

Ventilation in Underground Mines and Tunnels

February 2014

ACKNOWLEDGEMENTS

This material has been developed by WorkSafe New Zealand in collaboration with an independent group of New Zealand, Australian and UK mining experts and practitioners, to ensure that the approach to health and safety in the New Zealand mining industry aligns with international best practice.

In recognition of the valuable contribution made towards the development of this Approved Code of Practice, WorkSafe New Zealand would like to thank the members of the working group and those who provided input and feedback during reviews and consultation.

NOTICE OF APPROVAL

2013 was an exciting and rewarding year as the Government passed and began to implement legislation that brings New Zealand's mining regulatory regime on par with the highest international standards. The unwavering focus has been extending safety and environmental protection measures to ensure that New Zealanders can have confidence in the exploration and development of our valuable mineral resources.

The new regulatory framework for mining came into force in December 2013.

This Approved Code of Practice has been developed to improve health and safety practices and behaviours to reduce workplace accidents and fatalities in the New Zealand mining industry. This outcome will contribute directly to the Government's target of reducing workplace deaths and serious injuries by at least 25 percent by 2020.

The regulatory changes, and the practices outlined in this Approved Code of Practice, will strengthen health and safety performance so that people who work in the New Zealand mining industry are protected when they are at work.

A handwritten signature in black ink, appearing to read 'S Bridges', with a long horizontal flourish extending to the right.

Hon Simon Bridges
Minister of Labour

FOREWORD

This Approved Code of Practice is a very significant document for New Zealand's underground mining and tunnelling sectors. It gives operators very clear direction on their work in mines and tunnels. No-one in these industries should now be unclear on their responsibilities nor of the regulator's expectations.

In 2012 the report of the Royal Commission on the Pike River Coal Mine Tragedy recommended changes to the mining regulations in New Zealand, and the provision of codes of practice and guidance to assist mining operators to manage their operations safely.

New regulations have now been introduced for the mining industry, based on the specific technical recommendations of the Royal Commission and the Expert Reference Group formed to assist WorkSafe New Zealand in development of the regulations. To manage the major hazards present in mining operations the regulations require mining operations to have Principal Hazard Management Plans and Principal Control Plans as part of their overall Safety Management System.

To assist mine operators in the development of their plans, WorkSafe New Zealand is producing a series of codes of practice to provide technical information on the latest industry good practice. This Approved Code of Practice is part of that series of codes. It has been developed jointly with union and industry members after detailed consultation, and incorporates the latest good practice from Australia and the UK.

I am confident that following the standards in this Approved Code of Practice will assist the New Zealand industry to significantly reduce the risks that workers face in underground mining and tunnelling.



Brett Murray
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WorkSafe New Zealand

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INTRODUCTION

- 1.1 Background**
 - 1.2 Purpose**
 - 1.3 Legal status of this document**
 - 1.4 Structure of this document**
 - 1.5 References used in this document**
-

1.1 Background

A new regulatory framework for mining in New Zealand came into force in December 2013.

A set of Approved Codes of Practice and guidance supports the new Regulations. Each of the following Codes contains information to assist a site senior executive in developing the Principal Hazard Management Plans and Principal Control Plans required by the Regulations:

Principal Hazard Management Plans (PHMPs)

- > Ground or strata instability
- > Inundation and inrush of any substance
- > Mine shafts and winding systems
- > Roads and other vehicle operating areas
- > Tips, ponds and voids
- > Air quality
- > Fire or explosion
- > Explosives
- > Gas outbursts
- > Spontaneous combustion in underground coal mining operations
- > Any other hazard at the mining operation identified by the site senior executive 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.

Principal Control Plans (PCPs)

- > Ventilation
- > Mechanical engineering
- > Electrical engineering
- > Emergency management
- > Worker health

This Approved Code of Practice provides information on the content of the **Ventilation Principal Control Plan**.

1.2 Purpose

The purpose of this Approved Code of Practice is to provide practical guidance to employers, contractors, employees, and all others engaged in work associated with mining, on how they can meet obligations with respect to ventilation, under the Health and Safety in Employment Act 1992 (HSE Act) and its associated Regulations. It includes outcomes required and operating procedures where there is an identified hazard that requires ventilation controls.

An Approved Code of Practice applies to anyone who has a duty of care in the circumstances described in the Code – which may include employers, employees, the self-employed, principals to contracts, owners of buildings or plant, consultants and any person involved in the operations.

An Approved Code of Practice does not necessarily contain the only acceptable ways of achieving the standard required by the HSE Act. But, in most cases, compliance will meet the requirements of the HSE Act.

Non-compliance with an Approved Code of Practice is not, of itself, an offence, but failure to comply will require an employer and/or principal to demonstrate that they are controlling hazards to a standard equivalent to or better than that required by the Approved Code of Practice.

1.3 Legal status of this document

This Code of Practice has been approved by the Minister under section 20A of the HSE Act. It gives practical advice on how to comply with the law. Following the advice is enough to comply with the law in respect of those specific matters on which the Approved Code of Practice gives advice. Alternative methods to those set out in this Approved Code of Practice may be used in order to comply with the law.

1.4 Structure of this document

The Regulations reproduced in this Approved Code of Practice are from the Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013.

The Regulations and the Approved Code of Practice requirements are accompanied by guidance. This guidance does not form part of the Approved Code of Practice and provides additional information and recommended actions to assist the mine/tunnel operator. Following the guidance is good practice and mine/tunnel operators are free to take other action provided it is to a standard that complies with the HSE Act. WorkSafe NZ inspectors may refer to this guidance as illustrating good industry practice.

While every effort has been made to include and accurately reproduce each Regulation to which this Approved Code of Practice applies, it is the responsibility of the mine or tunnel operator to ensure that the Regulations are read and understood in their entirety to establish whether any additional compliance requirements must be met.

1.5 References used in this document

References in this Approved Code of Practice to other documents do not imply approval by WorkSafe NZ of that document except to the extent necessary to give effect to this Approved Code of Practice.

02/

SCOPE

- 2.1** Operating types to which this Approved Code of Practice applies
 - 2.2** References to mine and tunnel operations and operators
 - 2.3** References to roles, responsibilities, training and competencies
 - 2.4** References to methane
 - 2.5** References to risk assessment
 - 2.6** Mine plans and schematics
-

2.1 Operating types to which this Approved Code of Practice applies

This Approved Code of Practice applies to all coal and metalliferous underground mines, and tunnels under construction, as covered by the HSE Act.

These operating types are defined as below.

2.1.1 General

The content applies to any underground mine, or tunnel under construction, that meet the definition in the legislation.^{1 2}

2.1.2 Coal mine

The content is specific to underground mines where operations are focused on the exploration or extraction of coal, or metalliferous mines and tunnels where methane is present at levels greater than 0.25%.

2.1.3 Metalliferous mine

The content is specific to underground mines where operations are focused on the extraction of materials other than coal.

2.1.4 Tunnel

The content is specific to tunnels under construction.^{3 4}

Where applicable, and where it does not contradict the legislation or the requirements of this Approved Code of Practice, BS 6164:2011 “Code of Practice for health and safety in tunnelling in the construction industry” may be used as a reference for good practice in the construction of tunnels.

While every effort has been made to accurately describe the different types of operations to which this Approved Code of Practice applies, it is the responsibility of the mine or tunnel operator to undertake a risk assessment to establish whether their operation should be complying with any parts of this Approved Code of Practice.

2.2 References to mine and tunnel operations and operators

Where there are references in this Approved Code of Practice to mine and tunnel operations and operators, the meanings applied to each should be as per those outlined in sections 19L, 19M, 19O and 19P of the HSE Act.

2.3 References to roles, responsibilities, training and competencies

The Regulations and this Approved Code of Practice refer to safety critical roles, responsibilities, training and competencies. Mine and tunnel operators are required to ensure they appoint people to carry out key safety critical roles and that people appointed to these roles meet the competency requirements set out in the Regulations.

¹ Health and Safety in Employment Act 1992. Section 19O. Meaning of tunnelling operation

² Health and Safety in Employment (Tunnelling Operations—Excluded Operations) Order 2013

³ Health and Safety in Employment Act 1992. Section 19O. Meaning of tunnelling operation

⁴ Health and Safety in Employment (Tunnelling Operations—Excluded Operations) Order 2013

The Regulations also set out the legal responsibilities for developing Principal Hazard Management Plans and Principal Control Plans. The fulfilment of this requirement may be delegated by the person to whom the legal responsibility is appointed. For example, Regulation 143 outlines the legal responsibilities of the mine operator in relation to the quantity and velocity of air in underground parts of a mining operation. The mine operator may delegate the practical responsibility to the mine manager, however, the mine operator retains the legal responsibility for the requirement being met.

The relevant legislative and regulatory requirements are reproduced in Appendix B of this Approved Code of Practice. See separate guidance that provides more detailed information on the role of management, and requirements in relation to roles, responsibilities and competencies of people employed at underground mines and tunnels.

2.4 References to methane

The Regulations and this Approved Code of Practice refer to methane. References to methane should be taken to include all flammable gases that can be encountered underground such as ethane, propane, carbon monoxide, hydrogen sulphide and hydrogen, which can be present in coal and metalliferous mines, and tunnels.

2.5 References to risk assessment

The Regulations and this Approved Code of Practice refer to risk assessments. References to risk assessments should be taken to mean the requirements outlined in Regulation 55 of the Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013, and in associated standards such as:

- > MDG 1010:2011 “Minerals Industry Safety and Health Risk Management Guideline”;
- > AS/NZS ISO 31000:2009 “Risk Management – Principles and Guidelines”;
- > SA/SNZ HB 436:2013 “Risk Management Guidelines”; and
- > SA/SNZ HB 89:2013 “Risk Management – Guidelines on risk assessment techniques”.

2.6 Mine plans and schematics

Mine plans and schematics are included in this Approved Code of Practice to support some of the Code’s guidance information.

When preparing mine plans, the scale and use of symbols, abbreviations and colours should comply with AS 4368-1996 “Mine plans – Preparation and symbols”.

The accuracy of New Zealand mine plans is also important and should be relative to New Zealand co-ordinates. To ensure accuracy, the co-ordinate system for surveying, mapping and positioning is the “New Zealand Geodetic Datum 2000 – (NZGD2000)”, which should be used with AS 4368-1996 when preparing New Zealand plans.

For more detailed information on the preparation of mine plans and surveying requirements, see the Approved Code of Practice on Surveying.

03/

GENERAL PROVISIONS

- 3.1** Applicable Legislation and Regulations
 - 3.2** Mine and tunnel safety management - Requirement for systems and plans
 - 3.3** Requirement for a Principal Control Plan for Ventilation
 - 3.4** Controlling a hazard - The hierarchy of controls
-

3.1 Applicable Legislation and Regulations⁵

- > *Health and Safety in Employment Act 1992*
- > *Electricity Act 1992*
- > *Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013*
- > *Electricity (Safety) Regulations 2010 and Electricity (Safety) Amendment Regulations 2013*

Consultation

The site senior executive must consult with mine workers and site health and safety representatives about the content of the health and safety management system when—

- (a) preparing the health and safety management system; and
- (b) reviewing the health and safety management system, or any part of it.

3.2 Mine and tunnel safety management – Requirement for systems and plans

Part 2 of the Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013 requires all mines and tunnels to have in place formal health and safety management systems.

3.2.1 Safety Management Systems

A **Safety Management System** for a mine or tunnel is the primary means of ensuring safe operations at the site. It brings together a number of procedures and policies to suit the risks and complexity of the site’s operations. The Safety Management System should be part of, and integrated with, the overall management system for the mine or tunnel.⁶

3.2.2 Hazard Management Systems

A **Hazard Management System** is part of the Safety Management System. It ensures that hazards are systematically identified and assessed and suitable control measures put in place to mitigate the risks presented by a particular hazard.

3.2.3 Principal hazards

A **principal hazard** is defined as any hazard arising in the underground mine or tunnel that could create a risk of multiple fatalities in a single accident, or a series of recurring accidents, and for which particular processes must be adopted to mitigate the risks presented. Principal hazards have the potential for very serious consequences if not adequately controlled, even though the likelihood of them happening may be low.

⁵ See <http://www.legislation.govt.nz/>

⁶ Ministry of Business, Innovation and Employment. (2013). Guidance for a Hazard Management System for mines. Wellington, New Zealand. 7-9.

3.2.4 Principal Hazard Management Plans and Principal Control Plans

For each identified principal hazard, the mine or tunnel operator must have in place a **Principal Hazard Management Plan**, and a **Principal Control Plan**, depending on the type of hazard identified. Both of these plans are elements of the overall Safety Management System.

- (a) A Principal Hazard Management Plan helps the mine or tunnel operator to bring together all of the risks associated with an identified principal hazard at the mine or tunnel and manage the risks in a systematic way. The Principal Hazard Management Plan outlines a suite of controls for the management of the hazard.
- (b) A Principal Control Plan outlines processes that can address a number of principal hazards (for example, ventilation, electrical and mechanical engineering, and emergency management).

Regulation 60 requires consultation with mine workers in the development of the plans. The plans must be reviewed at least every two years, independently audited at least every three years, and be available for review by WorkSafe NZ.

For more detailed information on the relationships between safety systems and plans, and an explanation of their recommended content, see separate guidance.⁷

REG 93

93 General purpose of principal control plans

The purpose of a principal control plan is to document –

- (a) *the systems and processes in place at the mining operation to manage hazards at the operation; and*
- (b) *the measures that are necessary to manage principal hazards at the mining operation.*

REG 102

102 Ventilation control plan

- (1) *The ventilation control plan must, at a minimum, address the following matters:*
 - (a) *the installation of ventilation control devices to control the supply of ventilation to the underground parts of the mining operation and the means used to ensure that ventilation control devices are not interfered with:*
 - (b) *the development of procedures for the construction, installation, use and maintenance of ventilation control devices at the mining operation:*
 - (c) *the placement of the main fans, and provision of other devices for a main fan, such as measuring or monitoring devices:*

⁷ Ministry of Business, Innovation and Employment. (2013). *A guide to developing Safety Management Systems for the extractives industry*. Wellington, New Zealand.

- (d) *the maintenance of return airways in a suitable condition so that they are accessible to those who must inspect them or maintain them or travel through them in an emergency:*
 - (e) *the competencies of mine workers who operate, maintain, or adjust any part or the whole of the ventilation system at the mining operation:*
 - (f) *the processes that will ensure that only mine workers with the required competencies operate, maintain, or adjust any part or the whole of the ventilation system at the mining operation:*
 - (g) *the means by which heat stress conditions will be monitored and controlled:*
 - (h) *reporting procedures relating to ventilation:*
 - (i) *the maintenance of ventilation records and plans:*
 - (j) *if it is possible that an area or areas of the underground parts of the mining operation may need to be sealed, the manner of sealing such areas, and the precautions to be taken:*
 - (k) *ensuring that no person enters any area of the mining operation that is sealed, disused, or otherwise not ventilated:*
 - (l) *the procedures to be followed in the event of a failure of a part or the whole of the main ventilation system at the mining operation and, where considered necessary, the safe withdrawal of people from underground in the mining operation.*
- (2) *In the case of an underground mining operation or tunnelling operation, the ventilation control plan must, in addition to the matters in subclause (1), address the following matters:*
- (a) *how the exposure of mine workers to engine pollutants in the atmosphere at the mining operation will be controlled, including—*
 - (i) *the provision of sufficient ventilation to dilute harmful exhaust pollutants at the mining operation; and*
 - (ii) *regular testing, on at least a monthly basis, of the exhaust material from each diesel engine at the mining operation to verify that the ventilation provided is sufficient to dilute any harmful exhaust pollutants emitted by the engines:*
 - (b) *a procedure for the starting of a main fan:*
 - (c) *procedures for using the following types of fans, where they form part of the mining operation's ventilation system, including starting and stopping procedures:*
 - (i) *auxiliary fans; and*

- (ii) *booster fans; and*
 - (iii) *scrubber fans:*
 - (d) *the levels of methane at which a methane detector will activate its alarm, and the procedures to be followed when that occurs:*
 - (e) *measures to be taken if the effective temperature in the underground parts of the mining operation exceeds 28°C:*
 - (f) *providing for the recording of instances referred to in paragraph (e) as part of the health and safety management system:*
 - (g) *the procedure regarding the action to be taken when monitoring identifies the presence of noxious gases:*
 - (h) *the criteria for determining that ventilation is inadequate in a part or the whole of the underground parts of the mining operation, having regard to the quality, quantity, and velocity of air provided by the ventilation system such that workers must be evacuated from the affected part or the whole of the operation as required by Regulation 149:*
 - (i) *the procedure in the event that the main ventilation system at the mining operation fails (which, if the operation is ventilated by more than 1 main ventilation fan, means a failure of 1 or more of the fans), including—*
 - (i) *the action to be taken to ensure the safety of mine workers if the ventilation system fails in part or totally for at least 30 consecutive minutes; and*
 - (ii) *the safe withdrawal of mine workers from the underground parts of the mining operation to a place of safety when it is necessary to withdraw them from the underground parts; and*
 - (iii) *how the system that monitors the operation of the main ventilation fan or fans at the mining operation will ensure an alarm is given at the surface part of the mining operation in the event that 1 or more of the main ventilation fans stops.*
- (3) *In the case of an underground coal mining operation, the ventilation control plan must, in addition to the matters in subclauses (1) and (2), address the following matters:*
- (a) *an assessment of potentially explosive gas contained within the coal seam that is being mined:*
 - (b) *based on the assessment required by paragraph (a), the establishment of a system for the delivery of adequate ventilation that is designed to maintain the concentration of methane below 0.5% of the general body of air in any production area:*

COAL

- (c) *the design, monitoring, and control of the underground ventilation arrangements to ensure that the atmosphere underground in the mining operation is kept within the prescribed limits (including design, monitoring, and control of arrangements required to support air quality, dust, and airborne contaminant management, gas outburst management, spontaneous combustion management, or other hazard management arrangements at the mining operation that are dependent on ventilation):*
- (d) *the development and implementation of a procedure to ventilate the underground parts of the mining operation where work is performed, including specification of the maximum distances from the face where ventilation ducting and brattice lines may be located:*
- (e) *the placement of every main ventilation fan in a location and under such conditions that will prevent the fan being damaged during an explosion occurring underground at the mining operation:*

84 Principal hazard management plan for air quality

- (1) *The following matters must be considered in the development of the principal hazard management plan for air quality:*
 - (a) *the levels of oxygen in the natural or supplied air at the mining operation:*
 - (b) *the temperature and humidity of the air at the mining operation:*
 - (c) *the types of dust and other contaminants that are likely to be in the air from both natural and introduced sources and that may be hazardous for the health and safety of any mine workers exposed to the dust or contaminants:*
 - (d) *the levels of dust and other contaminants in the natural or supplied air at the mining operation:*
 - (e) *the length of exposure of mine workers at the mining operation to airborne dust or other contaminants, taking into account such matters as extended shifts and reduced recovery periods between shifts and any other relevant matters.*
- (2) *The principal hazard management plan must, at a minimum, identify the measures that will be taken to—*
 - (a) *monitor and assess airborne dust and contaminants at the mine:*
 - (b) *regularly monitor the atmosphere at the mining operation to manage hazards associated with unsafe concentrations of oxygen, methane, and other gases in the air:*
 - (c) *effectively reduce, dilute, or extract airborne dust and other contaminants, including through the use of appropriate suppression, ventilation, or exhaust extraction systems:*

- (d) *ensure air provided by the ventilation system at the mining operation is of sufficient volume, velocity, and quality to remove airborne dust and contaminants from the mining operation and to maintain a safe and healthy atmosphere at the mining operation:*
- (e) *ensure that the supply of fresh air to the ventilation system used in the underground parts of the mining operation is from the purest source available:*
- (f) *suppress dust that may arise as a result of activities at the mining operation, including through the use of dust collection and dust suppression plant where appropriate.*

3.3 Requirement for a Principal Control Plan for Ventilation

The Principal Control Plan outlines in one formal document the ventilation requirements present at the mining or tunnelling operation, and all of the activities being undertaken to establish and maintain a safe level of air supply to the underground workings. This ensures the systematic planning and effective implementation of suitable ventilation control systems.

When developing the Ventilation Principal Control Plan, the mine or tunnel operator should include detailed analysis of the following considerations:⁸

- (a) Ventilation requirements based on:
 - Mine and tunnel environment outcomes
 - Locations of potential hazards
 - Impacts of potential ventilation system failures
- (b) Fan design
- (c) Ventilation control devices
- (d) Accessibility of return airways
- (e) Sealing procedures
- (f) Hazard reporting procedures
- (g) Records maintenance, and auditing

It is important the Ventilation Principal Control Plan is developed in the context of the whole Safety Management System and not in isolation from other Principal Hazard Management Plans and Principal Control Plans that rely on the Ventilation Principal Control Plan as a control (eg Fire or Explosion, Air Quality, Spontaneous Combustion, Gas Outburst and Mechanical Engineering). This will ensure gaps and overlaps in information and procedures are identified and used in the implementation of suitable controls to minimise the likelihood and potential of a ventilation system failure event taking place.

⁸ See Regulation 102 of the Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013 for all of the content required in a Ventilation Principal Control Plan.

Regulation 212 requires that the draft Ventilation Principal Control Plan should be available for examination by a WorkSafe NZ inspector at least two months before the commencement of underground operations at a mine or tunnel. This includes excavation work where top cover and shaft sinking beyond the top soil is intended, but does not include general civil construction work.

GUIDANCE

3.4 Controlling a hazard – The hierarchy of controls⁹

To take all practicable steps to control a hazard, identifying how to control it must first be planned.

The control hierarchy is outlined in the HSE Act and requires that ‘all practicable steps’ to control each hazard be taken. The HSE Act is very specific about the order in which the appropriate controls for a hazard must be considered.

3.4.1 Elimination

Elimination of the hazard should be the first priority for controlling a hazard as it completely removes the potential harm that the hazard presents.

3.4.2 Isolation

Isolation of the hazard provides a barrier that prevents people being exposed to the hazard. The hazard still exists, but people are protected provided that the isolation method is monitored and maintained.

A hazard may be isolated using time or space or in conjunction with other control methods. For example, most workers may be isolated from the hazard, but trained or specialist personnel may be required to access the hazard in order to restore a safe environment.

Isolation of the hazard should only be used as a control method when elimination of the hazard is not practicable.

3.4.3 Minimisation

Minimisation is the least preferred method to control a hazard. Where practicable steps to eliminate or isolate a hazard are available, to use minimisation as a control contravenes the HSE Act. This is because unlike elimination and isolation, there is still a level of exposure to the hazard.

The HSE Act places duties of care upon duty holders to prevent harm. Minimisation only reduces the risk or actual harm that may result from the hazard.

Where minimisation steps are taken, workers may still be harmed. However the likelihood of harm, and the severity of potential injury, are minimised.

⁹ Health and Safety in Employment Act 1992. Part 2. Duties relating to health and safety in employment. Duties of employers in relation to hazard management.

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MINE ENVIRONMENT OUTCOMES

IDENTIFICATION OF HAZARDS CONTROLLED BY VENTILATION

- 4.1 Fresh air in an underground mine or tunnel**
- 4.2 Air quality**
- 4.3 Methane levels**
- 4.4 Heat and humidity**
- 4.5 Diesel engines**
- 4.6 Diesel particulate matter**

REG 4

4 Meaning of fresh air

A reference in these Regulations to fresh air means that the air—

- (a) *contains not less than 19% by volume of oxygen; and*
- (b) *contains not more than 0.25% methane; and*
- (c) *contains not more than 25 ppm of carbon monoxide; and*
- (d) *contains not more than 5 000 ppm of carbon dioxide; and*
- (e) *contains no other substance at a level that is likely to cause harm to a mine worker over the period that the mine worker is exposed to the substance at the mining operation.*

REG 143

143 Quantity and velocity of air

- (1) *The mine operator must ensure that—*
 - (a) *the volume of air passing through an active working face, other than a longwall working face, is not less than 0.3 cubic metres per second for each square metre of normal development cross-sectional area; and*
 - (b) *the volume of air passing through an active longwall working face is not less than 4 cubic metres per second for each metre of extracted height in the face.*
- (2) *The mine operator must ensure, in respect of any underground parts of a mining operation where a mine worker is doing work or may travel, that the air in that part is provided at an adequate quantity and velocity to ensure the mine worker will not be exposed to a concentration of dust that is likely to cause harm to the mine worker.*

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179 Air across and to working face

The mine operator must ensure that an adequate quantity and velocity of air is delivered across the working face of any production or development place, and within the roadways leading to any working face, to dilute and render harmless any accumulations or layering of methane.

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4.1 Fresh air in an underground mine or tunnel

4.1.1 General requirements

The site senior executive should ensure:

- (a) The minimum ventilation volume at the working face is established in the site-specific Ventilation Principal Control Plan to ensure a sufficient oxygen concentration, ensure adequate dilution of noxious and flammable gases, minimise other airborne contaminants, heat and humidity.

This volume should take into account potential changes in these conditions and concentrations at different stages of the mining operation. See section 5.2 on design considerations for ventilation systems for more information.

- (b) The ventilation system is arranged so that where practicable each production and development area in the mine or tunnel is adequately ventilated to maintain sufficient oxygen, dilute and render harmless noxious and flammable gases, and minimise airborne contaminants, heat and humidity.
- (c) The Ventilation Principal Control Plan takes into account the different flammability limits for, and combination of, the gases likely to be found in the mine or tunnel.
- (d) The volume of ventilating air for each working face should not be less than 0.3 cubic metres per second for each square metre of normal cross-sectional area of the roadway. The normal cross-sectional area is determined by measuring from roadside to roadside, ignoring the presence of ventilating devices and not measuring any partially or fully completed intersection of two roadways.
- (e) Systematic environmental monitoring is undertaken to determine that adequate ventilation requirements have been met.

GUIDANCE

4.2 Air quality^{10 11}

The atmosphere underground is limited and confined, and can quickly become sub-standard or dangerous if contaminants are not controlled, extracted, or diluted to harmless levels.

Contaminants may include dust, diesel fumes, and particulates and fumes from blasting. They may also include gases released from the oxidation of organic substances, or through desorption¹² from the surrounding geology.

Even under normal conditions, the air ventilating a mine may become contaminated with small quantities of hazardous (suffocating, flammable or toxic) gases.

4.2.1 Suffocating gases

There is generally no physiological warning of oxygen depletion. Oxygen-deficient atmospheres in underground mines can be caused by gas emission, or the consumption of oxygen by oxidation of coal or other organic material. It can result not only from oxidation of reactive sulphides, but oxidation of timber or solution and evaporation in stagnant or flowing water.

¹⁰ Department of Industry and Resources. (1997). *Underground Ventilation (Metalliferous Mines) Guidelines*. WA, Australia. 1.

¹¹ British Coal Technical Department. (1990). *Hazardous Gases Underground*. (Notes for Guidance NG/9). Staffordshire, England. 1-6.

¹² See Definitions.

The effect is most dangerous in a static, although not necessarily closed, atmosphere. In sustained airflows of reasonable volume, oxygen depletion is much less likely to present a serious risk. This means confined spaces, or areas where ventilation is inadequate, are particularly at risk of becoming dangerous due to layering of methane in the roof, or carbon dioxide in the floor.

Gases that can cause suffocation in a mine are methane, and blackdamp¹³ (which is a mixture of carbon dioxide and nitrogen).

Methane and nitrogen are not poisonous in themselves but if they occur in sufficient quantity they will reduce the oxygen content of the air to a life endangering level.

Low concentrations of carbon dioxide are generally not regarded as being hazardous to health, but high concentrations can affect breathing rate.

4.2.2 Flammable gases

Flammable gases such as methane, carbon monoxide, hydrogen sulphide and hydrogen may be present in both coal and metalliferous mines.

Methane is a flammable, buoyant gas with an explosive range of 5-15%. As an occupational health risk, methane is an asphyxiant. For more detailed information on methane management, see the Appendix.

Carbon monoxide and hydrogen are flammable gases, which are produced in the thermal decomposition of coal, wood and rubber.

Hydrogen sulphide is colourless and tasteless and has 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 may be released as the coal is mined and also when coal is heated and by the action of acid waters on easily decomposed sulphide ores. It may be present in explosive fumes.¹⁴

Hydrogen may also be given off during charging and discharging of electric storage batteries.

4.2.3 Toxic gases

Carbon monoxide and oxides of nitrogen are the most common toxic gases that may be present in a mine's atmosphere. Carbon monoxide occurs predominantly in the exhaust from diesel engines and in fumes from shotfiring. It also results from burning and welding and is the toxic component of an underground fire. Small amounts can be produced by the oxidation of coal, even at ambient temperatures.

Oxides of nitrogen (nitric oxide and nitrogen dioxide) also occur in the exhaust from diesel engines and in fumes from shotfiring.

¹³ See Definitions.

¹⁴ Safe Work Australia. (2011). *[Draft] Code of Practice – Ventilation of Underground Mines*. Canberra, Australia. 12.

Other toxic gases may be encountered underground in special circumstances:

- (a) Chlorine, hydrogen chloride, hydrogen cyanide and phosgene may be produced from the melting of synthetic materials such as PVC belting or refrigerants.
- (b) Sulphur dioxide may occur in some fumes from shotfiring and also in the exhaust from diesel engines, although its presence can be minimised by low-sulphur fuel oil and wet-scrubbing in the exhaust gas conditioner box).
- (c) Gases such as carbon dioxide, sulphur dioxide and hydrogen sulphide can be emitted as a result of chemical reactions in the surrounding rock. These reactions are exothermic (heat producing) and may become self-sustaining as the gases react with groundwater to produce more acid.
- (d) Ammonia occurs in the fumes from some types of explosives, from the reaction of alkaline whitewash on timber that has been soaked with fire retardant salts and some types of cement-based cavity fillers.
- (e) Radon is a radioactive, naturally-occurring, gas that can be present in coal and metalliferous mines, and tunnels. It is desorbed and expelled from rock, coal or water and, due to its radioactive properties, can have long term health effects on people after exposure.
 - (i) Radon daughters are fine solid particles created from the radioactive decay of radon gas. They release alpha radiation, or alpha particles, into the atmosphere. When radon daughters are inhaled, they can harm sensitive lung tissue and potentially cause lung cancer.

4.2.4 Limits for exposure ranges[†]

Fresh air contains the following gases at the lowest practicable level and at no more than the following levels:

	Time-weighted average exposure (ppm)	Short-term exposure limit (ppm)
Carbon dioxide	5 000	30 000
Carbon monoxide	25	200
Hydrogen sulphide	10	15
Oxides of nitrogen	3	5
Sulphur dioxide	2	5

Time-weighted average exposure is calculated as follows:

$$\frac{\text{Total exposure in day (concentration x time)}}{8 \text{ hours}}$$

[†] The TWA and STEL values quoted are taken from the Workplace Exposure Standards (WES) published by WorkSafe New Zealand. As these may change, please visit the WorkSafe New Zealand website for the latest values.

Short-term exposure limit means the average exposure measured over any 15-minute period in the working day.

4.2.5 Specialist advice when gases are detected

The sub-sections above outline most of the gases that may be detected underground. However, specialist advice should be sought when unusual or objectionable odours are detected underground and cause concern.

4.2.6 Blasting fumes

- (a) All underground mine workers should be trained in the risks associated with the release of fumes after blasting.
- (b) The danger of delayed adverse reaction from inhalation of oxides of nitrogen should be understood, as well as the requirement to clear fumes from tunnels, developments, shafts and other areas where mine workers are required to travel.
- (c) Gas monitors should be provided to mine workers so that the safety of the atmosphere can be determined.
- (d) The ventilation officer should carry out calculations and take samples to determine the time it takes to clear blasting fumes from the various parts of the mine. The results should be used to inform or update re-entry procedures for the mine or tunnel.

102 Ventilation control plan

- (3) *In the case of an underground coal mining operation, the ventilation control plan must, in addition to the matters in subclauses (1) and (2), address the following matters:*
 - (a) *an assessment of potentially explosive gas contained within the coal seam that is being mined:*
 - (b) *based on the assessment required by paragraph (a), the establishment of a system for the delivery of adequate ventilation that is designed to maintain the concentration of methane below 0.5% of the general body of air in any production area:*

100 Electrical engineering control plan

- (3) *In the case of an underground coal mining operation, the electrical engineering control plan must, in addition to the matters in subclauses (1) and (2), provide for—*
 - (d) *the isolation of the supply of electricity to the underground parts of the mining operation, but not the supply to safety-critical equipment, in the event of the following circumstances:*

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REG 102

COAL

REG 100

REG 152

- (i) *the presence of methane levels at or above,—*
 - (A) *in an NERZ, 0.5%:*
 - (B) *in an ERZ1, 1.25%:*

152 Application of regulation 153

Regulation 153 applies to—

- (a) *any underground coal mining operation; and*
- (b) *any underground metalliferous mining operation or tunnelling operation where methane has been detected.*

REG 153

153 Ventilation

The mine operator of a mining operation to which this regulation applies must ensure that—

- (a) *the percentage of methane in the general body of air in the underground parts of the mining operation where a mine worker is or may be present is not more than 2% by volume; and*

REG 164

164 Withdrawal of mine workers when high level of methane present

- (1) *This regulation applies when the level of methane in the general body of air in a part or the whole of the underground parts of an underground mining operation or tunnelling operation is detected to be 2% by volume or more.*
- (2) *The mine operator must ensure that—*
 - (a) *every mine worker in the affected part or parts of the mining operation withdraws from the affected part or parts including, as the case requires, the whole of the underground parts of the mining operation; and*
 - (b) *the only person who enters the affected part or parts of the mining operation or, as the case requires, any part of the underground parts of the mining operation, is—*
 - (i) *a competent person, to test for the presence of methane; or*
 - (ii) *a mine worker, to inquire into the cause of the presence of the methane or to remove the methane; and*
 - (c) *no other mine worker enters the affected part or parts of the mining operation, or, as the case requires, any part of the underground parts of the mining operation, until a competent person reports to the manager that it is safe to do so.*

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179 Air across and to working face

The mine operator must ensure that an adequate quantity and velocity of air is delivered across the working face of any production or development place, and within the roadways leading to any working face, to dilute and render harmless any accumulations or layering of methane.

4.3 Methane levels

See the Appendix for more detailed information on methane management.

4.3.1 Gas emissions

Gases released from the surrounding rock or other sources may be suffocating, toxic or explosive, and some may have both toxic and explosive properties.

Although the release of hydrocarbon gases (such as methane) is not commonly experienced in metalliferous mines and tunnels, it can occur, and the site senior executive should ensure that appropriate monitoring and control measures are in place for the early detection of such gases.

- (a) In areas of a mine where electrical equipment is situated, and methane levels cannot be kept below 0.25% by volume, those areas should be designated an ERZ1.
- (b) If the level of methane exceeds 1.25% by volume, all non-safety critical electrical and diesel equipment in the place where the level is exceeded should be de-energised, shut down or switched off.
- (c) Where the level of methane in the general body of air is 2% or more by volume, all mine workers in that part of the mine should be withdrawn to the surface or a place of safety.
- (d) Access to the affected area should be prevented with a secure barricade or fence that is clearly marked with appropriate signage to prevent access.
- (e) In a mine or tunnel where monitoring identifies that gas released from the surrounding rock is a risk, the mine or tunnel manager should ensure that the Ventilation Principal Control Plan includes control measures such as:
 - (i) Sealing of the surrounding rock.
 - (ii) Closure and sealing of the problem area of the mine.
 - (iii) Draining off the gases to exhaust.
 - (iv) Pressurising the area to contain gases in the surrounding rock.
 - (v) Dilution of gases to harmless levels by increased ventilation volumes.
 - (vi) Absorption by water percolation and spraying.
 - (vii) Monitoring systems with appropriate alarms.
- (f) In a mine or tunnel where gas being released from the surrounding rock is likely to occur, all mine workers should be trained in how to identify the hazard, the need to immediately report an occurrence, and procedures for the use of personal respiratory protection or refuge chambers, in the event that hazardous gas is identified as being released into the underground atmosphere.

