APPROVED
CODE OF PRACTICE

Air Quality in the Extractives Industry

SEPTEMBER 2016

New Zealand Government

WORKSAFE
NEW ZEALAND | MAHI HAUMARU AOTEAROA

ACKNOWLEDGEMENTS

WorkSafe New Zealand (WorkSafe) would like to thank the members of the industry working group for their contribution to the development of this code. Our thanks also go to the National Institute for Occupational Safety and Health, Engineering & Mining Journal, Solid Energy New Zealand, and OceanaGold for giving permission for their publication content to be used, and providing photographs.

NOTICE OF APPROVAL

The code of practice for *Air Quality in the Extractives Industry* sets out WorkSafe New Zealand's expectations in relation to identifying and controlling the work health and safety risks relating to air quality, in order to help PCBUs and workers achieve compliance with the Health and Safety at Work Act 2015, the Health and Safety at Work (General Risk and Workplace Management) Regulations 2016 and Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016.

WorkSafe New Zealand developed the code with input from unions, employer organisations, other key stakeholders and the public.

Together with the right attitudes and actions of PCBUs and workers focused on improving health and safety practices at work places, the code will contribute to the Government's targets of reducing the rate of fatalities and serious injuries in the workplace by at least 25% by 2020, improvements in work-related health, and a 50% reduction in asbestos disease by 2040.

Accordingly, I Michael Allan Woodhouse, being satisfied that the consultation requirements of section 222(2) of the Health and Safety at Work Act 2015 have been met, approve the code of practice for *Air Quality in the Extractives Industry* under section 222 of the Health and Safety at Work Act 2015.

Hon Michael Woodhouse
Minister for Workplace Relations and Safety

22 September 2016

FOREWORD

As the Chair of the Board of WorkSafe New Zealand, I am pleased to introduce this approved code of practice for *Air Quality in the Extractives Industry*.

It was developed with input from our social partners, industry and public consultation.

This approved code of practice will help duty holders comply with their requirement to provide healthy and safe work for everyone who works in the extractives industry. It will also help make sure that other people do not have their health and safety adversely affected by the work conducted.

A healthy and safe workplace makes good sense. An organisation with health and safety systems that involves its workers can experience higher morale, better worker retention, increased worker attraction and – most importantly – workers who return home to their families, healthy and safe, after they finish their work.

Organisations benefit from having less downtime from incidents and higher productivity.
An organisation known for its commitment to health and safety can benefit from its improved reputation.

We must all work together to make sure that everyone who goes to work comes home healthy and safe. By working together, we'll bring work-related harm down by making sure that all work conducted is healthy and safe work.

Gregor D. Coster

Professor Gregor Coster, CNZM
Chair, WorkSafe New Zealand

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The Health and Safety at Work Act 2015 (HSWA) is the key health and safety law. It sets out the health and safety duties that must be complied with.

Health and safety regulations sit under HSWA. They expand on duties under HSWA and set standards for managing certain risks and hazards.

Approved codes of practice (codes or ACOPs) are practical guides on how to comply with legal duties under the Act and Regulations. In this case under:

> Health and Safety at Work Act 2015 (HSWA)

> Health and Safety at Work (General Risk and Workplace Management) Regulations 2016 (GRWM Regulations)

> Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016 (MOQO Regulations).

See WorkSafe's special guide: *Introduction to the Health and Safety at Work Act 2015* for more information on health and safety law.

1.1 WHAT IS THE PURPOSE OF THIS CODE?

This code sets out WorkSafe New Zealand's (WorkSafe) expectations for managing risks relating to air quality in extractives operations. It applies to all mining and tunnelling operations, alluvial mining and quarrying operations, and provides expectations for:

> assessing air quality in extractive operations
> selecting and implementing controls for air quality in extractive operations
> developing a principal hazard management plan (PHMP) for air quality.

This code is for persons conducting a business or undertaking (PCBU) operating in the extractives industry, any person in a safety critical role in the extractives industry, the extractives operator, and anyone else involved in managing risks relating to air quality. This includes workers and other persons at the mining operation.

1.2 HOW DOES THIS CODE APPLY TO ALLUVIAL MINING AND QUARRYING OPERATIONS?

Under HSWA, all extractives operations must identify, assess and control risks to health and safety. The MOQO regulations require the development of principal hazard management plans (PHMPs) and principal control plans (PCPs) for principal hazards. However, alluvial mining and quarrying operations are not required to manage principal hazards in accordance with the MOQO Regulations.

There are a number of risks relating to air quality. Whether these are principal hazards or not, alluvial mining and quarrying operations must manage risks to health and safety arising from them under HSWA's primary duty of care.

The practices detailed in this code for assessing, selecting, and implementing controls for risks relating to air quality apply to:

> mining and tunnelling operations
> alluvial mining and quarrying operations.

Worksafe recommends that alluvial mine and quarry operators follow the systematic approach of developing PHMPs and PCPs to manage risks to health and safety.

The nature of the risks associated with air quality mean that air sampling and health monitoring might be required to fulfil the duties under HSWA and the GRWM Regulations.

1.3 WHAT IS THE LEGAL STATUS OF THIS CODE?

This code has been approved under HSWA. It can be used in court as evidence of whether the relevant duties under health and safety law were complied with. Courts may have regard to this code:

> as evidence of what is known about risks relating to air quality and how those risks can be controlled
> to decide what is reasonably practicable for managing air quality.

Following the code might not be the only way of complying with HSWA and the regulations. Other practices can be used as long as they provide a level of work health and safety equivalent to or higher than in this code, and comply with HSWA and the regulations.

1.4 HOW TO USE THIS CODE

1.4.1 INTERPRETING THIS CODE

Table 1 shows the terms used to describe the requirements in this code.

TERM	DEFINITION
Must	legal requirement that has to be complied with
Needs to, or content written as a specific direction (eg 'Make sure the...')	a practice or approach that has to be followed to comply with this code – WorkSafe's minimum expectation (subject to the legal status of this code described in section 1.3)
Should	recommended practice or approach, not mandatory to comply with HSWA or this code
May	permissible practice or approach, not mandatory to comply with HSWA or this code

Table 1: Requirements in this code

1.4.2 LEGISLATION

At the start of each chapter, the legislation that applies is listed in a box. For the full text, see the applicable legislation at www.legislation.govt.nz

1.4.3 TERMS USED IN THIS CODE

The term 'duty holder' used in this code refers to a PCBU; SSE; a mine, alluvial mine, or quarry operator; or other safety critical role, as appropriate.

The term 'extractives operation' refers to a mining operation, alluvial mining operation and quarrying operation. 'Extractives operator' has a corresponding meaning.

This code uses the term 'mining and tunnelling operations' even though the definition of 'mining operation' in HSWA includes a tunnelling operation. This is to emphasise that parts of the code apply to both mining and tunnelling.

1.4.4 STANDARDS

Use the most recent version of any standards referred to in this code, unless otherwise specified.

Where applicable, and provided it does not contradict the legislation or requirements of this code, refer to BS 6164 Code of practice for health and safety in tunnelling in the construction industry for good practices in the construction of tunnels.

1.5 ROLES AND RESPONSIBILITIES

HSWA defines the roles and responsibilities of different duty holders. These include PCBUs, officers, workers and other persons at workplaces. See WorkSafe's special guide: *Introduction to the Health and Safety at Work Act 2015* for more information.

Schedule 3 of HSWA and Part 2 of the MOQO Regulations set out the specific mining sector-related roles including mine operator, mine worker, site senior executive (SSE) and other safety critical roles, and industry health and safety representative.

All 'mine or tunnel operators' must appoint an SSE and a mine manager. The SSE is responsible for health and safety management, and the mine manager is responsible for the daily running of the mine or tunnel operation. Depending on the type of mining or tunnelling operation and the particular principal hazards, other safety critical roles are required.

Alluvial mine and quarry operators must appoint an alluvial mine or quarry manager who is responsible for managing the alluvial mining or quarrying operation and supervising health and safety. The certificate of competence that they require depends upon the size and type of operation. More information is available in WorkSafe's *Health and Safety at Opencast Mines, Alluvial Mines and Quarries*.

1.6 WORKER ENGAGEMENT, PARTICIPATION AND REPRESENTATION

All extractives operators must, so far as is reasonably practicable, engage with workers. They must also have effective worker participation practices, regardless of the size, location, hours of operation, or method of extraction.

Under HSWA, an extractives operator must:

> so far as is reasonably practicable, engage with its workers who are, or are likely to be, directly affected by a matter relating to work health and safety; and

> have practices that provide reasonable opportunities for its workers to participate effectively in improving work health and safety.

Worker engagement and worker participation practices can be direct (eg by individual workers talking directly to the PCBU) or through representation (eg using formal or informal representatives). Sections 3-5 of the good practice guidelines *Worker Engagement, Participation and Representation* provide information about worker engagement, worker participation practices and worker representation. The interpretive guidelines *Worker Representation through Health and Safety Representatives and Health and Safety Committees*, outline the rules for health and safety representatives (HSRs) and health and safety committees (HSCs).

A safe workplace is more easily achieved when everyone involved in the work:

> communicates with each other to identify hazards and risks

> talks about any health and safety concerns

> works together to find solutions.

The best ways to engage with workers and ensure their participation on an ongoing basis will depend on the views and needs of workers, the business or undertaking's size, and how, when and where work is carried out. A PCBU's commitment to improving health and safety is an essential first step.

ACT IN GOOD FAITH

Employers, unions and employees are expected to act in good faith. This is a requirement of the Employment Relations Act 2000 (ERA). When workers and PCBUs interact with each other honestly, openly and with mutual respect this reduces the risk of conflict and problems.

1.6.1 DUTIES UNDER HSWA AND THE MOQO REGULATIONS

All PCBUs have worker engagement and participation duties under HSWA. Mine and tunnel operators have extra duties under the MOQO Regulations, as follows:

> The SSE must engage with workers and HSRs when preparing and reviewing the health and safety management system (HSMS), including PCPs and PHMPs.

> Mine and tunnel operators must document worker participation practices.

> If a worker reports the existence of a hazard, the mine or tunnel operator must:
  - make sure the report is investigated
  - promptly advise the worker of the result of the investigation.

1.6.2 FURTHER INFORMATION ABOUT WORKER ENGAGEMENT, PARTICIPATION AND REPRESENTATION

For more information on worker engagement, participation and representation see

WorkSafe's website and the:

> good practice guidelines *Worker Engagement, Participation and Representation*

> interpretive guide *Worker Representation through Health and Safety Representatives and Health and Safety Committees*.

When reading the guidelines as a mine or tunnel operator replace the following terms with the extractive industry terms:

> replace 'PCBU' with 'mine or tunnel operator'

> replace 'work group' or 'members of a work group' with 'a group of workers who are represented by a health and safety representative' or 'workers in a mining or tunnelling operation'

> replace 'business or undertaking' with 'mining or tunnelling operation'.

1.7 HEALTH AND SAFETY MANAGEMENT SYSTEM

All mining and tunnelling operations must have a health and safety management system (HSMS). It is part of the mine or tunnelling operation's overall management system. While it is not a requirement under MOQO, WorkSafe recommends alluvial mining and quarrying operations have a HSMS. The air quality PHMP (air quality plan) is an essential part of the HSMS.

The SSE must:

> develop, document, implement and maintain the HSMS

> make sure the HSMS is easily understood and used by all workers

> engage with workers when preparing and reviewing the HSMS.

1.8 HAZARDS AND RISKS

A PCBU must eliminate risks to health and safety, so far as reasonably practicable. If it is not reasonably practicable to eliminate risks, they must be minimised so far as is reasonably practicable.

There need to be systems in place to:

> identify hazards (appraise risks) at the mining operation
> assess the risks of injury or ill-health to workers from the hazards
> identify the controls required to manage that risk.

At mining and tunnelling operations the SSE must develop these systems.

The risk appraisal might identify principal hazards; these are hazards that can create a risk of multiple fatalities in a single accident, or a series of recurring accidents, at the mining or tunnelling operation. They will either be one of ten hazards specified in the MOQO regulations, or any other hazard identified during the risk appraisal that meets the definition.

Unless hazards are identified and risks assessed properly, no amount of risk management will ensure a safe place and system of work. Unidentified hazards and risks can lead to serious consequences. See section 2 for information on risk assessments for air quality.

1.9 AIR QUALITY PLAN

The MOQO regulations do not require alluvial mining or quarrying operations to have an air quality plan. However, WorkSafe recommends that alluvial mine and quarry operators produce, and implement, an air quality management plan based on the PHMP principles.

The air quality plan identifies the risks presented by airborne dust and other contaminants at the mining or tunnelling operation, and the controls to manage them. It details the:

> types of dust and contaminants in the air
> amount and length of exposure
> monitoring of air quality
> control and suppression of dust and other contaminants
> circumstances and requirements for its periodic review and revision
> auditing programme.

The duty holder needs to produce the air quality plan in the context of the whole HSMS so that it relates to other PHMPs, PCPs, or processes and procedures that rely on the air quality plan as a control. This helps to prevent gaps and identify overlaps in processes and information where it relates to air quality, or where air quality may impact other PHMPs and PCPs.

The air quality plan must include the risk assessment for air quality. This provides the framework for initial and ongoing assessment of workers' exposure to airborne contaminants. See section 2 for more information.

1.10 EXPOSURE MONITORING AND HEALTH MONITORING

Exposure monitoring provides information to assist in determining whether workers are potentially being exposed to a hazard at harmful levels or if the measures in place to control exposure to that hazard are working effectively. Monitoring does not replace the need for control measures to reduce exposure.

Health monitoring is a way to check if the health of workers is being harmed from exposure to hazards while carrying out work, and aims to detect early signs of ill-health or disease.

Health monitoring can show if control measures are working effectively. Health monitoring does not replace the need for control measures to minimise or prevent exposure.

Exposure monitoring and health monitoring are requirements of the primary duty of care in HSWA, so far as is reasonably practicable. This code primarily identifies the need for monitoring as a requirement of HSWA.

1.10.1 ACUTE AND CHRONIC EXPOSURE

Acute exposure is short-term exposure to a hazard that affects worker health. Acute health effects happen quickly, are usually identified easily and can be serious in nature. Chronic exposure is long-term exposure, usually over several years, which can cause serious long-term health effects.

Many health risks are different depending on whether exposure is acute or chronic. Identify, assess and control risks for both acute and chronic exposure. Controls for acute and chronic exposure are generally similar.

Specialist help may be needed to identify potential chronic exposure and health effects, as they are often difficult to detect. For example, the early stages of lung cancer.

