must be immediately quarantined until the hazard has been dealt with. Access to all areas containing fibres should be strictly controlled and monitored.
- There should be regular surveillance of the ore mineralogy to identify the presence of fibrous minerals and ensure their disturbance is minimised.
- Mined ore must be regularly checked for the presence of fibrous minerals.
- Personal protective equipment should be regarded as secondary and complementary to engineering controls.
- Procedures must be developed for the secure disposal of asbestos-bearing materials.
- Employees should be provided with appropriate information (including written safe working procedures), instructional training, and supervision.
- Regular audits and air monitoring must be undertaken to confirm the effectiveness of engineering and procedural controls.



- The site's safety and health representatives and safety and health committee, where they exist, must be fully consulted on the above measures.

6.3 Detailed procedures

Identification and delineation of fibrous minerals

The Registered or Exploration Manager, as the case may be, should ensure that exposed mining faces and floors are inspected by a geologist on a regular basis. Areas with geological characteristics favourable for the formation of fibrous minerals should be studied in detail to confirm the presence or absence of such materials. Any previously undetected fibrous material should be immediately reported, and the Manager should investigate such reports as soon as practicable.

It is a regulatory requirement that the Manager ensures the District Inspector is notified in writing when contaminant asbestos is found at a mine (see Appendix 4).

If fibrous minerals are identified in waste or non-mineralised zones, they should be left undisturbed by mining, to the extent reasonably practicable.

Mine areas suspected or confirmed to contain fibrous minerals that could, if worked, consistently produce respirable fibres in concentrations in excess of the exposure standard, should be barricaded and clearly signposted (Figure 4). Such a location should be termed a "designated" area.

No-one should enter a designated area without permission from the Manager. As a minimum requirement, anyone entering a designated area should be provided with a disposable P1 or P2 filter respirator that complies with Australian Standard AS/NZS 1716:2003 *Respiratory protective devices*. These and other recommended respiratory protective equipment should be used and maintained in accordance with Australian Standard AS/NZS 1715:2009 *Selection, use and maintenance of respiratory protective equipment*. They are to be worn at all times by workers within designated areas. Bearded workers should be provided with a powered air-purifying ventilated helmet respirator. No-one should eat or smoke in a designated area, and drinking water should be supplied in closed containers.





Figure 4 Example of entry procedure signage for designated areas

The Manager should maintain a register containing the following information for each person required to work in a designated area for more than ten shifts in a 12-month period:

- full name;
- health surveillance number;
- dates of training and retraining sessions; and
- approximate time spent in the designated area during each shift.

The register should be kept for 30 years.

Decontamination procedures

Personnel intending to leave a designated area should use the following decontamination procedures. Personal decontamination should be conducted in a decontamination facility within the asbestos work area where re-contamination cannot occur.

- Prior to a “smoko”, “crib” or lunch break, all personnel should vacuum clean work clothing and protective equipment to remove any asbestos fibres. Footware should be wet wiped. Hands and face should be thoroughly washed.
- At the completion of a shift, personnel should vacuum clean their clothing, wet wipe footware then shower and wash their hair.



- The decontamination facility should be partitioned into three interconnecting well-ventilated areas:
 - “dirty” area used for washing hands and face as well as vacuuming and removing clothing;
 - shower area; and
 - “clean area” for changing into fresh uncontaminated clothing.
- The vacuum cleaner recommended should comply with Australian Standards AS/NZS 60335.2.69:2003 *Household and similar electrical appliances – Safety – Particular requirements for wet and dry vacuum cleaners, including power brush, for industrial and commercial use* and AS 4260:1997 *High efficiency particulate air (HEPA) filters – Classification, construction and performance*. Standard domestic or industrial vacuum cleaners must not be used. The vacuum collection bags and filters must be disposed of as asbestos waste.
- All work clothing worn in a designated area should be stored and laundered at an on-site facility. Alternatively, disposable coveralls may be used. Disposable contaminated clothing should be packed into heavy duty plastic bags and sent to an approved asbestos waste area. The bags should be labelled to indicate asbestos contamination.
- Every practicable effort should be made to limit the spread of asbestos contamination from designated areas by providing appropriate cleaning facilities such as equipment wash-down bays and boot-cleaning stations.



7 General mining operations

7.1 Vehicles and mining equipment in designated areas

Where practicable, all mining equipment and machinery (including light vehicles) used in designated areas should have sealed cabins fitted with appropriate air-conditioning and filtration units. If this is not practicable, subject to the approval of the District Inspector, workers operating such equipment should be supplied with the protective equipment described in Chapter 12. The Manager should implement a schedule of inspection and maintenance to ensure the efficiency and effectiveness of cabin seals and air-conditioning filtration systems.

Procedures for cleaning air-conditioning and engine filters should minimise the emission of dust and fibre (i.e. wet scrubbing should be used where practicable). Compressed-air cleaners should not be used. Cabins should be regularly cleaned using an appropriate industrial vacuum cleaner complying with Australian Standards AS/NZS 60335.2.69:2003 and AS 4260:1997. Disposal of air filters from equipment and machinery used in designated areas should be by burial in an approved asbestos waste area.