GUIDANCE

See Section 8 Monitoring for more information on procedures when monitoring identifies the presence of flammable or noxious gases, or other hazardous conditions.

4.3.2 Additional gases

In addition to the surrounding rock, the release of gases into the mine or tunnel atmosphere may be caused by other sources, such as stagnant pools of water or from decaying organic material (including timber). In some circumstances, changes in barometric pressure may also affect the release of gas from the surrounding rock.

Spontaneous combustion from reactive sulphide ores or from accumulations of organic material and timber has resulted in fires in some circumstances.

Ammonium nitrate explosive (ANFO) is a very powerful oxidising agent that may promote fire if it comes into contact with combustibles. In the presence of moisture, ANFO and cement will react to produce ammonia, which is extremely irritating in minute concentrations and highly toxic at moderate concentrations. For this reason, a hazard may be created when ANFO spills from holes during charging onto floors of drives or stopes where cement is in use for grouting rock bolts, or in the strengthening of stope filling.

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102 Ventilation control plan

- (2) *In the case of an underground mining operation or tunnelling operation, the ventilation control plan must, in addition to the matters in subclause (1), address the following matters:*
- (e) *measures to be taken if the effective temperature in the underground parts of the mining operation exceeds 28°C;*
 - (f) *providing for the recording of instances referred to in paragraph (e) as part of the health and safety management system;*

REG 141

141 Air quality and temperature

The mine operator must ensure, in relation to the underground mining operation or tunnelling operation, that—

- (a) *there is fresh air at the commencement of every section of the workings that has a working face; and*
- (b) *the humidity of the air is maintained at such a level as to minimise the likelihood of heat stress; and*
- (c) *measurements to ensure compliance with this Regulation are made at suitable intervals, and at suitable locations, using methods and measuring devices capable of giving accurate results; and*
- (d) *there is no recirculation of air within a working face other than through a scrubber fan.*

4.4 Heat and humidity¹⁵

4.4.1 General requirements

The site senior executive should ensure that the temperature, humidity and air velocity are controlled underground so that mine workers are not harmed from exposure to extreme heat, humidity or cold.

This includes the development of a programme for the control of heat stress.

Documented intervention measures are required when the Effective Temperature (ET) increases above 28°C. However, as the temperature and humidity increases, the mine or tunnel manager should continuously assess the situation by active monitoring of ET and ensure appropriate action is taken.

The following table provides recommended actions to be taken by the mine or tunnel manager at certain temperature/humidity levels.

Temperature	Action
Wet bulb > 25°C ¹⁶	An air velocity of not less than 0.5 metres per second should be provided.
ET > 28°C	The health of mine workers in the mine is managed by meeting the requirements of The Australian Institute of Occupational Hygienists (AIOH) Heat Stress Standard.
ET > 30°C	The mine or tunnel manager should ensure mine workers do not work in the mine unless carrying out work in an emergency situation to a Standard Operating Procedure.

The mine or tunnel manager should ensure there is a procedure and equipment available at the mine or tunnel to determine the ET.

4.4.2 Calculating Effective Temperature (ET)

Temperature, humidity and air flow all place a strain on the body, but it is not possible to estimate the strain by examining these factors in isolation.

The best heat stress index in the context of mining is the ET, because it takes air velocity into account. It gives a single value that represents the amount of heat risk.

The ET considers the Wet Bulb (WB)¹⁷ and Dry Bulb (DB)¹⁸ temperatures and the air velocity. It is important to consider all these factors, because a good air movement over the body has a cooling effect, whereas high relative humidity will reduce the body's ability to lose heat by sweating.

The ET is an accepted, straightforward and easy to use index. It can be determined without the need to use electronic instruments (which may be difficult to introduce into a coal mine).

¹⁵ Health and Safety Executive (HSE). (2007/06). *Prevention of Heat Illness in Mines*. Caerphilly, Wales. Retrieved from www.hse.gov.uk/pubns/mines07.pdf. 2-4.

¹⁶ Department of Industry and Resources. (1997). *Management and Prevention of Heat Stress Guideline*. (Document No ZMR002SX, version 1.0). WA, Australia. 3.

¹⁷ See the Appendix.

¹⁸ See the Appendix.

For more detailed information on calculating ET, see the Appendix.

4.4.3 Working in high temperatures

Working in high temperatures can cause loss of concentration leading to mistakes, which can lead to accidents. It could also cause heat illness or sometimes even death.

Where humidity is relatively high, the hazard is increased. More heat strain is placed on a mine worker as the WB and DB temperatures get closer. The absolute values of the temperatures are of less importance than the difference between them, as it is the relative humidity that causes the problem by inhibiting body cooling by the evaporation of sweat. For example, 28°C WB/45°C DB causes less heat strain than 32°C WB/36°C DB.

During work in hot conditions, the human thermo-regulatory system tries to maintain the body core temperature at 37°C. It does this by increasing blood flow to the skin to carry heat away from the core, and by causing sweating which cools the skin and the blood.

4.4.4 Initial symptoms of heat stress

If the body core temperature begins to rise, various physiological effects progressively result. Initial symptoms are:

- (a) Loss of interest in the task.
- (b) Difficulty in remaining alert.
- (c) Desire to seek more comfortable surroundings (suppression of this desire may result in irritability).

These initial symptoms lead to a loss of co-ordination and dexterity, which has significant safety implications.

4.4.5 Heat rash

Also known as prickly heat, heat rash is caused by constant perspiration, which inflames and blocks the sweat ducts. This can result in areas of tiny red blisters, causing irritation and soreness. Heat rash can cause secondary problems with infections of the skin and is an indication of adverse conditions that may potentially cause heat stroke.

4.4.6 Heat syncope (fainting)

Heat syncope occurs when blood pools in the lower parts of the body, causing a temporary reduction in blood supply to the brain and a short term loss of consciousness.

4.4.7 Heat exhaustion

Heat exhaustion results from the failure of the blood flow to adequately remove heat. A decrease in blood volume may result from dehydration caused by an inadequate intake of fluids, or the combination of environmental heat stress and work rate, which causes an excessively fast heartbeat. The time interval between successive contractions of the heart muscles may be insufficient to maintain an adequate supply of blood to the heart. Consequently, the rate of blood flow will drop. Core body temperature may rise to 39°C.

The symptoms of heat exhaustion are:

- (a) Tiredness, thirstiness, dizziness.
- (b) Numbness or tingling in fingers and toes.
- (c) Breathlessness, palpitations, low blood pressure.
- (d) Blurred vision, headache, nausea and fainting.
- (e) Clammy skin that may be either pale or flushed.

4.4.8 Heat stroke

This is the most serious of all heat-related illnesses and may occur when the body core temperature exceeds 40°C (it may reach 45°C), affecting the coordination of the involuntary nervous system including thermal regulation. Irreversible injury to the kidneys, liver and brain may occur. Heat stroke carries a high risk of fatality from cardiac or respiratory arrest, and should be treated as a medical emergency.

Some symptoms of heat stroke are similar to those of less serious heat illnesses (ie. headaches, dizziness, nausea, fatigue, thirst, breathlessness and palpitations), but the onset of illness may be sudden and dramatic, and pre-existing heat exhaustion is not necessary.

Additional symptoms of heat stroke can include:

- (a) Cessation of perspiration, the skin remains hot but is dry and may adopt a blotchy and red colouration, and the lips may take on a bluish tinge.
- (b) Disorientation, which may become severe, including dilated pupils, a glassy stare and irrational aggressive behaviour.
- (c) Shivering and other uncontrolled muscular contractions.
- (d) Loss of consciousness and convulsions.

154 Exposure to diesel emissions

The mine operator must ensure that—

- (a) *the design and maintenance of the ventilation system and transport system are such that no mine worker is exposed to diesel emissions that could cause harm to the mine worker; and*

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- (b) *if 1 or more diesel engines are being operated in a ventilating current, the volume of air is not less than the greater of—*
- (i) *0.05 cubic metres per second for each kilowatt of the maximum combined output capability of the engines; and*
 - (ii) *3.5 cubic metres per second.*

155 Assessment of hazards associated with fuel additives

The mine operator must ensure that any hazard to mine workers associated with fuel additives used in diesel engines underground at the mining operation is assessed, including by—

- (a) *comparison testing of underground diesel engines at appropriate load points; and*
- (b) *regular testing of undiluted exhaust emissions, including from the surrounding atmosphere.*

ACOP

4.5 Diesel engines

The mine or tunnel manager should ensure that:

- (a) Emissions from a diesel engine are minimised through use of an engine management system and good maintenance practices.
- (b) Diesel engines are maintained to minimise emissions, and the ventilation system is not specifically relied upon to do this by dilution.
- (c) The minimum ventilation requirements are met for all mobile fleet and plant working in any part of the underground mine.
- (d) Dust generated at stockpiles should also be a consideration during the planning of operations. For example, diesel equipment, including loaders and trucks used for loading at stockpiles, could have power ratings that require ventilation quantities typically between 40 m³/s and 60 m³/s at loading location. In many cases, this means that the velocity of air required at the stockpile is greater than 1.5 m/s.

For further guidance on the minimising of diesel emissions, refer to MDG 29:2008 “Guideline for the management of diesel engine pollutants in underground environments” and the Approved Code of Practice on Air Quality.

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108 Worker health control plan

- (1) *The worker health control plan must, at a minimum, address how the following hazards are to be monitored and controlled where they are present at the operation:*
- (d) *diesel particulates:*

4.6 Diesel particulate matter

The mine operator should ensure the provision of sufficient ventilation to dilute harmful exhaust pollutants for each type of compression ignition engine used in the mining operation.

The control of Diesel Particulate Matter (DPM) and other emissions from a diesel engine is addressed in the Approved Codes of Practice on Mechanical Engineering and Air Quality.

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DESIGN AND PLANNING

CONTROLLING RISK THROUGH DESIGN

- 5.1 General requirements**
 - 5.2 Design considerations for ventilation systems**
 - 5.3 Primary ventilation planning**
 - 5.4 Primary ventilation – Parallel intakes**
 - 5.5 Auxiliary ventilation in underground coal mines**
 - 5.6 Methane layering**
 - 5.7 Air velocity**
 - 5.8 Ventilation roadway designs**
-

102 Ventilation control plan

- (1) *The ventilation control plan must, at a minimum, address the following matters:*
- (a) *the installation of ventilation control devices to control the supply of ventilation to the underground parts of the mining operation and the means used to ensure that ventilation control devices are not interfered with:*
 - (b) *the development of procedures for the construction, installation, use, and maintenance of ventilation control devices at the mining operation:*
 - (c) *the placement of the main fans, and provision of other devices for a main fan, such as measuring or monitoring devices:*
 - (d) *the maintenance of return airways in a suitable condition so that they are accessible to those who must inspect them or maintain them or travel through them in an emergency:*
 - (e) *the competencies of mine workers who operate, maintain, or adjust any part or the whole of the ventilation system at the mining operation:*
 - (f) *the processes that will ensure that only mine workers with the required competencies operate, maintain, or adjust any part or the whole of the ventilation system at the mining operation:*
 - (g) *the means by which heat stress conditions will be monitored and controlled:*
 - (h) *reporting procedures relating to ventilation:*
 - (i) *the maintenance of ventilation records and plans:*
 - (j) *if it is possible that an area or areas of the underground parts of the mining operation may need to be sealed, the manner of sealing such areas and the precautions to be taken:*
 - (k) *ensuring that no person enters any area of the mining operation that is sealed, disused, or otherwise not ventilated:*
 - (l) *the procedures to be followed in the event of a failure of a part or the whole of the main ventilation system at the mining operation and, where considered necessary, the safe withdrawal of people from underground in the mining operation.*
- (2) *In the case of an underground mining operation or tunnelling operation, the ventilation control plan must, in addition to the matters in subclause (1), address the following matters:*
- (a) *how the exposure of mine workers to engine pollutants in the atmosphere at the mining operation will be controlled, including—*
 - (i) *the provision of sufficient ventilation to dilute harmful exhaust pollutants at the mining operation; and*

- (ii) *regular testing, on at least a monthly basis, of the exhaust material from each diesel engine at the mining operation to verify that the ventilation provided is sufficient to dilute any harmful exhaust pollutants emitted by the engines:*
- (b) *a procedure for the starting of a main fan:*
- (c) *procedures for using the following types of fans, where they form part of the mining operation's ventilation system, including starting and stopping procedures:*
 - (i) *auxiliary fans; and*
 - (ii) *booster fans; and*
 - (iii) *scrubber fans:*
- (d) *the levels of methane at which a methane detector will activate its alarm, and the procedures to be followed when that occurs:*
- (e) *measures to be taken if the effective temperature in the underground parts of the mining operation exceeds 28°C:*
- (f) *providing for the recording of instances referred to in paragraph (e) as part of the health and safety management system:*
- (g) *the procedure regarding the action to be taken when monitoring identifies the presence of noxious gases:*
- (h) *the criteria for determining that ventilation is inadequate in a part or the whole of the underground parts of the mining operation, having regard to the quality, quantity, and velocity of air provided by the ventilation system such that workers must be evacuated from the affected part or the whole of the operation as required by Regulation 149:*
- (i) *the procedure in the event that the main ventilation system at the mining operation fails (which, if the operation is ventilated by more than 1 main ventilation fan, means a failure of 1 or more of the fans), including—*
 - (iv) *the action to be taken to ensure the safety of mine workers if the ventilation system fails in part or totally for at least 30 consecutive minutes; and*
 - (v) *the safe withdrawal of mine workers from the underground parts of the mining operation to a place of safety when it is necessary to withdraw them from the underground parts; and*
 - (vi) *how the system that monitors the operation of the main ventilation fan or fans at the mining operation will ensure an alarm is given at the surface part of the mining operation in the event that 1 or more of the main ventilation fans stops.*

- (3) *In the case of an underground coal mining operation, the ventilation control plan must, in addition to the matters in subclauses (1) and (2), address the following matters:*
- (a) *an assessment of potentially explosive gas contained within the coal seam that is being mined:*
 - (b) *based on the assessment required by paragraph (a), the establishment of a system for the delivery of adequate ventilation that is designed to maintain the concentration of methane below 0.5% of the general body of air in any production area:*
 - (c) *the design, monitoring, and control of the underground ventilation arrangements to ensure that the atmosphere underground in the mining operation is kept within the prescribed limits (including design, monitoring, and control of arrangements required to support air quality, dust, and airborne contaminant management, gas outburst management, spontaneous combustion management, or other hazard management arrangements at the mining operation that are dependent on ventilation):*
 - (d) *the development and implementation of a procedure to ventilate the underground parts of the mining operation where work is performed, including specification of the maximum distances from the face where ventilation ducting and brattice lines may be located:*
 - (e) *the placement of every main ventilation fan in a location and under such conditions that will prevent the fan being damaged during an explosion occurring underground in the mining operation.*

REG 170

170 Escapeways in underground coal mining operation

- (1) *The mine operator of an underground coal mining operation must ensure that the mining operation has at least 2 egresses trafficable on foot (**escapeways**) to the surface that are separated in a way that prevents any reasonably foreseeable event happening in 1 of the escapeways that may stop a person from being able to escape through the other escapeway.*
- (2) *The mine operator must ensure each ERZ1 at the underground coal mining operation in which a mine worker works has 2 escapeways leading to the surface or a refuge.*
- (3) *Subclause (2) does not apply to an ERZ1—*
 - (a) *in which an inspection is being carried out under the mining operation's health and safety management system and no other mine worker is working in the ERZ1; or*
 - (b) *where the ERZ1 is located in a single-entry drive or shaft that is being sunk.*

- (4) *The mine operator must ensure that at least 1 of the escapeways at the underground coal mining operation is designated as the primary escapeway and is—*
- (a) *an intake airway or a combination of adjacent intake airways; and*
 - (b) *separated, as far as is reasonably practicable, from all other roadways by a separation stopping that is antistatic, fire-resistant, and of substantial construction that will ensure there is minimal leakage through the stopping;*
 - (c) *and*
 - (d) *as far as practicable, free from hazards associated with fire; and*
 - (e) *trafficable by a vehicle; and*
 - (f) *fitted with fire fighting equipment located on, or near, any equipment installed in the escapeway.*

REG 171

METAL TUNNELS

171 Escapeways in underground metalliferous mining operations and tunnelling operations

- (1) *The mine operator of an underground metalliferous mining operation or tunnelling operation must ensure that there are adequate means of escape from the underground parts of the mining operation.*
- (2) *When determining the means of escape from the underground parts of the mining operation, the mine operator must consider—*
- (a) *the need for mine workers to escape from the underground parts of the mining operation during an emergency; and*
 - (b) *the inclusion and placement of refuges.*
- (3) *The mine operator must ensure that a record is kept of the process undertaken to determine the means of escape from the underground parts of the mining operation, including the reasons for the final determination.*

REG 172

METAL

172 Additional requirements for escapeways in underground metalliferous mining operations

The mine operator of an underground metalliferous mining operation must ensure that, before stoping operations start at the mining operation, the operation has at least 2 egresses trafficable on foot (escapeways) that—

- (a) *are accessible from all stoping operations and lead to the surface; and*
- (b) *are located strategically in response to the hazards that may arise at the mining operation and that will require evacuation; and*
- (c) *allow for the passage of rescuers and rescue equipment, including stretchers; and*
- (d) *are separated in such a way that a reasonably foreseeable event happening in one of the escapeways would not prevent persons escaping through the other escapeway; and*
- (e) *are maintained in a safe, accessible, and useable condition.*

5.1 General requirements¹⁹

The ventilation system should be designed so that it is possible to maintain a healthy and safe atmosphere underground at all times.

Ventilation should provide adequate quantities of fresh air to mine workers. It should render harmless toxic, asphyxiant, flammable and otherwise harmful products, gases and dusts, and carry them out to the surface through dilution by fresh air.

The ventilation system design should consider the physical parameters of the airways, the layout of the mine, and the hazards likely to be encountered underground.

Ventilation planning should be based on mine or tunnel-specific properties, such as:

- (a) The gas content of coal.
- (b) Carbon monoxide emissions.
- (c) Dust levels created during production.
- (d) Fumes from blasting or diesel engines.

The early establishment of through flow (primary) ventilation circuits as the underground workings develop and deepen should also be considered.

As the complexity of the mining operation increases, it is likely that a ventilation simulation software model may be required to adequately design the ventilation system and assess the safety critical impact of changes or extension of the mine workings.

5.1.1 Design and planning for a new mine or tunnel

When designing or planning a new mine or tunnel, an engineer (specialising in ventilation) should consider:

- (a) The depth and length of the operation (the maximum distance from the surface to the furthest point to be mined).
- (b) The requirement for a second intake as an egress.
- (c) The geology (including the temperature) of the surrounding rock (ie gas potential).
- (d) Any diesel equipment used underground.
- (e) The seam layout (ie vertical, horizontal inclined).
- (f) Production methods and estimated maximum production levels.
- (g) The coal seam gas content and expected desorption rates.
- (h) The expected volumes of dust generated from concrete spraying or installing and grouting concrete segments.
- (i) The presence of ammonia, which may be created during grouting.²⁰

¹⁹ Safe Work Australia. (2011). *[Draft] Code of Practice – Ventilation of Underground Mines*. Canberra, Australia. 21.

²⁰ BS 6164:2011. *Code of Practice for safety in tunnelling in the construction industry*. (14.4.3.10) 91.

- (j) Any requirements specific to tunnels, such as working with compressed air pressurisation and air locks.
- (k) Site layout details, such as:
 - (i) The size of shafts or outlets.
 - (ii) The layout and size of roadways.
 - (iii) Conveyor transporting (ie mineral, people-riding and materials).
 - (iv) Other transport methods (eg rail, or mono-rail).
- (l) The effects of a potential fire on the ventilation system, including:
 - (i) Variations to ventilation pressure.
 - (ii) Response from the intake side.
 - (iii) The need for separated escape ways.
 - (iv) The impact of seasonal changes on temperature and humidity underground.
 - (v) Barometric pressure.

This information should guide design and planning for a new mine or tunnel, and subsequently, production levels.

5.1.2 Design and planning for an existing mine or tunnel

Most existing mines and tunnels will already have historical records of the above information, and to ensure continuous improvements, this information should be used to guide design and planning for any new production areas.

An engineer (specialising in ventilation) should consider:

- (a) The length of the new heading.
- (b) The surrounding rock.
- (c) Historical data on gas makes and other environmental problems or issues.
- (d) Previous production methods that have taken place in the heading.
- (e) The ventilation method.

5.1.3 Planning records

Whether a new or existing mine or tunnel, records that document planning and design, and monitoring of the primary ventilation system performance, should be prepared as detailed in AS 4368-1996 "Mine plans – Preparation and symbols" using LINZS25000 "Standard for New Zealand Geodetic Datum 2000".

The records should be continuously updated, at least monthly, in hard copy format.

See Section 10 Records for further information on the maintenance of records and plans.

REG 153

153 Ventilation

The mine operator of a mining operation to which this Regulation applies must ensure that—

- (a) the percentage of methane in the general body of air in the underground parts of the mining operation where a mine worker is or may be present is not more than 2% by volume; and
- (b) a quantity of fresh air adequate to ensure that paragraph (a) is complied with is circulated throughout the underground parts of the mining operation—
 - (i) before a mine worker enters the underground parts of the mining operation; and
 - (ii) whenever a mine worker is in the mine; and
- (c) there is fresh air at the following places:
 - (i) the commencement of an ERZ1;
 - (ii) every location that is 100 metres outbye of the most inbye completed line of cross-cuts in a panel or of a longwall or shortwall face; and
- (d) no air current passes through any stopping, or any unsealed, abandoned, or worked out area, before ventilating or passing through an active working place; and
- (e) the total number of mine workers ordinarily present in a ventilation district or ventilation circuit in the mine is kept to a minimum; and
- (f) a competent person measures, at least once in every week, the percentage of methane in the main return and split returns.

REG 163

163 Mine worker must inform person in charge of hazard from methane or noxious gas

- (1) If a mine worker knows or suspects that a location in the underground parts of the mining operation constitutes a hazard by reason of the presence of methane or noxious gas, the mine worker must immediately inform,—
 - (a) in the case of an underground coal mining operation, the underviewer; or
 - (b) in the case of an underground metalliferous mining operation or tunnelling operation, the supervisor; or
 - (c) the mine worker responsible for the part of the mining operation that includes the location that constitutes or is suspected to constitute a hazard.
- (2) A mine worker of the kind described in subclauses (1)(a) to (c) who is informed that a location in the underground parts of the mining operation may or does constitute a hazard by reason of the presence of methane or noxious gases must inspect the location as soon as practicable and as far as is safely possible.

REG 140

140 Separation of airways

- (1) *If the mining operation has more than one main airway, the mine operator must ensure that the airways are separated sufficiently to ensure—*
- (a) *stability; and*
 - (b) *ventilation to the standards required by Regulation 141(a) and (b).*
- (2) *The mine operator must ensure that no more than 2 temporary stoppings are installed in a line of stoppings that separate an intake airway from a return airway immediately adjacent to the last line of cut-throughs in the panel.*

REG 141

141 Air quality and temperature

The mine operator must ensure, in relation to the underground mining operation or tunnelling operation, that—

- (a) *there is fresh air at the commencement of every section of the workings that has a working face; and*
- (b) *the humidity of the air is maintained at such a level as to minimise the likelihood of heat stress; and*
- (c) *measurements to ensure compliance with this regulation are made at suitable intervals, and at suitable locations, using methods and measuring devices capable of giving accurate results; and*
- (d) *there is no recirculation of air within a working face other than through a scrubber fan.*

REG 143

143 Quantity and velocity of air

- (1) *The mine operator must ensure that—*
- (a) *the volume of air passing through an active working face, other than a longwall working face, is not less than 0.3 cubic metres per second for each square metre of normal development cross-sectional area; and*
 - (b) *the volume of air passing through an active longwall working face is not less than 4 cubic metres per second for each metre of extracted height in the face.*
- (2) *The mine operator must ensure, in respect of any underground parts of a mining operation where a mine worker is doing work or may travel, that the air in that part is provided at an adequate quantity and velocity to ensure the mine worker will not be exposed to a concentration of dust that is likely to cause harm to the mine worker.*

ACOP

5.2 Design considerations for ventilation systems²¹

- (a) The mine operator should ensure that ventilating air is provided in sufficient volume, velocity and quality, to:

²¹ Department of Industry and Resources. (1997). *Underground Ventilation (Metalliferous Mines) Guidelines*. WA, Australia. 4-10.



- (i) Remove, dilute or render harmless any harmful contaminants.
- (ii) Address the adverse effects of extreme heat and cold:
 - a. When the WB temperature reaches 25°C, an air velocity of no less than 0.5m/s should be provided.
 - b. At temperatures greater than 25°C, the requirements of section 4.4.1 should be met.

Where the temperature is less than 16°C, protective clothing should be provided. For more detailed information on the provision of PPE, see the Approved Code of Practice on Worker Health.

- (b) In order to provide ventilating air of sufficient volume, velocity and quality to working places, the mine operator should ensure that:
 - (i) The location of intake airways is such that the potential for contamination of air drawn into the mine or tunnel is controlled, as far as is reasonably practicable.
 - (ii) No activities generating harmful levels of dust and fumes take place in the vicinity of the intake.
 - (iii) All installations built of combustible materials, or containing combustibles or inflammable materials, are located where if they caught fire they would not cause an adverse effect on the intake air.
 - (iv) All installations in, or near, the primary intake airway are protected by an automatic fire suppression system.
 - (v) Workshops are not located in intake areas unless the return air feeds directly into the mine return airway.
 - (vi) The scheduling of return airway development is aligned with the general development of the mine.
 - (vii) Electrical infrastructure is advanced or retracted in a timely manner, and as changes are made to ERZs or as zones are removed
 - (viii) Where one auxiliary fan is used to ventilate multiple levels, there is no recirculation of air, regardless of which heading or level is being ventilated.
 - (ix) Fan characteristics match the duties required.
 - (x) Shift supervisors and workers representatives are aware of the ventilation standards in their operating areas.
 - (xi) Mine workers understand the requirements for re-entry examinations after blasting, and have access to monitors suitable for the range of gases likely to be encountered.

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- (xii) A system is in place to inform mine workers, so that they clearly understand, of the maximum number of diesel-powered equipment permitted in a particular section of the mine or tunnel.
- (xiii) entilation standards and practices are reviewed at three-monthly intervals by the ventilation officer and a report made to the mine manager.

5.3 Primary ventilation planning

The basic principle of effective ventilation is the effectiveness of the primary ventilation system (ie the total volume of air flow conducted through the major underground workings). This usually involves splits into parallel circuits.

Factors that determine total primary volume capacity (and pressure) requirements include:

- (a) The depth of the mine or tunnel.
- (b) The mine or tunnel complexity.
- (c) The mining, tunnelling and extraction methods.
- (d) The size of development openings.
- (e) The equipment being used underground.

One of the major constraints on primary ventilation volume is intake air capacity. This is because the greater proportion of ventilation pressure drop is used in overcoming the resistance of underground airways.

Roadway pressure requirements can be calculated using the following equation:

$$p = RQ^2 \text{ or } p = \frac{k s Q^2}{A^3}$$

p = ventilation pressure (Pa)

R = equivalent resistance (Ns² m⁻⁸)

Q = airflow (m³/s)

k = friction factor (see the Appendix to determine the 'k' value)

s = rubbing surface (m²) (length x perimeter)

A = cross-sectional area (m²)

The pressure drop is influenced by the cross-sectional area of the roadway, so roadway size is of great importance in ventilation planning.²²

High air velocities may be tolerable in return airways and exhaust rises and shafts (where no mine workers are exposed), but there is a practical limit to tolerable air velocity in main intakes (shafts and accesses) and main development openings where mine workers travel and work.

Dust generation is one problem caused by excessive intake velocities.

²² National Coal Board Mining Department. (1979). *Ventilation in coal mines. A Handbook for colliery ventilation officers*. London, England. 97/151.

This becomes more acute in antitropical layouts:

- (a) **Antitropical** – air flows against direction of the coal transport system.
- (b) **Homotropical** – air flows in same direction as the coal transport system.

High velocities require high pressure gradients and very high power costs to maintain them.

Another significant issue is that deep and complex underground mines tend to use series ventilation circuits. The main problem with series (or parallel-series) circuits is gradual contamination of the air by reusing air from secondary ventilation system returns, and the increased risk of fumes and smoke from any fire in the intake or upstream section of the mine.

The whole ventilation system changes as the mine develops and new areas are opened up. There are a range of options for controlling primary air flow.

Air flow may be regulated (closure or restriction of some paths), or 'boosted' through designated circuit fans, usually installed on the exhaust side.

Regulating flows is easier to perform and less costly, but increases the mine resistance and reduces total primary flow. Local circuit (booster) fans increase the total primary flow, and generally operate at high volume and low pressure, which requires less power.

Minimising the presence of water in the intake airways (eg shafts, tunnels, accesses, etc), and in the main primary airways, is an important aspect of primary ventilation, particularly in areas of high humidity or ambient surface temperatures.

Intake air becomes heated from conduction and radiation in the surrounding rock, which is caused by auto-compression in down cast shafts, and the operation of diesel vehicles and electrical equipment.

Where intake air is dry and of a moderate to high temperature, water pick up is rapid. The DB temperature decreases and the WB temperature increases.

To counter increasing temperature and humidity, it is necessary to increase air circulation, or introduce chilled service water. Both of these measures are much more costly than maintaining an efficient drainage system.

Where extremes of temperature and humidity are experienced, it may be necessary to introduce refrigerative cooling, on a "spot cooling" basis, or by large-scale treatment of the primary air flow. Water rings in shafts, covering drains, and piping drainage water to sumps are additional measures to counter humidity.

The potential for heat pick up requires assessing during the ventilation design stage, to ensure the necessary volumes and velocities of air flow are maintained when the mine or tunnel is fully operational.

5.4 Primary ventilation – Parallel intakes

The system should be designed and scheduled to provide parallel paths from the primary fresh air intakes through operating areas to return airways connecting to exhaust rises and shafts. Generally, the shorter and more direct the ventilation circuit through each working area, the better the system.

Maximum use of parallel paths will reduce the overall mine resistance for a given air flow, which in turn greatly reduces the power required and the operating cost. However, adequate volume flow through each working area must be maintained to dilute dust and contaminants.

Increasing production can dramatically increase the amount of ventilation required to ensure a safe environment. The basic principle of the mine layout design should be that contamination from working face(s) does not lead to contamination in other operational areas.

Similarly, efficiencies in ventilation can be achieved if the layout design and roadway configuration considers increased resistance of roadways as a result of deterioration over time. Dual intakes and returns can reduce the resistance of the mine substantially.

(a) Branch Resistances

Resistances are determined by calculation from observed values of p and Q .

$$\text{When: } R = \frac{p}{Q^2} \text{ (Ns}^2\text{m}^{-8}\text{)}$$

$$\text{In series: } R = R_1 + R_2 + R_3$$

$$\text{In parallel: } \frac{1}{\sqrt{R}} = \frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}} + \frac{1}{\sqrt{R_3}}$$

(b) Parallel Airway

If an airway is duplicated by a parallel airway of equal resistance, the combined resistance is reduced to one quarter.

$$\frac{1}{\sqrt{R}} = \frac{1}{\sqrt{r_1}} + \frac{1}{\sqrt{r_2}} = \frac{1}{\sqrt{r_1}} + \frac{1}{\sqrt{r_1}} = \frac{2}{\sqrt{r_1}}$$

$$\therefore R = \frac{r_1}{4}$$

Figure 1 – Roadway resistances in series and in parallel

5.5 Auxiliary ventilation in underground coal mines

The mine operator should ensure that:

- (a) Developments are sited in their own ventilation circuit.
- (b) The quantity of air required to dilute and render harmless explosive and toxic gases, reduce heat and minimise dust, is carefully planned with shafts, drifts and underground roadways an appropriate size to limit pressure losses.

- (c) Only approved ventilation fans and FRAS ducting is used.
- (d) The ventilation officer sets the minimum air quantity and velocity for development and production areas and each phase where the sequence will impact on critical values. Regular reviews should be undertaken to ensure that safe ventilation conditions are maintained underground at all times.
- (e) Calculations for the total quantity and velocity of the ventilation should take into account methane make (litres/second), methods of working, roadway gradients and extent of mining area.
- (f) Where the normal cross-sectional area is exceeded (eg at junctions and switch houses, etc) and the minimum air velocity cannot be achieved, extra measures (eg local air movers or hurdles and screens) should be used to prevent methane layering.
- (g) For any given rate of gas outflow from a 'feeder', and dimensions of an airway, there is a critical ventilation velocity below which layers will form. Generally, minimum velocities ranging from 0.3 m/s to 0.5 m/s are sufficient to prevent layering, but for other conditions, particularly in gassy mines with inclined roadways, it is not.

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5.5.1 Types of auxiliary ventilation

Auxiliary ventilation is the provision of ventilation to development ends, stopes, faces, headings and services facilities which constitute secondary circuits tapped off the primary circuit or main through flow of air. These circuits may be blind, parallel or in series.

The use of auxiliary ventilation fans and ducting is most commonly required in a "forced air" configuration, but pressure/exhaust overlap, or total exhaust, may also be used.

(a) Force-only ventilation

Force-only ventilation provides positive pressure and cooling to headings where dust levels are not a priority. The system has significant benefits in controlling gas layering and removing diesel and shotfiring fumes.

However, it has significant limitations in terms of respirable dust control and is therefore not suitable in machine cut headings where effective dust scrubbers are not being used.

Flat-lay duct can be used with this system which has advantages in terms of portability, low cost and minimal frictional losses.

Force ventilation is suitable for long headings in coal and metalliferous applications and in rising coal headings where methane gas layering is likely to be an issue.

(b) Exhaust-only ventilation

Exhaust-only ventilation is commonly used to extract dust and fume-contaminated air and conduct it directly to a return airway where it can be diluted. More expensive solid or semi-rigid (spiral wire reinforced) ducting is required for this system.

In metalliferous operations, static diesel equipment (eg compressors) can pipe diesel exhaust fumes directly into the rigid auxiliary exhaust duct with fumes removed and diluted in the main airway general body ventilation.

However, total exhaust ventilation has significant limitations and is generally not suitable for long headings because of increased frictional losses in the rigid or semi-rigid ducting. It is especially not suited to rising coal mine headings because of the increased risk of methane layering as it is ineffective at inducing turbulent air at the heading face.

(c) Auxiliary force/exhaust overlap auxiliary ventilation

Auxiliary force/exhaust overlap auxiliary ventilation systems combine the positive aspects and minimise the weaknesses of the systems referred to above.

Although not practicable during development work because of the heading length required to install the basic components and maintain the necessary ventilation control distances, once headings are developed beyond 100m in length, it may be practicable to install such a system.

Alternatively, more sophisticated auxiliary force/exhaust ventilation systems are mounted on a pantechnicon structure (as with longwall/TBM systems) and maintain the overlap distances at the optimum setting by moving the whole system as one.

(d) Secondary ventilation

Effective secondary ventilation can be established only if the primary ventilation system is adequately designed and maintained. The two systems are an integrated whole, and an unbalanced combination can cause air re circulation, which is inefficient and potentially hazardous.

Correct selection of fans for secondary ventilation and attention to the correct design of fan/duct combinations is essential where large ventilation volumes are required over extended distances to cater for large scale diesel equipment.

It is cost effective to provide twin ducts and two fans rather than to increase fan power to force larger volumes through a single duct at the much higher pressures required. The power cost can be reduced by 50% and the reduced pressure on the ducting greatly reduces leakage at joints and seams.

The cost of power saved offsets the cost of a second fan and the additional ducting, particularly when the system is to be split to service two or three workplaces.

Auxiliary systems on extended secondary circuits in development, and where auxiliary fans have to be turned off for blasting should be avoided where possible.