1.10.2 EXPOSURE MONITORING, AND HEALTH MONITORING – GRWM REGULATIONS

There are specific requirements to carry out exposure monitoring and health monitoring for substances hazardous to health under the GRWM Regulations. Whether specifically required under the GRWM Regulations, or not, so far as is reasonably practicable, exposure monitoring and health monitoring are requirements of the primary duty of care in HSWA.

A substance hazardous to health is defined as a substance, or product containing a substance, that is known or suspected to cause harm to health, and includes a substance:

> classified as having toxic or corrosive properties under the Hazardous Substances and New Organisms Act 1996 (HSNO)
> for which a prescribed exposure standard exists
> specified in a safe work instrument (SWI) as requiring health monitoring.

Under the GRWM Regulations:

> exposure monitoring is required where a PCBU is not certain on reasonable grounds whether the concentration of a substance hazardous to health at the workplace exceeds the relevant prescribed exposure standard
> health monitoring is required when a worker is carrying out ongoing work involving a substance hazardous to health that is specified in a safe work instrument as requiring health monitoring.

A prescribed exposure standard is a workplace exposure standard or a biological exposure index that has the purpose of protecting persons in a workplace from harm to health. and that is prescribed in:

> regulations
> a SWI

> an approval or a reassessment in accordance with section 77B of the Hazardous Substances and New Organisms Act 1996
> a group standard approval issued under section 96B of the Hazardous Substances and New Organisms Act 1996.

To find out if a substance has a prescribed exposure standard, you can:

> Go to the controls database on the Environmental Protection Authority website: www.epa.govt.nz to see if your substance has an exposure standard prescribed in a hazardous substances approval, a group standard approval or a reassessment (if this applies).

Note: there are currently no substances that have exposure standards prescribed in regulations or SWIs. These will be issued by WorkSafe as they are developed.

Refer to WorkSafe's website for more information on SWIs.

See the *Exposure Monitoring under the Health and Safety at Work (General Risk and Workplace Management) Regulations 2016* fact sheet for more information on exposure monitoring requirements under the GRWM Regulations.

See the *Health Monitoring under the Health and Safety at Work (General Risk and Workplace Management) Regulations 2016* fact sheet for more information on health monitoring requirements under the GRWM Regulations.

PART B

IN THIS PART:

PART B

02/

AIR QUALITY RISK ASSESSMENT, SAMPLING AND MONITORING

IN THIS SECTION:

Health and Safety at Work Act 2015

Section 36 *Primary duty of care*

Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016

Regulation 3 *Interpretation*

Regulation 11 *Mine operator must ensure site senior executive has sufficient resources*

Regulation 54 *Risk appraisal*

Regulation 55 *Risk assessment*

Regulation 56 *Content of health and safety management system*

Regulation 68 *Content of principle hazard management plans*

Regulation 69 *Review and revision of principal hazard management plans*

Regulation 84 *Principal hazard management plans for air quality*

Regulation 155 *Assessment of hazards associated with fuel additives*

Regulation 223 *Barometer, hygrometer and thermometer*

Health and Safety at Work (General Risk and Workplace Management) Regulations 2016

Regulation 6 *Hierarchy of control measures*

Regulation 28 *Managing risks associated with substances hazardous to health*

Regulation 32 *Duties relating to exposure monitoring*

2.1 IDENTIFYING HAZARDS

All duty holders need to systematically identify air quality hazards at the extractives operation. This is the risk appraisal, and is done by identifying airborne contaminants and dust and their potential to cause injury or ill-health.

Make sure there are processes in place for the timely collection of appropriate information to identify risks arising from air quality at the extractives operation. Involve a competent person, such as a suitably qualified occupational hygienist, when identifying risks arising from air quality.

Involve a team of workers with a range of expertise and experience, including health and safety representatives, in these processes.

Likely contaminants and their effects vary depending on the:

> size and type of operation

> activities carried out

> controls in place.

New extractives operations need to identify potential sources of dust and contaminants as early as possible, normally during the design and development process, as well as on an ongoing basis.

Proactively identify sources of airborne contaminants and dust using:

> core samples of the rock the mine or tunnel will be operating in

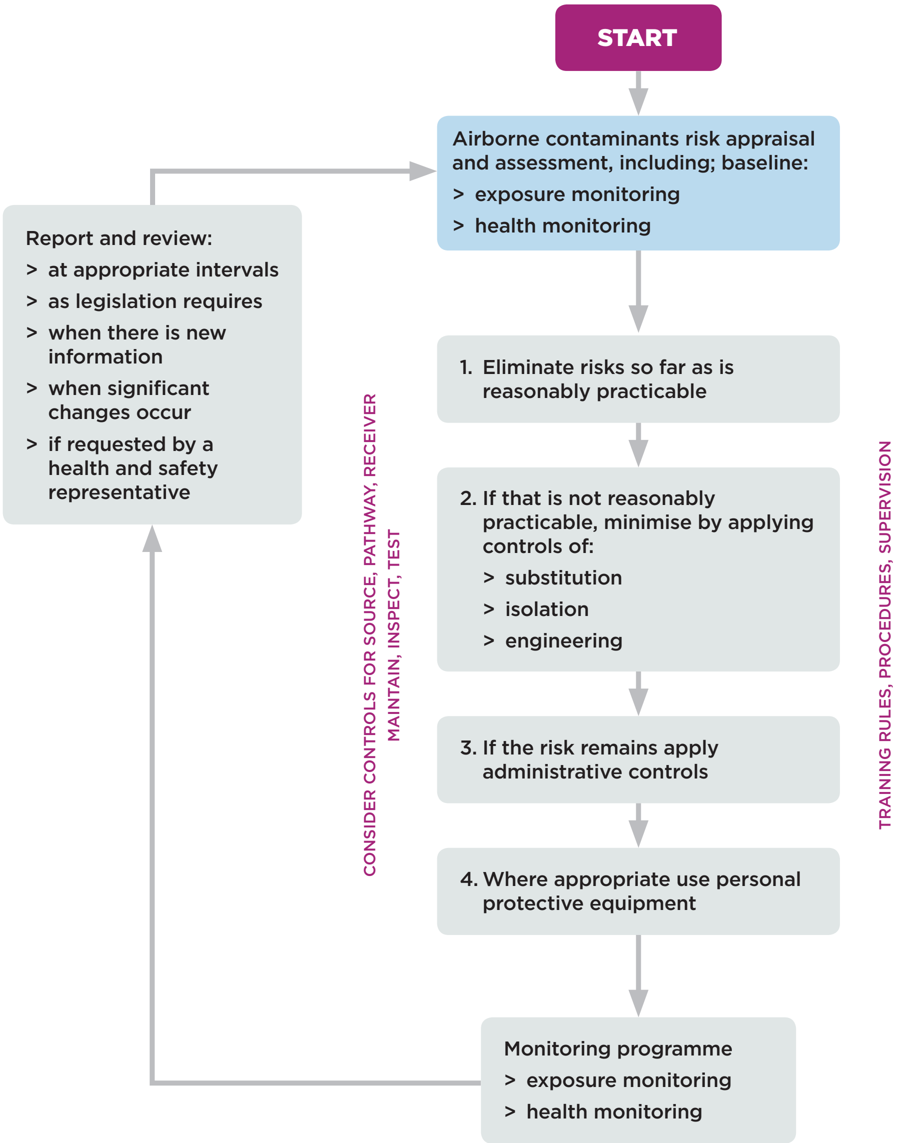

Figure 1: Health and safety management system overview

The blue highlight indicates the part of the process the current section addresses.

- geological data from site sampling and historical data
- soil and rock samples to determine the minerology
- information about mining or tunnelling methodologies and equipment used.

Figure 1 illustrates the health and safety management process.

The SSE must ensure that the initial data matches actual conditions, once the mining or tunnelling activities commence, and that no additional contaminants are present. This should be done by baseline or benchmark studies of the operation.

Consider the impact of weather conditions on air quality. Temperature, wind speed and direction, and air pressure can all affect the movement of air and contaminants.

If the initial risk appraisal identifies air quality as a hazard or principal hazard, duty holders need to carry out an air quality risk assessment.

Table 2 shows common mining and tunnelling activities and associated airborne contaminants. It is not an exhaustive list.

MINE ACTIVITY OR FEATURE	POTENTIAL AIR QUALITY CONTAMINANTS
Any activity that breaks up silica containing material (eg rock, coal, concrete), including: > excavating > drilling > blasting > crushing or transporting broken up material > conveying > screening > storage (ie wind picking up dust) > load-out.	Respirable crystalline silica. These activities can also disturb and release naturally occurring asbestos if it is present.
Blasting in tunnels, shafts and on the surface	Explosive fumes containing hazardous gases including: > carbon monoxide > oxides of nitrogen, including nitric oxide and nitrogen dioxide > hydrogen sulphide > sulphur dioxide > ammonia. The amount of gases produced depends on: > the type of explosives used > confinement and age of explosives > contamination of explosives with water or drill cuttings.
Coal mining	Coal mining produces coal dust when coal is broken from a seam, and crushed, screened, conveyed, stored and transported. It contains a range of elements and their sulphides, the composition varies from seam to seam. In underground coal mining, continuous mining and roof bolting produce the largest amounts of coal dust. Workers can be exposed when drilling, cleaning dust collectors or operating continuous mining machines. Coal dust also accumulates at conveyor transfer or loading points.
Cooling towers, water treatment plants, water cart mist sprays, and dust suppressing sprays	Growth of, and exposure to, Legionella bacteria.
Metal processing plants	Chemical extraction methods can produce a range of vapours, depending on the process used and rock type, including: > mercury > nitric acid vapour > lead > arsenic

<table>
<tr><th>MINE ACTIVITY OR FEATURE</th><th>POTENTIAL AIR QUALITY CONTAMINANTS</th></tr>
<tr><td></td><td>> reagents such as methyl isobutyl carbinol and xanthates, used in flotation
> hydrogen cyanide, from the accidental mixing of cyanide salts and acids.
Sulphur dioxide can be generated from the use of sodium metabisulphite.</td></tr>
<tr><td>Natural gases</td><td>1. Methane
Methane occurs naturally in coal mines. Increases in coal extraction rates often result in increased methane emissions. Methane can make up 0% to 100% of coal seam gas, with lower proportions of other gases, including carbon dioxide and nitrogen.
Methane is lighter than air, explosive at a range of concentrations (generally 5-15%) and displaces oxygen in the air.
2. Hydrogen sulphide
A colourless and tasteless gas with a powerful odour of rotten eggs at low concentrations. It occurs naturally in coal seams with high sulphur content. It also accumulates around stagnant water.
It can be released as the coal is mined, when coal is heated and by the action of acid waters on easily decomposed sulphide ores.
Gases can enter a working area:
> during removal of overburden
> when breaking into abandoned shafts
> when opening in-seam gas pockets
> from historical workings.
3. Radon
A radioactive gas that can be released from rock, coal or water. Radioactive decay of radon produces fine solid particles called radon daughters.
4. Reactions between groundwater and minerals in the rock can produce carbon dioxide, sulphur dioxide and hydrogen sulphide.</td></tr>
<tr><td>Other structures (eg buildings)</td><td>1. Man-made vitreous fibres (also known as synthetic mineral fibres or man-made mineral fibres), for example slag, rock and glass wool, refractory fibres, continuous filament glass fibres.
2. Asbestos in building materials, pipe and boiler lagging.
3. Ammonia from:
> reactions between alkaline whitewash and fire retardant salts in timber
> some types of cement-based cavity fillers
> ANFO and water.
4. If synthetic materials (eg PVC belting or refrigerants) melt they can release chlorine, hydrogen chloride, hydrogen cyanide or phosgene.</td></tr>
<tr><td>Oxygen deficient atmospheres</td><td>Oxygen-deficient atmospheres in underground mines can be caused by:
> emission of another gas (eg methane displacing oxygen)
> consumption of oxygen (eg oxidation of coal or organic material, metal rusting)
> oxidation of reactive sulphides, timber, or solution and evaporation in stagnant or flowing water.</td></tr>
</table>

MINE ACTIVITY OR FEATURE	POTENTIAL AIR QUALITY CONTAMINANTS
Spontaneous combustion	Spontaneous combustion of coal produces gases such as methane, hydrogen, carbon monoxide and hydrogen sulphide. Other flammable gases that act as indicators of fire might be present in small amounts, such as ethane, ethylene and acetylene.
Underground mining or tunnelling operations	Contaminants or lack of fresh air from: > poor or inadequate ventilation > contaminated intake air.
Use and maintenance of plant, including fixed and mobile plant	1. Diesel exhaust emissions including: > carbon monoxide > oxides of nitrogen (nitric oxide and nitrogen dioxide) > diesel particulate matter > sulphur dioxide. Diesel exhaust emissions are particularly hazardous in places without enough ventilation to dilute them (eg in workshops or underground). Emissions can also accumulate in surface operations if there is not enough wind to disperse them (ie in the pit). 2. Vapour from fuels, fuel additives and oils. 3. Man-made vitreous fibres (also known as synthetic mineral fibres or man-made mineral fibres), for example, slag, rock and glass wool, refractory fibres, continuous filament glass fibres. These fibres are present in gaskets, tapes and packings. 4. Asbestos might be in insulation materials, gaskets and friction materials including clutch and brake linings. 5. Metal dust from the use of angle grinders.
Use and storage of substances	Vapours might be released from substances including: > solvents (eg used for extraction, electrowinning, degreasing and painting) > liquid polymers (eg sludge treatment) > degreasers > paints > polymeric chemicals (eg phenolic resins, for strata stabilisation and sealing) > polyurethane foams (can liberate isocyanate vapour and mists, as well as other solvent vapours). Reactions between arsenic-containing substances and hydrogen in water or acids can produce arsine gas. This highly toxic gas is colourless, non-irritating and flammable.
Welding	1. Welding fumes and gases, including carbon monoxide 2. Metal dust.

Table 2: Mining activities and airborne contaminants

Table 3 shows common air pollutants and their effects. It is provided to assist duty holders with assessing risks arising from air quality. The list is not exhaustive.