Designated areas should be thoroughly wetted before and during loading and transport operations. All working faces, benches and haul roads should be kept moist. Trucks should be loaded so that there is no spillage during transportation, and the material should be offloaded in a manner that minimises dust generation.

All equipment and machinery used in designated areas should be decontaminated at an approved wash-down or cleaning facility before:

- being used outside designated areas; or
- maintenance work is undertaken.



7.2 Reverse circulation (RC) and percussion (PC) drilling

Dry drilling methods can produce a considerable amount of dust when an orebody is dry and above the water table (Figure 5). Dust from a drill cyclone can envelope the drill rig and operators on a still day, potentially exposing them to airborne fibrous and siliceous minerals. During windy conditions, dust and fibre emissions can move hundreds of metres downwind.

The following recommendations should be considered for RC and PC drilling.

- Wet drilling should be used wherever practicable. However, dry drilling may be used provided the drilling machine is fitted with an effective device that collects and contains the dust produced by drilling.
- For percussion drilling, the return air hose should be fed through a water sump.
- Water or dust-suppression systems should be used to reduce dust emerging from the cyclone and drill collar.
- Flexible ducting should be used to direct dust emissions from the T-piece and cyclone away from drilling staff.
- Care should be taken during RC drilling to ensure that the drill collar is sealed.
- While blast-hole drilling is in progress, the operator should remain in the cab with cabin doors and windows closed and air-conditioning operating.
- People who are not working inside a protected environment such as an air-conditioned drilling cab require respiratory protection. The minimum protection recommended is a Class P1 or P2 respiratory protective device in accordance with Australian Standard AS/NZS 1715:2009 *Selection, use and maintenance of respiratory protection devices*. All staff required to wear respirators must be trained in their use. Disposable masks should be changed regularly during a shift to prevent build up of dust and to ensure they remain efficient. Powered air-purifying respirators are recommended for bearded people.
- Drilling must be suspended if any personnel in the vicinity of the rig are not wearing properly fitted respiratory protective devices and there is a risk of exposure to atmospheric contaminants.



- Logging is to be carried out during sampling.
- Drilling residue and material removed during equipment wash-down should be transferred to a dedicated sump. As soon as practicable after completion of drilling, the sump must be backfilled and signage erected indicating the presence of buried asbestiform material.
- After drilling, all drilling personnel should undergo a decontamination procedure as outlined in Section 6.3.



RC dry drilling



RC wet drilling (water injection)

Figure 5 Comparison of dust production during dry and wet RC drilling



7.3 Diamond drilling in areas with fibrous minerals

To control dust and fibres, diamond drilling is preferred over other methods. A major advantage is that it generates slurry waste, which is collected in a sump. Providing the slurry is kept wet, the risk of exposure to airborne fibrous minerals during drilling is minimised.

Drilling dust control procedures

Personnel should wear eye protection, helmet, gloves, disposable overalls and respiratory protection when removing cores from core barrels. The minimum respiratory requirement is a P1 or P2 disposable mask.

Drill cores should be wrapped in heavy-duty plastic wrap after they are recovered from the core barrel and transferred to core trays. Trays of cores with potential fibrous mineral contamination should be clearly labelled to indicate the likely presence of asbestos. Core barrels and associated equipment should be washed and wiped down into a container, and the contents disposed of in a dedicated waste sump. On completion of a drill hole, all equipment should be decontaminated. Any visible contaminated material on the drill pad should be placed in the waste sump.

The greatest risk of exposure to airborne mineral fibres occurs when:

- drill core containing fibrous minerals is allowed to dry;
- drilling residue on the ground, in the sump and on clothing becomes dry; and
- drilling residue is transferred from clothing and footwear to vehicles, and then translocated to uncontaminated areas.

Drill core cutting and sample preparation

Personnel cutting cores should wear disposable overalls, eye protection and P1 or P2 respiratory protection. Cores must be wet cut and the cutting machine must be equipped with extractive ventilation and a dust collector. Personal decontamination procedures following core cutting should be the same as for other drilling operations.



The handling of dry samples (e.g. opening of sample bags, transfer of samples, mixer-mill operation and re-bagging of pulp) should be carried out in an appropriately designed dust-extraction cupboard with sufficient extraction ventilation to draw dust and fibres away from the operator. The cupboard ventilation system should be connected to appropriate air filtration.

Any accumulated dust should be removed with either an approved industrial vacuum cleaner or rag moistened with water. Compressed air or dry brushing should not be used for cleaning. The sample preparation area should be cleaned and vacuumed at the completion of every job run. Excess sample material should be re-bagged and disposed of as asbestos waste.

7.4 Blasting operations

Dust emissions from blasting should be minimised as far as practicable. In particular, the following issues should be addressed.

- To avoid transport of dust from blast sites to areas such as camp sites, weather forecasts of wind conditions should be considered before blasting.
- Blast sites should be thoroughly wetted down with water before and after blasting.
- After blasting, entry to the blast site should only be permitted after adequate time has been allowed for settlement or clearance of dust and after broken ore has been thoroughly wetted.
- Drill cuttings from designated areas should not be used to stem blast holes.

7.5 Underground mining operations

In addition to the general procedures listed elsewhere in this guideline, the following procedures should be applied in underground designated areas.