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5.6 Methane layering

- (a) The mine operator should ensure that the ventilation system provides sufficient velocity to prevent methane layering.
 - (i) Where methane layering is found to be present at a concentration greater than the general body concentration, the cause should be investigated and the layer diluted and rendered harmless.
- (b) The tendency for gas layering can vary depending on factors such as methane gas ‘make’ of the coal seam (litre/second), rate of output, gradient of roadways, roughness of the roadway surface and prevailing barometric pressure.

The ventilation officer should ensure sufficient resilience is built into the ventilation system so that variations in gas concentration conditions are accommodated.
- (c) Applying a layering number will assist with assessing the likelihood of methane layering occurring. The higher the number, the less likelihood for it to occur.
 - (i) In level roadways, a layering number of 5 should be used as a design parameter for roadways.
 - (ii) In steeply inclined roadways, a higher number is required.

$$\text{Layering number} = 6U$$

$$\sqrt{\frac{V}{D}}$$

U = Mean roadway air velocity (m/s)

V = Methane make at local source (litres/s)

D = Roadway width (m) (= $\frac{3}{4}$ maximum width of an arched roadway)

Figure 2 – Formula to calculate layering number

5.6.1 Ventilation design for the management of methane

The tables below show examples of the amount of ventilation that may be derived from the variables of production and gas makes. These are examples only. An engineer (specialising in ventilation) should be consulted to determine requirements specific to an individual mine or tunnel.

Ventilation requirements to achieve 0.5% without methane drainage	
Specific gas emission (m ³ /tonne)	10.00
Weekly tonnage	30,000.00
Ventilation Quantity m ³ /s	30.00
Total gas make m ³ per week	300,000.00
Number of seconds in a week	604,800.00
Gas make = m ³ /s	0.496
% of Methane in General Body	1.65
Litres/second	496.03
To get <0.5% would require m ³ /s	99.21

Ventilation requirements to achieve 0.5% with methane drainage	
Specific gas emission (m ³ /tonne)	10.00
Weekly tonnage	30,000.00
Ventilation Quantity m ³ /s	30.00
Methane drainage as % capture	0.50
Total gas make (m ³)	300,000.00
Number of seconds in a week	604,800.00
Gas make = m ³ /s	0.496
Methane % in General Body	1.65
Litres/second in General Body	496.03
Air Quantity Required to get <0.5%	99.21
Litres at 50%	248.02
Remaining Methane in air (l/s)	248.02
Air Flow required to achieve 0.5% (m ³ /s)	49.60

5.6.2 Assessment of methane layering potential

The ignition of methane is one of the most dangerous incidents that can occur in an underground environment, particularly when combined with a coal-dust explosion.

When methane is emitted from the surrounding rock into the mine workings, it will often be at concentrations in excess of 90%. As the gas percentage dilutes it will fall into the explosive range of 5-15%.

This means the time and space in which the explosive mixture exists must be kept as small as possible. This is achieved by good mixing of the methane and air at the point of its emission.

Methane is naturally buoyant (SG 0.55) and tends to concentrate in roof cavities and layer along the roof of airways or working faces.

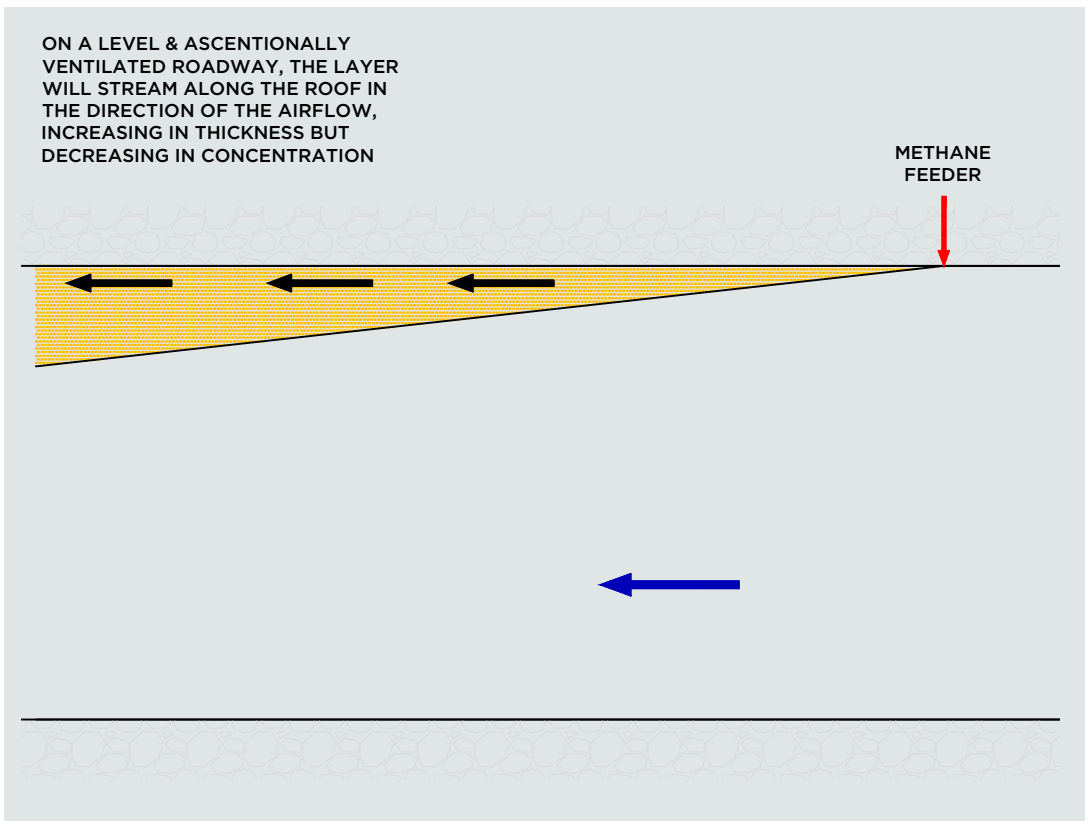


Figure 3 - Methane layering (level and ascensionally-ventilated roadways)

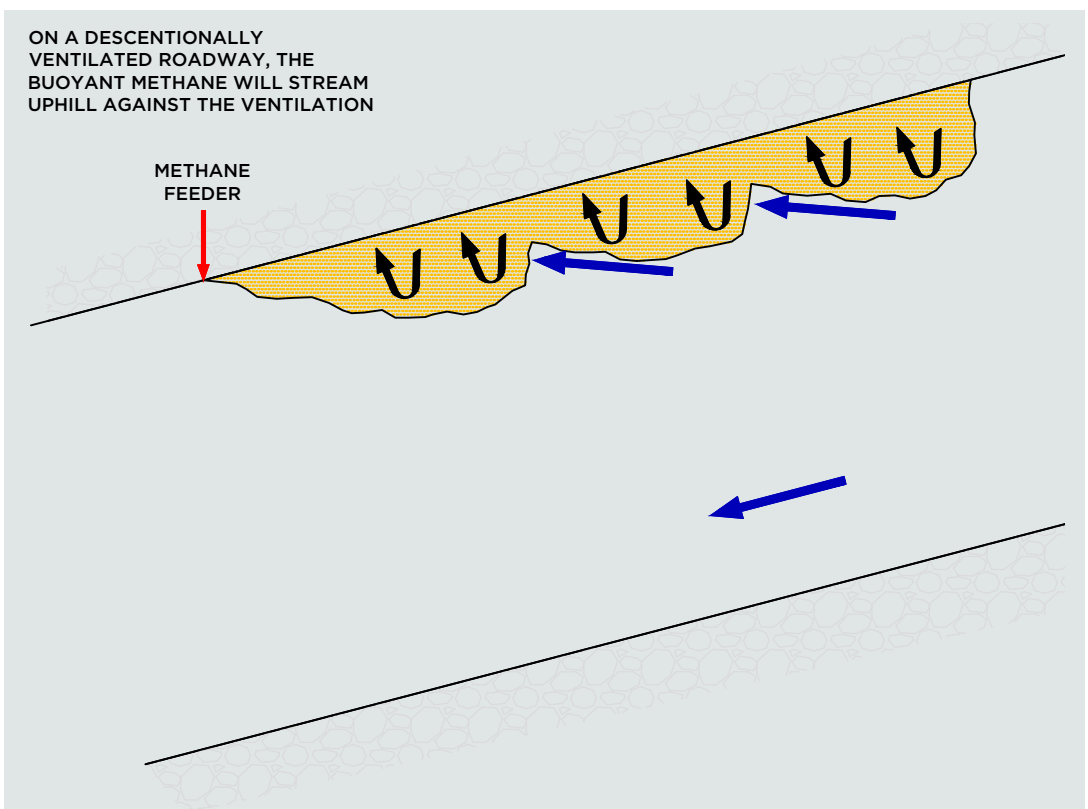


Figure 4 - Methane layering (descensionally-ventilated roadways)

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The two main hazards associated with methane layers are:

- (i) They extend the zones where ignition of gas can occur; and
- (ii) the layer acts as a fuse along which a flame can propagate, resulting in larger accumulations in cavities in waste areas.

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5.7 Air velocity

Within drives and tunnels developed in coal, the ventilation system should be able to provide sufficient air quantity throughout the length of the heading to achieve a minimum air velocity of at least 0.3 m/s in all parts of the roadway. At the head-end where the cutting machine is operating, the minimum velocity should not be lower than 0.4 m/s.

(a) **Example 1**

17.52 m²

5 m

3.5 m

→

Q=A x V
 Q=17.5 x 0.3
 Q=5.2 m³/s

(b) **Example 2**

25 m²

5 m

5 m

→

Q=25 x 0.3
 Q=7.5 m³/s

Cross-sectional area of heading m ²	velocity 0.3 m/s	m ³ /s
10	0.3	3
15	0.3	4.5
20	0.3	6
25	0.3	7.5
30	0.3	9
35	0.3	10.5

At roadway junctions where ventilation ducting is installed, the area around the junction should be designed around the ventilation system, with adequate clearances so that there is plenty of scope to install the correct sized ducting.

Although sufficient velocity is necessary to prevent gas layering, excessive velocities can also increase dust pick up across the face, and drive ventilation deeper into the goaf, increasing the risk of spontaneous combustion.

High seam gas content may require additional controls such as methane drainage, pre-drainage, post-drainage using cross measure boreholes, or goaf wells drilled from the surface. Such controls will reduce the percentage of methane in the general body.

5.8 Ventilation roadway designs

There are many variations on the following schemes but adequate ventilation of the underground workings, and the safe egress of workers in the event of an incident, are the most important factors when considering ventilation system options.

(a) U-tube ventilation

Figure 5 shows an example of U-tube ventilation, whereby ventilation flows towards and through the workings, then returns along adjacent airways separated from the intakes by stoppings and doors.

Adjacent airways are either all intakes or all returns.

(b) Through-flow ventilation

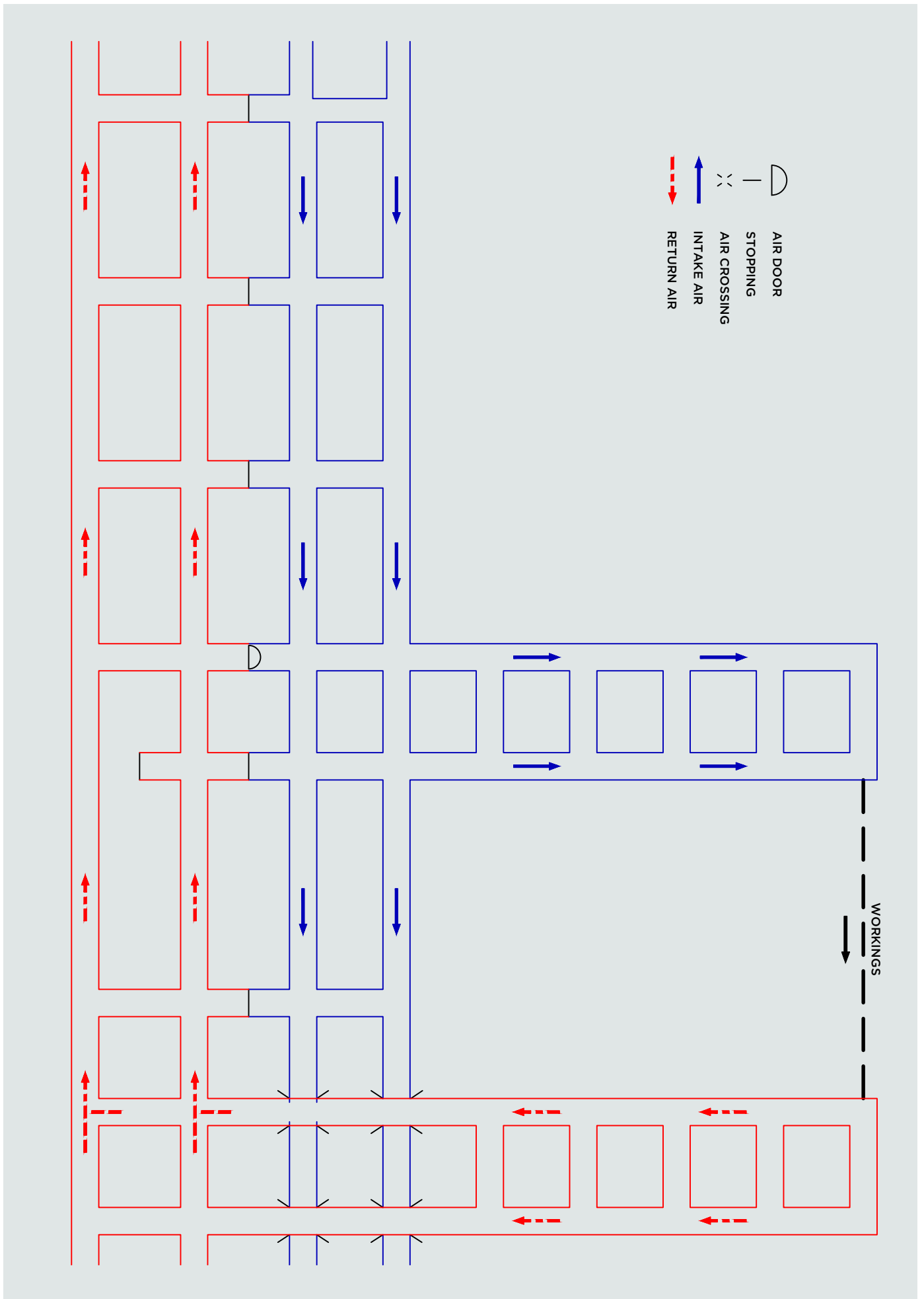
Through-flow ventilation requires the establishment of one or more connections between the main intake and return.

The advantages of through-flow ventilation include:

- (i) Leakage between intake and return roadways is virtually eliminated, lowering the total airflows required to ventilate the workings.
- (ii) Parallel airways reduce overall resistance, giving a short air travel time, which in turn reduces the ventilating pressures required to ventilate the mine or tunnel.
- (iii) The surface fan duty remains relatively stable.
- (iv) The combination of the above advantages generally means lower ventilation operating costs.

See Figure 6 for an example of through-flow ventilation.

Figure 5 - U-tube ventilation



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5.8.1 Return airways

The mine operator should ensure that district and main return roadways are:

- (a) Available at all times as a second means of egress from that district.
- (b) Of a reasonable cross-sectional area so that:
 - (i) Resistance is kept to a minimum.
 - (ii) An injured party can be transported along the roadway in the event of an emergency.
 - (iii) Excessive air velocities generated by a reduced cross-sectional area do not cause goaf gases being drawn out by a venturi effect.

5.8.2 Compressed air tunnelling

A compressed air atmosphere is not common in tunnelling in New Zealand, but may be used when tunnelling underneath water or through highly saturated ground.

This method provides additional temporary ground support in very soft and extremely wet ground conditions, and where other means of preventing excessive ingress of water or the collapse of ground into the tunnel, are not practical.

The pneumatic support process involves:

- (a) Providing a bulkhead with air locks for access into the tunnel.
- (b) Pressurising the tunnel with compressed air to hold back the water and weak surrounding rock.

Additional requirements and controls applicable to working in a pressurised atmosphere can be found in BS 6164 2011 Section 11 Compressed-air working.

06/

FANS

IMPLEMENTING AND MAINTAINING CONTROLS TO MANAGE RISK

- 6.1 General fan requirements**
 - 6.2 Monitoring of main and booster fans**
 - 6.3 Starting of main fan**
 - 6.4 Stoppage of fans**
 - 6.5 Ventilation system failure**
 - 6.6 Auxiliary fans**
 - 6.7 Compressed air operated auxiliary fans and venturi devices in coal mines**
 - 6.8 Scrubber fans**
 - 6.9 Diesel vehicles in headings**
 - 6.10 Continuous monitoring during an emergency**
-

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142 Measurement of air from fans

- (1) *The mine operator of an underground coal mining operation must ensure that, at least once in every week, a competent person—*
- (a) *measures the quantity of air being delivered to every working place in the underground parts of the mining operation; and*
 - (b) *determines whether air is being recirculated in the underground parts of the mining operation and takes suitable action to stop any such recirculation.*

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144 Ventilation fans other than auxiliary fans

The mine operator must ensure that,—

- (a) *where the main ventilation fan or fans, other than a portable fan that is the main ventilation fan for a tunnelling operation with a single entry tunnel, are on the surface of the mining operation, an effective airlock is provided and maintained on the surface at each shaft or outlet connected to the main ventilation fan or fans that is used for winding or the transport of people, plant, or material; and*
- (b) *each main ventilation fan has the following devices connected to it:*
 - (i) *a pressure gauge that continuously indicates the air pressure; and*
 - (ii) *a device that continuously indicates and records the volume of air passing through the fan; and*
 - (iii) *a device that continuously indicates and records the number of revolutions per minute of the fan; and*
- (c) *each main ventilation fan is fitted with a device that continuously monitors and records the condition of the fan, including the temperature, vibration levels, and static pressure, and that will, when the device detects a significant departure from the fan's normal operating parameters,—*
 - (i) *first, trigger a visible alarm; and*
 - (ii) *following such period of time as will provide a mine worker with a reasonable opportunity to respond to the alarm, isolate the supply of electricity to the fan if no other action has been taken by a mine worker in response to the departure from normal operating parameters; and*
 - (iii) *record the date and time that an alarm is triggered and the supply of electricity is isolated; and:*
- (d) *each booster fan installed underground is fitted with a device that continuously monitors and records the condition of the fan, including the temperature, vibration levels, and static pressure, and that will, when the device detects a significant departure from the fan's normal operating parameters,—*

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- (i) first, trigger a visible alarm; and
 - (ii) following such period of time as will provide a mine worker with a reasonable opportunity to respond to the alarm, isolate the supply of electricity to the fan if no other action has been taken by a mine worker in response to the departure from normal operating parameters; and
 - (iii) record the date and time that an alarm is triggered and the supply of electricity to the fan is isolated; and
- (e) each of the monitoring devices referred to in paragraphs (c) and (d) is designed and installed so that the part of the device that displays the results of the monitoring is located where it can be easily accessed by a mine worker required to check the condition of the fan; and
- (f) the devices referred to in paragraphs (b) to (d) are maintained:
- (g) any scrubber fan used at the mining operation is located and operated in a way that prevents the uncontrolled recirculation of air through the fan.

181 Position and electricity supply of main ventilation fan

- (1) The mine operator must ensure that no main ventilation fan is located in the underground parts of the mining operation.
- (2) The mine operator must ensure that the supply of electricity to the main ventilation fan does not enter into or travel through any part of the underground parts of the mining operation.

6.1 General fan requirements²³

- (a) Fans should be designed, constructed and installed to:
 - (i) Suit the duty, including the effect on other fan installations.
 - (ii) Minimise the risk of ignition of an explosive mix of gases passing through the fan.
 - (iii) Prevent access during operation.
 - (iv) Prevent unauthorised starting and stopping.
- (b) Fan requirements specific to tunnels:
 - (i) Fans supplying ventilating air to tunnels should be considered main fans where people normally work underground and the fan is installed on the surface.
 - (ii) Fans supplying ventilating air to tunnels where people do not normally work underground other than for maintenance or inspections, should be considered auxiliary fans and monitored for temperature and vibration.

²³ Safe Work Australia. (2011). [Draft] Code of Practice – Ventilation of Underground Mines. Canberra, Australia. 23-24.

- (iii) Fans supplying ventilating air to tunnels in which methane is present should be designed, installed and monitored in line with the requirements for an underground coal mine.
- (c) Main fans should have arrangements to:
 - (i) Monitor air quantity and pressure.
 - (ii) Monitor any flammable gases that are likely to pass through the fan if methane is present.
 - (iii) Minimise damage to the main fan and its infrastructure in the event of an air blast or explosion.
 - (iv) Activate explosion doors (optional for metalliferous mines).
 - (v) Have an auxiliary power supply in case of mains supply failure (optional for metalliferous mines).
 - (vi) Cut the power supply to booster and auxiliary fans in the ventilation circuit supplied by the main fan (optional for metalliferous mines).
 - (vii) Monitor vibration and bearing temperature.
 - (viii) Use non incendive materials, such as brass or copper, in the rotor of the housing.
- (d) Auxiliary fans should have arrangements to:
 - (i) Prevent recirculation.
 - (ii) Isolate mobile plant operating in the ventilation circuit supplied by the fan.
 - (iii) Only be started after an inspection has been carried out in the affected roadways.
- (e) Booster fans should have arrangements to:
 - (i) Monitor the operating status of the fan.
 - (ii) Monitor air quantity and pressure.
 - (iii) Prevent recirculation.
 - (iv) Allow for the fan to be bypassed in case of failure.
 - (v) Monitor general body levels of methane around the fan motors.
 - (vi) Cut the power supply to auxiliary fans in the ventilation circuit supplied by the booster fan, should the booster fan stop.

6.1.1 Other procedures to be considered for fan operation

The mine or tunnel manager should ensure that the mine or tunnel official responsible for fan operation has in place procedures that cover:

- (a) Actions in the event of a fan alarm (TARP).

- (b) Fan isolation.
- (c) Fan auto-restart.
- (d) Manually starting the fan.

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6.1.2 Types of fans

The ventilating air current is drawn around an underground mine or tunnel through pressure created by a fan. Different types of fans include:

- (a) Main fans, which create the primary ventilating pressure, either forcing or exhausting, that generates the ventilation circuit around the mine.
- (b) Auxiliary fans, which generate an air flow beyond the circuit created by the main and booster fans. These fans are used in headings and developments.
- (c) Booster fans, which are located underground and reduce the pressure that should be generated by the main fans in mines with complex underground workings.
- (d) Scrubber fans, which remove dust by passing air through a filter. Scrubber fans may have arrangements where the capacity of the fan is greater than the volume available in the workplace. This is planned recirculation, which removes dust through filtration. Such arrangements would have limited application in coal mines otherwise detailed design, methane monitoring and trip settings should be deployed.

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6.2 Monitoring of main and booster fans

- (a) All main and booster fans should be monitored locally at a place where the readings and alarms are easily seen and heard by the mine worker responsible for checking the fan conditions. The following monitoring equipment should be used:
 - (i) Automatic pressure recorder with alarms set at pre-determined levels above and below the normal running levels.
 - (ii) Oil level indicator and low level alarm.
 - (iii) Oil temperature and high temperature alarm.
 - (iv) Fan bearing temperature indicator and high temperature alarm
 - (v) Motor bearing temperature indicator and high temperature alarm.
 - (vi) Audible alarm covering any of the above alarm conditions.
 - (vii) Power off indicator.
- (b) All main and booster fans should be monitored remotely at the surface by the mine worker responsible for checking the fan conditions. The following monitoring equipment should be used:
 - (i) Power on indicator.

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- (ii) Fan pressure indicator.
- (iii) Visible and audible warnings, covering all alarm conditions monitored in the fan house.

For tunnels, this monitoring should be by electronic continuous monitoring at the surface. The monitoring results should be reviewed regularly during each shift and an automatic alarm should alert mine workers to abnormal operation of the fan.

6.2.1 Examinations

The mine worker responsible for undertaking main and booster fan examinations should ensure that:

- (a) Examinations of the fans are carried out during each shift.
- (b) Examinations of the fans includes:
 - (i) A thorough visual inspection of the motor and gearbox, and any unusual noise, or change in temperature or vibration, recorded.
 - (ii) The presence and security of guards is checked.
 - (iii) Any water gauge reading is compared with the automatic pressure gauge.
 - (iv) All temperature and pressure indicators are checked for unusual variations (and normal operating ranges are marked).
 - (v) Oil levels at sight glasses are checked.
- (c) Any damage, disarrangement or unusual circumstances is reported to the mine or tunnel manager.
- (d) During any periods when the remote monitoring is out of use, the surface control is unattended, or any of the above requirements cannot be complied with, the maximum interval between examinations is 30 minutes.
- (e) The mine or tunnel manager puts in place a TARP covering appropriate response protocols.

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147 Starting, stopping, etc, of fans

The mine operator must ensure that—

- (a) *no mine worker starts, stops, removes, or alters a fan that is ventilating a place underground unless the mine worker is authorised by the mine operator to do so; and*
- (b) *before a mine worker starts, stops, removes, or alters a fan that is ventilating a place underground, the mine worker ensures that every other mine worker likely to be affected by the action is notified about it.*

6.3 Starting of main fan

- (a) The main fan should not be re-started unless:
 - (i) A competent mine worker appointed by the mine or tunnel manager has deemed that it is safe to do so.
 - (ii) Surface airlock doors have been closed, where applicable.
- (b) After an interruption to ventilation exceeding 30 minutes, methane determinations and air measurements should be made as soon as practicable after restarting the fan.
- (c) The mine or tunnel operator should develop a Standard Operating Procedure (SOP) for re-entry after a prolonged primary fan stoppage. The SOP should consider:
 - (i) The standby period required to allow sufficient time for normal ventilation to be restored.
 - (ii) Flushing of the mine or tunnel prior to re-entry.
 - (iii) A staged re-entry being carried out by no less than two competent mine workers, to ensure that the mine or tunnel is free from any atmospheric hazards resulting from the primary fan outage.
- (d) The reversal of airflow should be carried out with the written authorisation of the mine or tunnel manager, and in accordance with the manufacturer's procedures.

148 Ventilation of work areas to be adequate before entry

The mine operator must ensure that—

- (a) *all areas underground at the mining operation that mine workers are permitted to enter are adequately ventilated before any mine worker may go underground; and*
- (b) *if at any time the requirements of the ventilation control plan are not being met in relation to a part or the whole of the mining operation that is underground, no mine worker enters the affected part or, as the case may be, the whole of the mining operation; and*
- (c) *despite paragraphs (a) and (b), if any area underground that mine workers are permitted to enter is not adequately ventilated, a mine worker may, if authorised by the mine operator, go underground—*
 - (i) *to restore ventilation to adequate levels; or*
 - (ii) *in the case of an emergency.*

149 Withdrawal of mine workers if ventilation inadequate

The mine operator must ensure that, if ventilation is found to be inadequate or a ventilation control device fails in a part or the whole of the mining operation that is underground,—

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- (a) every mine worker withdraws from the affected part or the whole of the mining operation; and
- (b) the mine worker with responsibility for the affected part or parts—
 - (i) immediately takes such measures as are available to the mine worker to restore adequate ventilation; and
 - (ii) notifies the ventilation officer.

178 Failure of ventilation system

In the event of a failure of the ventilation system to a part or the whole of an underground coal mining operation, the mine operator must ensure that—

- (a) the supply of electricity to the underground parts of the mining operation, but not the supply to safety-critical equipment, is isolated as soon as is reasonably practicable; and
- (b) every battery-operated mobile plant located in the affected parts of the mining operation is brought out without any delay to—
 - (i) a main intake airway or main intake airways; or
 - (ii) a charging or repair station of suitable fireproof construction that is normally ventilated with intake air; and
- (c) the supply of electricity is not restored until after the ventilation system has been safely restored and a competent person considers it is safe to restore the supply of electricity.

6.4 Stoppage of fans

6.4.1 Planned stoppage

The mine worker responsible for fan operation should ensure that:

- (a) The main fan is not stopped for inspection, maintenance or other planned reason without written authorisation from the mine or tunnel manager.
- (b) A SOP is in place to cover planned fan stoppages or changeovers.
- (c) Underground booster fans are stopped prior to any planned stoppage of the main fan. The supervisor's responsible for the affected area, or the most senior person at the mine at the time of the stoppage, should be notified in advance of the stoppage taking place and of its duration.

6.4.2 Unplanned stoppage

In the event of an unplanned main fan stoppage due to power failure, mechanical damage, or other reason, the mine worker responsible for fan operation should ensure that:

- (a) The most senior person at the mine at the time of the stoppage is notified immediately. If the unplanned stoppage is of a serious nature or longer than 30 minutes, then the mine or tunnel manager is to be informed.
- (b) Following an unplanned stoppage of the primary fan, the most senior person should consider parking up all heavy plant and stopping all activities that may be adversely affecting the air quality of the mine or tunnel. Consideration should also be given to whether underground booster fans should be stopped.
- (c) If the fan cannot be restarted within 30 minutes, then the most senior person should consider withdrawing from the mine or tunnel via a safe egress all mine workers who are not involved in responding to the primary fan failure.
- (d) Consideration is given to the opening of surface airlock doors during prolonged stoppages.

6.5 Ventilation system failure

This section contains general information about procedures to be followed in the event of failure of the main ventilation system and, when necessary, the safe withdrawal of mine workers from underground parts of the operation.

For more detailed information about mine evacuation, mine rescue and emergency procedures, see the Approved Code of Practice on Emergency Management.

6.5.1 Evacuation of the mine

- (a) Details of emergency planning should be provided in the mine's emergency plan.
- (b) The ventilation system design should be based on the safe evacuation of mine workers.
- (c) Mine evacuation planning should take into account environmental conditions underground with ventilations systems running and when these systems have been reduced, lost or shut down.
- (d) To assist in evacuation management, a time-delay plan should be constructed showing the rates at which contamination would spread throughout the mine ventilation circuit.
- (e) As a reference point, a fire event at the entrance of the main intake should be used.
- (f) Evacuation to a refuge chamber may be an appropriate course of action to take in certain circumstances.

For more information on refuge chambers, see the Approved Codes of Practice on Emergency Management and Fire or Explosion.

- (g) The main ventilation system should not be restored until a full risk assessment has been carried out and a mine worker of authority confirmed it is safe to do so.

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145 Auxiliary fans

The mine operator must ensure that—

- (a) *no auxiliary fan is installed or used unless the quantity of air reaching it is, at all times, sufficient to ensure that air is not recirculated by the fan; and*
- (b) *every forcing auxiliary fan is installed at least 5 metres from the intake side of the place to be ventilated by the fan; and*
- (c) *every exhaust auxiliary fan is installed at least 5 metres from the return side of the place to be ventilated by the fan; and*
- (d) *when forcing and exhaust auxiliary fans are used in an overlap system to simultaneously ventilate the same face,—*
 - (i) *the secondary fan is installed more than 15 metres from the face; and*
 - (ii) *the installed capacity of the secondary fan is less than the installed capacity of the primary fan; and*
- (e) *there is installed and maintained with every auxiliary fan an air duct for conducting a sufficient supply of air to and from the face or place to be ventilated; and*
- (f) *every auxiliary fan, whether powered by electricity or otherwise, is constructed in such a way as to prevent the possibility of an accumulation of an electrostatic charge; and*
- (g) *if an auxiliary fan is installed in a place, no mine worker enters or remains in that place while the fan is not operating, unless a competent person has inspected the place and found it to be safe.*

ACOP

6.6 Auxiliary fans

The mine or tunnel manager should ensure that:

- (a) When selecting fans, the following factors are considered:
 - (i) Duct size, length and type.
 - (ii) Fan duty.
 - (iii) Fan curves.
 - (iv) Fan location (to prevent recirculation and damage from equipment).
 - (v) Availability of sufficient power to start and run the fan.

- (vi) Noise generation (which may require the use of structural attenuation silencers bolted onto the fan, or a slower speed fan).
- (b) Where a forcing only or exhausting only auxiliary fan is used, ducting is installed and advanced to within 5m of the working face.
- (c) During planning, the area around the junction is designed around the ventilation system, with adequate clearances provided for, so that there is plenty of scope to install the correct sized ducting.
- (d) Where there is a conveyor drive in the heading, the ducting around the drive is fire resistant for 10m on the upstream side and 25m on the downstream side of the drive.
- (e) The installation of an auxiliary fan is carried out with the authority of the mine or tunnel manager by an engineer (specialising in ventilation), and in line with the SOP.
- (f) An auxiliary fan used to ventilate a heading, drift or blind end, is:
 - (i) Sited a minimum of 5m from the place to be ventilated (the point of reference is the beginning of the fan blade) in the fresh air supply.
 - (ii) Sited out of the way of traffic.
 - (iii) Earthed.
 - (iv) Silenced, either with silencing that is part of the fan design, or installed as a separate device.
 - (v) The air quantity in the roadway at the fan site should be at least 1.3 times (30%) greater than the open circuit capacity of the fan to prevent recirculation.

For example, if a fan on an open duct is capable of running at 10 m³/s, then the air quantity should be greater than 13.0 m³/s.
 - (vi) The fan is checked and inspected by an authorised mine worker at regular intervals, and maintained in accordance with the relevant SOP.
 - (vii) The fan monitoring includes:
 - a. Temperature
 - b. Vibration
 - c. CO and/or smoke

A Supervisory Control and Data Acquisition (SCADA) monitoring system will assist with the detection of early signs of deterioration.
 - (viii) The auxiliary ventilation system has a system to be able to carry out a degassing of the drivage, without exposing operators to any risk (a degassing device).

- (ix) All machines and electrical equipment working in the development heading supplied by the air from an auxiliary fan are interlocked to the auxiliary fan electrical supply, so that if the fan is stopped, all electrical apparatus in the heading is also stopped.
- (x) The auxiliary fan should switch off automatically in the event that the main ventilation system fails.

6.6.1 Stopping and starting of the auxiliary fan

- (a) Only a mine worker authorised by the mine manager should stop or start an auxiliary fan.
- (b) Before any fan is stopped or started, the mine worker referred to in (a) above should inform all mine workers likely to be affected by the change to the auxiliary fan.

6.7 Compressed air operated auxiliary fans and venturi devices in coal mines

- (a) All compressed air operating fans and venturi devices should be interlocked to the compressed air system, so that if the compressed air is lost to that section of the mine, the fan will be stopped.
- (b) Compressed air operated fans should be de-energised if the main ventilation system fails, even if the compressed air system remains operational.
- (c) The fan should remain isolated, even if the main ventilation system or compressed air is restored to that area, until an inspection of the district has been carried out, and it is deemed to be safe to be restarted.

In some situations it has been known for a compressed air fan to restart when compressed air is restored elsewhere, resulting in degassing of the heading without any control mechanism in place.

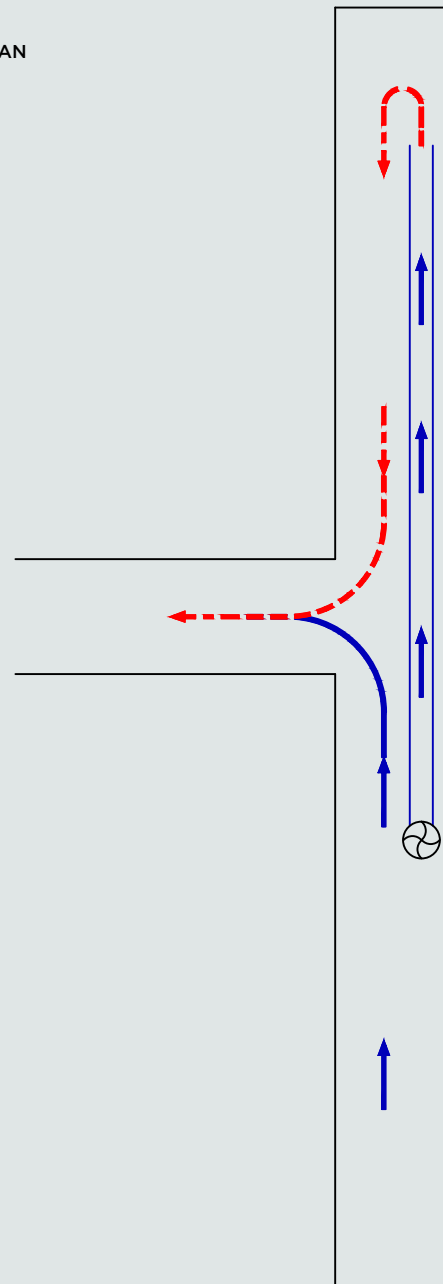
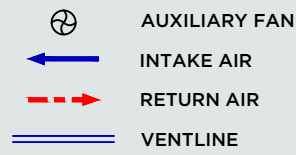
6.7.1 Auxiliary ventilation options

There are variations on the below themes but these are the main auxiliary ventilation options available.