AIRBORNE CONTAMINANT	HEALTH EFFECTS
Asbestos	Health effects associated with asbestos exposure include respiratory diseases, such as asbestosis (lung fibrosis), lung cancer and mesothelioma (cancer of the mesothelium).
Blasting fumes	Exposure to the fumes in a blast plume is usually very brief – seconds to minutes. For most people, any health effects from exposure to a blast plume are short lived. Symptoms from high levels of exposure might include: > eye, nose and throat irritation and coughing > dizziness and headache > shortness of breath > wheezing or exacerbation of asthma. Serious lung inflammation has been known to develop several hours after exposure to very high levels of nitrogen dioxide.
Coal dust	Inhalation of respirable coal dust can lead to serious respiratory disease including coal mine workers' pneumoconiosis and progressive fibrosis. These diseases can take many years to develop, but in the shorter term a reduction in lung function can also occur due to chronic obstructive pulmonary disease (COPD).
Diesel exhaust emissions	Short-term acute symptoms include headaches, dizziness, light-headedness, nausea, coughing, difficult or laboured breathing, tightness of chest, and irritation of the eyes and nose and throat. Long-term exposures can lead to chronic, more serious health problems such as cardiovascular disease, cardiopulmonary disease, and lung cancer.
Gases	Contaminant gases can present an acute or chronic health risk, or both. Acute health effects can include irritation and asphyxiation. Irritation can be mild to severe (eg mild irritation of the eyes, nose and throat, to severe damage to the lungs). Asphyxiation can occur either by the displacement of oxygen from the air (called simple asphyxiants such as carbon dioxide and nitrogen), or by interference with the body's ability to transport oxygen (called chemical asphyxiants, such as carbon monoxide and hydrogen cyanide). Chronic health effects from exposure to gases and vapours can include target organ effects (eg cardiac and central nervous system effects). Due to the radioactive properties of radon gas, it can have long term health effects on people after exposure. They release alpha radiation, or alpha particles, into the atmosphere. When radon daughters are inhaled, they can damage the lungs, and lead to lung cancer.
Legionella	Inhalation of mists containing the bacteria can cause Legionnaires disease, a potentially fatal respiratory disease, or the less severe Pontiac fever. In mining, the main risk areas for the growth of and exposure to Legionella bacteria are cooling towers or water treatment plants.

AIRBORNE CONTAMINANT	HEALTH EFFECTS
Man-made vitreous fibres (MMVFs)	Health effects from working with MMVFs include skin, eye and upper respiratory tract irritation. Ceramic fibres can possibly cause cancer; however, glass fibre, rock wool and slag wool are not classified as carcinogenic to humans.
Metal dust	Different metals give rise to different health effects, but can include: lung disease, such as pneumoconiosis (eg siderosis from iron exposure); chronic obstructive pulmonary disease; occupational asthma; cancer; target organ toxic effects (eg on the liver or kidney); or adverse skin effects (eg allergic contact dermatitis from skin contact with nickel metal).
Respirable crystalline silica (RCS)	Exposure to respirable crystalline silica can cause: > lung cancer > chronic obstructive pulmonary disease (COPD), also known as chronic bronchitis or emphysema > kidney disease > silicosis (a condition due to scarring of the lung). Workers may get some of these health conditions at relatively low levels of exposure, including levels below the workplace exposure standard (WES). Initially, workers with a health condition caused by exposure might have no symptoms. Recognisable early signs of COPD, lung cancer and silicosis are: > shortness of breath > severe cough > weakness. These symptoms can worsen over time and lead to death.
Vapours and mists	Health effects of vapours vary depending on the substance. Organic solvents are associated with central nervous system effects, some of which can target specific organs. > Mercury poisoning can result from both acute and chronic exposures. High mercury vapour concentrations can cause upper respiratory tract irritation and severe lung damage. At low vapour concentrations over a long time, neurological disturbances, memory problems, skin rash, and kidney abnormalities can occur. > Xanthates can liberate carbon disulphide, which is flammable and can cause peripheral and central nervous system effects, and inflammation of the optic nerve. > Di-isocyanates, such as TDI, MDI and HDI, are potent respiratory sensitizers causing occupational asthma and reduced lung function. > Some vapours and mists can also cause adverse skin reactions due to irritation, corrosion or allergy. Safety data sheets should be consulted for information on health risks. Read product safety data sheets for information on health risks.
Welding fumes	The health effects of welding fumes and gases depend on their composition. They can include metal fume fever (a short-term painful ailment with symptoms of fever and chills), chronic obstructive lung disease, pneumoconiosis (lung disease due to accumulation of mineral or metallic particles), occupational asthma, and irritation of the eyes and respiratory tract.

Table 3: Health effects of airborne contaminants

2.2 AIR QUALITY RISK ASSESSMENT

The air quality hazards identified in the risk appraisal need to be assessed to determine their risk of causing injury or ill-health. This is the risk assessment, or air quality assessment.

The air quality assessment needs to be produced by a competent person (refer to section 2.6 for more information). It determines air quality in the extractives operation, its likely impacts on worker health and identifies controls. It should include the:

> level of oxygen in natural or supplied air

> temperature and humidity of the air

> types of dust and other contaminants likely to be in the air

> levels of contaminants in the air

> length of exposure of workers to dust and contaminants, considering extended shifts

> recovery periods between shifts.

Table 4 lists examples of the information to consider in the air quality plan.

INFORMATION	EXAMPLES
Site characterisation	> material being mined > extraction rates > background air quality
Mining methods	> blasting > drilling
Weather conditions and changes	> wind speed and direction > rain > temperature > pressure
Equipment used	> mobile plant > light vehicles > fixed plant, including – crushers – screens – conveyors – drills – compressors
Hours of operation	> time weighted average exposure
Mine design	> ventilation systems > roads and other vehicle operation areas > location and size of stockpiles
Air quality monitoring	> frequency of measurements > instrumentation used
Worker exposure	> regulatory standards, including WES and site specific criteria
Controls	> effectiveness of existing controls > new controls

Table 4: information to consider in the air quality plan

2.2.1 SAMPLING METHODS

The person carrying out air sampling and analysis of airborne contaminants is to use the appropriate method, as detailed in the Table 5.

AIRBORNE CONTAMINANT	SAMPLING METHOD	REFERENCE
Respirable dusts including crystalline silica	AS 2985.	AS 2985 *Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust.*
Inhalable dusts including (most) metals	AS 3640.	AS 3640 *Workplace atmospheres – Method for sampling and gravimetric determination of inhalable dust.*
Coal dust	Measure using the approaches in AS 2985. Analyse using gravimetric determination.	AS 2985 *Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust.*
Diesel particulate matter	NIOSH 5040.	US National Institute of Occupational Safety and Health *Manual of Analytical Methods 4th Edition Method 5040.*
Asbestos	Refer to the approved code of practice for the *Management and Removal of Asbestos*.	WorkSafe's *Management and Removal of Asbestos* approved code of practice.
Synthetic mineral fibres	Use the methods set out in AS 3640 to measure the inhalable fraction. Suitable methods for measuring the respirable fraction are set out in the Australian SMF membrane filter method (NOHSC 1989b), or the asbestos methods in NOHSC 3003 and NIOSH 7400.	*Guidance note on the membrane filter method for estimating airborne asbestos fibres 2nd edition* [nohsc:3003(2005)].
Gases, vapours, mists	Apply AS/NZS 60079 and BS EN 45544-4 as appropriate. Direct-reading gas meters (eg electrochemical cells), or tubes and filter samples requiring laboratory analysis can be used to measure levels of gases, vapours and mists. Direct reading instruments are not available or practical to use for some gases, vapours and mists. Use appropriate standards to measure these, such as NIOSH, OSHA and HSE sampling and analytical methods. If direct-reading gas meters are used, it is essential that the meter is: > capable of detecting the gas or vapour in question > has an appropriate level of accuracy for the gas or vapour > is calibrated as specified by the OEM > has an appropriate response time for purpose.	AS/NZS 60079 *Explosive atmospheres – Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen.* BS EN 45544-4 *Workplace atmosphere: Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours. Guide for selection, installation, use and maintenance.*

AIRBORNE CONTAMINANT	SAMPLING METHOD	REFERENCE
	> is maintained and charged to ensure sufficient monitoring duration > located to enable early detection of airborne contaminant, or measurement of personal exposure > is able to record, log and average data if used for comparison against exposure standards. The operator needs to be aware of the limitations of the meter, such as cross-sensitivity and reduction in accuracy due to interference, high humidity, or low oxygen.	
Welding fumes and gases	Apply AS 3853.1 and AS 3853.2 as appropriate.	AS 3853.1 *Health and Safety in Welding and Allied Processes – Sampling of airborne particles and gases in the operator's breathing zone – sampling of airborne particles.* AS 3853.2 *Health and Safety in Welding and Allied Processes – Sampling of airborne particles and gases in the operator's breathing zone – sampling of gases.* ISO 10882-1 *Health and safety in welding and allied processes – Sampling of airborne particles and gases in the operator's breathing zone – Sampling of airborne particles.* ISO 10882-2 *Health and safety in welding and allied processes – Sampling of airborne particles and gases in the operator's breathing zone – Sampling of gases.*
Isocyantes	Follow the OSHA method 42/47 for di-isocyanates or MDHS method 25/4 for organic isocyanates in air.	United States Department of Labour. *Sampling and analytical methods number 42 – Diisocyanates*. Health and Safety Executive. MDHS 25/4 *Organic Isocyanates in Air method*.

Table 5: Sampling methods

2.3 ASSESSING WORKERS' EXPOSURE

Duty holders need to ensure that workers' exposure to airborne dust and other contaminants is assessed.

Exposure assessment must be carried out or supervised by a competent person (see section 2.6 for more information).

The design of the assessment strategy depends on the size and type of mining operation, and the activities carried out. A good assessment requires:

> a robust sampling strategy
> appropriate measuring and monitoring
> appropriate interpretation of results.

Most exposure monitoring will be occasional and workers will not wear monitoring equipment all the time, with some exceptions, such as underground mining gas detectors (eg for early warning of spontaneous combustion).

Exposure needs to be compared against *Workplace Exposure Standards and Biological Exposure Indices*.

Results of exposure monitoring should be made available to workers. This information is not to contain any information that identifies, or discloses anything about, an individual worker.

See Appendix A for more information on assessing worker's exposure.

2.4 WORKPLACE EXPOSURE STANDARDS

Workplace exposure standards (WES) are values of the airborne concentration of substances at which nearly all workers can be repeatedly exposed day after day without coming to harm. The values are normally calculated on work schedules of five shifts of eight hours over a 40-hour work week.

WESs relate to exposure measured by personal monitoring by collecting air samples in the worker's breathing zone. The breathing zone is a hemisphere of 300 mm radius in front of the face, measured from the midpoint of an imaginary line joining the ears.

Compliance with the designated WES does not guarantee that all workers are protected from discomfort or ill-health. Individuals have different levels of susceptibility to hazardous and toxic substances, and it is possible that some workers will experience discomfort or become ill from exposure at levels below the WES. This means that WES should not be used to differentiate between safe and unsafe exposure levels.

Some substances have multiple WES for different periods of exposure. These substances require monitoring for the specific periods that the WES apply. For example, a substance might have a time-weighted average WES (WES-TWA) so exposure needs to be assessed for the whole shift. This does not necessarily mean exposure has to be measured over the whole shift, but that full shift sampling will provide the most useful data as exposure varies over the shift. If the substance also has a short term exposure limit WES (WES-STEL), exposure needs to be assessed for 15-minute periods. When comparing monitoring results to a specific WES make sure that:

> monitoring results are measured and calculated over the appropriate time frame
> WES are adjusted for extended work shifts.

See *Workplace Exposure Standards and Biological Indices* for the levels that WES have been set.

Do not use the numerical value of two or more WES to directly compare the relative toxicity of different substances. This is because the biological basis for assigning WES varies from substance to substance, so the values are not comparable. For example, some WES are designed to prevent the development of ill health after long-term exposure (WES-TWA), others to reduce the possibility of acute effects (WES-Ceiling, WES-GEL, WES-STEL).

See Appendix B for more information on workplace exposure standards.

2.5 HEALTH MONITORING

Health monitoring is used to ensure that the controls in place are effective, and that airborne contaminants are not causing an adverse effect on the health of workers.

If there is a risk that workers could be exposed to harmful levels of respirable dust, or other airborne contaminants, duty holders are to carry out health monitoring.

Health monitoring must be carried out, or supervised by, a competent person who has sufficient knowledge, skills and experience in the appropriate techniques and procedures, including interpretation of results. Professional associations can be a good source for competent persons (eg NZOHNA).

Review controls if health monitoring indicates that the controls are not effective.

See the *Health Monitoring under the Health and Safety at Work (General Risk and Workplace Management) Regulations 2016* fact sheet for more information on health monitoring requirements under the GRWM Regulations, including reporting requirements.

2.6 COMPETENCY OF EXPOSURE ASSESSORS

Exposure monitoring must be carried out, or supervised by, a competent person who has sufficient knowledge, skills and experience in the appropriate techniques and procedures, including interpretation of results. Professional associations can be a good source for competent persons (eg HASANZ, NZOHS).

Use a competent person, such as a a suitably qualified occupational hygienist, to assess exposure, health risks or effectiveness of controls, who is competent in:

- the risk assessment process
- the tasks, processes or exposures being assessed
- development of sampling strategy
- selection and use of sampling equipment and sampling media
- sampling methods
- data interpretation
- the criteria upon which WES are based
- the relevance and application of statistical analysis of exposure data.

Reports, results and recommendations should be presented to the duty holders in a style and format that is easily understood. It is important that the assessor is aware of the limitations of their competencies and when to seek help from other assessors, or alert the duty holders to their limitations as appropriate.

Third party assessors and other duty holders (eg ventilation officer) need to work together to ensure health and safety risks are kept as low as is reasonably practicable. For example the ventilation officer would provide advice on the mine or tunnel design and airflow characteristics, and an occupational hygienist would provide advice on exposure assessment and health effects of airborne contaminants.