- To the extent practicable, any exposed mineral fibres should be sealed in situ by using an appropriate agent (e.g. epoxy-based paint, shotcrete).
- Underground roadways in designated areas should be kept wet. Hanging walls and footwalls should be regularly washed down to prevent the accumulation of dust.



- Ore discharged into bins or ore passes and at conveyor transfer points should be thoroughly wetted, preferably by using dust-suppression sprays.
- Every practicable effort should be made to route air flows such that air ventilated from a designated area does not contaminate other work areas.

8 Processing and earth-moving operations

8.1 Crushing, screening and stockpiling

Crushing, screening and stockpiling of ore can generate considerable quantities of dust, so proper dust-control measures are required. These may include:

- optimising the moisture content of processed ore;
- spraying aqueous polymeric compounds (e.g. polyvinyl acetate) on the surfaces of ore stockpiles;
- using water cannons or water mist sprays;
- using local dust extraction and ventilation systems;
- installing rubber skirtings, seals and shrouds;
- using dust collectors;
- minimising the height of free-falling ore or waste materials; and
- minimising ore loading speeds.

8.2 Road transport dust control

Large quantities of dust can be released from ore or waste on moving vehicles and during loading, unloading and stockpiling. Applying water to road surfaces and slowing traffic speeds reduce dust emissions, but there are other options. These include the use of:

- surfactants;
- soil cements;
- bituminous compounds;
- polymer films; and
- hygroscopic salts.



8.3 Foundation and trenching

Foundation and trenching operations are frequently conducted in areas where there is limited geological information and there may be as-yet-unidentified asbestiform minerals. Further, unrecorded burial sites of asbestos products may be inadvertently uncovered during these operations. Consequently, it is recommended for all foundation or trenching work sites that thorough geological surveys are carried out before work starts. Water sprays should be used to suppress dust emissions by keeping excavations and excavated materials damp.

9 Waste disposal

9.1 Within a mining operation

Waste material may include contaminated ore as well as waste from core cutting, laboratory samples, asbestos-cement products, brake linings, gaskets, and solid and slurry wastes from decontamination of equipment. The location, depth and quantity of fibrous waste material should be recorded on a plan, which must be sent to the District Inspector. Following approval, the fibrous waste disposal area must be clearly signposted and fenced. The Principal Employer should be aware that other agencies should be informed of the plan, including the Department of Health, Department of Environment and Conservation, and local Council Authorities.

Transport of asbestos waste material to a designated fibrous mineral waste disposal area and its subsequent burial must be carried out such that the liberation of mineral fibres to the atmosphere is prevented. All fibrous contaminated material (i.e. ore, drill cores, other asbestos-containing materials) should be buried to a depth of at least one metre as soon as possible after arrival at the disposal site. Fibrous waste material should be buried such that it will not be disturbed during subsequent rehabilitation.

For disposal of small quantities of contaminated waste, the following guidelines should be followed.

- Solid fibrous waste should be collected in heavy duty polythene bags, about 0.2 mm thick, or in other approved



containers. The recommended maximum bag size is 1200 mm long by 900 mm wide. The bags should be filled to no more than 50 per cent capacity. This minimises the potential for bag rupture and allows the bag to be adequately sealed.

- Any waste material that contains fibrous dust should be disposed of in labelled heavy-duty plastic bags. To avoid contamination due to bag rupture, fibrous mineral waste should be double bagged. If there are large metal storage bins or kibbles at or near the area from which the waste is being removed, single bags may be adequate. In these circumstances, washing down of bags in the removal area before loading into bins is a satisfactory method of contamination control.
- Fibrous material that is too large for the standard polythene bags should be placed in large disposable bins (preferably lined with polythene sheeting).
- Each bag or container must be labelled as shown in Figure 6.
- During dumping and subsequent burial, employees close to the site should wear P1 or P2 half-face disposable respirators.
- Fibrous waste should be offloaded in a manner that avoids the generation of dust and release of fibres.
- Bags that have held asbestos material should not be re-used for any purpose.
- Controlled wetting of waste should be employed, where practicable, to reduce fibrous dust emission during bag sealing or as a result of bag rupture during transportation. Over-wetting or water-logging should be avoided because excess contaminated water leaking from the bags can create a future source of airborne fibrous dust.



Figure 6 *Warning label for bags and other receptacles containing solid fibrous waste*



9.2 Offsite

Mining companies needing to dispose of asbestos waste at a location other than the mine site must inform the Department of Environment and Conservation, and comply with the Environmental Protection (Controlled Waste) Regulations 2004 and the Dangerous Goods Safety (Road and Rail Transport of Non-explosives) Regulations 2007.

9.3 Tailings

Processed tailings can contain similar concentrations of fibrous minerals to the feed ore, but the fibre bundles are generally thinner and shorter and therefore more biologically active and more hazardous. Consequently, it is imperative that tailings are properly managed so that fibres do not become airborne. The following information should be included in the “tailings” section of the site’s fibrous minerals management plan (Appendix 3):

- details of the design and operation of tailings dams;
- measures taken to ensure that fibrous mineral waste will not be disturbed during subsequent rehabilitation or as a result of severe weather conditions (e.g. flood or cyclone);
- measures taken to keep tailings wet;
- source and type of clean fibre-free rock or soil used to cap tailings; and
- location, depth and amount of fibrous waste material.