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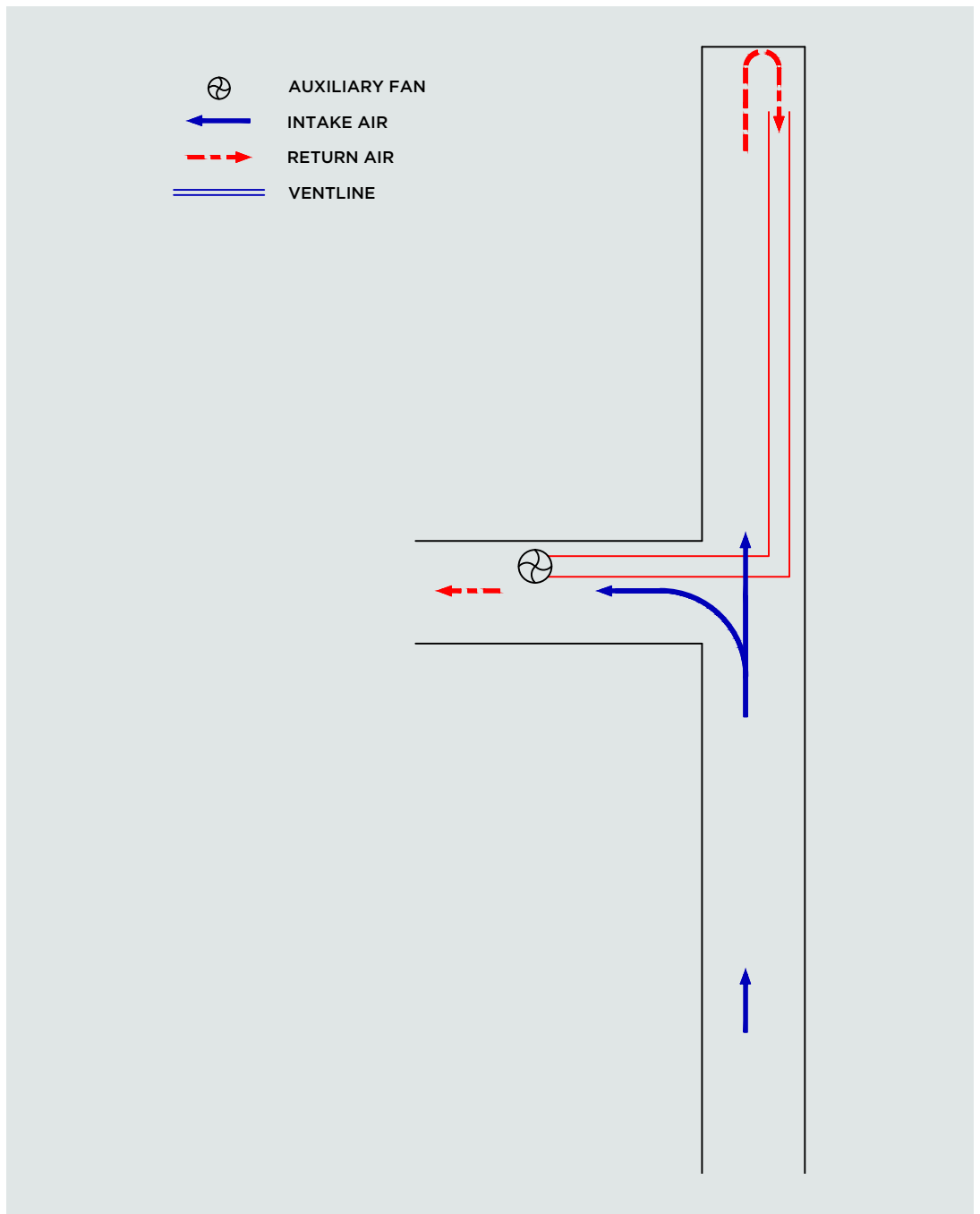
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- > Figure 7 shows a simple forcing system.
- > Ducting can be flat lay type, easy to transport and install.
- > The larger the ducting, the less resistance and more air quantity carried inbye (inbye end of duct to be within 5 metres of head end).
- > However, the greater the quantity, the greater the forward velocity, and the greater the potential dust problem.
- > A diffuser needs to be fitted to control the forward velocity.
- > Good for dealing with hot climates and gassy conditions.
- > Most useful in shot firing operations.
- > Less useful in machine cut operations to control dust.

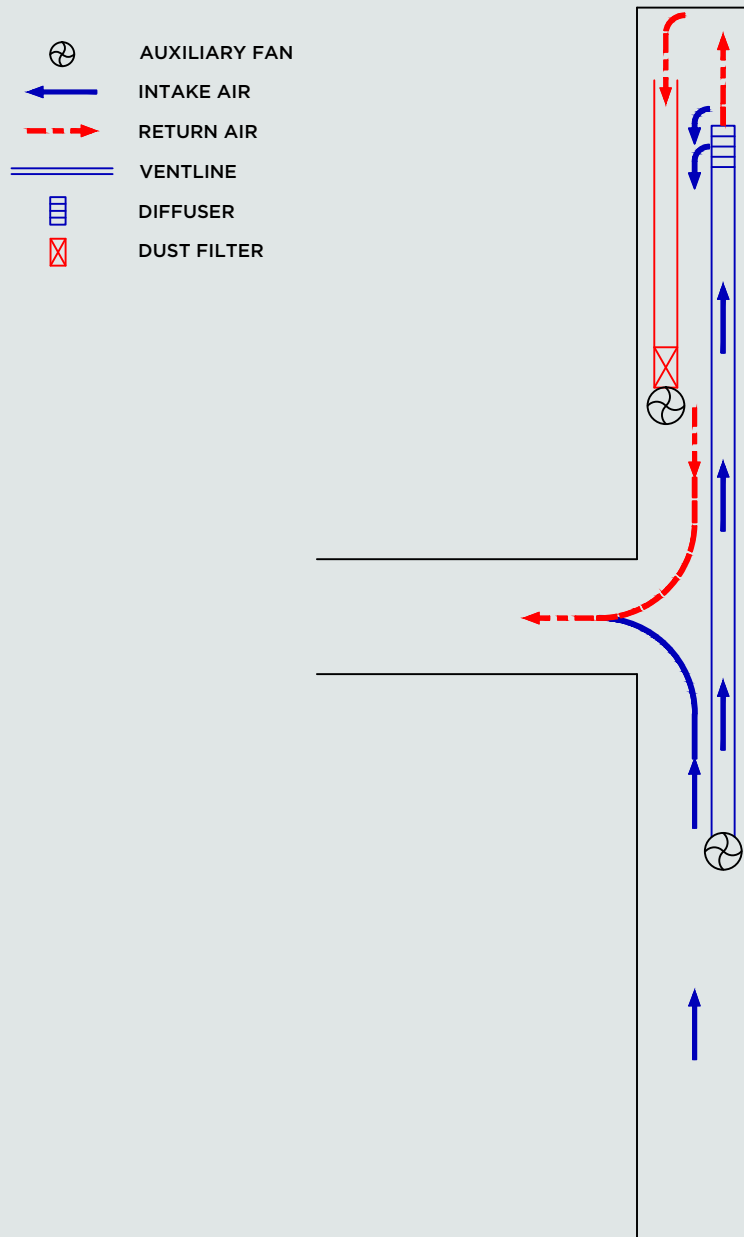
Figure 7 - Forcing auxiliary ventilation

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- > Figure 8 shows a simple exhausting system.
- > Ducting has to be reinforced because fan creates a negative pressure.
- > Exhaust duct must be as close as possible to the head end to ensure that the ventilation reaches the head end and pulls the dust into the ventilation ducting.
- > Good for dust control.
- > Useful in machine cut operations to control dust.
- > Not suitable in long, rising, gassy headings.

Figure 8 - Exhausting auxiliary ventilation



- > Figure 9 shows a forcing ventilation with an exhaust overlap and dust filter sited in the heading.
- > Gives gas control and dust control.
- > Beneficial in machine cut headings in excess of 500m.

Figure 9 - Forcing auxiliary ventilation with an exhaust overlap

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141 Air quality and temperature

The mine operator must ensure, in relation to the underground mining operation or tunnelling operation, that—

- (d) there is no recirculation of air within a working face other than through a scrubber fan.

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144 Ventilation fans other than auxiliary fans

The mine operator must ensure that—

- (g) any scrubber fan used at the mining operation is located and operated in a way that prevents the uncontrolled recirculation of air through the fan.

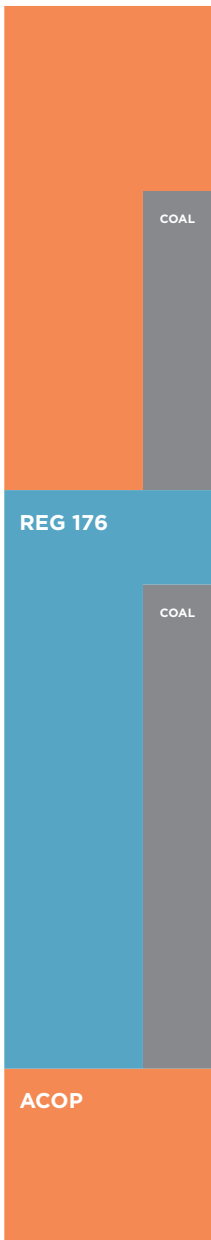
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6.8 Scrubber fans

- (a) Where scrubber fans are used, the mine or tunnel manager should ensure that they are:
 - (i) Sited in roadways to reduce and remove large amounts of inhalable dust in those airways. They should not be part of the auxiliary ventilation system, and the duct should be a maximum length of 2m.
 - (ii) Fitted with a means to regulate the flow of air passing through them.
 - (iii) Attenuated to reduce noise levels.
 - (iv) Fitted with a magnehelic gauge, which records the pressure across the filtration element. The gauge should be colour-coded to inform mine officials of when the element requires cleaning or changing (eg green = good, red = change).
- (b) If a scrubber fan is placed inside a heading or drivage, it should be interlocked to the main auxiliary fan so that if power is lost to the auxiliary fan, the scrubber fan is de-energised.
- (c) To prevent uncontrolled recirculation when using an onboard scrubber fitted to a continuous miner, Regulations 141 (d) and 144 (g) require that the ventilation duct should be maintained ahead of the scrubber fan. This may be achieved by fitting a 'trombone' device to the ventilation duct.
- (d) Specific operating rules should be in place for each scrubber fan application.

6.9 Diesel vehicles in headings

- (a) When a stoppage of auxiliary ventilation is planned, all diesel or electric equipment should be removed from the heading and should not re-enter until ventilation has been restored and a mine official has deemed it safe for the equipment to re-enter.



- (b) When an unscheduled stoppage of auxiliary ventilation occurs, where it is safe to do so, diesel equipment should be removed the heading, or isolated, until ventilation is restored and a mine official has deemed it is safe to restart the equipment.
- (c) If the level of methane in the general body of air reaches or exceeds 1.25%, all diesel equipment should be stopped immediately, and should not be restarted until a mine official has deemed it safe to do so.
- (d) All drivers of such vehicles should carry an automatic methane detector.
- (e) If the general body of the air in the heading contains more than 5ppm of nitrous fumes then this category of equipment should not be used in the heading.

176 Continued monitoring of atmospheric conditions underground during emergency

- (1) *The mine operator of an underground coal mining operation must ensure that a system is provided that monitors the atmospheric conditions in the underground parts of the mining operation during an emergency and provides information about those conditions to people on the surface.*
- (2) *The mine operator must ensure that—*
 - (a) *the system incorporates an adequate backup power supply; and*
 - (b) *the components for the system that are installed underground are recognised as being safe to operate in an explosive atmosphere, unless the components are installed in a drift or shaft being driven from the surface in material other than coal.*

6.10 Continuous monitoring during an emergency

For more detailed information on continuous monitoring during an emergency, see the Approved Code of Practice on Emergency Management.

07/

VENTILATION CONTROL DEVICES (VCDS)

IMPLEMENTING AND MAINTAINING
CONTROLS TO MANAGE RISK

- 7.1** Types of VCDs
 - 7.2** Design and construction of VCDs
 - 7.3** Permanent and temporary stoppings
 - 7.4** Doors
 - 7.5** Regulators
 - 7.6** Overcasts and underpasses
 - 7.7** Air crossings
 - 7.8** Line Brattice (for blind headings)
 - 7.9** Sealing parts of the mine (otherwise than in emergency situations)
 - 7.10** Commissioning of VCDs
 - 7.11** Goaf management
-

182 Ventilation control devices

The mine operator must ensure that all ventilation control devices, including seals, are designed, constructed, and maintained to meet the design criteria specified in Schedule 5.

Schedule 5

Ventilation control devices and design criteria

Ventilation control device	Design criteria
Ventilation ducting	Anti-static and fire-resistant
Brattice line or temporary stopping	Anti-static and fire-resistant
Separation stopping for a primary escapeway	Anti-static, fire-resistant and of substantial construction that will ensure minimal leakage
Stoppings, doors, overcast, or regulator installed as part of the main ventilation system	Capable of withstanding an overpressure of 35 kPa
Stoppings, doors, overcast, or regulator installed as part of the ventilation system for a panel	Capable of withstanding an overpressure of 14 kPa
Mine entry airlock	Capable of withstanding an overpressure of 70 kPa whilst it is open
Type B seal	Capable of withstanding an overpressure of 35 kPa
Type C seal	Capable of withstanding an overpressure of 140 kPa
Type D seal	Capable of withstanding an overpressure of 345 kPa
Type E seal	Capable of withstanding an overpressure of 70 kPa

7.1 Types of VCDs²⁴

Ventilation Control Devices (VCDs) are structures or equipment that control the direction and quantity of airflow around the mine or tunnel. Types of VCDs include:

- Doors**, which allow mine workers or vehicles to travel between an intake and return airway.
- Stoppings²⁵** or air doors, which separate the intake and return air streams in adjacent airways.
- Regulators²⁶**, which control the flow of air through various airways when the quantity has to be split between the airways.
- Seals²⁷** (coal mines) or ventilation bulkheads (metal mines), which provide an engineered, permanent barrier.
- Overcasts and underpasses²⁸**, which are an enclosed airway that allows one air current to pass over (or under) another without interruption or mixing, and maintaining the cross-sectional area similar to the roadway. Overcasts and underpasses can be natural or fabricated.

²⁴ Safe Work Australia. (2011). [Draft] Code of Practice - Ventilation of Underground Mines. Canberra, Australia. 24.

²⁵ See Definitions.

²⁶ See Definitions.

²⁷ See Definitions.

²⁸ See Definitions.

- (f) **Air crossings**, which are an enclosed airway that allows one air current to cross over another without interruption. These are always constructed and because of their reduced cross-sectional area, have a higher velocity of air stream flowing through them.
- (g) **Ducts or line brattice**, which allow a single roadway to be divided so that fresh air can be brought to the face.
- (h) **Coffin seals**,²⁹ which allow a conveyor belt to pass from an intake to a return airway.
- (i) **Air locks** for use in hyperbaric tunnels.

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7.2 Design and construction of VCDs

- (a) VCDs, including natural and fabricated air crossings, should be constructed so that they operate safely, and leakage is eliminated or minimised.
- (b) VCDs should be engineered and designed to meet the required ratings standards outlined in Schedule 5 of the Regulations – Ventilation control devices and design criteria.
- (c) Factors that should be considered when designing VCDs include:
 - (i) Fire resistance.
 - (ii) Anti-static properties.
 - (iii) Potential over pressure occurrences (eg falls in goafs).
 - (iv) Leakage.
 - (v) Required duty.
 - (vi) Ventilation pressure.
 - (vii) Accumulations of water.
 - (viii) Likely ground conditions/movement.
 - (ix) Likelihood of an explosion.
 - (x) Whether it is temporary or permanent.

140 Separation of airways

- (1) *If the mining operation has more than 1 main airway, the mine operator must ensure that the airways are separated sufficiently to ensure—*
 - (a) *stability; and*
 - (b) *ventilation to the standards required by Regulation 141(a) and (b).*

²⁹ See Definitions.

- (2) *The mine operator must ensure that no more than 2 temporary stoppings are installed in a line of stoppings that separate an intake airway from a return airway immediately adjacent to the last line of cut-throughs in the panel.*

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7.3 Permanent and temporary stoppings

- (a) Permanent stoppings, or stoppings with air doors, should be installed between all main intake and return roadways.
- (b) A maximum of two temporary stoppings may be erected between the main intake and return airways in a line of cross cuts developed from the working face, and outbye with permanent stoppings installed as soon as possible.

7.4 Doors

All doors installed underground should be:

- (a) Clearly marked with signage indicating whether they are to remain in an open, or closed, position.
- (b) Easily opened, or closed, by one mine worker.
- (i) Any mine worker using a door should ensure that it is closed firmly as soon as practicable after passing through it.
- (ii) No vehicle should be used to push a door open or shut.
- (c) Self-closing, and secured in an open position when not normally kept closed.
- (d) Installed as two sets of doors to provide an airlock where:
- (i) Short circuiting may lead to a hazard.
- (ii) A high pressure exists across the doors, and opening or closing the doors may lead to a hazard.
- (e) All doors located between main intakes and returns should be of permanent construction and fire-resistant.
- (f) All doors that contain a regulator should have a provision to lock the regulator.
- (g) Where a risk assessment identifies the potential for doors to be blown open during shotfiring, a simple latching system should be installed that can be operated from either side of the door.

7.4.1 Air doors

- (a) There should be a mine plan that shows where air doors are to be installed. When developing the plan, consideration should be given to air door design, and the purpose of the roadway where the air doors are to be installed (eg pedestrians, conveyors, transport vehicles, or a combination of all three).



- (b) The air door design should consider:
 - (i) The segregation of pedestrians from the transportation of materials.
 - (ii) The size and dimension of the doors, and whether the doors need to include ventilation tubing for future Regulation of flow around the district.
 - (iii) Whether coffin seals, or mousetraps, are required to allow for a conveyor to run through the doors and control leakage.
 - (iv) Whether the doors are to be automatically opened, and if so, electrically or mechanically.
 - (v) The roadway dimensions allow for the doors at the required spacing.
 - (vi) There are no geological features (eg faults or intrusions) where the doors are to be installed. If there are faults or intrusions, special precautions to reduce leakage and to prevent a spontaneous combustion from developing should be considered.

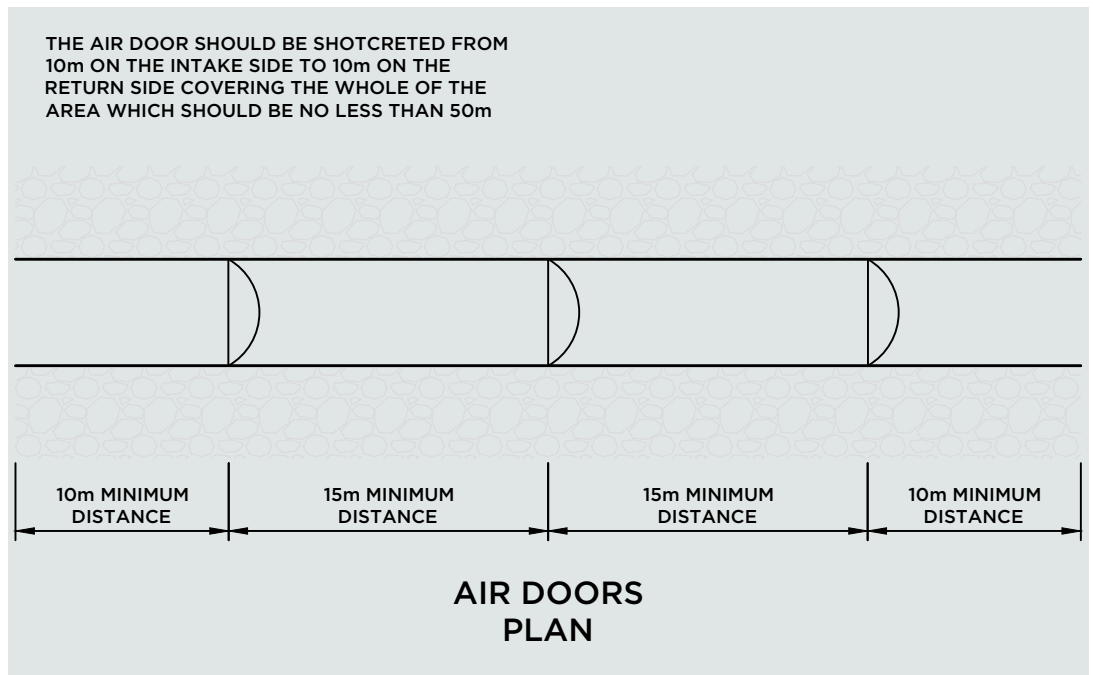


Figure 10 – Sample plan of air doors built within a coal seam

THE AIR DOOR SITES SHOULD BE PRESSURE GROUTED AROUND THE PERIPHERY TO A STANDARD OF NO LESS THAN 6m DEPTH & 4m OF PIPE (RATIO OF 3:2). 7 HOLES TO BE DRILLED AS PER DIAGRAM.

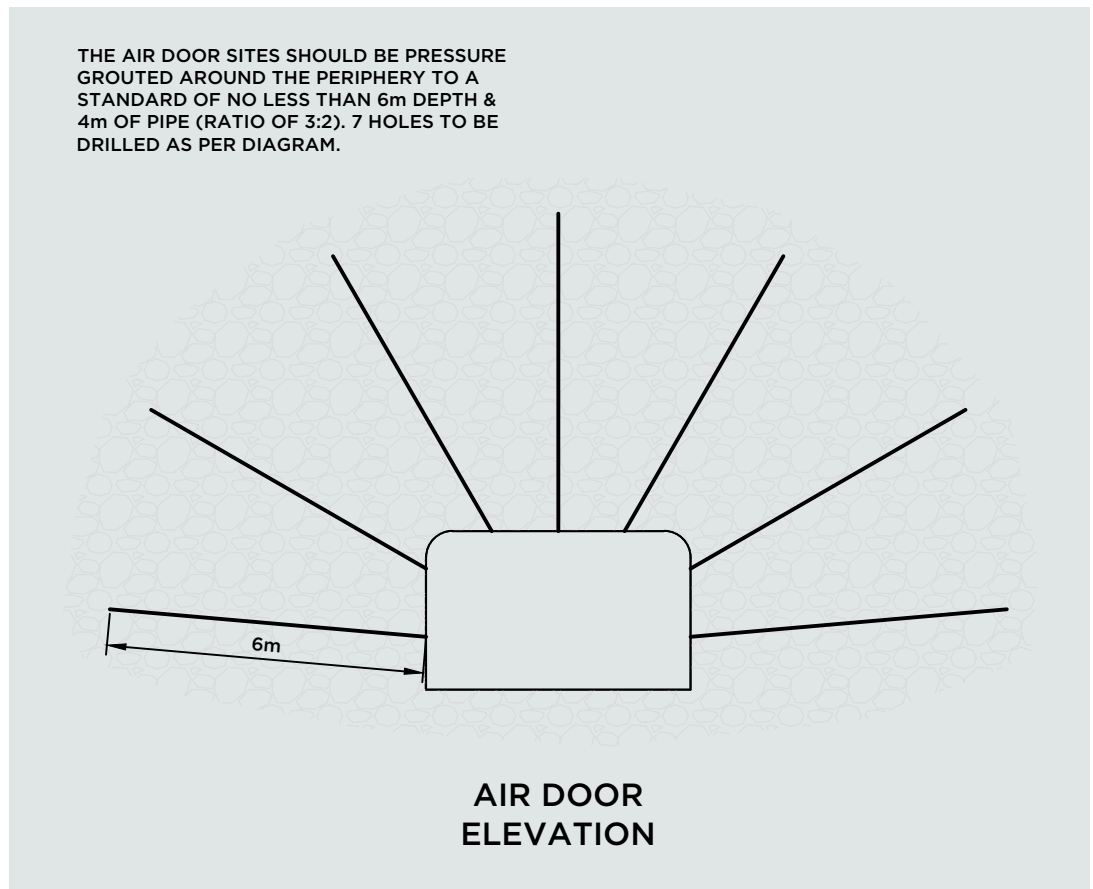


Figure 11 - Sample of grouting pattern around the periphery of a door

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7.4.2 Mobile equipment access doors

- (a) All mobile equipment access doors should be highlighted with reflector tape or paint.
- (b) Where practicable, mobile equipment access doors should have a separate door for personnel access installed.
- (c) The minimum spacing between mobile equipment access doors should be at least the length required to allow the longest vehicle in the mine or tunnel (with a trailer attached) to travel through without the need to open both doors at the same time.

7.5 Regulators

All regulators installed underground should be:

- (a) Installed according to the ventilation plan for the mine or tunnel, to direct/control ventilating air and velocity to the district.
- (b) Constructed so that the regulator frames meet design specifications required for their purpose.

- (c) Secured in position by a lock, and only altered by a ventilation officer, mine or tunnel manager, or mine worker authorised to do so.
- (d) All regulators should be clearly marked with signage indicating:
 - (i) Keep locked in position.
 - (ii) Only authorised mine workers are to adjust.
- (e) Any adjustments to regulators, including their impact on ventilation survey results, should be recorded by the ventilation officer.

7.6 Overcasts and underpasses

An engineer (specialising in ventilation) should ensure that:

- (a) Overcasts and underpasses are designed and constructed so that air leakage is eliminated.
- (b) There is a plan showing where overcasts and underpasses are to be located.
- (c) Overcasts and underpasses are not to be constructed with only coal separating the intake and return airways.
- (d) Where an overcast or underpass is constructed within the coal seam, the structure is built of non-flammable, fire-resistant and anti-static materials.
- (e) The tunnel sides, roof and floor is meshed and liberally injected with shotcrete or a similar sealant, to prevent leakage between intakes and return airways.
- (f) The installation site is continuously inspected by a competent mine worker before, during and after construction, to ensure compliance with the design requirements.

7.7 Air crossings

7.7.1 Design of air crossings

An engineer (specialising in ventilation) should ensure that the following requirements are considered during the design of the air crossing:

- (a) The type of surrounding rock, the presence of coal, and the likelihood of a spontaneous combustion event.
- (b) Where an air crossing is to be constructed within the coal seam, the structure should be built of non-flammable, fire resistant and anti-static materials.
- (c) The presence of water.
- (d) The need for service ducts for cables and pipes, or mineral loading chutes through the air crossing and their sealing to prevent leakage.
- (e) The need for materials access through the air crossing and the need to minimise air leakage.

7.7.2 Construction of air crossings

The mine operator should ensure that:

- (a) Air crossings are constructed to design specifications, which are certified as meeting the required rating.
- (b) The construction of the air crossings should be supervised by a competent mine worker.
- (c) Upon completion, the structure should be certified as meeting the required design ratings standard.

7.7.3 Removal of air crossings

- (a) When an air crossing is no longer required, it should be breached so as to minimise the pressure difference across it.
- (b) Once the air crossing has been decommissioned, it should be recorded and all relevant plans immediately updated (ie within 24 hours).

7.7.4 Examination of overcasts, underpasses and air crossings

- (a) Every 3 months, each overcast, underpass and air crossing should be examined by the ventilation officer who will submit a written report to the mine or tunnel manager.
- (b) The report should include details of the physical condition of the overcast, underpass and air crossing, and any associated doors and service ducts and ventilation measurements of air leakage.

7.8 Line Brattice (for blind headings)

- (a) Brattice leads should be constructed to prevent recirculation and deliver air to within 5m of the face.
- (b) They should be constructed from suitable lengths of brattice cloth, stretched along the length of the blind heading or road leading to a stopping or barrier, and held up either by props or tied to roof bolts or both.
- (c) The ventilation officer should ensure that the design of the brattice corridor is such that it delivers turbulent air at the working face to prevent gas layering.

183 Standards for sealing

The mine operator must ensure that a seal installed at the mining operation is of the following types or higher:

- (a) *if the level of naturally occurring methane at the mine is insufficient to reach the lower explosive limit for the gas under any circumstances, type B:*

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- (b) *if a mine worker or mine workers may remain underground when an explosive atmosphere exists and there is a possibility of spontaneous combustion, spark, or another ignition source, type D:*
- (c) *in any other situation relating to an underground part of the mining operation, type C:*
- (d) *for sealing the entrance to the underground parts of the mining operation, type E.*

185 Notice of intention to seal underground coal mining operation

- (1) *The mine operator must give notice to WorkSafe of any intention to seal the whole of the underground parts of the mining operation.*
- (2) *Except in case of emergency sealing, the notice must be given, 1 month in advance of the activity taking place.*
- (3) *The notice must include—*
 - (a) *the proposed locations of the seals to be installed; and*
 - (b) *the proposed sealing procedure; and*
 - (c) *a summary of hazards identified and how they will be managed; and*
 - (d) *any evidence of the presence of an ignition source in a part or the whole of the underground parts of the mining operation; and*
 - (e) *predictions of the rates at which methane and other gases will accumulate in the underground parts of the mining operation; and*
 - (f) *the gas monitoring procedures to be carried out during and after the sealing.*
- (4) *If sealing becomes impracticable in the way in which the procedure was described in the notice provided to WorkSafe, the mine operator must—*
 - (a) *promptly notify WorkSafe of the changes from the initial proposed method of sealing the underground coal mining operation; and*
 - (b) *if the notification under paragraph (a) is not in writing, confirm the notification in writing to WorkSafe as soon as reasonably practicable.*

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186 Sealing not to be done unless notified

- (1) *Except as provided in Regulation 187, the mine operator must ensure that the whole of the underground parts of a mining operation is not sealed unless WorkSafe has been notified of the intention to seal the mining operation as required by Regulation 185.*
- (2) *The mine operator must ensure that the whole of the underground parts of the mining operation is sealed in the way that has been notified to WorkSafe.*



7.9 Sealing parts of the mine (other than in emergency situations)

The mine operator should ensure the following requirements are met during the design and construction of seals.

7.9.1 Design of seals

- (a) A plan of the area to be sealed off should be developed, showing the nature of the surrounding rock at the site, including any coal seams and faulting.
- (b) The seal design should consider the position, size, type and construction materials and the method of construction.
- (c) The location of the seal should consider the requirement for balance chambers.

7.9.2 Construction of seals

- (a) Air sample pipes and water drainage pipes should be provided.
- (b) The visible wall should be constructed within 4.9m of the outbye junction of the roadway and the sample pipes extended to the outbye side and a sampling point.
- (c) The walls should be securely keyed into the floor, roof and sides, as per the design specifications.
- (d) Where filler is required, this should be an approved[†] monolithic material (ie gypsum) that is pumped into the cavity between the walls.
- (e) Where re-entry is planned or simultaneous sealing is required, seals should be constructed with either ventilation ducting type access tubes which are pump-filled and re-excavated at the time of re-entry, or proprietary explosion-proof access tubes.
- (f) If the seal is not in solid ground, the surrounding rock should be injected after the seal has been constructed.
- (g) Minimising the pressure difference between intake and return seals should be considered and pressure balancing applied where necessary.
- (h) Where possible, a seal should not be constructed where there is coal in the floor or roof of the roadway. If this cannot be avoided, the area should be injected after the seal has been constructed.
- (i) Prior to the construction of a permanent seal, a stone dust bag barrier scheme should be erected on the inside of the seal to arrest an explosion before it reaches the seal.
- (j) The areas to be sealed off should be sealed simultaneously.

[†] 'Approved' means a material approved in writing by WorkSafe New Zealand.

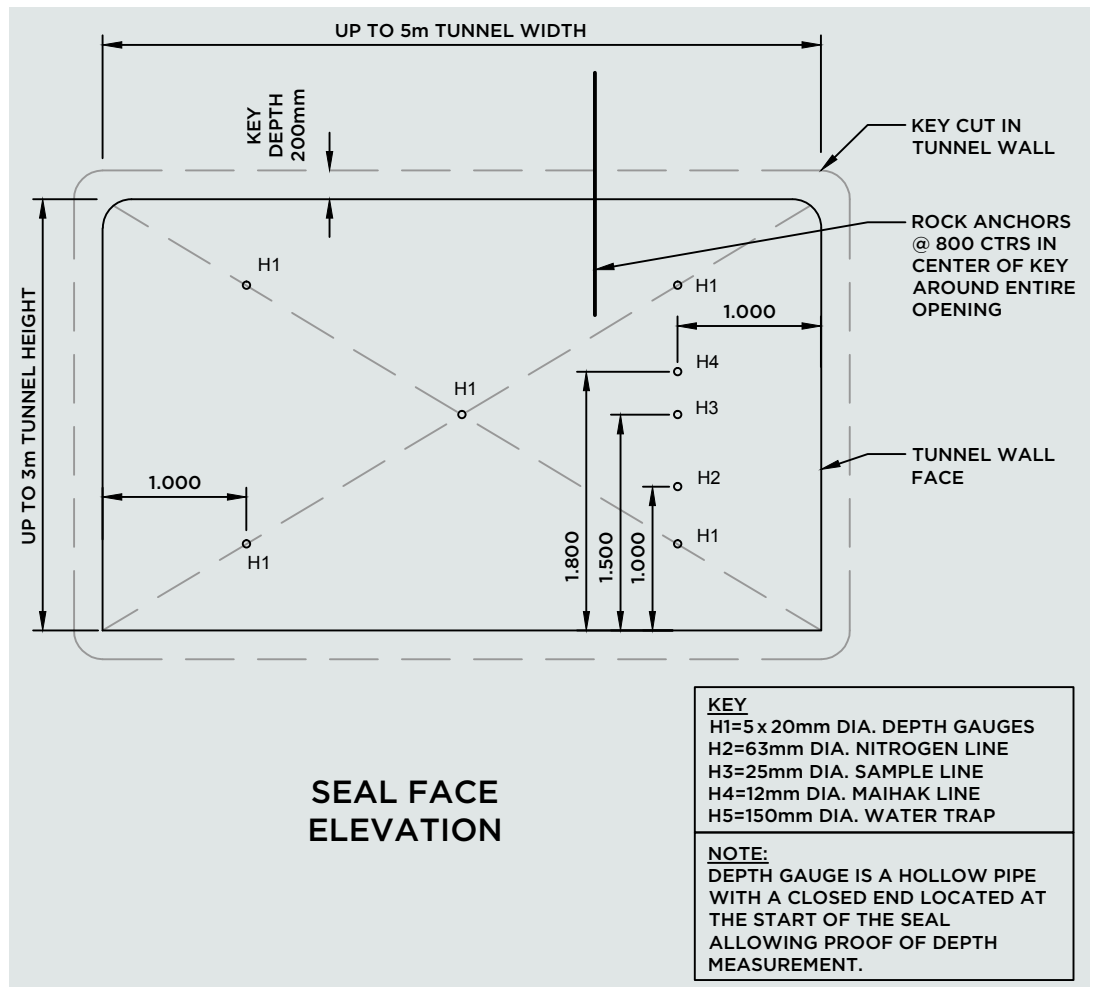


Figure 12 - Example of a Type C seal face

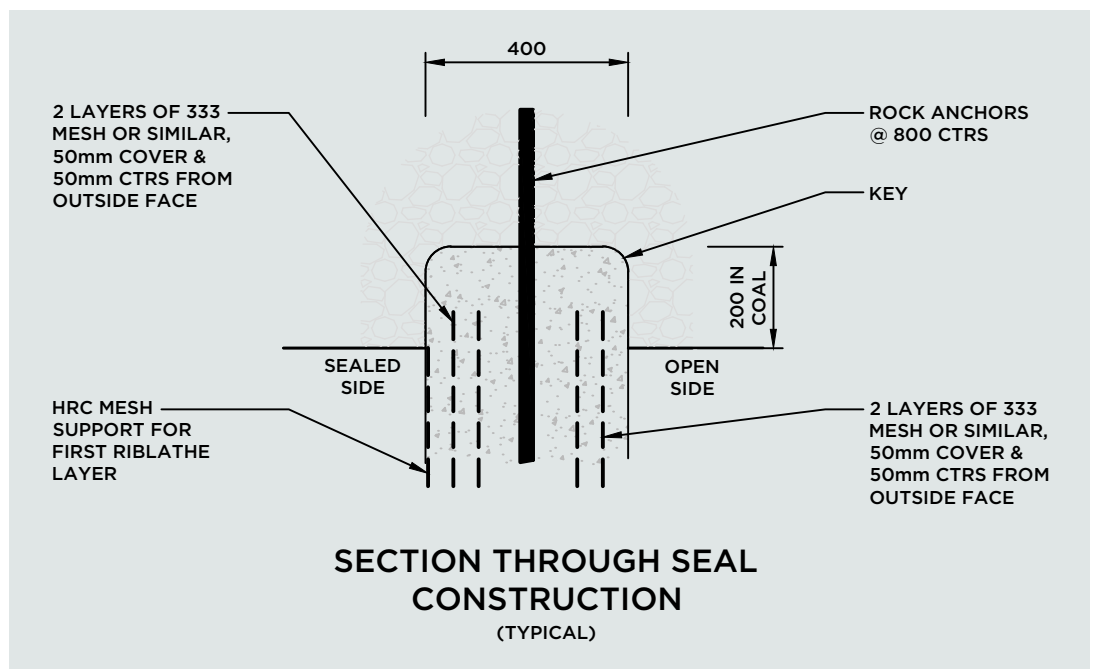


Figure 13 - Detail of typical section through a Type C seal

7.9.3 Fire plugs (temporary seal)

Where retreat mining (not longwall) with pillar extraction is practiced, and there is risk of spontaneous combustion following coal extraction, a fire plug (temporary seal) may be installed which, when Nitrogen is injected behind it, will provide an inert atmosphere. This will allow for the retreat mining process to recommence prior to the installation of a permanent seal.