PART B

03/

CONTROL MEASURES

IN THIS SECTION:

Health and Safety at Work Act 2016

Section 30 Management of risks

Section 36 Primary duty of care

Health and Safety at Work (General Risk and Workplace Management) Regulations 2016

Regulation 6 Hierarchy of control measures

Regulation 9 Duty to provide information, supervision, training, and instruction

Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016

Regulation 154 Exposure to diesel emissions

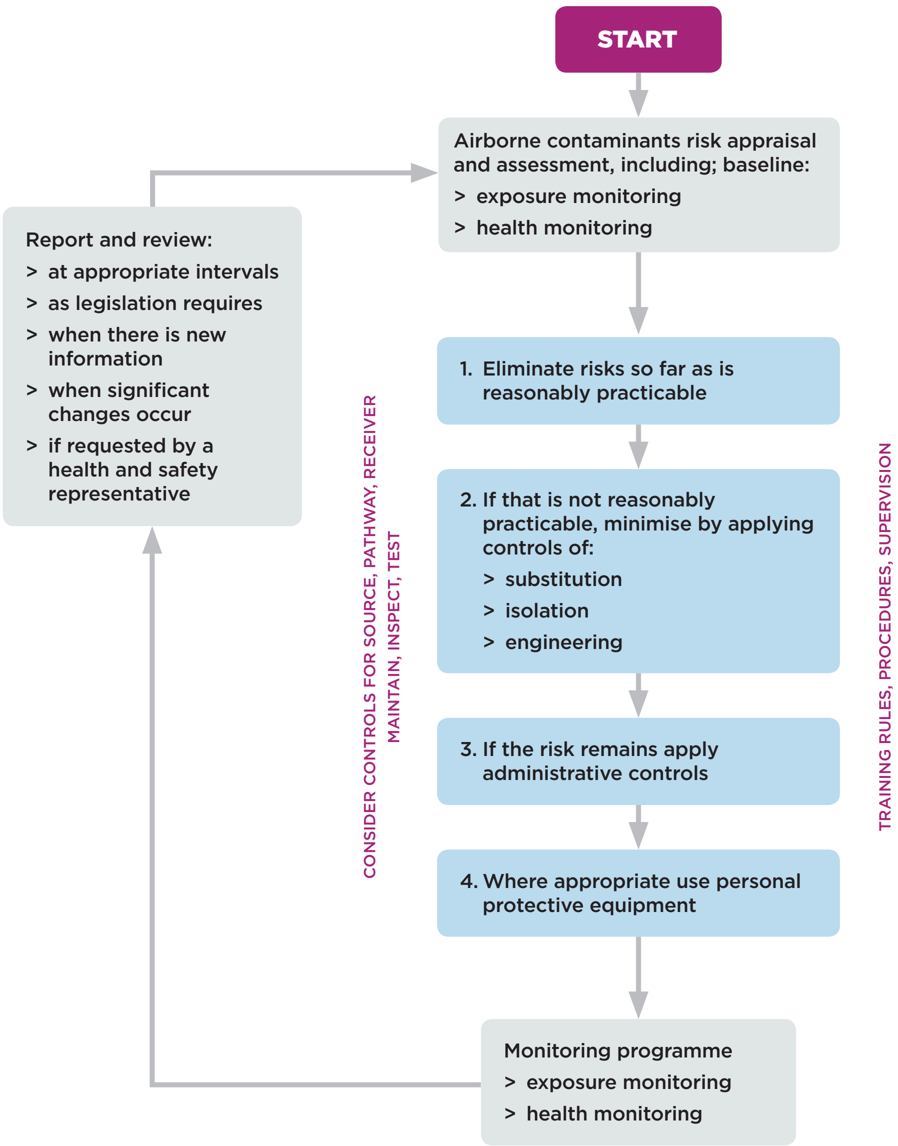

Figure 2: Health and safety management system overview

The blue highlight indicates the part of the process the current section addresses.

3.1 HIERARCHY OF CONTROLS

Duty holders need to apply the hierarchy of controls set out in the GRWM regulations. PCBUs must apply the hierarchy for substances hazardous to health. The PCBU must try to eliminate risks so far as is reasonably practicable. If elimination is not reasonably practicable, the risk must be minimised, so far as is reasonably practicable. The hierarchy is shown in Figure 3.

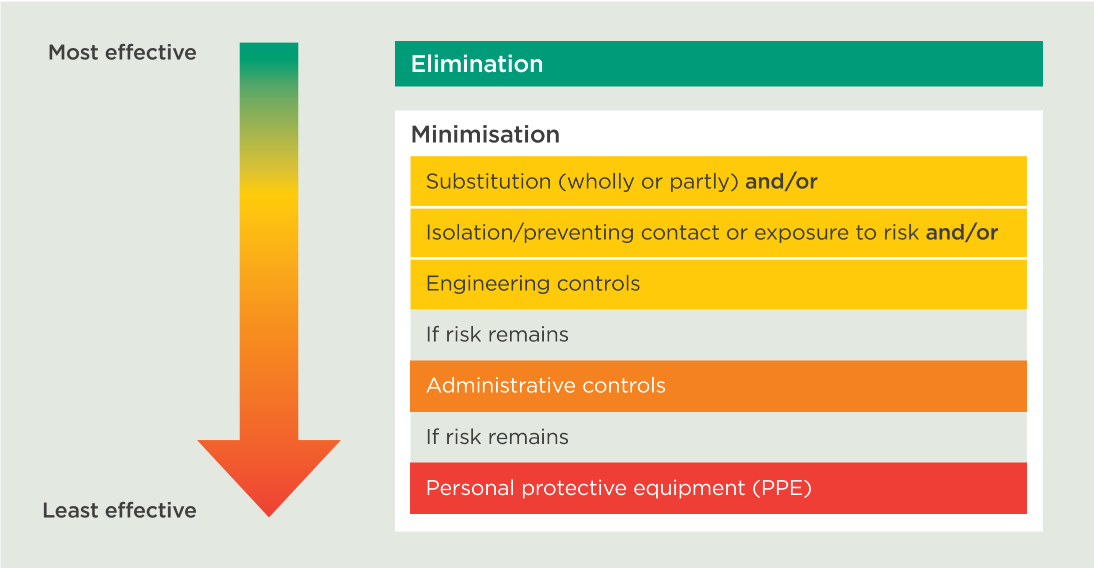

Figure 3: The hierarchy of controls

Where reasonably practicable, use the more effective control measures first. More than one type of control measure at a time can be used. The control measures used should be proportionate to the risk. Control measures include equipment, processes, procedures or behaviour to minimise risk.

If elimination is not reasonably practicable, PCBU's must minimise risks so far as is reasonably practicable. Risks need to be minimised by applying one or more of the following actions, that is the most appropriate and effective, taking into account the nature of the risk:

> substituting with a lower risk activity
> isolating people from the hazard/preventing people being exposed to the risk
> applying engineering control measures.

If a risk then remains, the duty holder needs to minimise the remaining risk, so far as is reasonably practicable, by putting in place administrative control measures.

Finally, if a risk still remains, the duty holder needs to minimise the remaining risk by ensuring the provision and use of suitable personal protective equipment (PPE). PPE is only used when other control measures alone cannot adequately manage the risk.

Figure 2 illustrates the health and safety management process. Table 6 explains the different types of control measures.

ACTION		WHAT IS THIS?
Elimination		Removing the sources of harm (eg equipment, substances or work processes).
Minimisation	**Substitution**	Substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk (eg using a less hazardous thing, substance or work practice).
	Isolation	Isolating the hazard giving rise to the risk to prevent any person coming into contact with it (eg by separating people from the hazard/preventing people being exposed to the hazard). Isolation focuses on boxing in the hazard or boxing in people to keep them away from the hazard.
	Impose engineering control measures	Using physical control measures including mechanical devices or processes.
	Impose administrative control measures	Using safe methods of work, processes or procedures designed to minimise risk. It does not include an engineering control; or the wearing or use of personal protective equipment.
	Use personal protective equipment (PPE)	Using safety equipment to protect against harm. PPE acts by reducing exposure to, or contact with the hazard. For information on PPE requirements, see the interpretive guidelines *Requirements for workplaces and facilities, training and supervision, personal protection equipment, monitoring, first aid, emergency plans and young people*.

Table 6: The hierarchy of controls

Duty holders need to apply the hierarchy of controls when selecting and implementing controls.

3.1.1 TYPES OF CONTROLS (LINES OF DEFENCE)

Every risk has three elements and different controls work on each of them. Table 7 shows the elements of risk and example controls.

RISK ELEMENT	DESCRIPTION	EXAMPLE	EXAMPLE CONTROL
Source	Hazard and its location	Dust at the working face	Dust suppression
Pathway	Route the hazard takes to the receiver	Dust in the air	Ventilation system
Receiver	Person, or organs, at risk from the hazard	Worker's lungs	Respiratory protective equipment

Table 7: Elements of risk

The duty holder needs to control risks at the source, so far as is reasonably practicable. Use controls along the pathway or at the receiver if control at the source is not reasonably practicable or sufficient.

Control at the receiver is the last choice because it does not reduce the hazard but only reduces the effects of the hazard. If controls at the receiver fail, there is no fall-back position and workers are likely to be injured or become ill.

Respiratory protective equipment can still be provided even if other controls are effective.

3.2 CONTROLS FOR DUST AND AIRBORNE CONTAMINANTS

The controls used for dust and other airborne contaminants depend on the type, size and nature of the operation. Table 8 shows an example hierarchy of controls.

HIERARCHY LEVEL	CONTROL
Elimination	> electric powered plant rather than diesel > sealed roads
Substitution	> welding methods that generate less, or less harmful, fumes
Isolation	> enclosed cabs with filtered conditioning units > designed ventilation systems (eg specific exhaust or return air system) > local exhaust ventilation (welding)
Engineering	> dry or wet collection systems > wet suppression systems > blast design to ensure there is not excessive fragmentation > water cartridges in shot firing > use of foggers to saturate atmosphere before blast > wet muck piles before excavation > regular plant maintenance – especially worn drill bits > wetting roads, and consider use of dust control substances > enclose the plant and have dust suppression systems > safe welding methods > exhaust
Administrative	> increase following distances on roads > established fume management zones to remove people from fume path > controlling excessive ventilation (which can pick up dust)
PPE	> respiratory protective equipment

Table 8: Hierarchy of controls for airborne contaminants

3.2.1 ROADWAY DUST

Duty holders need to eliminate road dust generation, so far as is reasonably practicable. Minimise roadway dust if it is not reasonably practicable to eliminate it.

Apply water to roadways, including haul roads and underground mine and tunnel roadways, to control dust generation. Water can be applied using a mobile tanker with sprays or fixed water sprays, as shown in Figure 4. Reapply water as the road surface dries out.

Figure 4: Dust suppression using a mobile tanker

The time between reapplication can be extended by treating the road surface with:

> salts

> surfactants (such as soaps and detergents)

> soil cements

> bitumens

> polymer films.

Vehicles operating on haul roads should have enclosed cabs and be equipped with air conditioning. Make sure doors and windows are always closed when the vehicle is operational. Check cab filters on a shift basis, and replace and clean them as required.

Use longer distances between vehicles to reduce driver dust exposure. A 40-60 second gap between vehicles reduces dust concentrations in the air by more than 300% compared to a 0-20 second gap (NIOSH).

3.2.2 DRILLING

Operators need to reduce dust generation at source when drilling, and use enclosed cabs on drilling rigs, so far as is reasonably practicable.

There are two main types of dust suppression for drilling operations:

> wet dust suppression

> dry dust collection.

Figure 5: Surface drilling

ENCLOSED CABS

Operators need to use modern drill rigs with enclosed cabs and filtration systems, so far as is reasonably practicable. Fit enclosed cabs to older drill rigs, so far as is reasonably practicable.

Duty holders need to ensure:

> there are no leaks and door seals are maintained

> high efficiency dust filters for intake and recirculation are used and replaced as required

> dust carried into cabs by operators is removed
> doors and windows are closed during drilling and tramming
> filters and ventilation are regularly checked and maintained.

Figure 6 shows a filtration system fitted to an enclosed cab.

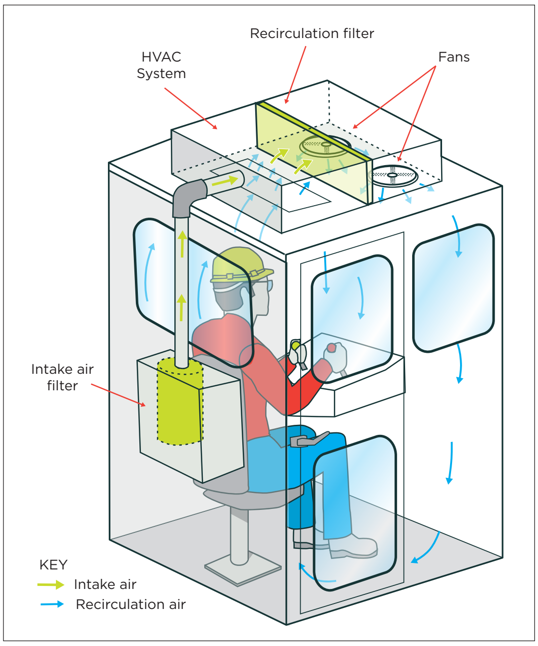

Figure 6: Filtration system for an enclosed cab

WET DUST SUPPRESSION SYSTEM

Wet dust suppression uses water to suppress dust at the drill bit. Clean water is passed along the drill rod to the drill bit. This reduces dust generation during cutting or percussion, and can increase the life of the drill bit. Make sure there are systems in place so drilling cannot happen if there is insufficient water pressure.

All drilling in underground mining and tunnelling operations needs to use wet dust suppression.

Only if it is not reasonably practicable to use wet dust suppression for underground drilling, can other controls be used, if supported by a risk assessment.

Wet dust suppression should be used for surface operations if a clean water supply can be provided. However, this is not always reasonably practicable.

Wet dust suppression can be used on different drilling methods and uses, including:

> top hammer
> coal auger drilling
> DTH hammer drills
> tri-cone bits
> diamond drilling.

Figure 7 shows the benefits of wet drilling over dry, and Figure 8 shows examples of wet drilling equipment.

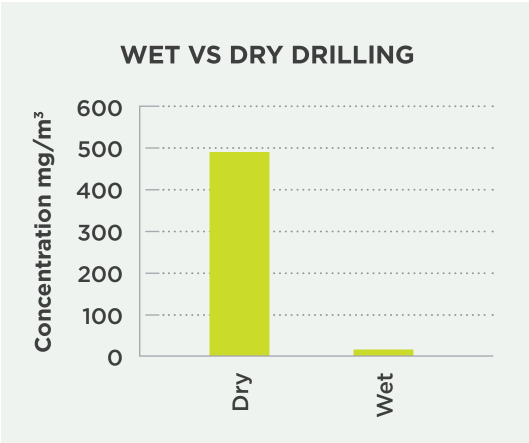

Figure 7: Reduction of dust for wet drilling

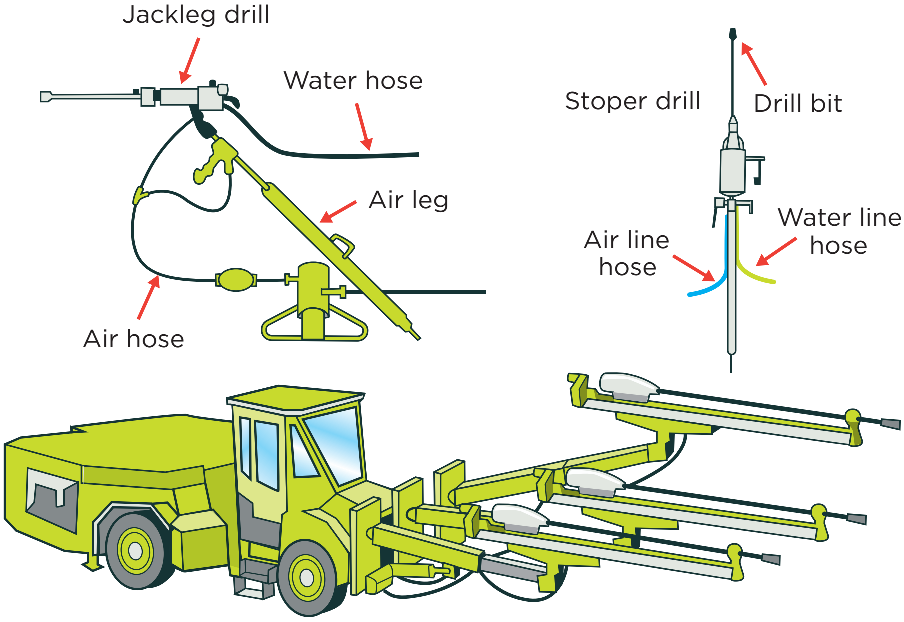

Figure 8: Wet drilling equipment

DRY DUST COLLECTION SYSTEMS

Dry dust collection systems are suitable for use in surface operations if it is not reasonably practicable to provide clean water for wet drilling methods. Figure 9 shows a dry dust collection system.