10 Information and training

The Manager must provide a training program to be completed by all employees required to work in designated areas before they start work in such an area. Refresher training should be completed at least annually thereafter.

The training program should cover:

- the type(s) and likelihood of occurrence of fibrous minerals at the mine;
- the nature and scope of operations involving potential exposure to fibrous minerals;
- the potential health effects of exposure to fibrous minerals, including the added risk of lung cancer due to the combination of cigarette smoking and asbestos exposure;
- required medical examinations;
- the proper use and maintenance of respirators, and their limitations; and
- required work practices, including the use of available engineering controls and other protective measures (e.g. personal hygiene, no smoking).

11 Warning signs and labelling

Warning signs must be placed in all areas of the workplace where asbestiform minerals are present. They should also be installed at all main entrances for such a site.

All warning signs must comply with Australian Standard AS 1319:1994 *Safety signs for the occupational environment*. Figure 7 shows examples of warning signs that may be used.



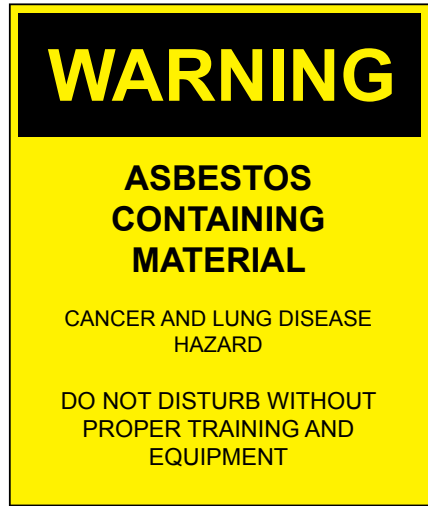
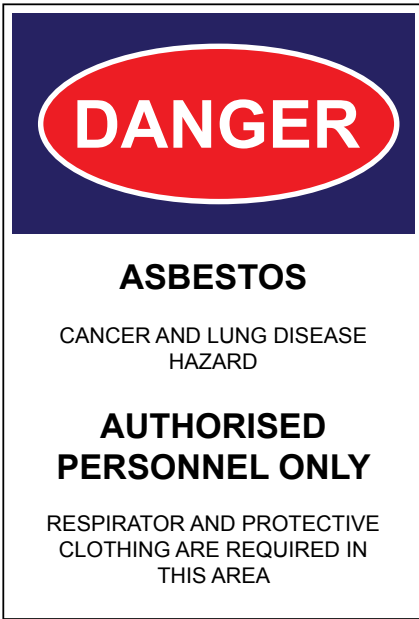


Figure 7 Examples of signs warning of the presence of asbestiform minerals



12 Personal protective clothing and equipment

The wearing of protective clothing is recommended for any operation where clothes could become contaminated with fibrous dust. The clothing should be made from fabric that protects against fibre penetration.

Suitable respiratory protection should be worn in designated areas. A disposable P1 or P2 respiratory mask is the minimum requirement for exposures up to five times the exposure standard. All disposable respirators must comply with Australian Standards AS/NZS 1715:2009 and AS/NZS 1716:2003.

Clothing should be decontaminated before leaving a designated area, as described in Section 6.3.

Eye protection should be worn in areas recommended by the mine site occupational hygienist or safety personnel.

13 Assessing exposure to airborne fibres

13.1 Risk assessment

A risk-based approach to assess the exposure of personnel to airborne mineral fibres comprises the following general steps:

- identify all sources of airborne mineral fibres;
- carry out risk assessments and evaluate (e.g. Appendix 5);
- implement controls;
- monitor personnel and workplace; and
- assess air monitoring results.

Appendix 5 shows the recommended risk-based approach when carrying out health surveillance for exposure to mineral fibres.



13.2 Recommended sampling strategy

Air sampling to determine exposure to airborne asbestos fibres should be carried out using a modified version of the membrane filter method (National Occupational Health and Safety Commission, 2005; Appendices 6 and 7).

All air sampling results should be recorded in a ventilation log book. The results of sampling should be reported to the District Inspector and be available to all employees. Regular audits should be undertaken to ensure that work and management procedures and control measures are operating effectively.

From the air monitoring program, a “quota” may be determined in consultation with an occupational health inspector familiar with Resources Safety’s CONTAM database (Appendix 8). A “quota” is a representative set of samples derived from the air monitoring program. The results of the quota are sent to Resources Safety primarily for regulatory compliance. The quota may be adjusted over time as the risk is determined to increase or decrease. In addition, the District Inspector may invoke specific sampling management procedures by requisition, in writing, at any time.

13.3 Routine monitoring

The main purpose of a routine monitoring program is to confirm that control measures adopted on the basis of the initial monitoring campaign remain appropriate.



14 Further information

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Go to www.dmp.wa.gov.au/ResourcesSafety for further information on occupational safety and health in the mining industry, including the CONTAM system.