- (a) The heading (or headings) should be sealed with a fire plug (temporary seal) immediately after the extraction of coal.
- (b) The design and construction of the fire plug (temporary seal) should meet the requirements outlined in points (a), (b) and (c) of 7.9.1 and 7.9.2 above.
 - (i) In a single entry heading, the fire plug (temporary seal) may be of single wall construction.
 - (ii) In intake and return roadways, fire plugs (temporary seals) should be of double wall construction, and Nitrogen should be injected between the two plugs.
- (c) Fire plugs (temporary seals) should be fitted with water traps and pipes that will allow Nitrogen to be injected and gas samples to be taken from behind the seal.
- (d) Fire plugs (temporary seals) should be daily examined until they are removed or replaced with an additional plug or a permanent seal.

For more detailed information on the management of spontaneous combustion, see the Approved Code of Practice on Spontaneous Combustion.

7.9.4 Explosion-proof sealing of a district

Significant changes will occur in the sealed area once the airflow has been terminated. The oxygen level will decrease, and the concentration of combustible gases will increase. At some point the atmosphere may pass through the explosive range and, if an ignition source is present, it may produce a series of small explosions.

- (a) Monitoring the atmosphere at the surface should allow for the identification of the conditions behind the seal.
- (b) Where there is a potential source of ignition identified such as spontaneous combustion, the mine should be isolated for at least 24 hours and conditions continuously monitored.
- (c) Type D seals should be no less than 5m long and filled with a constant pour of a cementitious material.



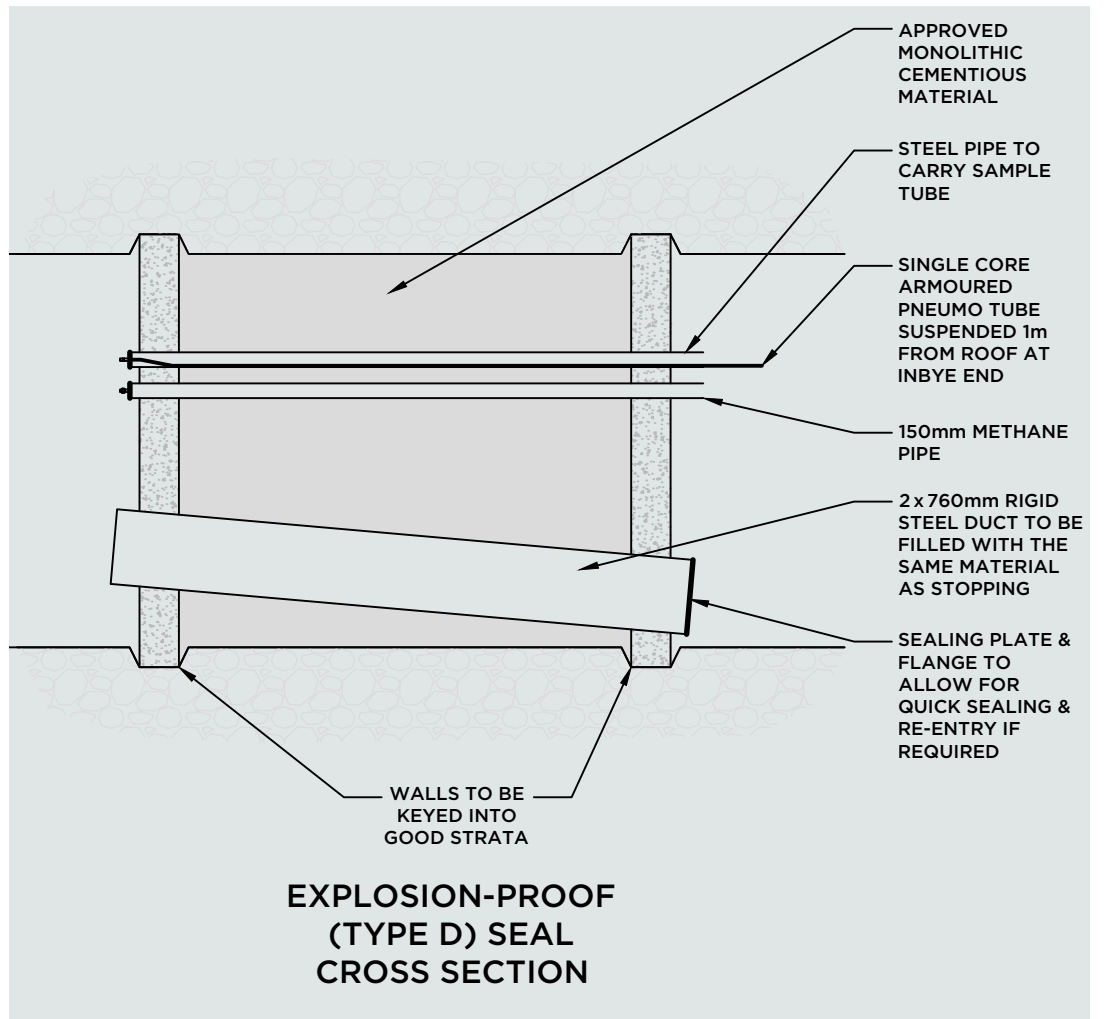


Figure 14 - Example of a Type D seal

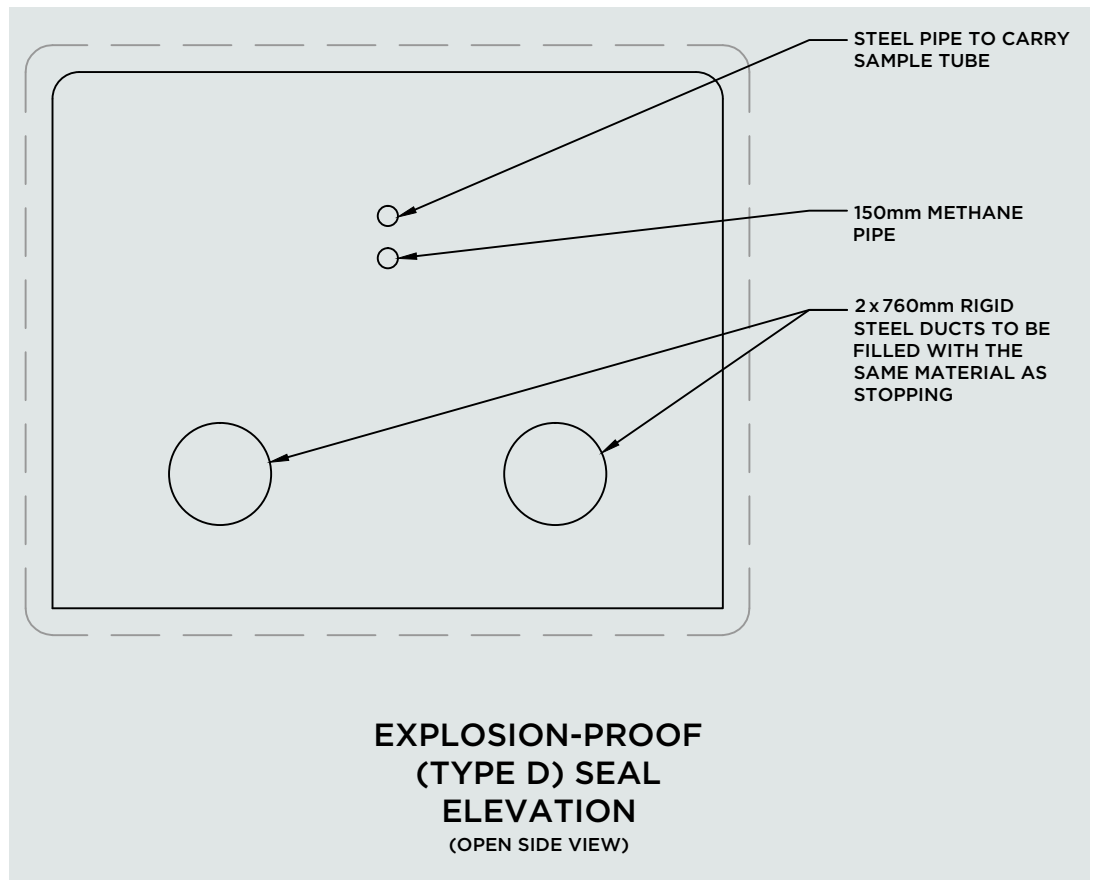


Figure 15 - General arrangement of a Type D seal face

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7.9.5 Pressure balance of seals

Seals are not leak-proof and over time will be subjected to different pressures and stresses. Leaks can supply oxygen into the heating area and prolong its life.

Seals can be balanced by re-arranging doors or regulators, or de-commissioning air crossings, to ensure that each part of the seal is subjected to the same pressure.

Alternatively, a pressure balance chamber may be created by building a wall 5m outbye of the existing seal. A duct/pipe connects the chambers, equalising the pressure, as there is no airflow or pressure differential across them.

Total inertisation of the waste area may be carried out using nitrogen or carbon dioxide or other inert gases. These can be placed behind the stopping using existing pipe ranges, or pipes that are laid in when the stopping is being prepared.

The amount of inert mixture to be supplied should be calculated by the ventilation officer.

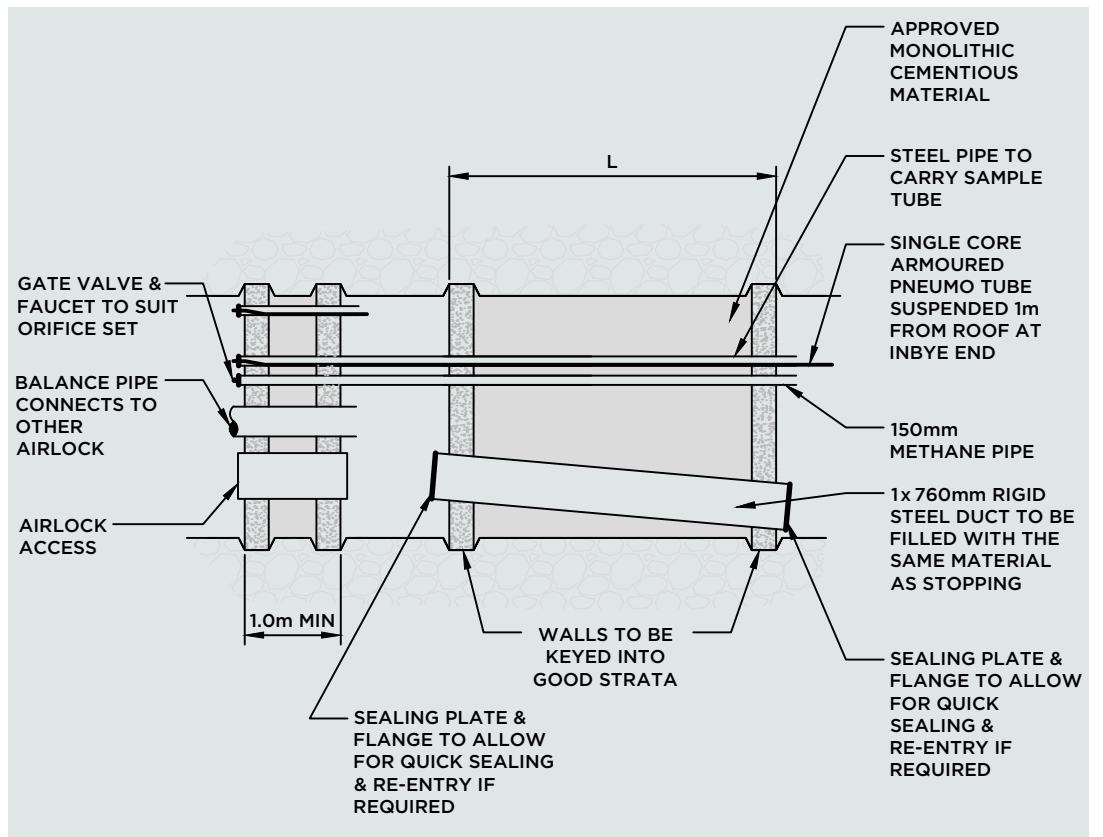


Figure 16 - Example of a Type D seal with pressure balance

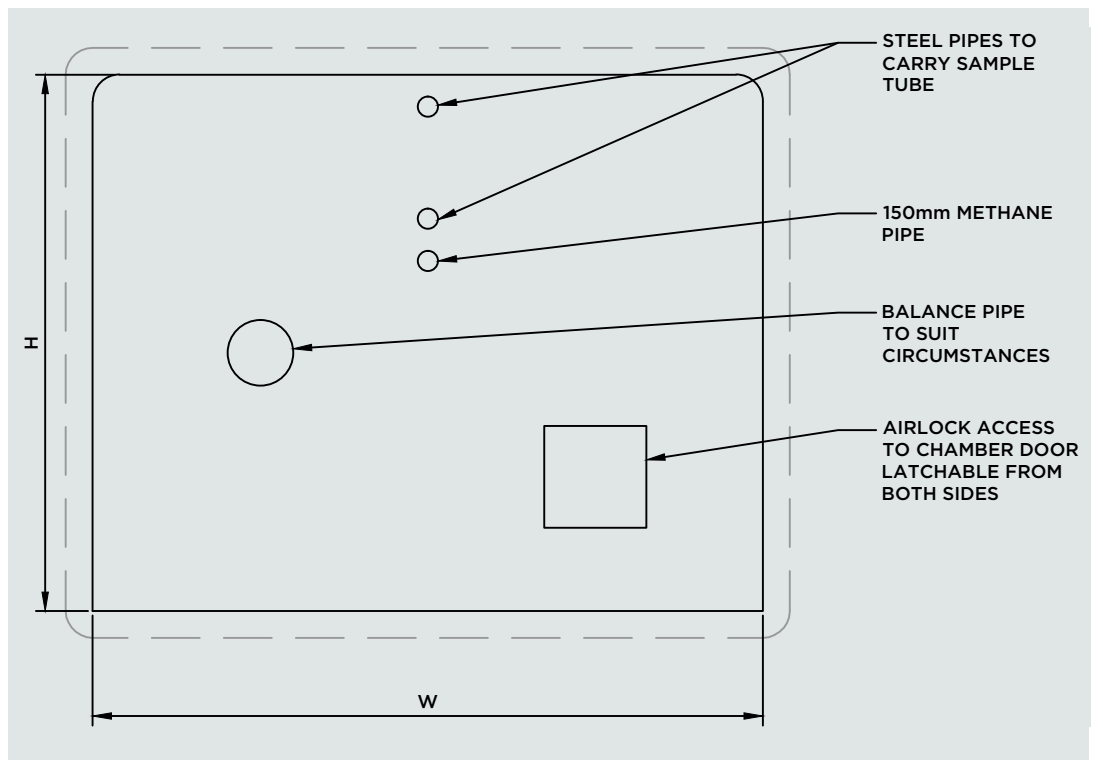


Figure 17 - General arrangement of a Type D seal face with pressure balance

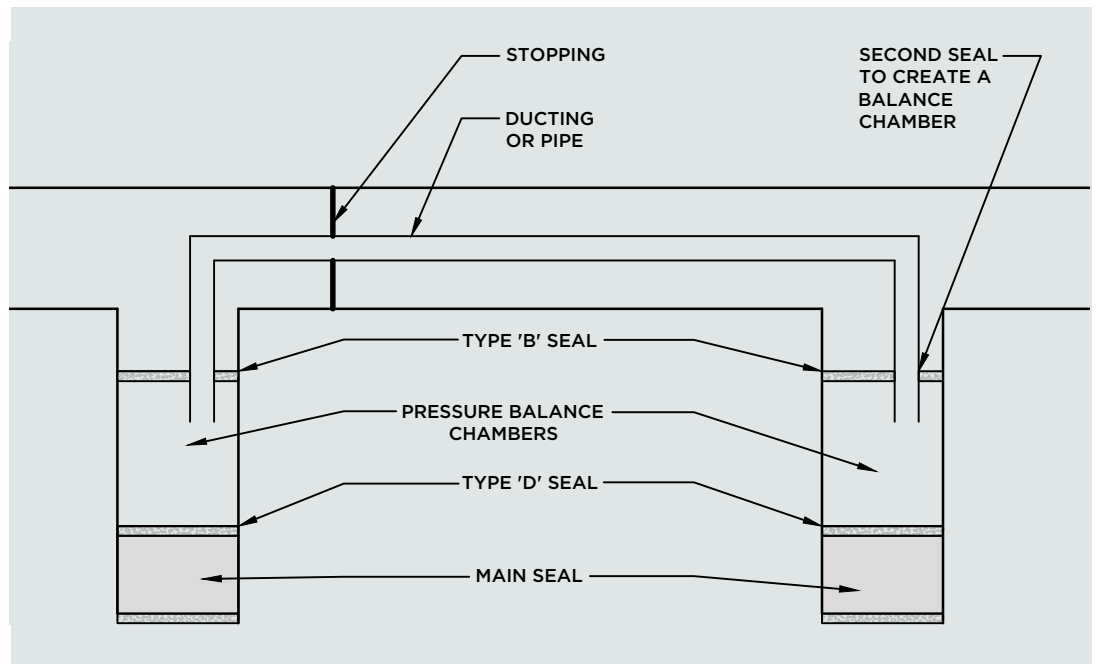


Figure 18 - Method of pressure balance for multiple seals of the same goaf area

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7.9.6 Sampling

- The mine manager should ensure that a monitoring scheme is in place for each newly constructed seal. Samples should be taken from behind, and in front of, each seal for no less than a two year period or until the face of the seal is no longer ventilated.
- After sealing, the ventilation officer should ensure the environment behind the seal is continuously monitored until such time that trends can be determined from the readings. The monitoring should include taking seal pressure readings.
- At the time the samples are taken, the facing wall should be checked for leakage using a smoke tube.
- Once trends for each seal have been determined, ongoing samples should be taken at periods of no more than one week apart to ensure there have been no significant changes.

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7.9.7 Ventilation changes on a balanced seal

- (a) If any major change is to be made to ventilation which will significantly affect the pressure on any seal, the ventilation officer should check for whether any additional pressure balances are necessary. Any pressure balances required should be constructed before the change is made to the ventilation.
- (b) Where no new pressure balance is introduced, the sampling programme required by section 7.9.6 above should be restarted as soon as the ventilation changes are made.
- (c) Where new pressure balances are introduced, the sampling programme required by section 7.9.6 above should be introduced.

7.10 Commissioning of VCDs

When commissioning VCDs, the mine manager should ensure that:

- (a) The doors are fitted, and sealed around the periphery.
- (b) The frames and retaining structure are securely keyed into roadway sides.
- (c) The doors have been tested by a smoke test to ensure no leakage.
- (d) The installation complies with the design document and any special precautions have been taken.
- (e) The restraining fittings are in place and secure.
- (f) Doors that are to be used as regulators are locked in the correct position.
- (g) Air quantity in the roadway has been measured and any leakage is within design.
- (h) The door pressure has been measured and recorded.
- (i) Correct signage is on the doors, the doors are numbered, and the size of each door is recorded so that in the case of damage occurring, a replacement door can be quickly installed.
- (j) The ventilation officer should update the relevant records with the new installation details.
- (k) The surveyor should update the relevant plans within 24 hours.
- (l) The ventilation officer should inform all shift supervisors that the new VCD has been installed and commissioned. This information should be cascaded down to ensure all mine workers are aware of the new VCD in operation.

180 Sealed goafs

If an underground coal mining operation has a sealed goaf, the mine operator must ensure that appropriate steps are taken to control any hazards that may be presented or caused by the emission of methane and noxious gases from the sealed goaf, including by—

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- (a) *preventing intake air from travelling across the face of a permanent seal at the mining operation; or*
- (b) *minimising the risks of inrush and leakage of atmospheric contaminants from sealed goaf areas and abandoned or sealed workings into intake airways, which must include—*
 - (i) *use of no less than a type C seal; and*
 - (ii) *minimising leakage through seals; and*
 - (iii) *preventing damage to seals and*
 - (iv) *installing a monitoring device in each intake airway on the return side of the seals over which the intake air passes to detect the intake airway's general body concentration of—*
 - (A) *oxygen; and*
 - (B) *carbon dioxide, if it is present behind the seal in a general body concentration greater than 3%; and*
 - (C) *any other gas that is present behind the seal in a quantity and concentration that is likely to create a hazard if it enters the intake airway adjacent to the seal and*
 - (v) *for longwall workings, installing a monitoring device at the intersection of the longwall face and the intake airway to detect the intake airway's general body concentration of—*
 - (A) *oxygen; and*
 - (B) *carbon dioxide, if it is present behind the seal in a general body concentration greater than 3%; and*
 - (C) *any other gas that is present behind the seal in a quantity and concentration that is likely to create a hazard if it enters the intake airway adjacent to the seal and*
 - (vi) *ensuring that every monitoring device installed as required by subparagraphs (iv) and (v) triggers an alarm to warn every mine worker who may be affected when a gas required to be detected by the device is present at the predetermined concentration.*

7.11 Goaf management

When developing procedures for the management of goafs or waste areas, the mine operator should ensure that the following requirements in relation to working, and inactive goafs, are met.

7.11.1 A working goaf

- (a) The goaf should be classified as ERZO.



- (b) Specific consideration should be given to any working panel using advancing methodologies, in order to minimise the effects of air penetrating the goaf.
- (c) 'Retreating' panels or faces should be used where possible.

7.11.2 A sealed goaf

- (a) When a goaf is worked out and mining in that district has ceased, or the hydro or longwall panel is complete, the goaf management plan, which forms part of the Ventilation Principal Control Plan, should be reviewed.
- (b) The mine manager should ensure that a plan of the area is available, that shows the nature of the surrounding rock within the goaf, and details of any previous ground falls. The plan should include the presence of remaining coal and/or seams and faulting, water make and impacts on the goaf of other working areas of the mine.
- (c) Monitoring devices (as detailed in Section 8 Monitoring) should be installed and automatically monitored.
- (d) As the sealing of the goaf may require multiple seals, ventilation should be considered during the construction of each seal, and construction should be in line with the requirements specified by an engineer (specialising in ventilation).
- (e) Signage that clearly marks the area as a goaf, and fences to prohibit entry into the area, should be erected immediately.
- (f) Methane drainage may be used to control gas behind the seals, and more detailed information on this is outlined in the Appendix.
- (g) Consideration should be given to the possibility of over-draining, which may increase leakage into the stopped off area, encouraging the potential for spontaneous combustion. The taking of frequent tube samples from the methane drainage system or electronic monitoring of the system should identify trends.

08/

MONITORING

**DEVELOPING, IMPLEMENTING
AND MAINTAINING
MEASUREMENT CONTROLS TO
MANAGE RISK**

- 8.1 General provisions in relation to monitoring**
 - 8.2 Monitoring of underground ventilation**
 - 8.3 Selection of monitors**
 - 8.4 Positioning of monitors**
 - 8.5 Alarms**
 - 8.6 Inspections**
 - 8.7 Types of monitors**
-

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8.1 General provisions in relation to monitoring

The monitoring requirements outlined in this section are generally the same as those included in the Approved Code of Practice on Fire or Explosion. This is because monitoring requirements are an integral part of the Ventilation Principal Control Plan and the Fire or Explosion Principal Hazard Management Plan, and should not be considered in isolation of each other. There may be additional requirements specific to either of these plans, and where this is the case, they are included in addition to the general requirements.

REG 4

4 Meaning of fresh air

A reference in these Regulations to fresh air means that the air—

- (a) *contains not less than 19% by volume of oxygen; and*
- (b) *contains not more than 0.25% methane; and*
- (c) *contains not more than 25 ppm of carbon monoxide; and*
- (d) *contains not more than 5 000 ppm of carbon dioxide; and*
- (e) *contains no other substance at a level that is likely to cause harm to a mine worker over the period that the mine worker is exposed to the substance at the mining operation.*

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85 Principal hazard management plan for fire or explosion

(2) *The principal hazard management plan for fire or explosion must include—*

- (e) *details of the type and location of the systems for prevention, early detection, and suppression of fire (including remote monitoring systems) and of the equipment for firefighting at the mining operation;*
- (f) *where a gas monitoring system is in place, provision for the use of portable gas detectors fitted with suitable extension probes to monitor the presence of methane in the event that the gas monitoring system, or part of it, fails or becomes non-operational;*

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102 Ventilation control plan

(1) *The ventilation control plan must, at a minimum, address the following matters:*

- (g) *the means by which heat stress conditions will be monitored and controlled;*
- (2) *In the case of an underground mining operation or tunnelling operation, the ventilation control plan must, in addition to the matters in subclause (1), address the following matters:*
- (d) *the levels of methane at which a methane detector will activate its alarm, and the procedures to be followed when that occurs;*

- (e) *measures to be taken if the effective temperature in the underground parts of the mining operation exceeds 28°C:*
 - (f) *providing for the recording of instances referred to in paragraph (e) as part of the health and safety management system:*
 - (g) *the procedure regarding the action to be taken when monitoring identifies the presence of noxious gases:*
 - (h) *the criteria for determining that ventilation is inadequate in a part or the whole of the underground parts of the mining operation, having regard to the quality, quantity, and velocity of air provided by the ventilation system such that workers must be evacuated from the affected part or the whole of the operation as required by Regulation 149:*
- (3) *In the case of an underground coal mining operation, the ventilation control plan must, in addition to the matters in subclauses (1) and (2), address the following matters:*
- (a) *an assessment of potentially explosive gas contained within the coal seam that is being mined:*
 - (b) *based on the assessment required by paragraph (a), the establishment of a system for the delivery of adequate ventilation that is designed to maintain the concentration of methane below 0.5% of the general body of air in any production area:*
 - (c) *the design, monitoring, and control of the underground ventilation arrangements to ensure that the atmosphere underground in the mining operation is kept within the prescribed limits (including design, monitoring, and control of arrangements required to support air quality, dust, and airborne contaminant management, gas outburst management, spontaneous combustion management, or other hazard management arrangements at the mining operation that are dependent on ventilation):*

142 Measurement of air from fans

- (1) *The mine operator of an underground coal mining operation must ensure that, at least once in every week, a competent person—*
 - (a) *measures the quantity of air being delivered to every working place in the underground parts of the mining operation; and*
 - (b) *determines whether air is being recirculated in the underground parts of the mining operation and takes suitable action to stop any such recirculation.*
- (2) *The mine operator of an underground metalliferous mining operation or tunnelling operation must ensure that, at least once in every month, a competent person—*

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- (a) *measures the quantity of air being delivered to every working place in the underground parts of the mining operation; and*
- (b) *determines whether air is being recirculated in the underground parts of the mining operation and takes suitable action to stop any such recirculation.*

143 Quantity and velocity of air

- (1) *The mine operator must ensure that—*
 - (a) *the volume of air passing through an active working face, other than a longwall working face, is not less than 0.3 cubic metres per second for each square metre of normal development cross-sectional area; and*
 - (b) *the volume of air passing through an active longwall working face is not less than 4 cubic metres per second for each metre of extracted height in the face.*
- (2) *The mine operator must ensure, in respect of any underground parts of a mining operation where a mine worker is doing work or may travel, that the air in that part is provided at an adequate quantity and velocity to ensure the mine worker will not be exposed to a concentration of dust that is likely to cause harm to the mine worker.*

REG 144

144 Ventilation fans other than auxiliary fans

The mine operator must ensure that,—

- (b) *each main ventilation fan has the following devices connected to it:*
 - (i) *a pressure gauge that continuously indicates the air pressure; and*
 - (ii) *a device that continuously indicates and records the volume of air passing through the fan; and*
 - (iii) *a device that continuously indicates and records the number of revolutions per minute of the fan; and*
- (c) *each main ventilation fan is fitted with a device that continuously monitors and records the condition of the fan, including the temperature, vibration levels, and static pressure, and that will, when the device detects a significant departure from the fan's normal operating parameters,—*
 - (i) *first, trigger a visible alarm; and*
 - (ii) *following such period of time as will provide a mine worker with a reasonable opportunity to respond to the alarm, isolate the supply of electricity to the fan if no other action has been taken by a mine worker in response to the departure from normal operating parameters; and*

- (iii) *record the date and time that an alarm is triggered and the supply of electricity is isolated; and*
- (d) *each booster fan installed underground is fitted with a device that continuously monitors and records the condition of the fan, including the temperature, vibration levels, and static pressure, and that will, when the device detects a significant departure from the fan's normal operating parameters,—*
 - (i) *first, trigger a visible alarm; and*
 - (ii) *following such period of time as will provide a mine worker with a reasonable opportunity to respond to the alarm, isolate the supply of electricity to the fan if no other action has been taken by a mine worker in response to the departure from normal operating parameters; and*
 - (iii) *record the date and time that an alarm is triggered and the supply of electricity to the fan is isolated; and*
- (e) *each of the monitoring devices referred to in paragraphs (c) and (d) is designed and installed so that the part of the device that displays the results of the monitoring is located where it can be easily accessed by a mine worker required to check the condition of the fan; and*

REG 150

150 Quantity of air to be measured

The mine operator must ensure that a competent person measures, at least once in every month, the quantity of air—

- (a) *in the main current; and*
- (b) *in every split; and*
- (c) *at the commencement of the main return airway; and*
- (d) *in each ventilating district; and*
- (e) *at any additional place identified by the mine operator as a hazard.*

REG 152

152 Application of Regulation 153

Regulation 153 applies to—

- (a) *any underground coal mining operation; and*
- (b) *any underground metalliferous mining operation or tunnelling operation where methane has been detected.*

REG 153

153 Ventilation

The mine operator of a mining operation to which this Regulation applies must ensure that—

- (a) *the percentage of methane in the general body of air in the underground parts of the mining operation where a mine worker is or may be present is not more than 2% by volume; and*

- (b) *a quantity of fresh air adequate to ensure that paragraph (a) is complied with is circulated throughout the underground parts of the mining operation—*
 - (i) *before a mine worker enters the underground parts of the mining operation; and*
 - (ii) *whenever a mine worker is in the mine; and*
- (c) *there is fresh air at the following places:*
 - (i) *the commencement of an ERZ1:*
 - (ii) *every location that is 100 metres outbye of the most inbye completed line of cross-cuts in a panel or of a longwall or shortwall face; and*
- (d) *no air current passes through any stopping, or any unsealed, abandoned, or worked out area, before ventilating or passing through an active working place; and*
- (e) *the total number of mine workers ordinarily present in a ventilation district or ventilation circuit in the mine is kept to a minimum; and*
- (f) *a competent person measures, at least once in every week, the percentage of methane in the main return and split returns.*

REG 157**157 Fire protection and early warning systems**

- (1) *The mine operator must ensure that suitable and sufficient devices are installed in the underground parts of the mining operation to monitor for early signs of fire.*
- (2) *If a device installed as required by subclause (1) detects signs of fire in the underground parts of the mining operation, the device must—*
 - (a) *activate an audible alarm that will warn mine workers in the affected part or parts of the mining operation to escape to a place of safety:*
 - (b) *activate an alarm at the surface of the mining operation.*
- (3) *The mine operator must ensure that suitable and sufficient fire extinguishers are provided beside all high-voltage electrical plant and, if a significant risk of fire exists, beside all other electrical plant.*

REG 158**158 Testing for methane**

- (1) *The mine operator must ensure that testing for the presence of methane in the underground parts of the mining operation is carried out—*
 - (a) *as often as practicable: and*
 - (b) *with a suitable device.*
- (2) *The mine operator must ensure that, in respect of the devices used to test for the presence of methane, suitable procedures are in place dealing with—*
 - (a) *their safe use for that purpose; and*

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(b) *their examination and maintenance; and*

(c) *their regular calibration.*

(3) *The mine operator must ensure that no locked flame safety lamps are taken into or used in the underground parts of the mining operation.*

162 Monitoring for methane

The mine operator of a mining operation to which this Regulation applies must ensure that monitoring is carried out continuously at every working face where methane has been detected and a mine worker is present.

REG 164

164 Withdrawal of mine workers when high level of methane present

(1) *This Regulation applies when the level of methane in the general body of air in a part or the whole of the underground parts of an underground mining operation or tunnelling operation is detected to be 2% by volume or more.*

(2) *The mine operator must ensure that—*

(a) *every mine worker in the affected part or parts of the mining operation withdraws from the affected part or parts including, as the case requires, the whole of the underground parts of the mining operation; and*

(b) *the only person who enters the affected part or parts of the mining operation or, as the case requires, any part of the underground parts of the mining operation, is—*

(i) *a competent person, to test for the presence of methane; or*

(ii) *a mine worker, to inquire into the cause of the presence of the methane or to remove the methane; and*

(c) *no other mine worker enters the affected part or parts of the mining operation, or, as the case requires, any part of the underground parts of the mining operation, until a competent person reports to the manager that it is safe to do so.*

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176 Continued monitoring of atmospheric conditions underground during emergency

(1) *The mine operator of an underground coal mining operation must ensure that a system is provided that monitors the atmospheric conditions in the underground parts of the mining operation during an emergency and provides information about those conditions to people on the surface.*

(2) *The mine operator must ensure that—*

(a) *the system incorporates an adequate backup power supply; and*

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- (b) *the components for the system that are installed underground are recognised as being safe to operate in an explosive atmosphere, unless the components are installed in a drift or shaft being driven from the surface in material other than coal.*

180 Sealed goafs

If an underground coal mining operation has a sealed goaf, the mine operator must ensure that appropriate steps are taken to control any hazards that may be presented or caused by the emission of methane and noxious gases from the sealed goaf, including by—

- (a) *preventing intake air from travelling across the face of a permanent seal at the mining operation; or*
- (b) *minimising the risks of inrush and leakage of atmospheric contaminants from sealed goaf areas and abandoned or sealed workings into intake airways, which must include—*
 - (i) *use of no less than a type C seal; and*
 - (ii) *minimising leakage through seals; and*
 - (iii) *preventing damage to seals; and*
 - (iv) *installing a monitoring device in each intake airway on the return side of the seals over which the intake air passes to detect the intake airway's general body concentration of—*
 - (A) *oxygen; and*
 - (B) *carbon dioxide, if it is present behind the seal in a general body concentration greater than 3%; and*
 - (C) *any other gas that is present behind the seal in a quantity and concentration that is likely to create a hazard if it enters the intake airway adjacent to the seal; and*
 - (v) *for longwall workings, installing a monitoring device at the intersection of the longwall face and the intake airway to detect the intake airway's general body concentration of—*
 - (A) *oxygen; and*
 - (B) *carbon dioxide, if it is present behind the seal in a general body concentration greater than 3%; and*
 - (C) *any other gas that is present behind the seal in a quantity and concentration that is likely to create a hazard if it enters the intake airway adjacent to the seal; and*

- (vi) ensuring that every monitoring device installed as required by subparagraphs (iv) and (v) triggers an alarm to warn every mine worker who may be affected when a gas required to be detected by the device is present at the predetermined concentration.