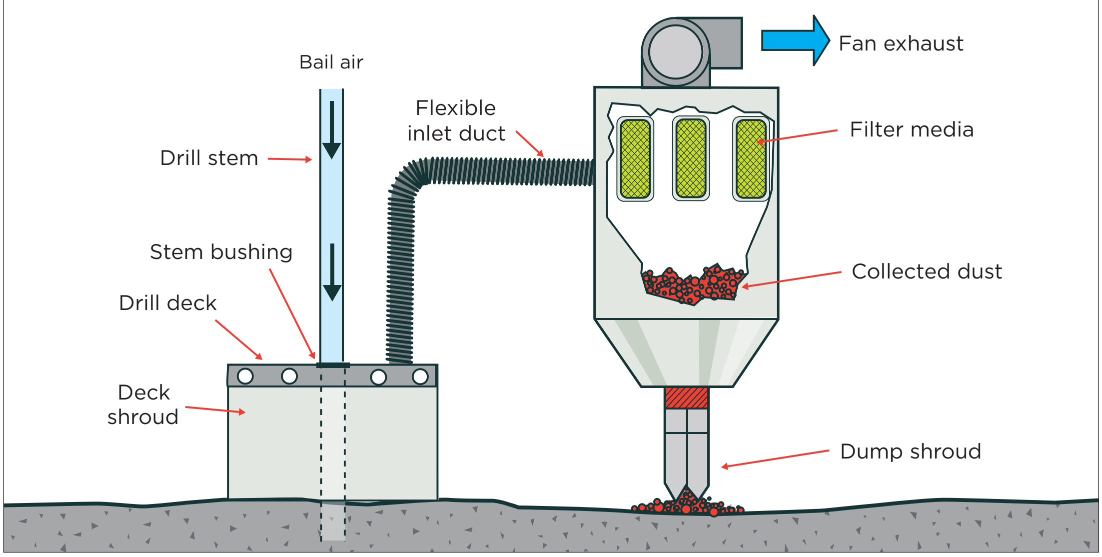

Figure 9: Dry dust collection

3.2.3 BLASTING – SURFACE AND UNDERGROUND

When explosives are used, both hazardous gases and dusts are generated. This can include quantities of dust (eg silica, coal) along with other airborne contaminants. Gases produced include carbon monoxide and oxides of nitrogen (eg nitric oxide and nitrogen dioxide).

When undertaking blasting activities in surface mines and quarries the blast should be properly designed to ensure no fly-rock or excessive fragmentation takes place, including geotechnical factors (eg rock properties). Duty holders should consider using hoses or water carts to control dust by dampening the area after the blast.

Water cartridges can be effective in reducing dust generated during the blast. Figure 10 shows a water cartridge in use.

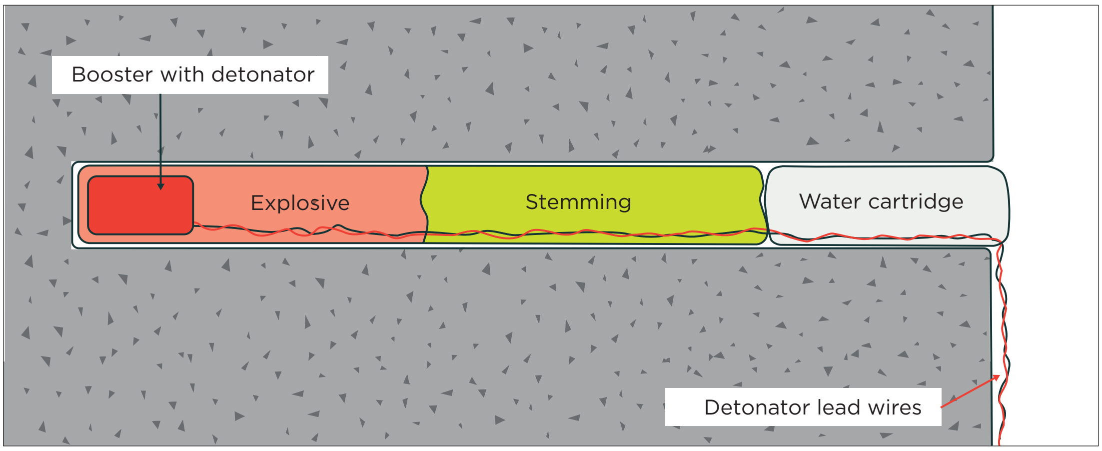

Figure 10: Water cartridge

When blasting on the surface, consider the wind directions and strengths. Note the area likely to be affected by dust or fumes and ensure the area is kept clear until they have dissipated. Refer to daily weather and wind forecasts.

When blasting underground, thoroughly wet down the muck piles generated from each blast before any material is moved. Further wetting down should take place as muck piles are removed to ensure dry material inside the muck pile is also prevented from generating airborne dust.

Dust can also be reduced by the use of ‘Fogger Sprays’ at the end of forcing ventilation ducting to saturate the air during the actual blast occurrence. Figure 11 shows a fogging spray in use for underground blasting.

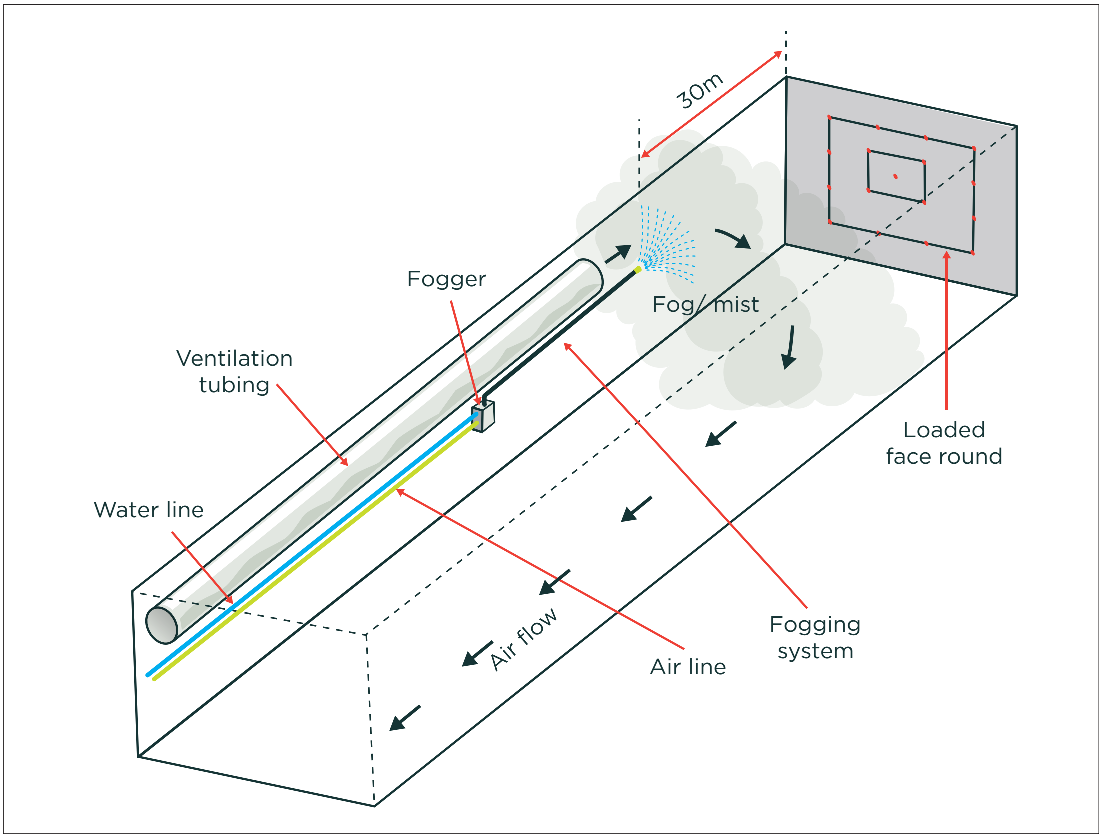

Figure 11: Fogger spray

Gases, fumes and other hazardous by-products of explosives should be controlled by the mine or tunnel's ventilation (see *Ventilation in Underground Mines and Tunnels* approved code of practice for more information).

3.2.4 DIGGING

Large quantities of dust can be liberated by equipment being used to dig blasted material, or by ripping or free digging ore or minerals.

The use of fogging systems can have a significant effect on reducing airborne dust. These are placed at key locations and the fine droplets of water will suppresses airborne dust in the same manner as other water sprays.

Use fogging systems where reasonably practicable.

Heavy machinery used for digging is to have enclosed cab with filtration systems fitted. See section 3.2.2 for more information on the use of enclosed cabs.

Keep workers away from areas where dust is being put into the air, so far as is reasonably practicable (eg where excavation is taking place).

Where work can be scheduled to take advantage of these, the following significantly reduce the amount of dust in the air:

> low wind
> rainfall
> early mornings when dew is present.

3.2.5 UNDERGROUND COAL PRODUCTION

Where continuous miners or road-headers are used, cutting needs to be undertaken with water sprays on all cutting picks. This may be as a hollow pick with water passing through it or spray directed onto the cutting point. This keeps dust to a minimum, and significantly reduces the potential for incendive sparking from the cutting action.

Further sprays should be in place behind the cutting head and to each side of the boom. Incorporate safety systems into the machines that prevent cutting if water sprays are not working.

If the dust has not been controlled sufficiently at source, additional ventilation might be required.

In addition to the above:

> design ventilation appropriate to the mining method and mine design to dilute and extract dust
> ensure ventilation is appropriate at the face to dilute and extract dust
> ensure the cutter head, rotation speed and pick design are appropriate to minimise dust production so far as is reasonably practicable
> ensure a rigorous maintenance regime is in place.

Continuous miners and road headers should also be fitted with dust scrubbers (see *Ventilation in Underground Mines and Tunnels* approved code of practice).

If drilling and blasting operations are permitted and notified (see section 6), the face needs to be wetted down before and after blasting. Keep the coal pile continuously wetted down during loading out operations. See also section 3.2.3. for use of water cartridge stemming.

3.2.6 OTHER SOURCES OF DUST

Dust can be generated when loading trucks and trailers for product haulage, and at:

> crusher dump hoppers
> crushers and screening plants
> stockpiles.

Dust is to be controlled wherever it is generated. Make sure the air quality plan covers all likely sources of dust.

Water sprays and enclosures are the most effective methods of dust control.

Use water sprays and curtains to control dust at hoppers and transfer points. These need to use water at approximately 1% of the weight of material being moved or processed.

Stockpiles need to be wetted regularly to control dust. Fogging systems can be very effective at controlling dust at stockpiles.

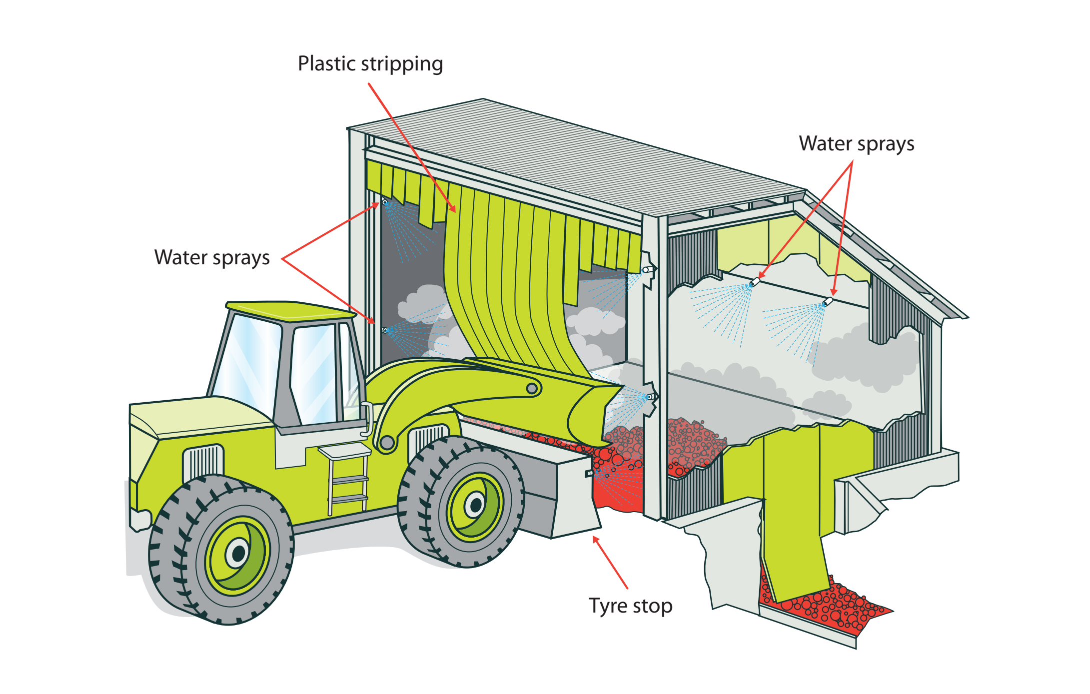

Figure 12: Example of enclosed hopper with water sprays

Use a spray bar that is incorporated into the tyre stop at stockpiles and hoppers. This will also reduce carry back on loader or truck tyres.