Appendix 1 – Legislative provisions

Mines Safety and Inspection Regulations 1995

Safety signs

r. 4.10

- (1) Each responsible person at a mine must ensure that sufficient safety signs are posted in workplaces and travelways to —
 - (b) identify hazards

Penalty: See regulation 17.1.

- (2) Safety signs referred to in subregulation (1) must, so far as is practicable, use the text, colours, shapes, symbols and sizes specified in AS 1319, or AS 1614, as applicable.
- (3) The manager of, and each employer at, a mine must ensure that safety signs referred to in subregulation (1) are at all times —
 - (a) placed so that they can be readily seen; and
 - (b) maintained in a clean and readable condition.

Penalty: See regulation 17.1.

- (4) A person must not —
 - (a) damage, deface or obscure a safety sign at a mine; or
 - (b) remove a safety sign at a mine unless the person is authorised to do so by the manager of the mine.

Penalty: See regulation 17.1.

Terms used

r. 9.1

In this part, unless the contrary intention appears —

Contaminant asbestos means crocidolite, chrysotile, grunerite (amosite), or the asbestiform of actinolite, tremolite or anthophyllite present in rock in or about the mine;



Suppression of dust — drilling operations

r. 9.17

(1) The manager of an underground mine must ensure that wet drilling is used so far as is practicable in the mine.

Penalty: See regulation 17.1.

(2) If it is necessary for dry drilling to be carried out in a mine (whether underground or on the surface), each responsible person at the mine must ensure that the drilling machine used is fitted with an effective device that —

- (a) collects and contains the dust produced by drilling; or
- (b) discharges that dust through ducting to a position where it will not be breathed by any person or where it will be effectively suppressed or contained.

Penalty: See regulation 17.1.

Use of dust collection and dust suppression appliances

r. 9.19

(1) If dust collection or dust suppression appliances are provided at a mine, each responsible person at the mine must ensure that the appliances are —

- (a) fitted and operated in accordance with the manufacturer's or supplier's specifications; and
- (b) maintained in efficient operating condition.

Penalty: See regulation 17.1.

(2) An employee at a mine who is engaged in any operation in which dust is produced must use any dust collection or dust suppression appliances provided at the mine for collecting or suppressing the dust.

Penalty: See regulation 17.1.

Smoking prohibited in certain workplaces

r. 9.31

A person must not smoke in any of the following places —

- (b) a workplace where —
 - (i) the air contains asbestos

Penalty: See regulation 17.1.



Control of contaminant asbestos

r. 9.33

- (1) If any contaminant asbestos occurs at a mine, the manager of the mine must ensure that –
 - (a) such action is taken as is necessary to protect the health of employees at the mine from the effects of the asbestos; and
 - (b) the district inspector is notified in writing of that occurrence.

Penalty: See regulation 17.1.

- (2) If in the course of any mining operation at a mine it is necessary to assess exposure to airborne asbestos fibres, the manager of the mine must ensure that the assessment is carried out using the method specified in the *Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres* [NOHSC:3003(2005)].

Penalty: see regulation 17.1.

- (3) For the purposes of subregulation (2), a countable fibre is taken to be defined in the document referred to in that subregulation as any object having a maximum width of 1 micrometre or less and a length exceeding 5 micrometres.

Note: The only authorised versions of the Act and regulations are those available from the State Law Publisher (www.slp.wa.gov.au), the official publisher of Western Australian legislation and statutory information.



Appendix 2 – Adjustment of exposure standards for extended work shifts

Owing to the limitations of the three models commonly used to adjust occupational exposure standards for extended shifts — Brief and Scala Model, OSHA Model, Pharmacokinetic Model (Tranter, 2004) — an adjustment regime has been developed specifically for Western Australian mining operations (Department of Mines and Energy, 1999).

Table A2.1 provides recommended exposure reduction factors for various substances, including asbestos.



Table A2.1 Recommended exposure reduction factors for the Western Australian mining industry

Exposure standard	Timeframe for action	Health effect	Typical substances	Shift roster	Exposure reduction factor
Peak	Fast – immediate	Acute poisoning	Cynaide, caustic, acid mists	n/a	1
STEL	Fast – immediate	Acute poisoning	Nitrogen dioxide, sulphur dioxide, hydrogen sulphide, ammonia	n/a	1
TWA	Medium – within shift or over a few shifts	Respiratory irritation, narcosis	Solvents, nitrogen dioxide, sulphur dioxide, hydrogen sulphide, carbon monoxide	10 h/day	0.7
				12 h/day	0.5
TWA	Long – over many shifts or years	Cumulative poisoning, respiratory disease (silicosis, asbestosis), cancer	Silica, asbestos, nickel, lead, welding fumes, talc, inspirable dust, respirable dust, diesel fumes	< 170 h/month	1
				> 170 h/month	170/x*
TWA	Unknown or unsure			10 h/day	0.7
				12 h/day	0.5

x* Average number of hours worked in a month. A normal monthly work cycle comprising eight-hour days, five days per week is 170.

STEL Short term exposure limit

n/a Not applicable



Appendix 3 – Fibrous minerals management plan

A fibrous minerals management plan helps mining companies to comply with the *Mines Safety and Inspection Act 1994* and associated regulations. The plan should set out clear objectives, stating what will be done, how it will be done, and the timetable for doing it. Some suggested headings and subheadings for the management plan are given below.