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184 Facilities required for sealing

The mine operator must ensure that—

- (d) when sealed, the mining operation has facilities allowing the following:
 - (ii) monitoring of the atmosphere behind the seal from a safe position; and

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196 Monitoring for methane at the working face

The mine operator must ensure that monitoring for the presence of methane—

- (a) is continuous at every working face of the mining operation at which a mine worker is present and is carried out—
 - (i) as near to the face as possible; and
 - (ii) at an elevation determined by the principal hazard management plan for fire or explosion; and
- (b) is also carried out when required by Regulation 162.

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197 Methane monitors in intake airways

The mine operator must ensure that—

- (a) there is at least 1 methane monitor in each intake airway at the boundary between an NERZ and an ERZ1; and
- (b) every methane monitor located at the boundary between an NERZ and an ERZ1 is visible at the boundary and will,—
 - (i) if the concentration of methane detected in the general body of air at the boundary reaches 0.25% or more, automatically activate a visible alarm; and
 - (ii) if the concentration of methane detected in the general body of air at the boundary reaches 0.5% or more, automatically isolate the supply of electricity to all plant, other than safety critical equipment, in—
 - (A) the ERZ1 and the NERZ; or
 - (B) if the NERZ has been subdivided, the ERZ1 and the subdivided part of the NERZ adjacent to the ERZ1.

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198 Methane monitors in return airways

The mine operator must ensure that—

- (a) there is at least 1 methane monitor in each main return airway and in each return airway in a ventilation split; and

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- (b) every methane monitor located in a return airway automatically activates a visible alarm at the surface of the mining operation when the concentration of methane detected in the general body of air in the return airway reaches or exceeds the percentage stated in the ventilation control plan as the percentage at which the methane detector activates its alarm; and
- (c) a record is kept of every occasion that the methane monitor activates a visible alarm as required by paragraph (b).

199 Methane monitors on mobile plant powered by battery or diesel engine

- (1) The mine operator must ensure that all mobile plant used in an ERZ1 that is powered by a battery or diesel engine is fitted with a methane monitor that will,—
 - (a) if the concentration of methane detected in the general body of air around the mobile plant reaches 1% or more, automatically activate a visible alarm to warn the operator of the mobile plant; and
 - (b) if the concentration of methane detected in the general body of air around the mobile plant reaches 1.25% or more,—
 - (i) automatically shut down the mobile plant; and
 - (ii) in the case of mobile plant powered by a diesel engine, automatically prevent the diesel engine from restarting.
- (2) The mine operator must ensure that, in the case of non-explosion-protected mobile plant that is powered by a battery or diesel engine and that is fitted with an automatic methane monitor, the mine worker operating the mobile plant immediately parks and shuts down the plant if the methane monitor fails while the mobile plant is in use.

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200 Methane monitors on certain mobile plant powered by electricity through trailing or reeling cable

- (1) The mine operator must ensure that every coal cutter, continuous miner, tunnel-boring machine, road-heading machine, and longwall shearer used at the mining operation is fitted with a methane monitor that will,—
 - (a) if the concentration of methane detected in the general body of air around the mobile plant reaches 1% or more, automatically—
 - (i) activate a visible alarm to warn the operator of the mobile plant; and
 - (ii) isolate the electricity supply to the cutters:
 - (b) if the concentration of methane detected in the general body of air around the mobile plant reaches 1.25% or more, automatically isolate the supply of electricity to the trailing cable or reeling cable supplying the mobile plant.

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- (2) *The mine operator must ensure that every mobile bolting machine, loader, load-haul-dump vehicle, and shuttle car used at the mining operation is fitted with a methane monitor that will,—*
- (a) *if the concentration of methane detected in the general body of air around the mobile plant reaches 1% or more, automatically activate a visible alarm to warn the operator of the mobile plant; and*
- (b) *if the concentration of methane detected in the general body of air around the mobile plant reaches 1.25% or more, automatically isolate the supply of electricity to the trailing cable or reeling cable supplying the mobile plant.*

201 Monitoring of other mobile plant powered by electricity through trailing or reeling cable

- (1) *This Regulation applies to any mobile plant of a kind other than that specified in Regulation 200.*
- (2) *The mine operator must ensure—*
- (a) *that the mobile plant is fitted with a methane monitor that will perform the functions described in Regulation 200(2); or*
- (b) *that the mobile plant is recognised as being suitable for use in an ERZO by or under the Electricity (Safety) Regulations 2010; or*
- (c) *in any other case, that any mine worker who detects a concentration of methane in the general body of air that reaches 1.25% or more immediately isolates the supply of electricity to the trailing cable or reeling cable supplying the mobile plant.*

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COAL

202 Auxiliary and booster fans

- (1) *The mine operator must ensure that each auxiliary and booster fan is fitted with a methane monitor and that,—*
- (a) *if the concentration of methane detected in the general of body of air around an auxiliary fan reaches 1.25% or more, the supply of electricity to the auxiliary fan is automatically isolated; and*
- (b) *if the concentration of methane detected in the general body of air around a booster fan reaches 1.25% or more, the methane monitor automatically activates an audible and visible alarm.*
- (2) *The audibility and visibility of the alarm required by subclause (1)(b) must be sufficient to ensure that necessary action will be taken in response to the alarm.*
- (3) *Nothing in this Regulation applies to an auxiliary fan or a booster fan located in a drift or shaft being driven from the surface of a mining operation in material other than coal.*

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204 Failure of methane monitoring system

- (1) *This Regulation applies if the methane monitoring system fails or becomes non-operational, affecting a part or the whole of the underground parts of the mining operation, and the mining operation does not have—*
- (a) *a procedure for the use of portable monitors to detect methane; or*
 - (b) *a sufficient number of portable monitors to continually monitor the affected part or the whole of the underground parts of the mining operation to the extent necessary to ensure that the levels of methane in the affected part or the whole of the underground parts of the mining operation remain below 2%.*
- (2) *The mine operator must ensure that every mine worker underground is withdrawn to a place of safety.*
- (3) *The mine operator must ensure that no mine worker enters or remains in an unsafe part of the underground parts of the mining operation, except to repair or replace the affected parts of the methane monitoring system.*
- (4) *For the purposes of subclause (3), a part or the whole of the underground parts of the mining operation is unsafe if the concentration of methane in the general body of air in that part or the whole of the underground parts of the mining operation cannot be monitored as required by these Regulations.*

REG 222

222 Examination of mining operations

- (1) *The mine operator must ensure that a competent person—*
- (a) *examines,—*
 - (i) *before the start of each working shift and at suitable times during each working shift, every area of the mining operation where a mine worker is or will be present; and*
 - (ii) *at least weekly, every accessible area of the mining operation, including every area containing barriers, machinery, seals, underground or surface infrastructure, and ventilation stoppings; and*
 - (iii) *at least weekly, every vehicle in the mining operation; and*
 - (iv) *before it is started, any fixed or mobile plant in the mining operation that has been stopped for the preceding 24 hours or longer; and*
 - (b) *takes all practicable steps to eliminate, isolate, or minimise any significant hazard identified during the examination; and*
 - (c) *ensures that all plant examined either is safe or is made safe.*

- (2) *The mine operator must ensure that a written procedure for the conduct of examinations required by subclause (1) is included in the health and safety management system for the mining operation and sets out—*
 - (a) *the matters to be covered by the examination; and*
 - (b) *a timetable (subject to the minimum requirements of subclause (1)) for the carrying out of the examinations; and*
 - (c) *the process for recording findings; and*
 - (d) *the process for taking action as a result of findings.*

223 Barometer, hygrometer, and thermometer

- (1) *The mine operator of an underground mining operation or tunnelling operation must ensure that—*
 - (a) *a barometer and thermometer are placed on the surface of the mining operation in a conspicuous position near the entrance to the underground parts of the mining operation; and*
 - (b) *a hygrometer is available for use in every underground mining operation or tunnelling operation.*
- (2) *The mine operator must ensure that a competent person reads the barometer and thermometer before the examinations required by Regulation 222(1).*

8.2 Monitoring of underground ventilation

The mine operator should ensure that the air supplied to every underground place where mine workers are working meets the requirements of the applicable Regulations, and safe levels, in relation to:

- (a) Air velocity, quantity and composition.
- (b) Fire.
- (c) Methane or noxious gases.
- (d) Humidity.
- (e) Diesel emissions.
- (f) Radon.

8.2.1 Monitoring of air velocity, quantity and quality

The site senior executive should ensure that suitable arrangements are in place to monitor air velocity, quantity and quality, and that any significant changes to the following are investigated immediately:

- (a) Air velocity, quantity and quality at all critical underground locations as required by the ventilation system plan.

- (b) Total air quantity at the main fan, and booster fans.
- (c) Ventilation distribution.

8.2.2 Monitoring for the early detection of fire

The mine or tunnel manager should ensure that:

- (a) Suitable monitors are installed underground to alert all mine workers in the vicinity, and on the surface, of the early onset of fire.
- (b) A monitoring and review process, including visual inspections and regular auditing, is implemented at the mine or tunnel.

8.2.3 Monitoring for the presence of methane

It is a requirement under Regulation 158 that the mine operator must test for methane and under Regulation 162 if methane is detected at any working face that monitoring is continuous.

- (a) To meet this requirement, all mine operators should ensure that monitoring for the presence of methane is undertaken.
- (b) In the event that the presence of methane is detected at an underground metalliferous mine or tunnel at a level of 0.25% or greater, the mine operator should:
 - (i) Establish Explosion Risk Zones as detailed in Regulation 190; and
 - (ii) be required to meet the explosion risk requirements as detailed in the Regulations, and as they apply to an underground coal mine, until such time as the methane is reduced to a level below 0.25%; and
 - (iii) immediately notify WorkSafe NZ (ie within 24 hours) of any such re-classification of the underground operation and/or workplace.
- (c) Increasing the ventilation volume to dilute the methane to a level below 0.25% is the simplest method to reduce the presence of methane. The source of the methane should also be investigated to establish whether it will present additional hazards in the future.

8.2.4 Monitoring of humidity

- (a) The shift supervisor should determine underground humidity levels using a hand held whirling hygrometer, or other suitable instrument.
- (b) ET should be determined by:
 - (i) Use of a hygrometer to find the WB and DB temperatures in a particular section of the mine or tunnel.
 - (ii) Use of an anemometer and watch, to determine the velocity in that particular section of the mine or tunnel.
 - (iii) Plotting all three readings on the ET chart in the Appendix.



8.2.5 Monitoring of diesel emissions

- (a) The site senior executive should ensure that the risks associated with diesel engine emissions and Diesel Particulate Matter are identified and the emissions monitored, and exposure levels are adequately managed and documented in the mine or tunnel's Air Quality Principal Hazard Management Plan. For more detailed information, see the Approved Code of Practice on Air Quality.
- (b) The site senior executive should be aware of, and keep up to date with, new technologies in this area, and the Ventilation Principal Control Plan and/or the Mechanical Engineering Principal Control Plan should include controls and measures that reflect new technological developments. Such controls may include, but are not limited to:
 - (i) The use of Tier 3 and 4 low emission engines
 - (ii) System components to capture or convert diesel pollutants
 - (iii) Ventilation quantities
 - (iv) Maintenance and management systems
 - (v) Traffic management systems
 - (vi) Emission monitoring systems
 - (vii) Exposure monitoring systems
 - (viii) Use of personal protective equipment
 - (ix) Any other emerging technologies in this area.

8.2.6 Monitoring for radon

- (a) The site senior executive should ensure that monitoring arrangements are in place for the detection of radon.
- (b) As uranium is known to be present in New Zealand, all mine and tunnel operators should ensure specific monitoring arrangements are in place for its detection.
- (c) Monitoring for radon should be by short term passive dosimeters, which are positioned at specific locations for set periods (usually 7-14 days). At the end of the set period, the dosimeter is sent to an independent testing facility for analysis.
- (d) When the presence of radon is detected, the site senior executive should ensure that arrangements are in place to monitor the levels of radon using short term passive dosimeters or air sampling monitors.

8.3 Selection of monitors

The selection of monitors should be based on suitability for each underground environment and each individual mine or tunnel. The mine or tunnel manager should ensure that there is in place:

- (a) The ability to detect all of the gases outlined in Regulation 4.
- (b) Where required, additional monitors to detect hydrogen sulphide, hydrogen, nitrous oxide, sulphur dioxide, nitrogen and smoke.
- (c) When exposed to a potentially explosive atmosphere, safety critical monitors and detectors.
- (d) Appropriate maintenance and calibration programmes.
- (e) Monitors connected to a control room (where practicable), or some form of automatic alarm system (eg a pager, mobile phone, or RT system) where the underground environment is being continuously monitored for any indication of a contaminated atmosphere.
- (f) Modelling that shows all monitors in the logical sequence created by the airflow and where the pick-up of contaminants starts.
- (g) Suitable backup systems that allow data to be continuously transmitted to the surface in the event of a fire or explosion.
- (h) A system for checking the accuracy of hand held gas monitors at the surface prior to each shift.
- (i) A system for immediately notifying management and the workers representative of any abnormal recordings.
- (j) For each installed tube bundling sampling point, a sampling board with a flow meter arrangement and the minimum flow available at this point so that the sampling point can be checked for accuracy.
- (k) A review process, by the ventilation officer, of any alarms recorded over the month prior and, if necessary, revision of the alarms, either higher or lower.

8.4 Positioning of monitors

8.4.1 Positioning of CO monitors or smoke detectors

Depending on the depth and length of mine or tunnel, and the location of conveyors, electrical equipment, hydraulic systems and the ventilation velocity, the mine or tunnel manager should ensure that monitors are positioned:

- (a) Before the commencement of a working face, unless there is a belt drive sited in that area.
- (b) On the downstream side of any belt drive.
- (c) Against the auxiliary fan, or in a position that will alert mine workers in a blind heading of a fire developing in a part of the mine or tunnel used to supply the blind heading with fresh air.
- (d) In the return from the main working face.

- (e) At the point where return airways form a single tunnel or if multiple main returns, then in each main return.
- (f) At the outlet side of any underground main fan (in a metalliferous mine) or booster fan.
- (g) At any other location where a risk assessment identifies it as a requirement.
- (h) In the flow path as indicated by a smoke test. The smoke test should be carried out prior to installation and again on commissioning.
 - (i) To ensure correct positioning is maintained, the tests should be re-taken when there is any significant change in airflow (+/- 20%) at that location.

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8.4.2 Factors influencing the position of monitors and detectors

The positioning of CO monitors or tube bundle sample points is critical to the quality of data collected, reported and interpreted.

If a monitor is positioned too close to the potential source/location to be monitored, it may not be in the main airstream so any combustion products may evade the monitor.

If a monitor is positioned too far away from the monitored location, the time it takes for an incident to intensify may be quicker than it takes for contaminated air to travel to where the monitor is positioned.

8.4.3 Positioning of methane monitors

- (a) The mine manager should ensure that methane monitors are installed so that:
 - (i) They meet the minimum location requirements as specified in Regulations 162 and 196-202 inclusive.
 - (ii) Due to the buoyancy of methane, they are positioned so that methane will not pass over the monitor without being detected.
 - (iii) They are clear of obstructions that may cause turbulence and are positioned to ensure they record the reading where the gases are completely mixed.
 - (iv) Power cables and tube bundle tubes are protected from damage and impacts.
- (b) The mine manager should ensure that electrically-powered methane monitors are safety critical and have a back-up system that ensures the monitor to function in the event of a power failure.

8.4.4 Monitors on explosion-protected vehicles energised by a battery or diesel engine

The mine or tunnel manager should ensure that an explosion-protected vehicle energised by a battery or diesel engine is fitted with at least one automatic methane monitor to:

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- (a) Detect the concentration of methane around the vehicle.
- (b) Automatically activate a visible alarm to warn the operator when the concentration exceeds 1%; and either:
 - (i) Trip the electricity supply to the machine electrical motors when the concentration exceeds 1.25%; or
 - (ii) Stop the diesel engine when the concentration exceeds 1.25%.

8.4.5 Monitors on other explosion-protected mobile plant

This section applies to explosion-protected mobile plant energised by a reeling or trailing cable.

- (a) The mine or tunnel manager should ensure that the explosion-protected mobile plant is fitted with at least one automatic methane monitor to:
 - (i) Detect the general body concentration of methane around the plant.
 - (ii) Automatically trip the electricity supply to the plant when the concentration exceeds 1.25%.
- (b) The methane monitor should be sited as follows:
 - (i) The methane monitor at the head end of a development heading or multi-entry panel system should be sited as close as possible to the roof within 3.5m of the working face. This should cut off electricity to the machines trailing cable if the level of methane reaches 1.25%.
 - (ii) In any secondary mining process where de-pillaring or floor-coal recovery is taking place, the methane monitor at the head end should be sited as close as possible to the roof, no further than 3.5m outbye of the goaf edge, and on the opposite side of the roadway to the ventilation duct. This should cut off electricity to the machines trailing cable if the level of methane reaches 1.25%.

8.4.6 Monitors on a hydro mining panel

- (a) Where developments are located on the intake side of a hydro mining panel, sufficient methane monitors should be located before and after the development roadway to ensure fresh air is supplied to the panel.
- (b) At least two telemetric methane monitors (provided with a digital reader and linked to the high pressure water pump) should be sited no further than 20m from the goaf edge in the return roadway on a hydro mining panel.
- (c) Where primary, secondary and tertiary dilution doors are required, methane monitoring is required in the hydro mining panel when methane accumulation and uncontrolled discharge is predicted. This will allow instant operation of the dilution doors and pressure control of the hydraulic monitor when necessary.

- (d) In a hydro mining panel where no mine workers are working and no equipment is present in the return airway, telemetric methane monitoring is required and should be linked to the operator of the water jets and the control room, so that power to the water jets is tripped before the methane level reaches 2.0%.
- (e) A methane monitoring station should be positioned at the outbye end of the hydro mining district return. This is the most effective location for gathering information for the deputy and the control room as the district methane make will pass this point.

The methane monitors should have duties to:

- (i) Show the rising trend of methane with alarms set at various levels dependant on the legislation requirements; and
- (ii) rip power to the hydro mining equipment at a set percentage or rate of change; and
- (iii) Allow the operator to control the mining rate and the methane levels.

Power to the hydro mining water jets could be restored as methane reduces to allow production to continue.

- (f) At the outbye end of the hydro mining district return, the methane monitor should be connected to a flashing beacon that initiates at a set level to prevent worker or mobile equipment access.

8.4.7 Use of portable gas monitors

Approved, portable gas monitors may be hand held, and are used to provide a continuous reading of the underground atmosphere, and warn with visible and audible alarms when particular levels are reached.

Approved portable gas monitors should be used:

- (a) At each production face where a coal cutter, continuous miner or road heading machine is used to win coal, suspended from the roof; and:
 - (i) Within the distance between the face and the inlet of the ventilation ducting if the face is ventilated in exhausting mode; or
 - (ii) above the general body of a coal cutter, continuous miner or road heading machine in any other ventilation set-up.
- (b) The monitors in (a) (i) and (ii) above should be in place during any work activity associated with production process (including bolting).
- (c) At each hydro monitor face, suspended from the roof above the operator's cab during any work activity.
- (d) At any auxiliary ventilated place where mine workers continuously work during any work activity.

- (e) Any place where a seal is constructed to isolate a goaf or worked out area during any work activity.
- (f) Suitable extension probes should be readily available for use with hand held gas detectors to test for methane layering or accumulations in cavities and voids.

8.4.8 Monitoring where methane drainage is in place

Where a system of methane drainage is in place:

- (a) High reading methanometers should be used in conjunction with standard methane monitors to ensure the early detection of system failure.
- (b) Additional monitors should be installed as part of the methane extraction system design. See the Appendix for more detailed information on methane management.

8.5 Alarms

The site senior executive should ensure that there are SOPs in place for monitoring and the response to changes in detected gas (or smoke) levels.

The SOP should require that:

- (a) All monitors are maintained and calibrated according to the manufacturer's specifications, and with the requirements of the Electricity (Safety) Regulations 2010.
- (b) All mine workers are trained in the operation of the monitoring system.
- (c) There are instructions available for all mine workers on the process to be followed, who should be notified above and below ground, and the records to be documented, when a warning or alarm is activated.
- (d) Where continuous monitoring is in place, there is a system for recording the mine worker responsible for controlling the monitoring system.
- (e) Alarms are reset only when a competent mine worker has deemed it safe to do so.
- (f) Alarm data is stored, and can be retrieved at any time, for the review of an alarm activation event, the actions that were taken, and by whom.
- (g) When an alarm is added, removed or changed, a documented process is in place to ensure the mine worker responsible for controlling the monitoring system is notified of the change, and is trained in any new procedures or actions resulting from the change, where required.

8.5.1 When alarms warn of the presence of methane

Methane monitors should alarm at pre-determined levels locally, in the control room, or by automatic notification (where there is no control room).

When higher levels of methane are reached, machines should be automatically shut down and/or the power isolated to the mine. Generally, the alarm and isolation levels are:

- (a) 0.25% to indicate the presence of methane in a NERZ, or in a metalliferous mine.
- (b) 0.5% at the point of transition from an ERZ1 to NERZ.
- (c) 1.0% to warn operators of mobile plant, hydro monitors, coal cutting equipment, or in the general body ventilation, of an increase in methane.
- (d) 1.25% to de-energise or isolate all electrical equipment, excluding safety systems in the affected area.
- (e) 2.0% (or lower, as determined by the mine), to trigger the withdrawal of all mine workers from the affected area to a safe location.
- (f) 4.5% to warn that methane has reached the explosive range (typically, this will occur when monitoring of a recently sealed goaf is in place).
- (g) The withdrawal of mine workers is to be carried out in line with the requirements of Regulation 149.

The regulatory alarm and cut off requirements for methane monitoring are provided in the Appendix.

8.5.2 When monitoring detects the presence of radon

When the presence of radon is detected, it should be controlled in the same way that the presence of other gases are managed, including:

- (a) Dilution of the gas by permanently increasing ventilation quantity.
- (b) Directing the ventilation in the area where radon is being generated to a return airway.
- (c) Sealing the area where radon is being generated.
- (d) If the radon is desorbed from water, by containing the water in pipes, directing the water to returns, or preventing turbulence of the water until it can be contained in pipes.

8.6 Inspections³⁰

- (a) The mine or tunnel manager should ensure that regular inspections of working areas are carried out to:
 - (i) Monitor compliance with the underground ventilation requirements.
 - (ii) Identify sub-standard work practices (behaviours) and conditions (hazards).

³⁰ Ministry of Business, Innovation and Employment. (2013). *Guidance for a Hazard Management System for Mines*. Wellington, New Zealand. 4-20

- (b) It is the shift supervisor's responsibility on each shift, as part of their inspection duties, to examine all parts of the mine or tunnel that they are responsible for, to ensure that:
 - (i) Fresh air is supplied at the commencement of every section of the workings that has a working face.
 - (ii) The level of methane is no greater than 1.25% in an area classified as ERZ1.
- (c) If the shift supervisor finds the level of methane to be 2% or greater, all mine workers should be immediately withdrawn from the affected area to a safe location, or to the surface, and access to the affected area prevented with a secure barrier or fence. The barrier should be clearly marked with appropriate signage to prevent access.
- (d) No mine worker should enter the affected area until a documented risk assessment has been carried out and a competent mine worker confirmed it is safe to re-enter to:
 - (i) Carry out an inspection/investigation.
 - (ii) Restore or repair the ventilation system.
 - (iii) Save life.
- (e) The mine or tunnel manager should ensure that inspections are time-based and activity-based:
 - (i) Time-based inspections of all working places on a regular basis (ie shift, daily, weekly or monthly), depending on the level of risk (eg weekly magazine inspections), and that generally involve the use of area-specific or task-specific checklists to record any defects.
 - (ii) Activity-based, or 'on-the-job', inspections undertaken by mine workers or teams on an 'ad hoc' basis. The format for this type of 'dynamic' inspection may vary between operators, but may include 'Time Out', 'Take 5', or 'Positive Attitude Safety System (PASS)' systems. Activity-based systems are usually documented.
- (f) Where time-based inspections are undertaken, the mine operator or site senior executive should ensure that³¹:
 - (i) Mine workers are assigned to inspect specific areas in the mine or tunnel for each shift and for each day of the week (and inspections may include more than one district or section of the mine or tunnel).

³¹ Health and Safety Executive (HSE). (1993). Approved Code of Practice. The Management and Administration of Safety and Health at Mines. Management and Administration of Safety and Health at Mines Regulations 1993. Sheffield, England. 25-29.

- (ii) Inspections undertaken during a shift are carried out by the same mine worker to ensure assessment continuity. Districts should be of an adequate size so that this can be achieved.
- (iii) The frequency of inspections takes into consideration changes in the mine or tunnel operation (eg mine workers, equipment, systems and environmental factors). Intervals between inspections should allow for actions to be taken to fix problems identified during a previous inspection.
- (iv) The frequency of inspections is influenced by schedules and working areas unique to the mine or tunnel operation, and the presence of potential hazards unique to a particular site. Inspection frequencies should be:
 - a. Pre-shift, before work commences.
 - b. At suitable times during the shift, and when mine workers are working alone, at least twice each shift.
 - c. 24 hours (daily), on non-production days.
 - d. At the end of each shift (where continuous working is in place), as part of a pre-shift inspection for the oncoming shift.
 - e. After blasting.
 - f. Weekly.
 - g. Monthly, by the ventilation officer.
 - h. Fire watch inspections, including:
 - 1. When a coal conveyor has been stopped for more than 90 minutes, and no later than 3 hours after it has stopped.
 - 2. Following procedures that require a permit, such as hot work.

GUIDANCE

8.7 Types of monitors

8.7.1 Smoke detectors

Smoke detectors identify and provide a warning when particles of smoke are detected in a mine atmosphere. There are two types of smoke detectors used in an underground environment:

- (a) Ionisation chambers (which are similar to those used in most residential homes).
- (b) Optical smoke detectors (which are more sensitive to smouldering fires).

Both types of detectors are prone to dust build up and should be cleaned regularly to ensure they function correctly.

8.7.2 Carbon Monoxide detectors (ppm)³²

Carbon monoxide monitors measure CO levels and sound an alarm before dangerous levels accumulate. CO monitors can detect the onset of fire through spontaneous combustion – events that can both be disguised by the running of diesel-powered vehicles and the use of explosives (which can lead to poisoning of the CO monitors).

The positioning of CO monitors or tube bundle sample points is critical to the quality of the data collected and how it is reported and interpreted.

If a monitor is positioned too close to the potential source/location to be monitored, it may not be in the main airstream resulting in the combustion products evading the monitoring instrument.

If a monitor is positioned too far away, the time it takes for the incident to intensify may be quicker than it takes for the contaminated air to travel to the site of the monitor.

8.7.3 Airflow monitors (m/s)³³

Airflow monitors are used to measure:

- (a) Air velocity of air going into main surface fans.
- (b) Air velocity at the outbye end of the districts.
- (c) Air velocity in an auxiliary ventilation duct or tube (ie pitot tube type).

8.7.4 Pressure transducers (Pa or kPa)³⁴

Pressure transducers are used to measure:

- (a) Static pressure at main surface fans to alarm at +/- 10% of normal pressure.
- (b) The pressure difference across a set of doors usually sited between intake and returns near to the working face. It will give an indication of the pressure variance as operations are carried out on the district.
- (c) The static pressure of an auxiliary fan giving an indication if the fan is operating and if the ducting is damaged or restricted.
- (d) On methane drainage ranges:
 - (i) The vacuum being applied to the district.
 - (ii) The differential pressure across an orifice plate to determine the district flow.
- (e) Across a working panel/roadway where the resistance is known. The quantity can be calculated using the $p=RQ^2$ equation (see the Appendix to determine values).

³² See Definitions.

³³ See Definitions.

³⁴ See Definitions.

8.7.5 Tube bundle system

A tube bundle system draws air from set points underground via small bore tubing to the surface analyser through a vacuum pump, and provides an accurate analysis of the underground environment.

The further the distance from the mine's outlet, the longer the delay time for the sample to reach the surface. The time delay is not usually a problem as the system gathers historical information from that site, and should the mine lose power underground, the information is still gathered and remains continuous throughout the time of the power outage.

To establish delay times, and to ensure that the system is exhausting from its sample point, a known sample is placed into it and the time taken from introducing the samples to reaching the analyser establishes the delay time. To ensure the system's efficiency, the sample received should be greater than 95% of the known sample introduced inbye.

If this percentage is not achieved there is a leak in the system and the sample is being diluted along its length. The leakage point should be identified and fixed in order that a true district reading and flow is analysed.

8.7.6 Telemetric monitoring

Telemetric monitoring provides real time information, but only while live. Loss of power for any length of time will quickly render the system unreliable.

A combination of telemetric monitoring and tube bundle monitoring will provide the best information to the surface.

8.7.7 Methane monitors (methanometers)

Methane monitors, or methanometers, detect the presence of methane gas in a mine or tunnel.

8.7.8 Monitors for other gases

Monitors used to detect other gases that might be present underground (such as radon, hydrogen sulphide, hydrogen, nitrous oxide, sulphur dioxide and nitrogen), include automatic detectors, tube bundle systems, hand held monitors, dosimeters, chemical detector tubes and gas chromatographs.

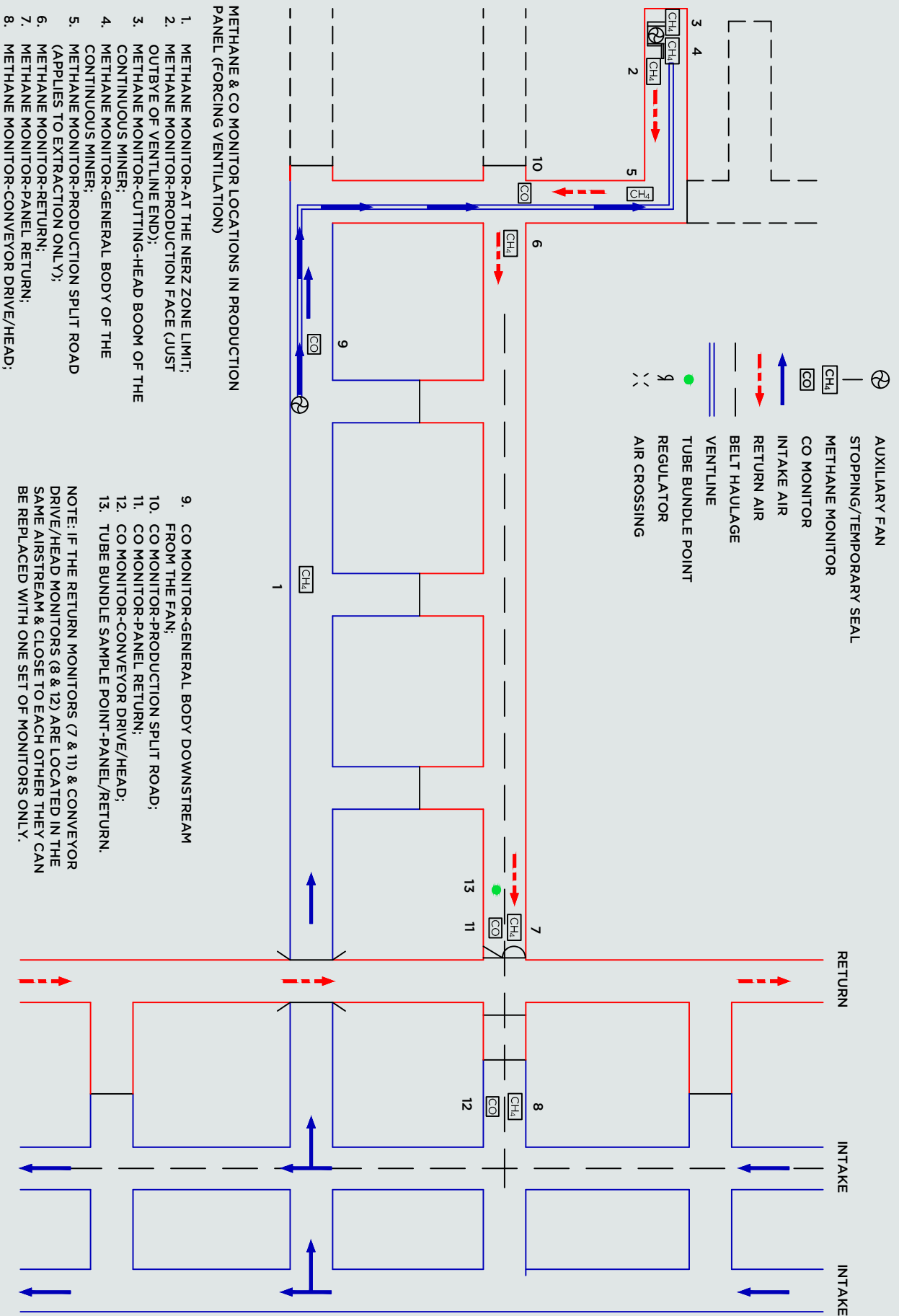
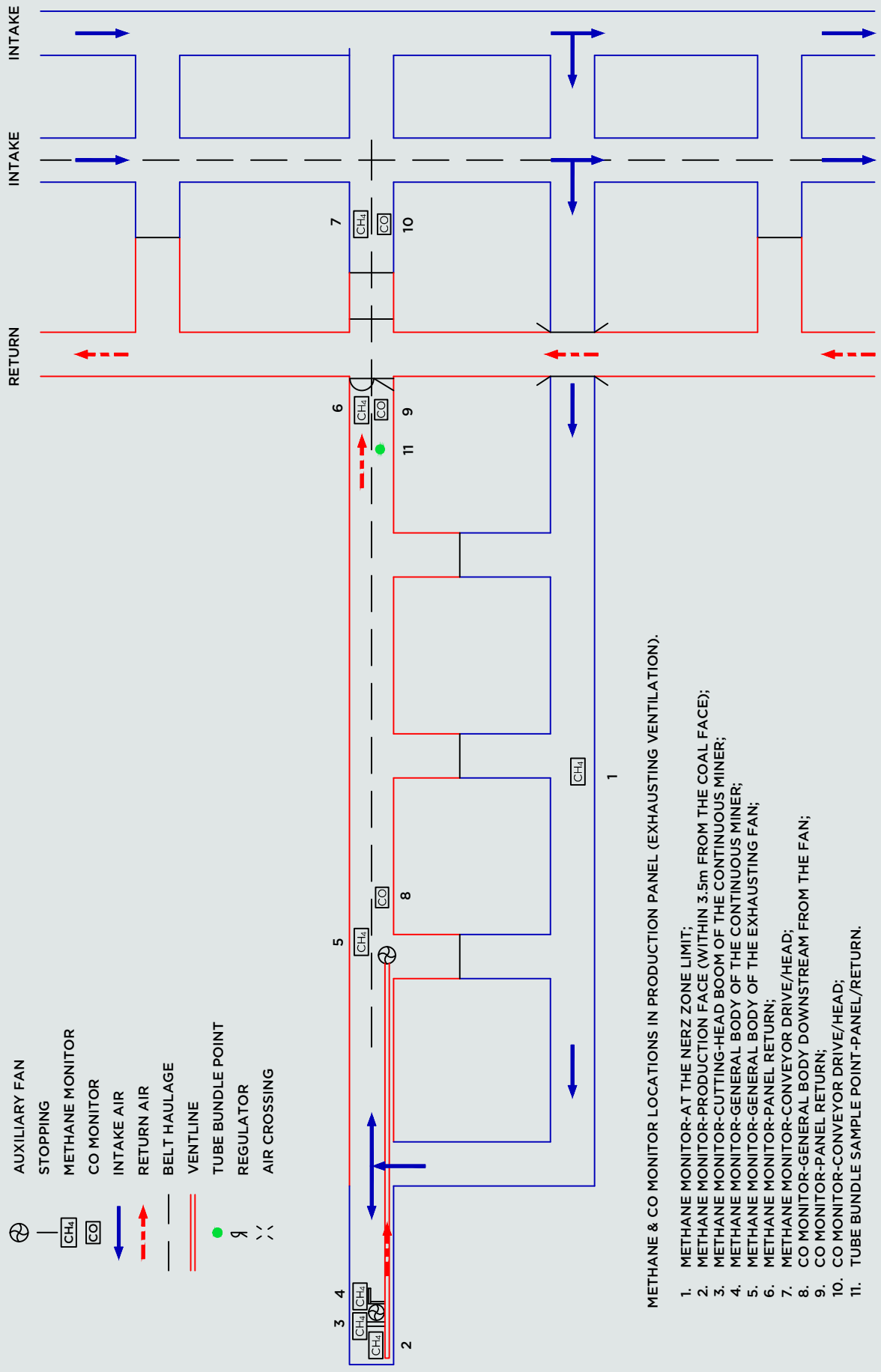


Figure 19 – Methane and CO monitor locations in production panel (forcing ventilation)



METHANE & CO MONITOR LOCATIONS IN PRODUCTION PANEL (EXHAUSTING VENTILATION).