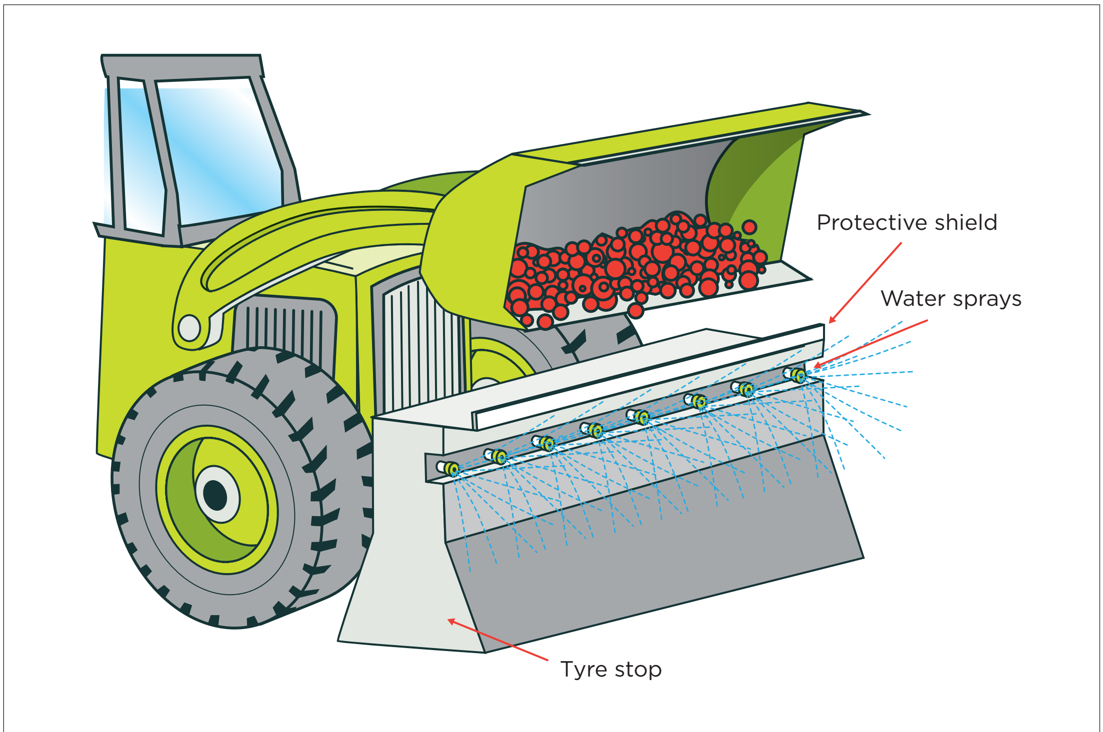

Figure 13: Example of spray bar in a concrete tyre stop

At crushing and screening plants:

> enclose transfer areas

> use sprays on screens and where material is placed into stockpiles

> use sprays on conveyors and screens, when material is dropped.

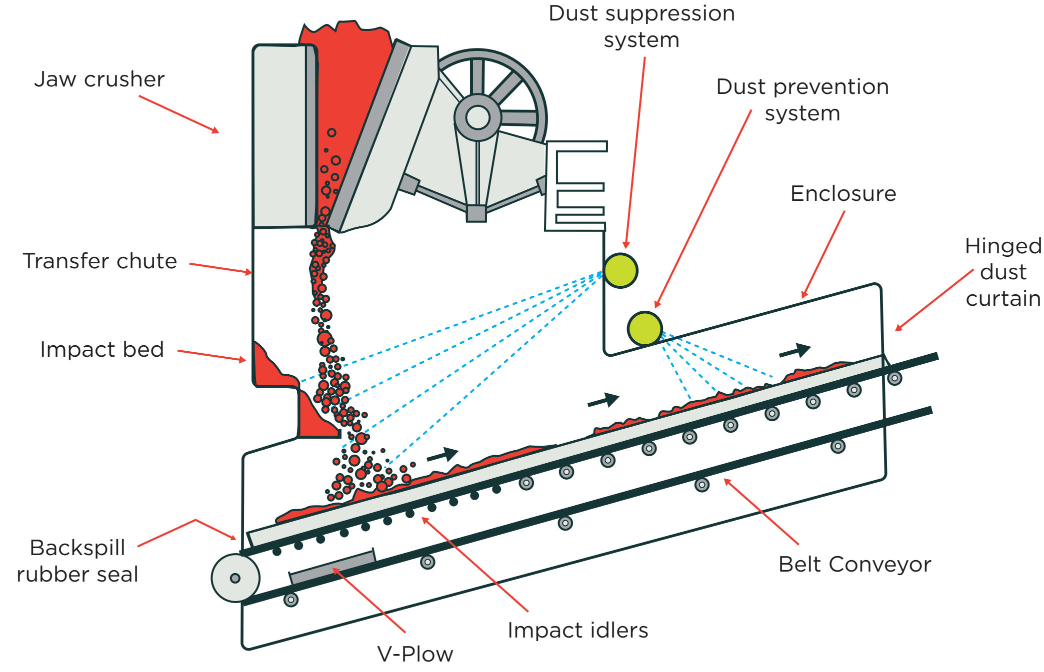

Figure 14: Example of enclosed discharge from jaw crusher with water sprays

If the use of water is a problem for the material, or is not reasonably practicable to provide, then the use of dust extractors, cyclones, filters and load out hoppers/bins can be an effective way to control and remove dust and then deposit the collected dust back into the product stream prior to loadout.

3.2.7 FURTHER INFORMATION

For more information refer to:

> NIOSH *Best Practices for Dust Control in Coal Mining*

> NIOSH *Best Practices for Dust Control in Metal/Nonmetal Mining*

> MSHA *Handbook Series*.

3.2.8 ASBESTOS

Asbestos can be found in building materials, pipe and boiler lagging. It might be in insulation materials, gaskets and friction materials including clutch and brake linings.

Any activity that breaks up or disturbs geological material can also disturb and release naturally occurring asbestos if it is present.

The *Health and Safety at Work (Asbestos) Regulations 2016* specify how to manage asbestos risks. Asbestos is present in many workplaces in New Zealand.

Airborne asbestos is the most dangerous form of asbestos, because the fibres can enter the body on breathing and can settle in the lungs.

PCBUs must make sure that exposure to airborne asbestos (including natural asbestos) is eliminated so far as is reasonably practicable. If it is not reasonably practicable, they must minimise exposure so far as is reasonably practicable.

PCBUs must also make sure the asbestos airborne contamination standard is not exceeded at the workplace.

See the approved code of practice for the *Management and Removal of Asbestos* for more information and controls.

3.3 CONTROLS FOR DIESEL ENGINE EMISSIONS

Extractives operators need to prevent diesel emissions being generated (elimination), so far as is reasonably practicable, and control them so far as is reasonably practicable if they cannot be prevented.

Controls for diesel emissions vary depending on the type and nature of the operation and the type of plant and engines used. There is not a single control that can be used and several controls are normally used in combination. Use substitution, isolation and engineering controls first, administrative controls second, and PPE as a last resort. Table 9 shows an example hierarchy of controls for diesel emissions.

HIERARCHY LEVEL	CONTROL
Elimination	> electric powered plant rather than diesel
Substitution	> use cleaner burning diesel or biofuel mixes
Isolation	> use ventilation to dilute and remove diesel emissions > designed ventilation systems (eg specific exhaust or return air system) > use enclosed air conditioned operator cabs
Engineering	> use diesel engines that meet the emissions control standards > fit exhaust filtration systems
Administrative	> regularly maintain plant and equipment > limit speeds and use one-way systems to reduce congestion > prevent engine idling or lugging > restrict the amount of diesel-powered equipment in a given area > restrict worker access to areas with high amounts of diesel emissions > use engine warm-up and cool-down practices > prevent contamination of fuel when refuelling > report blue or black smoke and make sure plant is repaired as necessary > use qualified mechanics to repair and maintain plant
PPE	> respiratory protective equipment

Table 9: Hierarchy of controls for diesel emissions

3.3.1 EXPOSURE TO DIESEL EMISSIONS IN UNDERGROUND MINING AND TUNNELLING OPERATIONS

The legislation that applies this section is:

Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016

Regulation 154 *Exposure to diesel emissions*

Mining and tunnelling operators must ensure that the ventilation and transport system does not allow workers to be exposed to diesel emissions that could cause injury or ill-health.

If one or more diesel engines are operating in a ventilating current the volume of air must be at least the larger of:

> 0.05 cubic metres per second for each kilowatt of the maximum combined output capability of the engines
> 3.5 cubic metres per second.

In addition to the requirements of Regulation 154, ensure there is adequate fresh air for persons in the mine.

Consider the risk of ventilation picking up dust and other airborne contaminants.

See WorkSafe's approved code of practice on *Ventilation in Underground Mines and Tunnels* for more information.

3.3.2 ENGINE DESIGN

Duty holders need to use diesel engines that emit the lowest emission so far as is reasonably practicable. Diesel engines are rated according to the emissions they release, for example under the US Environmental Protection Agency emissions standards[1]. Under this scheme higher ratings or tiers equate to better emissions controls. This is summarised in Table 10.

TIER	YEARS OF MANUFACTURE	EMISSION CONTROLS
none	before 1996	none
1	1996 to 2004	basic engine design modifications
2 and 3		one or more of: > high pressure fuel injection with multiple injections per stroke > increased peak cylinder pressure > single-stage variable geometry turbocharger > high-performance exhaust gas recirculation > centrifugal closed crankcase ventilation
4 and 5	2005 onwards	> diesel particulate filters > NOx filters

Table 10: Emission controls for diesel engines

[1] This information is based on the American EPA emission standards. European Union emission standards or other suitable emissions standards can be used. While the standards might differ the principle remains the same.

The tier of engines used at the operation influences the controls required in the pathway and at the receptor. For example, a tier 1 engine produces more emissions than a tier 4, both of which need to be controlled.

It is likely that each operation will have a mix of different age and emissions rated engines. Duty holders need to ensure there is a strategy in place that accounts for different engine characteristics, as appropriate.

All engines need to be regularly maintained according to the manufacturer's specifications. Some engines can require extra controls for use in extractives operations because the specifications are for highway use. This is especially so for operations more than 1500 m above sea level.

3.3.3 FUEL TYPE

Consider whether alternative fuels could improve the emission from diesel engines. Examples of alternative fuels include:

> low sulphur diesel
> biodiesel including soy diesel
> synthetic diesel
> emulsified diesel fuel
  – during hot weather: 20% water
  – during cold weather: 10% water and 2% methanol.

They can also significantly increase levels of NOx. Some of these fuels are difficult to obtain in New Zealand due to low volumes.

Competent advice should be sought if the use of alternative fuels is being considered.

All supply lines to the end user on site (pump/hose/filler) should have a filter and water trap.

3.3.4 FILTRATION SYSTEMS

There are three types of filter systems that can be used on diesel engines:

> diesel particulate filters
> disposable diesel exhaust filters
> active diesel particulate filtration system.

DIESEL PARTICULATE FILTER SYSTEMS

Diesel particulate filters are available for a wide range of extractives operations. The most common uses a catalytic converter, with a precious metal catalyst, to convert carbon monoxide to carbon dioxide and remove diesel particulate matter. Removable filters are available that need to be cleaned at regular intervals (eg every 250 hours) or as required by backpressure indication.

Catalytic converters are not suitable for underground coal mining operations because they produce too much heat.

Figure 15 shows a diesel particulate filter above the wheel.

Figure 15: Diesel particulate filter

DISPOSABLE DIESEL EXHAUST FILTERS

These filters are suitable for use in underground coal mining operations, if used with a water scrubber exhaust system. They are placed in the exhaust system of vehicles and filter the exhaust gas. They require maintenance and changing on a regular basis, sometimes every shift. Do not use them in a vehicle that is not fitted with a water scrubber exhaust system as they can get too hot, and even catch fire.

ACTIVE DIESEL PARTICULATE FILTRATION SYSTEM

Active, or self-regenerating, filter systems are only suitable for surface operations. Do not use them in underground applications because they can generate high temperatures and release NO_2 during the cleaning cycle. These filters trap soot and raise the exhaust temperature to burn the soot. This regenerates the filter.

The filters can use the vehicle's diesel fuel or electrical system as a source of heat.

3.3.5 WATER SCRUBBERS

Water scrubbers cool exhaust gases and prevent sparks and fire. Diesel exhaust is cooled by passing through water.

However, they can reduce diesel particulate matter by up to 30% in pre-1997 engines and up to 10% in newer engines.

3.3.6 FURTHER INFORMATION

For more information refer to:

> HSE *Controlling and monitoring exposure to diesel engine exhaust emissions in non-coal mines*

> HSE *Controlling and monitoring exposure to diesel engine exhaust emissions in coal mines*.

3.4 RESPIRATORY PROTECTION

Personal protective equipment (PPE) does not alter the type or amount of airborne contaminants.

PPE is the lowest order control in the hierarchy of control and relies heavily on worker compliance and enforcement by supervision to be effective. Failure to wear suitable, correctly fitted PPE, when required can result in a worker being directly exposed to hazardous airborne contaminants.

Only use respiratory protective equipment (RPE) as the primary control on a temporary or interim basis. If RPE is being used as the primary control, a thorough risk assessment needs to have been undertaken to show that this is the most effective control, so far as is reasonably practicable.

However, RPE can be routinely provided as an optional measure.

Every effort should be made to reduce airborne contaminants to levels that do not require the mandatory use of respiratory protection (eg ventilation), so far as is reasonably practicable.

Because diesel engine exhaust particles are so small careful consideration should be given to the selection of RPE.

Refer to WorkSafe's website for more information on RPE.

Further guidance about the selection, use and maintenance of respiratory protection is provided in *AS/NZS 1715 Selection, use and maintenance of respiratory protective equipment*.

3.5 WELDING FUMES

Welding fumes can either be controlled by using a safer working method which produces less (or less harmful) airborne contaminants or providing ventilation (ie local exhaust ventilation). Safer working methods need to be applied in preference to ventilation.

WorkSafe has published guidance on the necessary controls for different welding situations. Apply these controls, as relevant.

Powered air purifying respirator (PAPR) welding helmets should be used if RPE is needed while welding.

For more detailed control methods refer to WorkSafe's *Health and Safety in Welding* good practice guideline.

Refer to Appendix C for a Welding Fume Control Worksheet.

3.6 HAZARDOUS SUBSTANCES

Many substances and fuels used in extractive operations are hazardous and are controlled under the Hazardous Substances and New Organisms Act 1996 (HSNO). The steps used to control exposure to a number of gases, mists and vapours that are or are the result of hazardous substances are detailed in the relevant Safety Data Sheet (SDS) for the substance. Apply the controls specified in the applicable SDS.

Hazardous substances used in the extractive industry include:

- explosives and detonators
- compressed gases
- resins
- paints and solvents
- petrol, diesel and liquefied petroleum gas (LPG).

3.6.1 PERSON IN CHARGE

HSNO requires a person in charge at all workplaces, to manage hazardous substances. They must make sure that the extractives operation complies with all the HSNO controls. Duties to maintain a safe and healthy workplace continue to apply to other duty holders.