1. Introduction

- Mine site location
- Mine history and type of mining activity
- Type of exploration activity (if any)
- Scope of the plan
- Objectives of the plan
- Definitions
- Document control processes
- Referenced documents (e.g. fibrous mineral register)

2. Fibrous mineral identification

- Geology of the mine site
- Mineralogy of fibre types present

3. Fibrous mineral management

The general principles of fibrous mineral management usually incorporate four phases:

- Hazard identification phase
- Evaluation and risk analysis phase
- Control phase
- On-going monitoring and re-assessment

4. Employee information and training

5. Contractor training



6. Legislative requirements

- Fibrous minerals management hierarchy
- Employees responsibility
- Management responsibility
- Reporting to regulatory authorities

7. Work and hygiene

- Personal protective equipment
- Personal decontamination
- Equipment decontamination

8. Asbestos exposure assessment

- Legislative requirements
- Airborne asbestos monitoring
- Airborne asbestos action levels
- Plan and timeframe for receiving and assessing monitoring results

9. Asbestos removal work

- Asbestos removal
- Asbestos monitoring
- Clearance certification
- Construction and/or demolition work
- Disposal of asbestos-containing materials

10. Transport, storage and disposal of fibrous minerals

11. Incident procedures (i.e. exposure reporting)

12. Emergency procedures (provision of emergency dust suppression)

13. Drilling or dust and fibre controls

14. Labelling and signage



15. Designated areas

16. Tailings

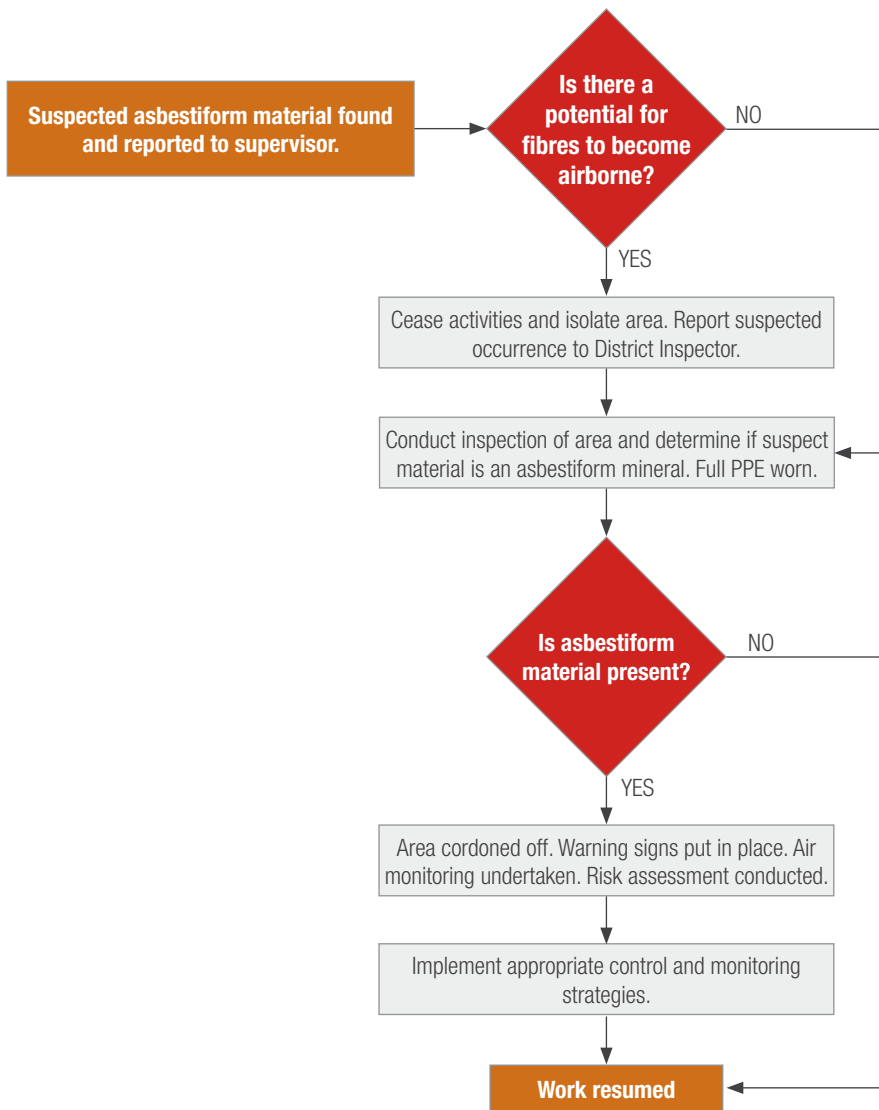
- Details of the design and operation of the tailings dam
- Controls to minimise exposure to airborne fibres