1. METHANE MONITOR-AT THE NERZ ZONE LIMIT;
2. METHANE MONITOR-PRODUCTION FACE (WITHIN 3.5m FROM THE COAL FACE);
3. METHANE MONITOR-CUTTING-HEAD BOOM OF THE CONTINUOUS MINER;
4. METHANE MONITOR-GENERAL BODY OF THE CONTINUOUS MINER;
5. METHANE MONITOR-GENERAL BODY OF THE EXHAUSTING FAN;
6. METHANE MONITOR-PANEL RETURN;
7. METHANE MONITOR-CONVEYOR DRIVE/HEAD;
8. CO MONITOR-GENERAL BODY DOWNSTREAM FROM THE FAN;
9. CO MONITOR-PANEL RETURN;
10. CO MONITOR-CONVEYOR DRIVE/HEAD;
11. TUBE BUNDLE SAMPLE POINT-PANEL/RETURN.

NOTE: IF THE RETURN MONITORS (6 & 9) & CONVEYOR DRIVE/HEAD MONITORS (7 & 10) ARE LOCATED IN THE SAME AIRSTREAM & CLOSE TO EACH OTHER THEY CAN BE REPLACED WITH ONE SET OF MONITORS ONLY.

Figure 20 – Methane and CO monitor locations in production panel (exhausting ventilation)

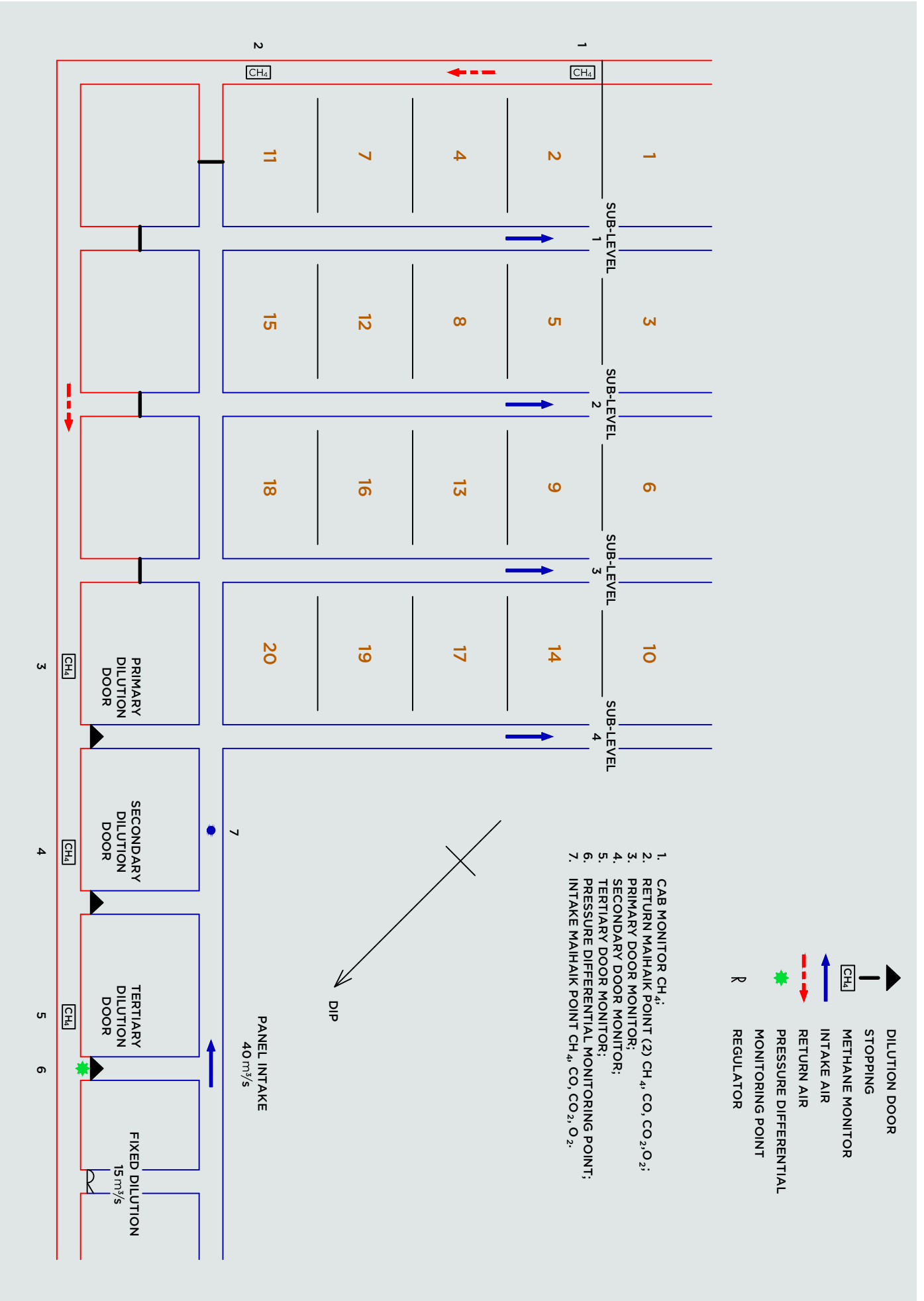


Figure 21 – Sample plan showing gas monitoring and dilution doors for a hydro panel



09/

NOTIFICATIONS

9.1 Notifications

REG 185

COAL

185 Notice of intention to seal underground coal mining operation

- (1) *The mine operator must give notice to WorkSafe of any intention to seal the whole of the underground parts of the mining operation.*
- (2) *Except in case of emergency sealing, the notice must be given, 1 month in advance of the activity taking place.*
- (3) *The notice must include—*
 - (a) *the proposed locations of the seals to be installed; and*
 - (b) *the proposed sealing procedure; and*
 - (c) *a summary of hazards identified and how they will be managed; and*
 - (d) *any evidence of the presence of an ignition source in a part or the whole of the underground parts of the mining operation; and*
 - (e) *predictions of the rates at which methane and other gases will accumulate in the underground parts of the mining operation; and*
 - (f) *the gas monitoring procedures to be carried out during and after the sealing.*
- (4) *If sealing becomes impracticable in the way in which the procedure was described in the notice provided to WorkSafe, the mine operator must—*
 - (a) *promptly notify WorkSafe of the changes from the initial proposed method of sealing the underground coal mining operation; and*
 - (b) *if the notification under paragraph (a) is not in writing, confirm the notification in writing to WorkSafe as soon as reasonably practicable.*

REG 203

203 Recording and notification of isolation of electricity supply

- (1) *If the supply of electricity is automatically isolated or mobile plant is shut down as required by any of Regulations 197 and 199 to 202 (except to cutters as required by Regulation 200(1)(a)(ii)), the mine operator must ensure that a record is kept of the date, time, and location of the event.*
- (2) *If the supply of electricity is automatically isolated as required by Regulation 197(b)(ii), the mine operator must ensure that WorkSafe is notified as soon as practicable.*

REG 227

227 Notification of accidents and serious harm

- (1) *For the purpose of section 25(2)(b) of the Act, every accident specified in Schedule 8 is required to be notified to WorkSafe if the accident occurs at a mining operation.*
- (2) *For the purpose of section 25(3)(b) of the Act, the mine operator must notify the following to WorkSafe:*

- (a) every accident specified in Schedule 8 if the accident occurs at the mining operation; and
 - (b) every occurrence of serious harm at the mining operation.
- (3) The mine operator must notify the accident or serious harm to WorkSafe by providing the particulars prescribed in Schedule 7 to WorkSafe.
 - (4) The mine operator must also provide the particulars of the accident or serious harm, except for personal information about any mine worker, to every site health and safety representative at the mining operation.
 - (5) WorkSafe must make the particulars of the accident or serious harm, except for personal information about any mine worker, available to industry health and safety representatives.
 - (6) For the avoidance of doubt, a mine operator is not required, in relation to any mine worker, to separately notify the accident or serious harm to WorkSafe on the basis that the mine worker is an employee of or a self-employed person contracted to the mine operator.

REG 229

229 Notification of high-risk activities

- (1) Before a high-risk activity specified in Schedule 9 is undertaken, the mine operator must ensure that notice of the activity is given to WorkSafe.
- (2) The period of notice to be given is the waiting period specified in Schedule 9 in relation to that activity, or any other longer or shorter period of notice that WorkSafe, by notice in writing, directs.
- (3) The notice must specify—
 - (a) the nature of the high-risk activity; and
 - (b) the intended commencement date of the activity.
- (4) The date that notice is given is the date that the notice is received by WorkSafe.
- (5) WorkSafe may request further information about the activity between the time of the notification of the activity by the mine operator and the expiry of the waiting period.
- (6) The mine operator must ensure that the high-risk activity is not commenced until the period of notice under subclause (2) has expired.

SCHEDULE 8

Schedule 8 Notifiable accidents

A notifiable accident is any of the following that occurs at a mining operation:

Ventilation and gas

- (1) any accident where mine 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

- (2) *any unplanned stoppage of the main fan in excess of 30 minutes*
- (3) *any unplanned accumulation of methane or other gas requiring formal degassing operations*
- (4) *the loss of consciousness of any mine worker including asphyxia*

Emergency, escape, and rescue

- (1) *any initiation of the mine emergency plan other than during a planned exercise*
- (2) *use of emergency escape equipment, including self-contained self-rescuers or other breathing apparatus, except during training*
- (3) *failure in use or training of any emergency escape equipment or mines rescue breathing apparatus*
- (4) *any emergency evacuation of a part or the whole of a mining operation*
- (5) *the unplanned unavailability of 1 or more of the emergency escapeways from an underground mining operation or tunnelling operation*
- (6) *any occasion where a mine worker or mine workers are trapped or unable to leave their place of work in a mining operation*

Schedule 9 High-risk activities

SCHEDULE 9

ACOP

9.1 Notifications

The Regulations require WorkSafe NZ to be notified two months prior to the proposed date of commencement of a mining operation. Where a new development is proposed in an existing mining operation, WorkSafe NZ should be notified two months prior to the start of the new development.

A development of an existing mine or tunnel includes (but not exclusively) significant changes to:

- > The physical layout of the mine or tunnel; or
- > Equipment, electrical or ventilation systems.

The notification for a new mining operation, or new development of an existing mine or tunnel, should include (in addition to any regulatory requirement):

- (a) The layout of the development in relation to existing roads and to previous workings.
- (b) The ventilation arrangements for each stage of that development, including air quantities and velocities throughout the development.
- (c) Any gas makes that may affect other workings.
- (d) Any environmental monitoring required by that development.



- (e) Any requirements to be in place for the heading or tunnel breakthrough of that development, such as doors or regulators.
- (f) The ventilation requirements whilst that working area is being equipped.
- (g) The ventilation arrangements for the coal face, including air quantities and any ventilation control system required such as doors, regulators or air crossings.
- (h) The position of any primary and secondary stoppings or bulkheads.
- (i) The tunnelling method to be used and arrangements for the transporting of materials.
- (j) If the tunnelling will require any special arrangements, such as hyperbaric pressure, grouting, or freezing of strata.
- (k) Any methane drainage requirements such as range sizes, and positioning of ranges.
- (l) Any spontaneous combustion prevention work required to be carried out at each stage of the development, such as roadway sealing around the junction area before the heading has advanced beyond x metres.
- (m) Salvage arrangements for the district after production is complete.
- (n) Final sealing arrangements, if applicable.

10/

RECORDS

10.1 Maintenance of ventilation records and plans

REG 61

61 Maintenance of records of health and safety management system

- (1) *The mine operator must ensure that the following records are kept:*
 - (a) *the current version of the health and safety management system;*
 - (b) *any previous versions of the health and safety management system that applied in the preceding 7 year period;*
 - (c) *records of all reviews and audits of the health and safety management system, or any part of it, that have been conducted in the preceding 7 year period;*
 - (d) *records of any risk appraisal carried out to identify principal hazards at the mining operation as required by Regulation 66(1)(a).*
- (2) *The mine operator must ensure that the records referred to in subclause (1) must be maintained in such a way that—*
 - (a) *the current version of the health and safety management system can be clearly identified; and*
 - (b) *every previous version of the health and safety management system required to be kept is kept as it was while it was current and shows the period during which it was current.*
- (3) *The mine operator must ensure that the records referred to in subclause (1) are made available, on request, to WorkSafe, a site health and safety representative, or an industry health and safety representative.*

REG 62

62 Providing health and safety management system documentation to mine workers

- (1) *The mine operator for a mining operation must ensure that, before a mine worker commences work at the mining operation,—*
 - (a) *the mine worker is given a written summary of the health and safety management system for the mining operation; and*
 - (b) *the mine worker is informed of the right to access the current version of the health and safety management system.*
- (2) *The mine operator must ensure that the current version of the health and safety management system is readily accessible by a mine worker at the mining operation.*
- (3) *The mine operator must ensure that a mine worker is given access to—*
 - (a) *the current versions of the principal hazard management plans that are relevant to the work the mine worker is to carry out; and*
 - (b) *the current versions of the principal control plans that are relevant to the work the mine worker is to carry out; and*

REG 63

- (c) *the current versions of any other plans or documented processes for the management of hazards that are relevant to the work the mine worker is to carry out.*
- (4) *If the health and safety management system is revised under subpart 4, the mine operator must ensure that each mine worker at the mining operation is made aware of any revision that is relevant to work being carried out by that mine worker.*

63 Providing health and safety management system documentation to contractor

- (1) *This Regulation applies to a person who is engaged by the mine operator to provide services where the person's employees or other workers engaged by the person to provide those services will be mine workers in relation to the mine operator.*
- (2) *The mine operator must ensure that the current version of the health and safety management system, and records of all audits and reviews of the health and safety management system, or any part of it, and other audits of the site itself that have been conducted, are made available on request to any person to whom this Regulation applies.*

REG 102

102 Ventilation control plan

- (1) *The ventilation control plan must, at a minimum, address the following matters:*
 - (i) *the maintenance of ventilation records and plans:*

REG 129

129 Records of first aid provided to mine workers

The mine operator must ensure that records of first aid provided to mine workers who are seriously harmed at the mining operation are kept for at least 7 years after the accident concerned.

REG 144

144 Ventilation fans other than auxiliary fans

The mine operator must ensure that,—

- (b) *each main ventilation fan has the following devices connected to it:*
 - (ii) *a device that continuously indicates and records the volume of air passing through the fan; and*
 - (iii) *a device that continuously indicates and records the number of revolutions per minute of the fan; and*
- (c) *each main ventilation fan is fitted with a device that continuously monitors and records the condition of the fan, including the temperature, vibration levels, and static pressure, and that will, when the device detects a significant departure from the fan's normal operating parameters,—*
 - (i) *record the date and time that an alarm is triggered and the supply of electricity is isolated; and*

REG 151

- (d) *each booster fan installed underground is fitted with a device that continuously monitors and records the condition of the fan, including the temperature, vibration levels, and static pressure, and that will, when the device detects a significant departure from the fan's normal operating parameters,—*
- (iii) *record the date and time that an alarm is triggered and the supply of electricity to the fan is isolated; and*

151 Plan of ventilation system to be updated every month

- (1) *The mine operator must ensure that a plan of the ventilation system is prepared and updated at least once a month.*
- (2) *The plan must show—*
- (a) *the direction, course, and volume of airflow; and*
- (b) *the location and description of every device used to regulate or distribute air; and*
- (c) *the measurements taken as required by Regulation 150.*

REG 203

203 Recording and notification of isolation of electricity supply

- (1) *If the supply of electricity is automatically isolated or mobile plant is shut down as required by any of Regulations 197 and 199 to 202 (except to cutters as required by Regulations 200(1)(a)(ii)), the mine operator must ensure that a record is kept of the date, time, and location of the event.*
- (2) *If the supply of electricity is automatically isolated as required by Regulation 197(b)(ii), the mine operator must ensure that WorkSafe is notified as soon as practicable.*

REG 212

212 Giving draft principal hazard management plans and principal control plans to WorkSafe

- (1) *mine operator must give the following to WorkSafe not less than 2 months before the mining operation commences:*
- (a) *all draft principal hazard management plans for the mining operation; and*
- (b) *all draft principal control plans for the mining operation.*
- (2) *Nothing in subclause (1) applies where a mining operation recommences after being suspended.*

REG 213

213 Plans of mining operation

- (1) *The mine operator must ensure that a plan is made of the mining operation as at the date of commencement of the mining operation.*
- (2) *The mine operator must ensure that the plan of the mining operation is reviewed and, if necessary, updated—*

- (a) *at least once every 3 months in relation to the parts of the plan that identify points of access, egresses, and refuges:*
 - (b) *when there has been a significant modification to the mining operation:*
 - (c) *if the mining operation has been suspended, before the mining operation recommences:*
 - (d) *otherwise, at least once every 6 months.*
- (3) *The plan, including any updated plan, must—*
- (a) *be prepared by a mine surveyor using the New Zealand Geodetic Datum 2000 and to a suitable scale; and*
 - (b) *be kept at the site office; and*
 - (c) *be available for inspection at all times at which a mine worker is present at the mining operation.*
- (4) *The mine surveyor who prepares the plan must hold a certificate of competence as a mine surveyor or, in the case of an opencast mining operation or tunnelling operation only, be a licensed cadastral surveyor.*

REG 214**214 Copy of plan of mining operation to be given to WorkSafe**

The mine operator must ensure that a copy of the plan of the mining operation is given to WorkSafe—

- (a) *as soon as practicable after the date of completion of the plan for the first time; and*
- (b) *at intervals of 12 months after that date; and*
- (c) *whenever any significant changes are made to the plan.*

REG 215**215 Copy of plan of mining operation to be available to industry health and safety representative**

The mine operator must ensure that the plan of the mining operation, including any updated plan, is made available, on request, to an industry health and safety representative.

REG 216**216 Plans of ceased mining operation**

- (1) *The mine operator must ensure that, immediately following the suspension or abandonment of the mining operation, a plan is made of the mining operation.*
- (2) *The plan must be—*
- (a) *prepared by a mine surveyor using the New Zealand Geodetic Datum 2000 and to a suitable scale; and*
 - (b) *correct as at the date of suspension or abandonment; and*
 - (c) *copied to WorkSafe.*

217 Details to be included in plans

The mine operator must ensure that the plans, including any updated plans, prepared under Regulations 213 and 216 include such details as exist of—

- (a) every explosion risk zone:
- (b) every area of an underground metalliferous mining operation or tunnelling operation where methane has been detected:
- (c) tenure boundaries:
- (d) the angle of inclination, datum level at the collar, depth, and location of every borehole or shaft:
- (e) the direction, extent, and location of every known barrier, fault, intrusive dyke, old workings, washout, water accumulation, or aquifer:
- (f) the floor levels and location of every traverse station:
- (g) the angle of dip, direction, nature, and thickness of every known coal seam:
- (h) the cross and longitudinal sections of every level and lode:
- (i) the horizontal and vertical sections of the ventilation system, including details of—
 - (i) the direction, course, and volume of air flow; and
 - (ii) the location and description of every device used to regulate or distribute air; and
 - (iii) the location of firefighting, rescue, and emergency facilities, including emergency egresses, changeover stations, refuges, and first-aid stations:
- (j) the separation distances between shafts:
- (k) the location of inrush control zones:
- (l) the location of electrical installations, including the route and voltage of all conductors (excluding trailing cables) and the position of all major switchgear:
- (m) water dams, tailing dams, and tip heads:
- (n) areas where spontaneous combustion has occurred, including sealed areas:
- (o) places where hydrocarbons and explosives are stored:
- (p) roads and other key features of the traffic management system within the mining operation:
- (q) any other identified hazards present at or close to the mining operation:
- (r) natural features surrounding the mining operation:
- (s) the location of every device that provides for oral communication between the underground parts of the mining operation and the surface:

REG 219

- (t) *an indication of every location at which it is proposed to develop the mining operation with the next 12 months.*

219 Mining operation records

- (1) *The mine operator must ensure that mining operations records—*
- (a) *are kept at the site office; and*
 - (b) *are available for inspection by a mine worker or the site senior executive at any time at which a mine worker or the site senior executive is present at the mining operation.*
- (2) *The mining operations records must consist of—*
- (a) *information about the mine operator, including the information provided in the notice given to WorkSafe under Regulation 211:*
 - (b) *information about the appointment of the site senior executive, including the person's name:*
 - (c) *all notifications and reports to WorkSafe under Regulations 211 and 227 to 229:*
 - (d) *the current and all previous plans of the mining operation:*
 - (e) *plans of any abandoned mining operation above, below, or within 200 metres of the boundary of the mining operation, including where any part of an abandoned mining operation is above, below, or within 200 metres of the boundary of the mining operation:*
 - (f) *records of the certificates of competence held by mine workers at the mining operation and any other training or qualifications they have received:*
 - (g) *records of mine workers underground:*
 - (h) *the register of accidents and incidents required under section 25 of the Act and the records kept under Regulation 226:*
 - (i) *the results of examinations performed under Regulation 222:*
 - (j) *statutory notices received from WorkSafe and the responses to those notices, including any remedial action taken as a result of those notices:*
 - (k) *the details of any inspections completed by a site health and safety representative or industry health and safety representative and any actions taken by a site health and safety representative or industry health and safety representative, including any notices issued under sections 19ZF to 19ZH of the Act.*
- (3) *A matter must be kept in the mining operation record for 7 years after the matter is included in the record.*

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220 Record of mine workers underground

The mine operator must ensure that—

- (a) no mine worker is allowed to enter the underground parts of an underground mining operation or tunnelling operation without the permission of the manager; and
- (b) an accurate record is made of every mine worker's entry into, and exit from, the underground parts of an underground mining operation or tunnelling operation; and
- (c) the record, or a copy of it, is kept at the entry point.

REG 221

221 Shift reports

- (1) The mine operator of an underground coal mining operation must ensure that—
 - (a) the underviewer of each shift at the underground coal mining operation completes a written report on—
 - (i) the current state of the workings of the mining operation and plant at the mining operation; and
 - (ii) any material matters that may affect the health and safety of mine workers arising from work done during the shift; and
 - (iii) any hazards or potential hazards identified during the shift; and
 - (iv) the controls (if any) put in place during the shift to manage those hazards; and
 - (b) the underviewer communicates the content of the written report to the underviewer of the incoming shift; and
 - (c) the content of the written report is communicated to the mine workers on the incoming shift.
- (2) The mine operator of a mining operation other than an underground coal mining operation must ensure that—
 - (a) the supervisor of each shift at the mining operation completes a written report on—
 - (i) the current state of the workings of the mining operation and plant at the mining operation; and
 - (ii) any material matters that may affect the health and safety of mine workers arising from work done during the shift; and
 - (iii) any hazards or potential hazards identified during the shift; and
 - (iv) the controls (if any) put in place during the shift to manage those hazards; and
 - (b) the supervisor communicates the content of the written report to the supervisor of the incoming shift; and

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- (c) *the content of the written report is communicated to the mine workers on the incoming shift.*
- (3) *If the content of the written report is communicated to the interviewer or supervisor of the incoming shift orally under subclause (1)(b) or (2)(b), the mine operator must ensure that the written report is made available to the interviewer or supervisor of the incoming shift during his or her shift.*
- (4) *A procedure for performing the tasks described in subclauses (1) and (2) must be included in the health and safety management system for the mining operation.*

224 Visits to solitary mine workers

The mine operator of an underground mining operation or tunnelling operation must ensure that—

- (a) *a competent person visits or contacts a mine worker required to be alone in the underground parts of the mining operation at least twice during each shift and at intervals not exceeding 4 hours; and*
- (b) *a record is kept of visits to or contact made with a mine worker as required by paragraph (a).*

REG 226

226 Register of accidents and serious harm

- (1) *The mine operator must record the particulars of the following in relation to any mine worker:*
 - (a) *every accident that harmed (or, as the case may be, might have harmed) the mine worker at the mining operation; and*
 - (b) *every occurrence of serious harm to the mine worker at work, or as a result of any hazard to which the mine worker was exposed while at the mining operation.*
- (2) *For each accident or occurrence of serious harm, the particulars described in Schedule 7 must be recorded in a register of accidents and serious harm maintained by the mine operator.*
- (3) *The mine operator must ensure that a copy of the register is provided to WorkSafe at intervals of not more than 6 months.*
- (4) *For the avoidance of doubt, a mine operator is not required, in relation to any mine worker, to maintain a separate register of accidents and serious harm under section 25(1) or (1B) of the Act.*

REG 228

228 Accident investigations

- (1) *The mine operator must ensure that—*
 - (a) *any accident at the mining operation is investigated; and*

- (b) *the investigation findings are made available to the mine workers at the mining operation.*
- (2) *If the accident is a notifiable accident, the mine operator must ensure that a report of the investigation findings is provided to WorkSafe within 30 days of the date on which the accident occurred.*
- (3) *A procedure for making findings available to workers must be included in the health and safety management system.*
- (4) *Nothing in this Regulation affects section 7(2) of the Act.*

230 Quarterly report to WorkSafe

- (1) *The mine operator must give WorkSafe the information set out in Schedule 10.*
- (2) *The information must be given every 3 months.*

10.1 Maintenance of ventilation records and plans

- (a) Records of ventilation measurements, changes, installations and data should be maintained, and be reviewed as part of the audit process.
- (b) Records of ventilation measurements should be kept for a minimum of 5 years.
- (c) Any ventilation layout change that takes place underground should be documented within 24 hours of the change taking place. The documentation should include an updated ventilation plan showing the layout change, which is signed by the ventilation officer, the mine or tunnel manager and the surveyor, acknowledging the change and that the underground ventilation plan and the Fire or Explosion Principal Hazard Management Plan and Emergency Management Principal Control Plan and their associated procedures have been updated accordingly
- (d) The ventilation plan should be reviewed quarterly by the ventilation officer, the mine or tunnel manager, and the surveyor. The plan should show air direction, Ventilation Control Devices such as doors, regulators and air crossings, and air measuring points.
- (e) Emergency Management Principal Control Plan and its associated procedures should be reviewed quarterly, or after any significant change that might affect self-rescue, or assisted rescue, out of the mine or tunnel.

The plan should clearly identify the escape routes and give estimated travel times from each section of the mine, any refuge chamber position, and any re-circulation points that could pollute the intake roadways in the event of a major fire or explosion.

The review of the plan should be carried out by the mine or tunnel manager, surveyor and the ventilation officer, to ensure that the mine or tunnel manager is completely aware of, and up to date with, the requirements of the plan in the event of an incident.

11/

REVIEW AND AUDIT

- 11.1 Review of controls
 - 11.2 Review requirements
 - 11.3 Audit requirements
-

REG 94

94 Review and revision of principal control plans

- (1) *In addition to the requirements of Regulation 58, the site senior executive must ensure that each principal control plan is reviewed at least once every 2 years after the date on which the principal control plan is approved by the site senior executive.*
- (2) *In addition to the requirements of Regulation 59, the site senior executive must ensure that a principal control plan is reviewed after:*
 - (a) *the occurrence of an accident at the mining operation involving any hazard that the principal control plan was intended to manage;*
 - (b) *a material change in the management structure at the mining operation that may affect the principal control plan;*
 - (c) *a material change in plant used or installed at the mining operation that may affect the principal control plan;*
 - (d) *the occurrence of any other event identified in a principal control plan as requiring a review of the plan.*
- (3) *In addition to the requirements of Regulation 61, the mine operator must ensure that records of all reviews and revisions of principal control plans are kept for at least 12 months from the date on which the mining operation is abandoned.*
- (4) *The mine operator must, on request, provide records relating to a review of a principal control plan to an inspector or a site health and safety representative.*

REG 95

95 Audits of principal control plans

- (1) *The mine operator must engage, and pay for, a competent person to carry out an independent external audit of all principal control plans, ensuring that—*
 - (a) *external audits are carried out once every 3 years after the date the principal control plan is approved by the site senior executive.; and*
 - (b) *the external auditors are independent of the mining operation.*
- (2) *In addition to the requirements of Regulation 61, the mine operator must ensure that results of all audits of principal control plans are kept for at least 12 months from the date on which the mining operation is abandoned.*

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11.1 Review of controls³⁵

The site senior executive should consider the following when reviewing controls:

- (a) Parameters and limitations and how they can be checked.
- (b) Verification of the effectiveness of the control.

³⁵ Ministry of Business, Innovation and Employment. (2013). Guidance for a Hazard Management System for Mines. Wellington, New Zealand. 15.

- (c) The level of maintenance required to ensure the effectiveness of the control, and whether it is included on the maintenance schedule.
- (d) The consequences if the control fails.
- (e) Training/re-training required for mine workers.
- (f) How often the control needs reviewing.
- (g) Whether the hazard for which the control is in place has changed.

11.2 Review requirements

- (a) The Ventilation Principal Control Plan should be reviewed for effectiveness:
 - (i) No later than two years after the initial Principal Control Plan is approved.
 - (ii) After each audit, if any non-conformances are identified.
 - (iii) Following an incident where ventilation is identified as a contributing factor.
 - (iv) When the ventilation system has been found to be inadequate.
 - (v) Following changes to the mine or tunnel operating system which may affect the Ventilation Principal Control Plan.
 - (vi) At least once every two years.
- (b) A full underground pressure/quantity survey should be carried out bi-annually to ensure the efficiency of the ventilation system and to highlight any changes in resistance or increased pressure drops along the mines roadway.

11.3 Audit requirements

- (a) The review of the Ventilation Principal Control Plan should be audited internally by a person or people independent of those responsible for developing and implementing the plan.
- (b) An external audit of the Ventilation Principal Control Plan should be conducted at periods not exceeding three years. The external audit should be carried out by a competent person who is independent of the mining operation and the development and implementation of the Ventilation Principal Control Plan.
- (c) Details of the above audits should be retained for the life of the mine or tunnel, and be available to a workers representative and WorkSafe NZ upon request.



A/

APPENDIX

- A1** Calculation to determine Effective Temperature
 - A2** k values for calculating airflow resistance based on roadway construction/condition
 - A3** Sample plan showing distance of ducts from face of heading in a forcing with an exhaust overlap
 - A4** Sample rules for auxiliary ventilation
 - A5** Sample auxiliary ventilation plan
 - A6** Sample mine gas chart
 - A7** Methane monitor alarm settings [from the Regulations]
 - A8** Sample plan showing layout of a forced exhaust overlap monitoring system
 - A9** Methane management
 - A10** Sample TARP for methane control
-

A1 Calculation to determine Effective Temperature³⁶

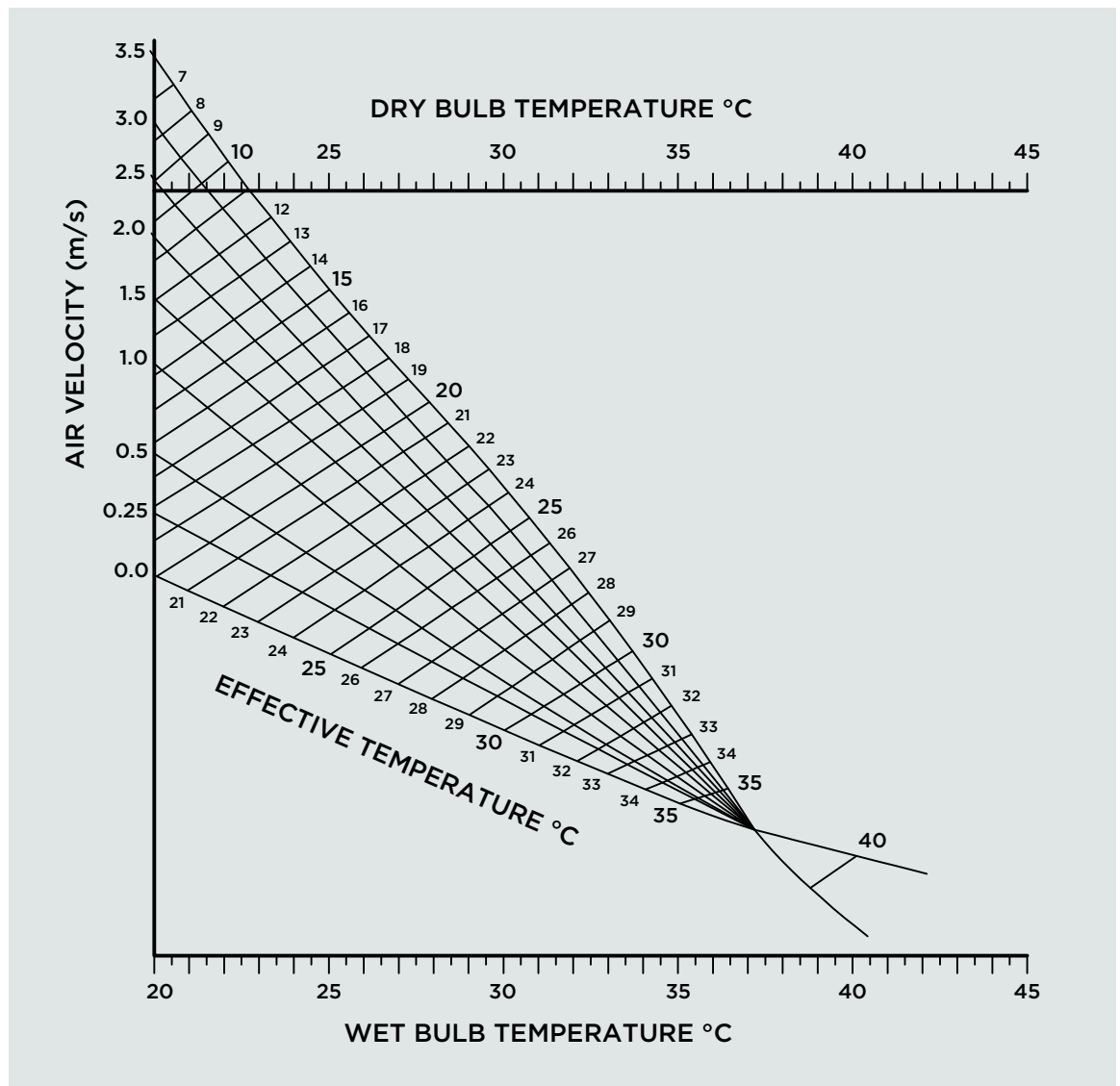


Figure 22 - Effective Temperature (ET) calculation chart

The above chart represents the relationship between the WB temperature, the DB temperature, and air velocity. It is a useful tool for calculating ET. To determine ET, the WB, DB and air velocity figures should be known.