3.6.2 MORE INFORMATION

The Hazardous Substances website (www.hazardoussubstances.govt.nz) provides information on hazardous substances and controls. It also has the HSNO calculator, which is a tool to help work out what key HSNO controls are needed based on the hazardous substances are used and stored at the workplace..

The Environmental Protection Authority's website (www.epa.govt.nz) contains information about hazardous substance approvals.

3.7 TRAINING

Training on the applicable controls must be completed by all workers involved in any activity that might have an effect on the air quality. They are to have an understanding of the:

> airborne contaminants that they might be exposed to or generated through their activities
> controls in place to eliminate or minimise the effects of airborne contaminants
> correct operation of equipment and mobile plant affecting airborne contaminants
> correct use of any PPE required to be worn during these activities
> monitoring arrangements and testing procedures (as appropriate).

Standard operating procedures are to be readily available to all workers so they are fully knowledgeable about the type(s) of airborne contaminants that can be generated and the controls in place.

Workers must be provided with appropriate supervision based on their experience and qualifications.

Additional training should be provided where there are changes to air quality. Refresher training should be provided to workers as needed. Records of training should be kept.

PART B

04/

MONITORING AND ONGOING REVIEW OF AIR QUALITY

IN THIS SECTION:

Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016

***Regulation 4** Meaning of fresh air*

***Regulation 84** Monitoring of levels of oxygen, temperature, humidity and dusts at the mining operations*

***Regulation 221** Regular inspections and shift reports*

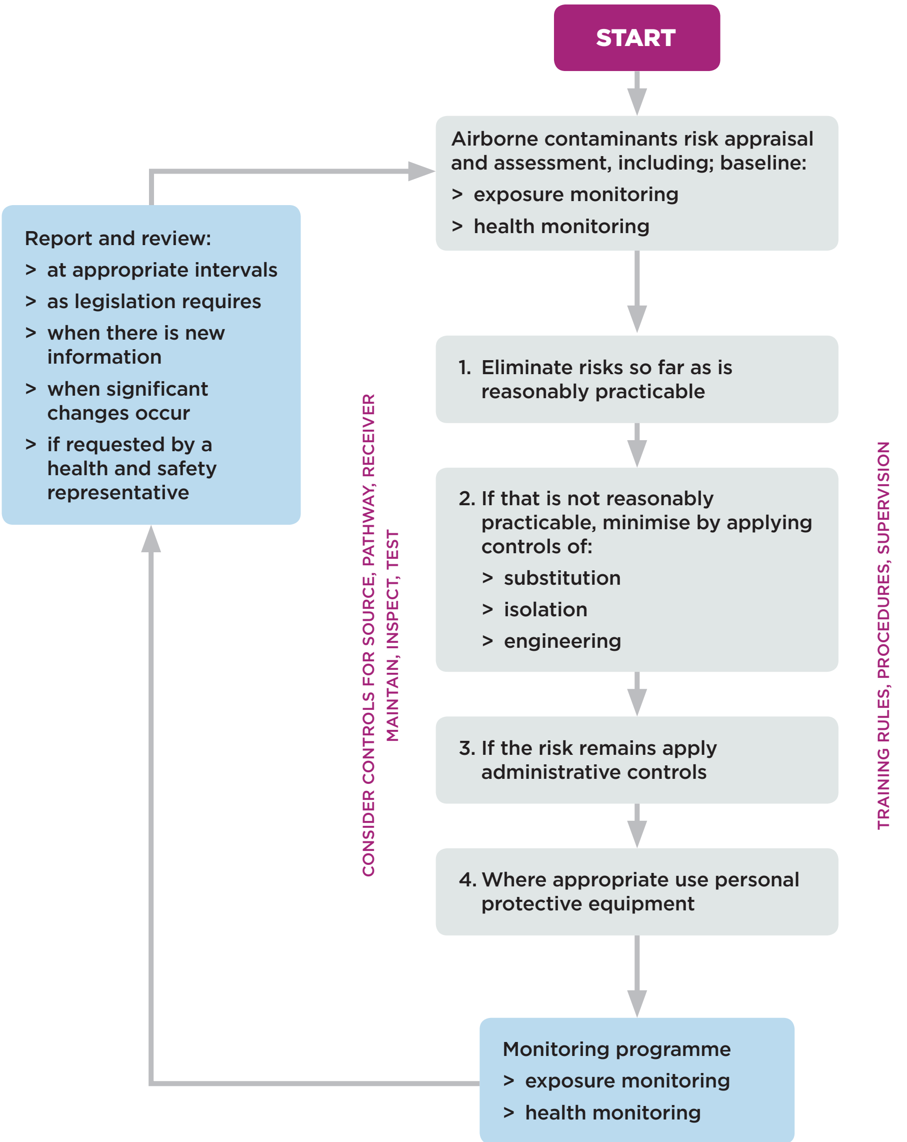

Figure 16: Health and safety management system overview

The blue highlight indicates the part of the process the current section addresses.

4.1 MONITORING AIR QUALITY IN UNDERGROUND MINING OPERATIONS

The duty holder should ensure all airborne contaminants, including the constituents of *Fresh Air*, are monitored and results regularly reviewed to provide, so far as is reasonably practicable the best air quality at underground mining or tunnelling operation. Details of these requirements are specified in the approved codes of practice for:

> *Ventilation in Underground Mines and Tunnels* and

> *Fire or Explosion in Underground Mines and Tunnels*.

4.2 ONGOING REVIEW OF AIR QUALITY, DUSTS AND OTHER AIRBORNE CONTAMINANTS

Make sure that systems and procedures are in place for regular air quality review, including sampling and testing to identify any changes that might occur at the operation.

Review:

> if any WES or other exposure guidance is exceeded (taking into account the validity of the sample and possible need for additional sampling)

> if exposure monitoring indicates that the controls are not effective

> if health monitoring indicates that the controls are not effective

> if there is a significant change to extractive methodology.

Figure 16 illustrates the health and safety management process.

The duty holder should also ensure workers can recognise that changes can occur and one way of doing this is the use of detailed trigger action response plans (TARPs).

4.2.1 USE OF TARPS

Use TARPs to specify the actions to be taken when changes in air quality happen, including but not limited to when:

> variations from the norm occur

> results of gas or dust monitors indicate changes

> engine exhaust sampling is outside of the expected levels

> weather events create excessive dust.

For example, if a gas monitor detects a sudden rise in the level of carbon monoxide over a specified level, the TARP requires evacuation.

PART B

05/

REVIEWING AND AUDITING THE AIR QUALITY PLAN

IN THIS SECTION:

Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016

***Regulation 61** Maintenance of records of health and safety management system*

***Regulation 62** Providing health and safety management systems documentation to mine workers*

***Regulation 63** Providing health and safety management system documentation to contractor*

***Regulation 69** Review and revision of principal hazard management plans*

***Regulation 70** Audits of principal hazard management plans*

5.1 REVIEWING THE PHMP

The MOQO regulations do not require alluvial mining or quarrying operations to have an air quality plan. However, WorkSafe recommends that alluvial mine and quarry operators produce, implement, and review, an air quality management plan based on the PHMP principles.

The SSE must review the air quality plan at least once every two years after it was written. The review determines whether the controls continue to be suitable and effective in managing the risks associated with air quality.

The air quality plan must also be reviewed after:

> an incident involving air quality at the mining or tunnelling operation
> a material change in the management structure that could affect the PMHP
> a material change in plant used or installed at the mining or tunnelling operation that could affect the PHMP
> the occurrence of any event specified in the PHMP as requiring a review of the PHMP.

Review the air quality plan after:

> each audit, if any non-conformances are identified
> if any WES or other exposure guidance is exceeded (taking into account the validity of the sample and possible need for additional sampling)
> if exposure monitoring indicates that the controls are not effective
> if health monitoring indicates that the controls are not effective
> if there is a significant change to mining methodology.

When reviewing the PHMP also review the risk assessment used and referred to within it. There could be new risks for which controls are needed, or existing risks that have changed meaning controls could need changing.

During the review, the SSE needs to consider any other relevant information gathered during:

> routine risk appraisals and assessments
> monitoring and results of inspections by the mine or tunnel operator or WorkSafe
> review of TARPs

> incidents or near misses
> feedback from workers, industry health and safety representatives or other health and safety representatives.

The air quality plan and supporting documents might need to be revised and re-issued after the review. Make sure that workers are informed about any updated documents and train or re-train them where required.

The mine or tunnel operator must keep records relating to the review and revisions of the PHMP from the last 7 years and for at least 12 months from the date the operation is abandoned. Records about the review must be provided, on request, to an inspector or a health and safety representative.

5.2 AUDITING THE PHMP

The mine or tunnel operator can carry out internal audits of the air quality plan, from time to time. Develop a structured internal audit programme that reviews how workers comply with relevant operational procedures and support plans. This can be done through inspection, spot checks and documentation review.

Independent external audits of the air quality plan must be undertaken by a competent person at least once every three years from the date the plan was made.

The external audit needs to examine the adequacy, implementation, and compliance with the air quality plan. The following areas might be audited:

> hazard identification and risk assessment
> air quality sampling strategy
> compliance with WES and biological indices
> results of exposure monitoring
> results of health monitoring
> quality and supply of consumables.

The final audit report needs to include the findings of the audit, recommendations for corrective action, review mechanisms, and outline who is responsible.

Records of the audit of the air quality plan must be kept for at least 12 months from the date the mining or tunnelling operation is abandoned. Records of any risk appraisals carried out to identify PHMPs must also be kept. Make sure details of audits and the risk appraisals are available to WorkSafe, a health and safety representative or an industry health and safety representative.

PART B

06/

NOTIFICATIONS AND NOTIFIABLE EVENTS

Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016

Regulation 229 Notification of high-risk activities

Schedule 7 High-risk activities

The extractives operator must inform WorkSafe about particular work activities and notifiable events. More details on these notifications are set out in WorkSafe's special guide: *Introduction to the Health and Safety at Work Act 2015*.

Notifications specific to air quality are discussed below.

6.1 HIGH-RISK ACTIVITIES

The mine or tunnel operator must notify WorkSafe before starting high-risk activities. WorkSafe's website contains instructions on how to notify WorkSafe, including forms to use. Table 11 shows high-risk activities relating to air quality.

TYPE OF OPERATION	HIGH RISK ACTIVITIES THE MINE OR TUNNEL OPERATOR MUST NOTIFY WORKSAFE
All mining and tunnelling operations	Shot-firing underground, where shot-firing has not been undertaken within a year before the intended time of shot-firing
Underground mining operations and tunnelling operations	Entry by any worker into any sealed area of the underground parts of the mining or tunnelling operation

Table 11: High-risk activities relating to air quality

Do not start the high-risk activity until the period of notice, starting from the date of notification, has expired. WorkSafe can, in writing, extend or reduce the period of notice, and can request further information on the activity.

6.2 NOTIFIABLE EVENTS

Health and Safety at Work Act 2015

Regulation 23 Meaning of notifiable injury or illness

Regulation 24 Meaning of notifiable incident

Regulation 25 Meaning of notifiable event

Regulation 55 Duty to preserve sites

Regulation 56 Duty to notify notifiable events

Regulation 57 Requirement to keep records

Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016

***Regulation 225** Declaration of notifiable injury or illness and notifiable incidents*

***Regulation 226** Record of notifiable events*

***Regulation 228** Investigation of notifiable events*

***Schedule 5** Injuries, illnesses and incidents declared to be notifiable events under Act*

***Schedule 6** Particulars of notifiable events*

Health and Safety at Work (General Risk and Workplace Management) Regulations 2016

***Regulation 41** Duty to give health monitoring report to regulator*

The PCBU must notify WorkSafe if a worker dies or a notifiable event, illness or injury occurs as a result of work activities. Notifiable injuries, illnesses and incidents are specified in HSWA and the GRWM Regulations/MOQO Regulations.

Notifiable events specific to air quality include:

> an accident where workers are required to evacuate a part or the whole of the underground parts of a mining operation or tunnelling operation because of methane or any other gas

> an unplanned stoppage of the main fan in excess of 30 minutes

> an unplanned accumulation of methane or other gas requiring formal degassing operations

> the loss of consciousness of any worker, including as a result of asphyxia.

See WorkSafe's website and the special guide: *Introduction to the Health and Safety at Work Act 2015* for further information on:

> notifiable events, illness and injuries

> how to notify WorkSafe

> what information to provide

> what to do after a notifiable event, including not disturbing the site

> record keeping.

The results of health monitoring must be reported to WorkSafe under certain circumstances. See the *Health Monitoring under the Health and Safety at Work (General Risk and Workplace Management) Regulations 2016* fact sheet for more information on health monitoring and reporting requirements under the GRWM Regulations.

PART C

IN THIS PART:

PART C

07/

GLOSSARY

TERM	DEFINITION
Aftercooling	Cooling intake air prior to induction into the combustion chamber to increase power and reduce the emission of oxides of nitrogen.
After-treatment devices	Devices such as filters which remove constituents of diesel exhaust as they leave the equipment.
ANFO	An explosive material consisting of ammonium nitrate and fuel oil.
BEI (biological exposure index)	Guidance values for assessing biological monitoring results. It indicates a concentration below which nearly all workers should not experience adverse health effects from exposure to a particular substance.
Competent person	A person who has the knowledge, relevant experience and skill to carry out a particular task. Skills and knowledge may be acquired through training, qualification, or experience, or a combination of these.
Diamond drilling	Cutting rock by means of a rotary hollow drill with diamond tips that is used to obtain core samples of the rock/ ore.
Diesel particulate matter (DPM)	Diesel particulate matter (DPM) is a component of diesel exhaust emissions that includes soot particles made up primarily of carbon, ash, metallic abrasion particles, sulfates and silicates. Diesel soot particles have a solid core consisting of elemental carbon, with other substances attached to the surface, including organic carbon compounds known as aromatic hydrocarbons.
Duty holder	A PCBU; SSE; a mine, alluvial mine, or quarry operator; or other safety critical role, as appropriate.
Elemental carbon	Elemental carbon is sometimes used as a surrogate measure for DPM. It is composed of graphitic carbon, as opposed to organic carbon, and usually accounts for 40 to 60 percent of the DPM by mass.
Exhaust back pressure	Buildup of pressure against the engine created by the resistance of the exhaust flow passing through the exhaust system components.
Extractives operation	A mining operation, alluvial mining operation and quarrying operation. Extractives operator has a corresponding meaning.
Fuel-to-air ratio	The ratio of the amount of fuel to the amount of air introduced into the diesel combustion chamber.
Health and safety representative (HSR)	A health and safety representative (HSR) is a worker elected by the members of their work group to represent them in health and safety matters, in accordance with subpart 2 of Part 3 of HSWA.
HVAC system	Heating, ventilation and air conditioning system.
Mesothelium	A membrane that forms the lining of several body cavities.
Mining operation	Has the meaning given in HSWA, Schedule 3, Part 1, Clause 2.
Mine operator	Has the meaning given in HSWA, Schedule 3, Part 1, Clause 1.
NOx	Oxides of nitrogen. Generated as a fume from blasting activities.
OEM	Original equipment manufacturer.