17. Mine site laboratory (description)

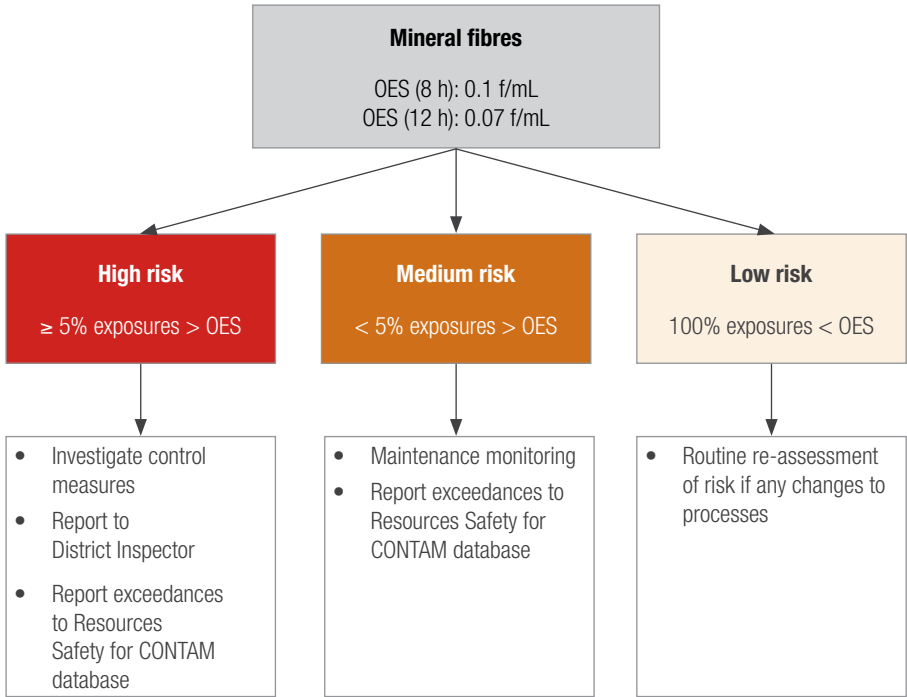
18. Environmental considerations and site cleanup



Appendix 4 – Incident response for uncovered fibrous minerals



Appendix 5 – Risk assessment for mineral fibres



OES = Occupational exposure standard



Appendix 6 – Sampling method for contaminant fibrous minerals

Method outline: A measured quantity of air is pumped through a membrane filter. The fibre concentration is determined by phase-contrast microscopy and is expressed in fibres per millilitre of air (f/mL).

Sampling apparatus: Sampling pump; open-faced filter holder fitted with a protective cowl; 0.8 µm pore size (mixed esters of cellulose or cellulose nitrate) filter with printed grid; support pad.

Procedure

1. Sampling assembly

Use tweezers to carefully place the support pad and then filter (gridded side up) into the filter holder.

2. Calibration of sampling pumps

Pumps must be calibrated to a flow rate within the range of 0.4 to 2.0 L/min. Refer to step 4 below for flow-rate selection. The flow rate through the filter holder must be checked before and after sampling. If the difference is greater than 10 per cent of the initial flow rate, the sample must be rejected.

Note: Pumps should be run for about 15 minutes before calibrating to allow flow rates to stabilise.

3. Sampling

The total sample duration should be at least four hours, and be representative of average exposure during a shift.

- Attach the sampling pump to the worker (or place in position for static sampling).
- Fasten the filter holder to the worker's clothing in the breathing zone. Ensure that the tubing is free from leakage and kinks, and is located to minimise inconvenience to the worker. The filter holder should point directly downward (it is often useful to have two clips on the tubing for secure attachment). Remove the cap from the cowl.
- Turn on the pump and record the following information:
 - filter holder identification;
 - sample start time;
 - initial flow rate;



- worker's name (or position);
 - description of worker's task;
 - ventilation controls and atmospheric conditions; and
 - any other relevant data.
- At the conclusion of the sampling period, record the time, remove the sampling system from the worker, place the cap on the cowl and switch off the pump. Transport the filter holders with care.
 - Reject filters if they:
 - show signs of contamination by substances such as water or oil;
 - are damaged; or
 - are suspected of being tampered with.
 - Filter holders and cowls must be thoroughly washed with detergent and water and then rinsed before being re-used.

4. Sample flow rates and volumes

The amount of non-asbestiform particulate matter in the air will determine the sample volume and flow rate. Contamination of filters by non-asbestiform particles such as dust or fume can cause overloading such that the filters cannot be analysed. Therefore, filters may need to be changed several times for a single sample.

Feedback from laboratory staff about dust loading of filters after analysis will assist in determining future flow rates and sample volumes.

The following flow rates may be used as a guide:

- at the surface in general — 1.0 L/min
- at the surface in areas of minimal dust— 1.5 or 2.0 L/min
- underground – 0.5 L/min

For sample results to be reported to a practical detection limit of 0.01 f/mL, sampling of 400 to 600 L of air is required (e.g. 1 L/min for 7 hours = 420 L; 1.5 L/min for 5 hours = 450 L).

Where it is not practical to sample such a large volume (e.g. if more than three or four filters are required for each sample), a sample volume of 80 to 120 L is sufficient (e.g. 0.5 L/min for 4 hours = 120 L). However, this results in a practical detection limit of 0.05 f/mL.