TERM	DEFINITION
Ore	A mineral deposit that is mined in metalliferous mining operations.
Organic carbon	Non-graphitic soluble organic carbon material associated with DPM.
Oxygenates	Fuel additives which contain a substantial fraction of oxygen by weight (eg ethanol, methanol, and methyl soyate).
Principal control plan (PCP)	A plan required under MOQO Regulation 92. The plan documents systems and processes in place at the mining or tunnelling operation to manage hazards at the operation, and the measures that are necessary to manage principal hazards at the mining or tunnelling operation. See MOQO Regulation 93.
Principal hazard	Any hazard arising at any mining operation (including a tunnelling operation) that could create a risk of multiple fatalities in a single accident or a series of recurring accidents at the mining operation in relation to any of the following: i. ground or strata instability: ii. inundation and inrush of any substance: iii. mine shafts and winding systems: iv. roads and other vehicle operating areas: v. tips, ponds, and voids: vi. air quality: vii. fire or explosion: viii. explosives: ix. gas outbursts: x. spontaneous combustion in underground coal mining operations. It also includes any other hazard at the mining operation (including a tunnelling operation) that has been identified by the site senior executive under MOQO Regulation 66 as a hazard that could create a risk of multiple fatalities in a single accident, or a series of recurring accidents at the mining operation. See MOQO Regulation 65.
Principal hazard management plan (PHMP)	A plan required under MOQO Regulation 66. The PHMP describes a principal hazard and sets out the controls used to manage it. A PHMP must be prepared for each principal hazard identified at the mining or tunnelling operation. MOQO Regulations 68, 69 and 70 cover what needs to be included in a PHMP, and requirements for reviews, revisions and audits. MOQO Regulation 84 specifies what must be included in a PHMP for air quality.
Regeneration	Process of oxidizing DPM collected on a diesel exhaust particulate filter to remove it. This process cleans the filter and reduces back pressure to acceptable limits.
Rib	The sides of a roadway typically associated with coal mines.
Roadways	The formed underground excavations, that once supported provide access for people, equipment or services through them. Roadways can be a simple excavation forming one roadway or multiple excavations forming a network of roadways in an underground environment (see also Tunnels).
Standard operating procedures (SOPs)	Documented standard operating procedures for installation, maintenance, removal and quality control.
TARPs	TARPs specify the actions to be taken when changes occur. For example, if a gas monitor detects a sudden rise in the level of carbon monoxide over a specified level, the TARP requires evacuation.

TERM	DEFINITION
Tramming	Travelling.
Tunnelling operation	An operation (including the place that it occurs) involving extraction of fill with the purpose of creating a tunnel or shaft or enlarging or extending any tunnel or shaft. It excludes certain tunnelling operations set out in regulation 5 of the MOQO Regulations.
Tunnel operator	In this code has the same meaning as Mine operator.
Top hammer drilling	Drilling of rock by means of percussion and rotation provided by a drill passing percussive action down the drill steel.
Total carbon	Refers to the sum of the elemental and organic carbon associated with the diesel particulate matter and accounts for about 80-85 percent of the DPM mass.
Tri-cone drilling bit	A rotary cutting bit usually associated with hole diameters larger than 150 mm.
Tunnels	An excavation usually associated with civil works that once supported creates an underground passage for transportation, services or people (see also roadways).
Turbocharge	Process of increasing the mass of intake air by pressurisation to the engine which allows more fuel to be burned and results in increasing the engine's power output.
Volatility	Measure of the ability of a fuel to vaporise.
Welding fumes	Metal and fluxing fumes made up of toxic gases and very fine particles, produced from welding and hot cutting.
WES (Workplace exposure standard)	Workplace exposure standards are a value that refers to the airborne concentration of substances, at which it is believed that nearly all workers can be repeatedly exposed to day after day without coming to harm. The values are normally calculated on work schedules of five shifts of eight hours duration over a 40 hour work week.

PART C

08/

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Workplace Exposure Standards and Biological Indices.

Welding Health and Safety Assessment Tool fact sheet.

Worker Engagement, Participation and Representation good practice guidelines.

A Practical Guide and Workbook for Completing a MOSHH Assessment in Your Workplace good practice guidelines.

Health and Safety in Welding good practice guidelines.

Ventilation in Underground Mines and Tunnels approved code of practice.

Fire or Explosion in Underground Mines and Tunnels approved code of practice.

See also www.worksafe.govt.nz

USEFUL WEBSITES

Accident Compensation Corporation
www.acc.co.nz

Environmental Protection Agency
www.epa.govt.nz

www.hazardoussubstances.govt.nz

Ministry of Health
www.health.govt.nz

WorkSafe New Zealand
www.worksafe.govt.nz

PART C

APPENDICES

IN THIS SECTION:

APPENDIX A: ASSESSING WORKERS' EXPOSURE

SAMPLING STRATEGY

The sampling strategy will usually include identifying groups of workers for whom risk and exposure profiles are similar. These groups are called SEGs (similar exposure groups). Choosing a representative, unbiased, subsample of the SEG should be sufficient for assessing exposure and risk for the whole SEG.

The frequency of worker exposure monitoring will depend on the objectives and outcomes of the risk identification and analysis. For example, it might identify that exposure can vary from day to day, so monitoring will need to be more regular, so the variation is included in the assessment.

Monitoring should occur when:

> there are any changes in processes or activities that result in, or can result in, a change to exposure

> if it is not certain whether or not the airborne concentration exceeds the workplace exposure standard (WES)

> if it is not certain whether the airborne contaminant presents a health risk.

VARIATION IN EXPOSURE

Exposure levels are commonly variable even in work that is regular and consistent. Variation in worker exposure arises from variation in work activities, control methods and environmental conditions (called 'random variation') and systematic error (eg sampling and analytical error).

Due to this variation, exposure measured on a single day might not reflect exposure on other days. Even samples from multiple days might not reflect the true variation in exposure that can occur over the long term. With this in mind, the monitoring strategy must be designed to provide sufficient measurements to reflect the risk to the worker from the variation in exposure.

It is very rare for all exposures for a worker to be measured all the time. Frequently only one or two shifts will be sampled and this data will be used to make judgements about exposures over many months or years. If the worker is exposed every day for five years, and their exposure is assessed once a year, then five days of data is being used to make judgements about 1250 days of exposure. Various methods are available for determining an appropriate number of samples to account for variation, and it is recommended these methods are consulted when developing the sampling strategy. Methods include:

> NIOSH Occupational exposure sampling strategy manual (1977)

> at least one employee in five from a properly selected SEG (UK Health and Safety Executive HSG173 (2006)

> a calculated number of samples based on previous data, using t-statistics and co-efficient of variation (source W501 OH Learning, *Measurement of Hazardous Substances*, 2009)

> methods of Rappaport, Selvin and Roach (1987) based on the number of samples needed to test the mean exposure of a lognormal distribution of exposures against an exposure standard (source W501 OH Learning, *Measurement of Hazardous Substances*, 2009)

> South African Mines Occupational Hygiene Programme – sample 5% of workers in an SEG
> American Industrial Hygiene Association suggests 6-10 samples are sufficient to give a picture of an exposure profile. In respect to the minimum number of samples to be collected, fewer than six samples in any one SEG leaves a great deal of uncertainty about the exposure profile (AIHA 2006) (source W501 OH Learning, *Measurement of Hazardous Substances*, 2009).

STATISTICAL ANALYSIS OF SAMPLING RESULTS

Multiple samples generally allow for better understanding of the variation in exposure, and thus provide more detailed information for the risk assessment.

Where multiple samples are taken, application of appropriate statistical analysis to sampling results can be valuable in:

> assessing confidence that the results represent the ‘true’ exposure profile (the profile you would see if you were to measure the exposure every shift, and you were to measure all workers in the SEG)
> interpreting whether WES are complied with
> managing uncertainties in exposure assessment and health risk assessment.

Application of appropriate statistical analysis to sampling results is important in order to assess how closely the results represent the ‘true’ exposure profile and can be used to assess compliance with WES and assess risk. For example, the mean (average) exposure calculated might be below a WES, but random variation, sampling and analytical error will introduce some uncertainty around that average. This uncertainty can be described as confidence limits around the average. If the upper confidence limit exceeds the WES, it indicates less certainty around whether the average exposures truly fall below the WES. If the upper confidence limit gives us 95% confidence that the ‘true’ average falls comfortably below the WES, then that provides a high level of certainty that exposures comply with the WES.

A useful tool for statistical analysis of occupational hygiene samples is the IHSTAT spreadsheet developed by the American Industrial Hygiene Association.

APPENDIX B: WORKPLACE EXPOSURE STANDARDS

COMPLIANCE WITH WES

When evaluating exposure in relation to a WES, the following points need to be considered:

> How representative is the sampling programme in regard to variation in exposure, and how accurately do the results represent the 'true' exposure profile?

> Variability of exposure means that occasional high results can occur even where the exposure is generally well controlled.

> The criteria for setting a specific WES might be for a different health outcome than the risk being assessed. For example the WES might be based on reducing risk of irritation, however risk of more serious adverse effects might be the focus of the health risk assessment, therefore the WES might not be a stringent enough guideline to use in this case.

> Compliance with the designated WES level does not guarantee that all workers are protected from discomfort or ill health due to individual susceptibility.

Assessing compliance with WES isn't necessarily a straight forward process of comparing a sample result, or an average, to a WES.

Various organisations have developed guidelines to address this issue of how to assess WES compliance and whether further control of exposure needs to occur. Organisations that have developed guidance include the British and Netherlands Occupational Hygiene Societies (BOHS/NOHS), the American Industrial Hygiene Society (AIHA), the International Council on Mining and Metals (ICMM), and Utrecht University. A summary of their approaches is given below, but for more detail their guidance should be referred to:

> BOHS/NOHS – Assumes a WES can be regarded as complied with if, with 70% confidence, less than 5% of the exposures in the SEG exceed the WES. An individual worker's exposure complies if there is less than 20% probability that greater than 5% of their exposure exceeds the WES.

> AIHA – Has a rating scheme that categorises exposures as trivial (very low), highly controlled, well controlled, controlled, poorly controlled based on the estimated 95th percentile of the exposure distribution.

> ICMM provides guidance on rating exposures (eg if a result is less than 50% of the WES, exposures are well controlled below the WES). Results between 50% to 100% of the WES indicate there is potential for breaches of the WES.

> The Utrecht University, Institute for Risk Assessment Sciences SPEED (statistical program for the evaluation of exposure data) Excel application assesses whether the within-worker and between-worker exposures are acceptable in relation to the WES. It provides a stepwise approach to the sampling and statistical analysis of data.

ADJUSTMENT OF WORKPLACE EXPOSURE STANDARDS FOR EXTENDED WORKSHIFTS – LENGTH OF EXPOSURE AND RECOVERY TIME

Workplace exposure standard time weighted averages (WES-TWA) are derived on an eight hour work day and 40 hour work week. When shifts are longer than this, either over a day or a week, the WES-TWA needs to be adjusted to account for the longer period of exposure and shorter recovery time.

Various models are available to make the adjustment and each can result in a different adjusted WES.

The selection of an appropriate model is dependent on various factors such as:

> ease of use
> availability of an adjustment model for a specific WES
> availability of relevant toxicology and pharmacokinetics data for pharmacokinetic models.

A useful document for discussion on adjustment models is the Australian Institute of Occupational Hygienists Position Paper on 'Adjustment of Workplace Exposure Standards for Extended Workshifts' (March 2013).

MIXED EXPOSURES

If two or more hazardous substances have similar toxicological effects on the same target organ or system, their combined effect should be considered. In this case the combined exposures need to be compared against the WES of the mixture, as well as each individual substance against its specific WES.

More information on mixed exposures is available in WorkSafe's *Workplace Exposure Standards and Biological Indices*.

SUBSTANCES WITHOUT A WES

In many cases well-documented data exist to help determine WES. But for some substances, the available toxicological and industrial hygiene information is insufficient to enable highly reliable standard-setting. As such some substances do not have a WES. If a substance does not have a WES, this should not be taken to mean that it is safe under all conditions, and that no restriction should be placed on their use. Regardless of the substance, it is important to take all practicable steps to eliminate or minimise the concentration of airborne substances so far as reasonably practicable.

APPENDIX C: WELDING FUME CONTROL WORKSHEET

PART 21: WELDING FUME CONTROL SUMMARY WORKSHEET

This worksheet can be used to obtain an idea of the level of protection required for different welding processes.

a. Select a process weighting factor

PROCESS	WEIGHTING
Submerged arc welding (remote operation) Laser cutting and welding Micro plasma Gas cutting (remote operation)	0
Submerged arc welding (manual) Submerged arc welding (multi arcs)	2
Brazing (manual operation) Gas tungsten arc welding (TIG) (manual operation) Gas welding and cutting (manual) Silver soldering (manual) Resistance spot welding (manual) Plasma cutting (under water table) Plasma arc welding Gas metal arc welding (MIG) (remote operation) Resistance seam welding (remote operation) Electroslag welding	4
MIG (hand-held) Manual metal arc welding (MMAW) Resistance seam welding (manual operation) Thermit welding Electrogas welding	7
Arc cutting Plasma arc gouging Air arc gouging Flux cored arc welding (manual and remote operation)	9
Plasma arc cutting	15

b. Select a fume constituent weighting

FUME GROUP	WEIGHTING
a. Iron, aluminium, tin, titanium – less than 5% of group B or C or less than 0.05% of group D	0
b. Copper, magnesium, manganese, molybdenum, silver, tungsten, zinc. Flux fumes such as fluorides, rosin, phosphor acid, zinc chloride and boric acid	10
c. Barium, chromium, cobalt, lead, nickel, ozone, vanadium, phosgene, organic fume	20
d. Beryllium, cadmium	55

c. Select a work location weighting

WORK LOCATION	WEIGHTING
Outdoor workspace	0
Open workspace	12
Limited workspace	16
Confined worksapce	24

d. Add the three weightings you obtain at a, b and c to determine the control actions needed as below:

SUM OF WEIGHTING FACTORS	CONTROLS
≤ 9	Natural ventilation
> 9 to 21	Mechanical ventilation
> 21 to 54	Local exhaust ventilation
> 54	Local exhaust ventilation and respiratory protection

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