5. Transportation of filters for analysis

Filters may be transported in the capped filter holders in which the samples were collected. Alternatively, filters may be removed from the filter holders and placed in Petri dishes, in which case they must be placed dust side up and fastened to the bottom of the dish by one or two pieces of tape attached to the unexposed edge. The filter holders or Petri dishes should be packed in a rigid container with soft packing material to prevent crushing and minimise vibration. Every sample should be clearly labelled.

6. Blanks

For each batch of filters used for a sampling in a particular area, or for every 25 filters in a batch, select one unused filter for analysis as a blank. This filter should be subjected to the same handling and transportation treatment as normal samples, but without drawing any air through it or attaching it to a worker.



Appendix 7 – Application of the membrane filter method to contaminant asbestos in mining operations

Airborne asbestos fibre concentrations are currently assessed using phase-contrast optical microscopy by the membrane filter method (National Occupational Health and Safety Commission, 2005). This method involves the physical counting of fibres according to morphology criteria in 100 randomly selected graticule fields for each filter sample. The regulatory definition of a fibre is any object that has an aspect ratio greater than 3:1, a length greater than 5 μm and a width less than 3 μm .

The membrane filter method does not distinguish between asbestiform fibres and non-asbestiform fibres (such as riebeckite, clay minerals, iron oxide, gypsum, mica, hornblende and talc) or other particles conforming to the size criteria for a fibre. As a consequence, using this method will tend to overestimate true asbestos fibre concentrations.

The method was originally developed to measure asbestos fibre concentrations in circumstances where the airborne particles were predominantly asbestos fibres, such as in manufacturing industries where asbestos is regularly and deliberately handled, and in asbestos removal work. It has been widely recognised that, in the mining environment, asbestiform minerals are commonly associated with non-asbestiform minerals, and it is often impossible to differentiate non-asbestiform fragments from asbestiform fibres by using phase-contrast microscopy. Consequently, the application of this method has some limitations (Sonter and Hewson, 1994). However, it should be noted that although mesothelioma, lung cancer, asbestosis, and fibrosis are associated with exposure to airborne asbestiform fibres, a number of non-asbestiform fibre types of certain dimensions also pose some risk to health. Should mineralogical identification of fibres be desired, analysis can be carried out using scanning electron microscopy — energy dispersive X-ray analysis (SEM-EDAX).

In recognition of the limitations of the method for determining levels of contaminant asbestos in mining operations, the following variations to the membrane filter method were authorised by the State Mining Engineer in April 1995.



- A fibre touching or attached to, but not embedded in, a particle shall be counted as a fibre if it meets the geometric criteria specified in the method.
- A sample volume in excess of the 100 L \pm 20% specified for occupational (personal) sampling is permitted.
- Results must be reported in accordance with the method, but may additionally be reported as the “actual” fibre concentration, except that where less than three fibres are counted per 100 graticules, a value of “3 fibres” is used.

In addition, regulation 9.33(3) of the Mines Safety and Inspection Regulations 1995 was formulated to provide greater selectivity between asbestiform and non-asbestiform minerals, whereby “a countable fibre is taken to be defined ... as any object with a maximum width of 1 micrometre or less and a length exceeding 5 micrometres”.

Airborne fibre concentrations should be determined by an appropriately qualified person, such as a fibre counter approved by the National Association of Testing Authorities, Australia (NATA).



Appendix 8 – Contaminant monitoring

CONTAM

Resources Safety's CONTAM system uses a database to record personal exposure monitoring results reported by industry. The main objectives of CONTAM are to:

- collect data to determine exposure to atmospheric contaminants for various occupational groups, locations and industry sectors;
- identify those groups at risk of adverse health effects from such exposure; and
- monitor compliance with exposure standards.

Resources Safety, in consultation with the employer, assigns a quota to mine sites for their occupational hygiene monitoring.

For exploration activities, it is recommended that representative personal exposure monitoring samples are taken at least annually for each employee potentially at risk of exposure to airborne contaminants.

Registered samplers

Samples for exposure monitoring reported to Resources Safety may only be collected by registered samplers. To be registered for CONTAM, samplers must demonstrate that they have suitable qualifications and experience in air-sampling techniques (occupational hygiene monitoring). This can be shown through either:

- satisfactory completion of specific competency-based training; or
- proven substantial experience in sampling of atmospheric contaminants.

CONTAM registration lasts for five years. After this time, samplers who wish to continue to submit CONTAM sample records must either:

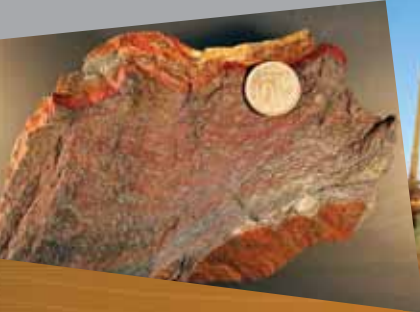
- apply for an exemption from further training; or
- successfully complete of an approved CONTAM sampler refresher course.



The quality of data submitted by CONTAM registered samplers may be reviewed. Where the quality is deemed to be unacceptable, the State Mining Engineer may revoke CONTAM registration. Competency must then be re-assessed in order to regain CONTAM-registered sample status. Available alternatives for assessment are successful completion of:

- the Certificate IV Surface Ventilation Officer (Mining Industry);
or
- an approved CONTAM sampler refresher course.





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