The **DB temperature** is the temperature of the air, measured with a standard thermometer.

The **WB temperature** is measured using a thermometer, the mercury bulb of which is surrounded by a wetted gauze. The effect of the gauze is to saturate the atmosphere locally by evaporation, so the WB temperature is reduced in proportion to the dryness of the air.

³⁶ Retrieved from www.hse.gov.uk/mining/effectivetempchart.pdf

The two temperatures are usually taken simultaneously using a whirling hygrometer. If required, the relative humidity can be calculated from the two temperatures.

The **air velocity** is usually measured using an anemometer and stopwatch. Air velocity produces a wind chill factor, which lowers the apparent temperature, giving a mine worker the sensation of being exposed to a lower temperature than actually being experienced.

The chart is used by drawing a straight line between the points on the upper and lower scales corresponding to the measured DB and WB temperatures. From the point at which the line intersects the curve corresponding to the measured air velocity, the ET can be read off the ET scale.

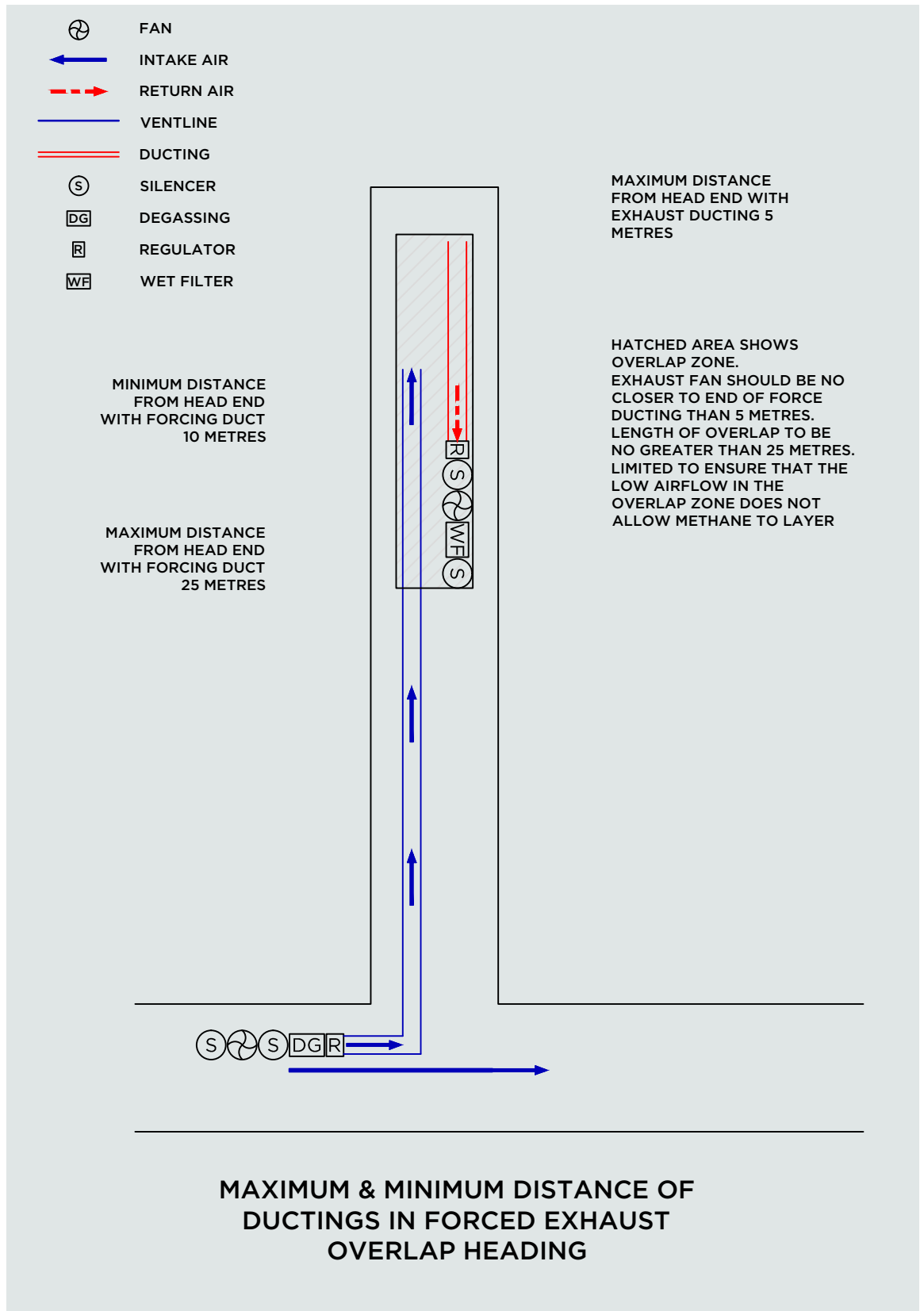
For example, the ET corresponding to 25°C WB, 29°C DB and an air velocity of 1.5 m/s is 23°C.

A2 k values for calculating airflow resistance based on roadway construction/condition³⁷

Condition of Lining				
Smooth concrete all round	Concrete slabs or timber lagging between flanges to spring	Concrete slabs, timber or bricks between flanges to spring	Lagging behind arches - good straight airways	Rough conditions with irregular roof, sides and floor
k=0.0037	k=0.0074	k=0.0093	k=0.0121	k=0.0158

³⁷ National Coal Board Mining Department. (1979). *Ventilation in coal mines. A Handbook for colliery ventilation officers.* London, England. 151.

A3 Sample plan showing distance of ducts from face of heading in a forcing with exhaust overlap



A4 Sample rules for auxiliary ventilation

<p>XXXXX HEADING</p>	<p>XXXXX MINE AUXILIARY VENTILATION RULES</p>	<p>SIGNED _____ MINE MANAGER</p> <p>DATE _____</p>
<p><u>PLAN OF AUXILIARY VENTILATION SYSTEM</u></p> <p>DETAILS OF PLANNED CHANGES WILL BE SHOWN ON ACCOMPANYING WORKING VENTILATION DEVELOPMENT PLAN</p>	<p><u>KEY</u></p> <ul style="list-style-type: none"> AUXILIARY FAN DOORS & REGULATORS STOPPINGS & FENCES INTAKE ROADWAY RETURN ROADWAY DIRECTION OF AIRFLOW MINIMUM AIR QUALITY m³/sec MAXIMUM QUALITY OF AIR TAKEN BY THE FAN FROM THE AIR CURRENT WET FILTER FREE STANDING DUST FILTER SILENCER DEGASSING DEVICE FAN REGULATOR 	<p><u>MONITORING EQUIPMENT</u></p> <ul style="list-style-type: none"> SMOKE DETECTOR CO DETECTOR AIRFLOW TRANSDUCER METHANE MONITOR HYDROCARBON MONITOR CARDOWAN <p><u>PARAMETERS</u> <u>DETECTOR</u></p> <ol style="list-style-type: none"> 1. METHANE _____ 2. TEMPERATURE _____ 3. VIBRATION _____ 4. SMOKE _____ 5. ELECTRICAL _____ 6. AIRFLOW (FAN) _____ 7. AIRFLOW (HEAD END) _____ 8. METHANE (HEAD END) _____ 9. METHOD OF INTERLOCKING _____ <p style="text-align: right;">AUTO RESTART FACILITY YES/NO</p>
<p><u>DESCRIPTION OF VENTILATION EQUIPMENT TO BE USED</u></p> <ol style="list-style-type: none"> 1. FANS _____ 2. MESH SCREEN _____ 3. NOISE CONTROL _____ 4. AIR COOLING EQUIPMENT _____ 5. DUST FILTER _____ 6. DUCTING _____ 7. DUCT SUSPENSION _____ 8. DE-GASSING EQUIPMENT _____ 9. SPECIAL PUMPS (FOR SWILLEYS) _____ 	<p><u>METHOD OF BARRIER CONSTRUCTION DURING TEMPORARY STOPPAGE OF VENTILATION</u></p> <div style="text-align: center; border: 1px solid black; padding: 10px; margin: 10px auto; width: fit-content;"> </div> <p>THERE MUST BE MATERIALS AVAILABLE AT THE ENTRANCE TO THE HEADING FOR THE CONSTRUCTION OF A BARRIER</p>	
<ol style="list-style-type: none"> 1. THE AUXILIARY FANS IN THE HEADING SHOULD NOT BE STOPPED EXCEPT IN THE EVENT OF: <ol style="list-style-type: none"> (a) EMERGENCY (b) BREAKDOWN (c) INSPECTION (d) MAINTENANCE (e) THE DRIVAGE IS NOT IN OPERATION AND ALTERNATIVE MEANS OF VENTILATION HAVE BEEN PROVIDED (f) A PLANNED SYSTEM CHANGE AUTHORISED BY THE MINE MANAGER 2. THE MINE OFFICIAL MUST INCLUDE IN THE SHIFT REPORT ALL INVOLUNTARY STOPPAGES OF THE AUXILIARY FANS, INCLUDING: <ol style="list-style-type: none"> (a) CAUSE (b) CONSEQUENCES (c) ACTIONS TAKEN TO RESTORE THE AUXILIARY VENTILATION (d) ANY ABNORMALITIES WITH THE AUXILIARY VENTILATION SYSTEM 		
<p style="text-align: center;"><u>SENIOR OFFICIAL TO BE INFORMED IMMEDIATELY</u></p> <ol style="list-style-type: none"> 1. IF THE VENTILATION OR POWER TO THE FAN IS CUT OFF FROM THE HEADING. 2. IF THE VENTILATION IS INADEQUATE AND THERE IS AN UNACCEPTABLE ACCUMULATION OF FLAMMABLE OR NOXIOUS GASES. 3. WHEN MONITORING INDICATES IN THE SURFACE CONTROL ROOM A FAULT OR FAILURE OF THE AUXILIARY VENTILATION SYSTEM. <p>THE SENIOR OFFICIAL MUST TAKE ACTION TO RESTORE THE VENTILATION TO NORMAL.</p>		
<ol style="list-style-type: none"> 1. THE MECHANICAL AND ELECTRICAL CONDITION OF ALL EQUIPMENT ASSOCIATED WITH THE VENTILATION OF THE HEADING SHOULD BE DETERMINED PRIOR TO COMMISSIONING, RE-COMMISSIONING, AND AT INTERVALS SPECIFIED IN THE MAINTENANCE PLAN. 2. THE VENTILATION OFFICER MUST INCLUDE IN THE WEEKLY AUXILIARY FAN REPORT: <ol style="list-style-type: none"> (a) THE QUANTITY OF AIR BEING DELIVERED TO THE HEAD END. (b) THE CONDITION OF THE DUCTING AND METHOD OF SUSPENSION. (c) THE CHECKS FOR RECIRCULATION OF AIR. 		
<p>NO WORK IS TO BE CARRIED OUT IN THE HEADING WHEN THE FAN OR FANS ARE STOPPED AND NO ALTERNATIVE VENTILATION IS PROVIDED (EXCEPT TO RESTORE THE VENTILATION).</p>		

A5 Sample auxiliary ventilation plan

This plan is specific for each of the headings required to be ventilated and should be displayed at the entrance for all mine workers to see and understand. The plan should show:

- 1 Identification of the heading by name or number.
- 2 A diagram showing the drivage ventilation system and any environmental monitoring required for that heading to work.
- 3 A written description of the ventilation system to be used.
- 4 A procedure outlining that the fan should be kept running at all times unless there is an emergency, breakdown or interruption. The underviewer should ensure that they report on their shift report if the fan is stopped or interrupted to ensure continuous ventilation in the heading.
- 5 The procedure should include diagrams that show how to seal the heading, either permanently, temporary or showing the arrangement to prevent mine workers entering into the heading when the fan is stopped.
- 6 There should be a procedure for informing the senior official at the mine if:
 - (a) Ventilation or power to the fan is cut off from the heading.
 - (b) Ventilation is inadequate and an unacceptable accumulation of flammable or noxious gas has occurred.
- 7 When the monitoring of the fan indicates a fault or failure at the surface or underground:
 - (a) The senior official should take action to restore the ventilation to normal. They should first assess the risk to any other production place. They should inform the mine or tunnel manager and write a full report of such incidents.
 - (b) The fan should be commissioned before electrical power is introduced to the heading or any mineral is mined. The commissioning should be carried out as a team consisting of the ventilation officer, a mechanical engineer and an electrical engineer. The commissioning document should be entered onto the mine scheme for maintenance of the mine.
 - (c) The fan quantity at the inbye end and outbye end of the ducting should be measured on a weekly basis by a competent mine worker and those figures recorded in a report for mine officials.

A6 Sample mine gas chart³⁸

Symbol	Legal Limits	Detection Method	Relative Density	Flammable and Explosive limits	Physical properties	Occurrence in mines	Effect on People
Hydrogen H ₂	None	GC	0.07	4 - 74% explosive range ignition temperature 580-590°C	Colourless Odourless Tasteless Non-toxic	Mine fires and explosions Battery charging Spontaneous combustion	Will not support life but no effect as long as enough oxygen present
Methane CH ₄	1.25% - Electricity off, shoftiring ceases, diesels prohibited 2% Men withdrawn from the area	Electronic TBS GC	0.55	0 - 5% will burn at source of ignition with intensity of flame increasing as level of CH ₄ increases 5 - 15% explosive range 15 - 100% - will burn and become explosive on dilution with oxygen 7.5% - most easily ignited 9.5% - most explosive 600 - 750°C ignition temperature	Non-toxic	Methane is liberated through newly won coal, outbursts, blowers, and is found in cavities, behind seals, in unventilated headings, layering and open goafs	Slight anaesthetic effect Will not support life and has ill no effect as long as enough oxygen is present
Nitrogen N ₂	None	GC or measure all other gases - remainder is N ₂	0.97	Non - flammable (inert)	Colourless Odourless Tasteless Non-toxic	79% by volume in normal air	Will not support life but no effect as long as enough oxygen present
Carbon Monoxide CO	TWA 25ppm Ceiling 400ppm STEL 50ppm = 60min 100ppm = 30min 200ppm = 15min Only once per day	TBS CRT GC	0.97	12.5% - 74% Explosive range and has an ignition temperature of 605°C 29% most explosive Burns with a blue flame to form CO ₂ Product of incomplete combustion	Odourless Tasteless Toxic	Mine fires and heatings Explosions Shoftiring Diesel exhausts	Displaces the oxygen in the blood forming carboxyhaemoglobin CO has a 30:1 preference rate over oxygen CO is cumulative in its effect
Oxygen O ₂	19% Minimum	Electronic TBS CRT GC	1.11	Accelerates combustion and increases the flammability of substances 12.5% - flaming combustion ceases 2.0% - all combustion including smouldering ceases	Colourless Odourless Tasteless Non-toxic	20.9 % by volume of normal air	16% - Breathing becomes laboured < 10% - dangerous to man
Hydrogen Sulphide H ₂ S	TWA 10ppm STEL 15ppm	Electronic CRT GC	1.18	4.5- 45% explosive range Burns to form SO ₂	Colourless Rotten egg smell Sweet taste Soluble in water Toxic	Decomposition or rotting of animal or vegetable matter containing sulphur, Shoftiring in high sulphur coal Forms in stagnant water	Deadens the sense of smell Irritates eyes and respiratory tract Narcotic effect on the central nervous system
Carbon Dioxide CO ₂	TWA 0.5% STEL 3.0%	Electronic TBS CRT GC	1.53	Non - flammable Product of complete combustion	Colourless Pungent smell Soda water taste Soluble in water Non-toxic except in high concentrations	Oxidisation of coal, breathing of persons, shoftiring, diesel exhaust In some coal seams it is an outburst gas	Will not support life Asphyxiation due to the lack of oxygen Increased respiratory rate by 50% @ 2% CO ₂ and 100% @ 3% CO ₂
Nitrogen Dioxide NO ₂	TWA 3ppm STEL 5ppm	Electronic CRT GC	1.6	Non - flammable	Reddish/brown colour Acid smell Acid taste Soluble in water forming nitric acid Toxic	Diesel exhausts Shoftiring using nitro-glycerine based explosives	Irritates eyes and respiratory tract Causing violent coughing Delayed bronchitis and pneumonia develops. Low concentrations (4ppm) will anaesthetise the nose.
Sulphur Dioxide SO ₂	TWA 2ppm STEL 5ppm	Electronic CRT GC	2.26	Non - flammable	Colourless Sulphur smell Acid taste Soluble in water forming sulphuric acid Toxic	Burning of high sulphur coal and rubber Diesel exhausts	Irritates eyes and respiratory tract Causing violent coughing Delayed bronchitis and pneumonia develops

KEY: Electronic = Hand held detectors and telemetric systems GC = Gas Chromatography CRT = Chemical Reaction Tube TBS = Tube Bundle System

³⁸ Supplied by New Zealand Mine Rescue Service

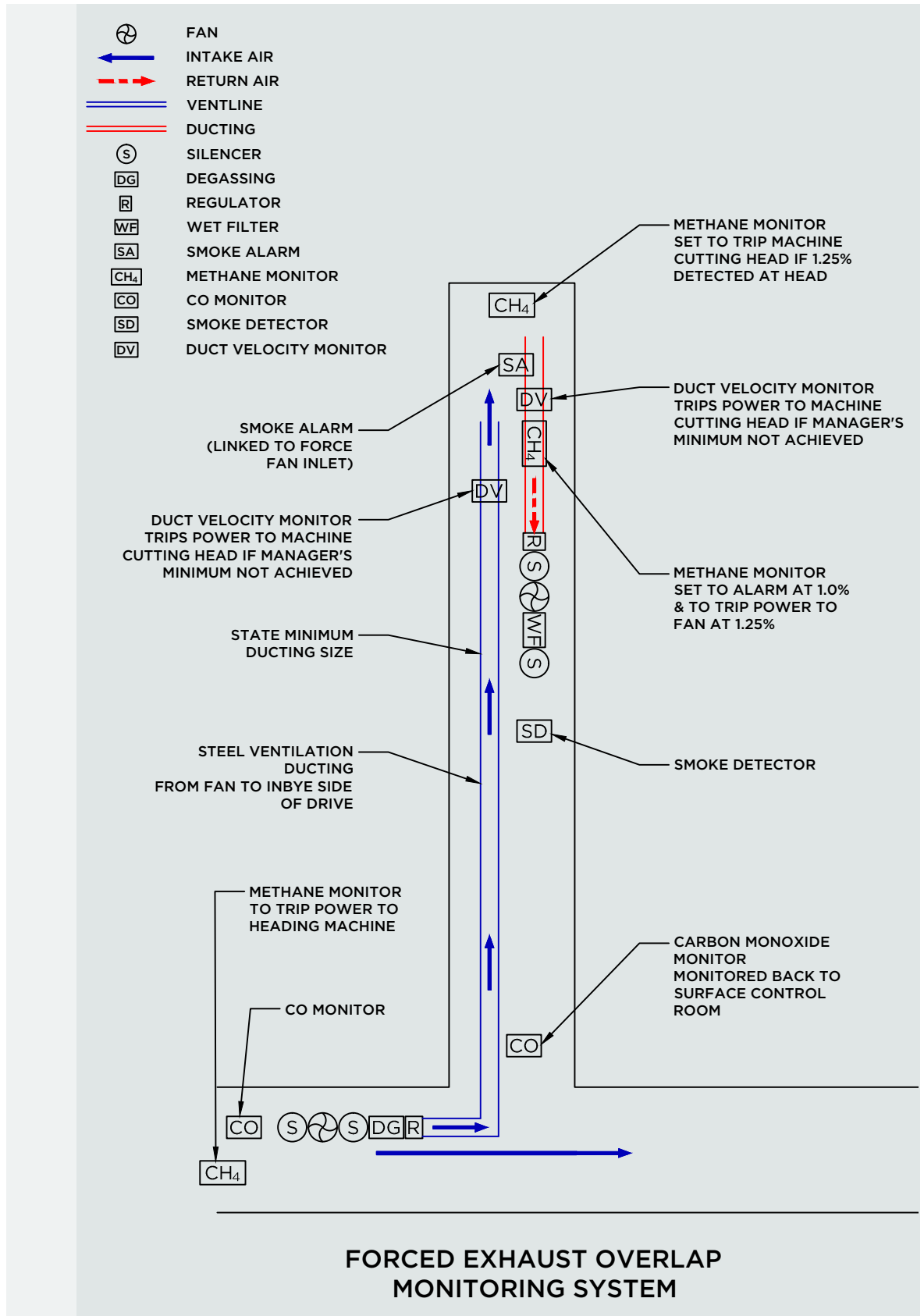
A7 Methane monitor alarm settings [from the Regulations]

Methane level %	Where	Indicates/Required Action	Reg No
≤ 0.25	Anywhere	Definition of fresh air	4
≤ 0.25	Must have fresh air at commencement of ERZ1	Requirement	153(c)(i)
≥ 0.25	Between NERZ and ERZ1	Automatically activate a visible alarm.	197(b)(i)
≥ 0.5	In a NERZ	Isolate the supply of electricity underground except to safety-critical equipment.	100(3)(d)(i)(A)
≥ 0.5	At the boundary between a NERZ and ERZ1	Automatically isolate the supply of electricity to all plant, except safety-critical equipment, in the ERZ1 and NERZ; or, if the NERZ has been subdivided, in the ERZ1 and the subdivided part of the NERZ adjacent to the ERZ1.	197(b)(ii)
≥ 1.0	General body of air around mobile plant in an ERZ1 powered by a battery or diesel engine	Visible alarm to warn operators of the mobile plant.	199(1)(a)
≥ 1.0	General body of air around mobile plant powered by electricity through trailing or reeling cable	Visible alarm to warn operators of the mobile plant.	200(1)(a)(i) and 200(2)(a) and 201(2)
≥ 1.0	General body of air around cutting plant powered by electricity through trailing or reeling cable	Automatically isolates the electricity supply to the cutters	200(1)(a)(ii)
≥ 1.25	General body of air around mobile plant in an ERZ1 powered by a battery or diesel engine	Automatically shut down the mobile plant, and in the case of diesel engines automatically prevent a restart.	199(1)(b)
≥ 1.25	General body of air around mobile plant powered by electricity through trailing or reeling cable	Automatically isolate the supply of electricity to the trailing or reeling cable supplying the mobile plant.	200(1)(b) and 200(2)(b) and 201(2)
≥ 1.25	General body of air around an auxiliary fan	Automatically isolate the supply of electricity to the fan	202(1)(a)
≥ 1.25	General body of air around a booster fan	Automatically activate an audible and visible alarm	202(1)(b)
≥ 1.25	In an ERZ1	Isolate the supply of electricity underground except to safety-critical equipment	100(3)(d)(i)(B)
≤ 2.0	Where a mine worker is or may be present	Maximum per cent in the general body of air	153(a)
≥ 2.0	An affected part or parts of the mining operation	Withdrawal of all workers in the affected area	164(2)(a)

Green = no action required **Orange** = alarm **Red** = action required

NOTE: This table is a summary of the requirements. Refer to the full regulations for complete regulatory requirements.

A8 Sample plan showing layout of a forced exhaust overlap monitoring system



- FAN
- INTAKE AIR
- RETURN AIR
- VENTLINE
- DUCTING
- SILENCER
- DEGASSING
- REGULATOR
- WET FILTER
- SMOKE ALARM
- METHANE MONITOR
- CO MONITOR
- SMOKE DETECTOR
- DUCT VELOCITY MONITOR

METHANE MONITOR SET TO TRIP MACHINE CUTTING HEAD IF 1.25% DETECTED AT HEAD

DUCT VELOCITY MONITOR TRIPS POWER TO MACHINE CUTTING HEAD IF MANAGER'S MINIMUM NOT ACHIEVED

METHANE MONITOR SET TO ALARM AT 1.0% & TO TRIP POWER TO FAN AT 1.25%

SMOKE ALARM (LINKED TO FORCE FAN INLET)

DUCT VELOCITY MONITOR TRIPS POWER TO MACHINE CUTTING HEAD IF MANAGER'S MINIMUM NOT ACHIEVED

STATE MINIMUM DUCTING SIZE

STEEL VENTILATION DUCTING FROM FAN TO INBYE SIDE OF DRIVE

SMOKE DETECTOR

METHANE MONITOR TO TRIP POWER TO HEADING MACHINE

CO MONITOR

CARBON MONOXIDE MONITOR MONITORED BACK TO SURFACE CONTROL ROOM

A9 Methane management

This appendix provides guidance on techniques for the management of methane in an underground coal mine. The techniques outlined may have particular application for hydro mining or longwall operations in New Zealand.

1. Introduction³⁹

Methane gas occurs naturally in coal mines and is a natural by-product of mining. In the history of coal mining, methane explosions have caused more loss of life than any other factor.

Increases in coal extraction rates often result in higher rates of methane emissions. But sustainable coal production should not be limited by a mine's inability to prevent gas concentrations from exceeding statutory safe limits, or be compromised by uncontrolled gas-related incidents that endanger life. The installation of an effective gas drainage system will help to ensure that the mine meets production targets safely.

2. Methane gas

Coal seam gases typically consist of 80-95% methane, with lower proportions of other gases, including carbon dioxide and nitrogen.

Methane and other gases stored in the coal seam and the surrounding rock can be released if they are disturbed by mining activity. The amount of gas and the rate of release or emission depend on several factors including the initial gas content of the coal, the distribution and thickness of the coal seams, the strength of the surrounding rock, the geometry of the mine workings, the rate of coal production and the permeability of the seam. The total gas flow varies proportionally to how much mining activity disturbs the surrounding rock and coal seam.

Coal seam gases become flammable and potentially explosive only when mixed with air. Methane is flammable when mixed with oxygen in a wide range of concentrations, but generally between 5-15% methane in air by volume. Gas released from mining activity inevitably mixes with the mine's ventilation air, is diluted and passes through the flammable range. It is therefore critical that methane concentrations in the flammable range are limited in time and location as much as possible to reduce the potential for exposure to ignition sources and the risk of explosion.

Concentrated methane tends to collect in roof cavities and layer along roofs of airways or working faces because it is buoyant and rises in air. In level and ascentionally ventilated airways with inadequate airflow, the layer will stream along the roof in the direction of airflow, increasing in thickness and decreasing in concentration as it spreads. Multiple feeders of gas will tend to maintain the concentration at a high level close to the roof.

³⁹ Royal Commission on the Pike River Coal Mine Tragedy. (2012). Volume 2: Part 1 - What happened at Pike River. Wellington, New Zealand. 9(1-330). 112-115.

Layering extends the area where an ignition of methane can occur and acts as a fuse along which a flame can propagate. There is a risk of ignition of much larger accumulations of gas in roof cavities and goaf areas.

It is critical to reduce the risk of explosion by preventing explosive mixtures occurring wherever possible, and ensuring separation from potential ignition sources. It is essential to dilute high-purity methane by ventilation air to safe general body concentrations at the points of gas emission. This requires a well-designed ventilation system and knowledge of the seam's gas emission characteristics. Capturing high-purity gas in drainage boreholes at its source before it can enter mine airways, and removing it from the mine, is another way to minimise the risks of a methane explosion.

3. Gas emission characteristics

Peak flows of gas occur in a mine's return airways during the coal production cycle and following roof caving. This is particularly the case with hydro mining, which is designed to quickly extract large quantities of coal from thick seams.

The volume of gas released from any coal disturbed by mining decreases over time, while continued mining activity adds new gas sources. When mining activity stops, gas continues to desorb from the coal seam and flow from rider seams and surrounding rock, but at a declining rate. Coal seams above and below the working seam may release methane that will migrate through the relaxed surrounding rock into the goaf. Unless methane drainage is carried out, this methane will also be released into the mine ventilation system.

When assessing gas flows and ventilation requirements, mine operators assume steady state coal production and uniform predictable gas emission characteristics. Although this approach suits most planning needs, other factors such as outburst and sudden emissions of gas from the floor create safety hazards and are not easily predicted.

Outburst is the sudden ejection of gas, coal and sometimes rock from a solid coal face into mine workings. Outburst hazards include asphyxiation, burial and impact injuries, and damage to mine equipment and systems. Outburst is a risk in certain mining situations where coal seams have a high gas content and low permeability. Structures in the coal seam, such as faulting, may increase the potential for outburst where they change gas migration or the gas drainage characteristics of the coal. Assessing the outburst risk for a coal seam requires collection, testing and analysis of gas data from core samples, and relating the results to other coal seams where outbursts have occurred.

The use of this data for safety planning cannot be overstated. Management of the hazard typically involves pre-draining the coal before mining begins to reduce its methane content to below an identified critical gas content amount (m³/tonne).

4. Pre-drainage

Pre-drainage of gas ahead of mining is done by drilling boreholes into the coal seam. Drilling can occur from the surface or within the seam from underground drill rigs.

Horizontal in-seam drilling for pre-drainage involves the drilling of boreholes from underground roadways into future mining areas. Moderate to high natural coal seam permeability is required to ensure significant decay of gas content over a reasonable period of time. A standpipe is installed at the collar of the borehole and connected to a pipeline that removes the captured gas from the area. Problems with this method can include high water emissions pressurising the pipeline, borehole instability and directional control of drilling. Additional hazards are created if actively draining boreholes are later intersected by mining operations.

Coal permeability directly affects the time needed to drain gas to the required average gas content value. The lower the coal's permeability, the more time is necessary. The ultimate feasibility of pre-drainage depends on the available time for degassing the coal before mining and the cost of the drilling operation.

Modern directional in-seam drilling techniques and patterns can maximise the amount of gas removed from the seam. Patterns designed for pre-drainage purposes typically involve multiple boreholes about 20–30m apart drilled from one location in a fan, or parallel, orientation, and in a formation to ensure minimal intersection by future mine workings. Boreholes are designed to target the gas and drain the coal, with a sufficient lead time, typically more than six months, before there is intersection by mining.

The flow rate of gas from a gas drainage borehole will vary with time. High initial flow occurs from the expansion and desorption of gas in the immediate vicinity of the hole. This may diminish fairly rapidly but then increase again as the surrounding rock is dewatered, which increases the relative permeability of the coal and also the flow of gas. This in turn is followed by further decay as the area of influence is depleted of gas. Structures in the surrounding rock, including faulting, can also affect gas emission and flow rates.

From a strictly regulatory perspective, only enough gas needs to be captured to ensure that a mine's ventilation system can adequately dilute the methane to a level below the permitted maximum. However, methane drainage also affects productivity, since the capacity of the ventilation system and the efficiency of a mine's methane drainage system will determine the maximum rate of coal extraction.

Introducing a gas drainage system, or increasing its effectiveness, is often cheaper than increasing ventilation air volumes. Investment in good practice gas drainage systems therefore results in less downtime from gas emission problems, a safer mining environment and the opportunity to reduce emissions and use more gas, which may have financial benefits under emissions trading schemes.

5. The need for gas data

Pre-planning of methane drainage is critical, and the design of gas drainage and ventilation systems to ensure safe mining requires knowledge of the amount of gas adsorbed in the coal (the gas content). Coal seam methane contents typically range from trace levels up to around 30 m³/t.

To assess gas content, core samples are taken from the coal seam, sealed in canisters in as fresh a state as possible, and maintained at near reservoir temperature while gas is allowed to desorb. The measured release rate allows estimation of the quantity of gas lost before sampling, and the gas remaining in the coal is also measured by crushing the coal and measuring the amount released. An overall gas content assessment can then be made. The composition of the gas can also be established by chemical analysis.

6. Methane drainage⁴⁰

6.1 Design of a gas drainage system

The design of a methane drainage system should reflect the maximum expected gas flows from all sources in the mine. The system should ensure that gas in the drainage pipeline is not diluted to less than 30% methane in air, safely above the explosive range. That requires quality borehole sealing, including proper installation of standpipes, the systematic regulation of individual boreholes and suction pressure from the surface to assist with the flow of gas from the holes and through the pipeline, if assistance is required. Water also needs to be controlled in the system to prevent pressure build-ups.

Underground drainage pipe systems are vulnerable to damage from mining equipment, blasting activities, surrounding rock movement and roof collapse. The drainage system should be designed to minimise these risks.

6.2 Monitoring of drainage systems

Gas drainage systems require continuous monitoring and management to determine effectiveness and performance. Mixture, gas flow and concentration, gauge pressure and temperature should all be monitored, with measurements made of individual boreholes, the gas drainage pipework and at the surface. Changes in barometric pressure affect gas flows and should also be recorded to assist in standardisation of flow data. The data obtained from monitoring these parameters is essential for safety planning.

Modelling of gas emissions can provide predictive information on the effects of increased coal production rates on gas flows. Modelling can also forecast the maximum controllable gas flow and the associated maximum coal production rate, depending upon methane limits and ventilation quantities.

6.3 Boreholes

Before any holes are drilled for the tapping and draining of methane, the mine manager should ensure that there is a pipe available for the collection and conveying of methane to a point where it can be safely discharged. Drilling should be undertaken using a 'device' that allows for boreholes to be sealed in the event of a sudden flow of methane from the hole.

⁴⁰ Health and Safety Executive (HSE). (1979). *The Law Relating to Safety and Health in Mines and Quarries. Part 2. Section A*. London, England: Department of Trade and Industry. A118.

Before any borehole is drilled in stone, water should be flowing through the drill rods, and should continue to flow while drilling is taking place. Water should also be flowing out of the mouth of the borehole while the drill rods are rotating.

Monitoring should be in place at each borehole to measure the percentage by volume of inflammable gas in the gaseous mixture flowing through the borehole.

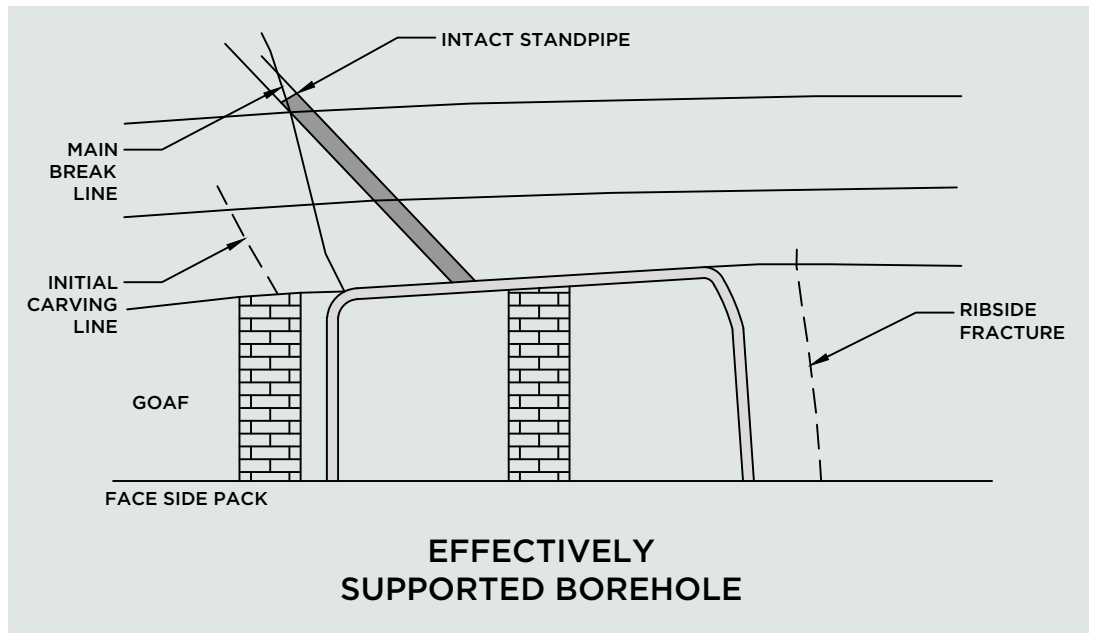


Figure 23 - Methane drainage effectively supported borehole

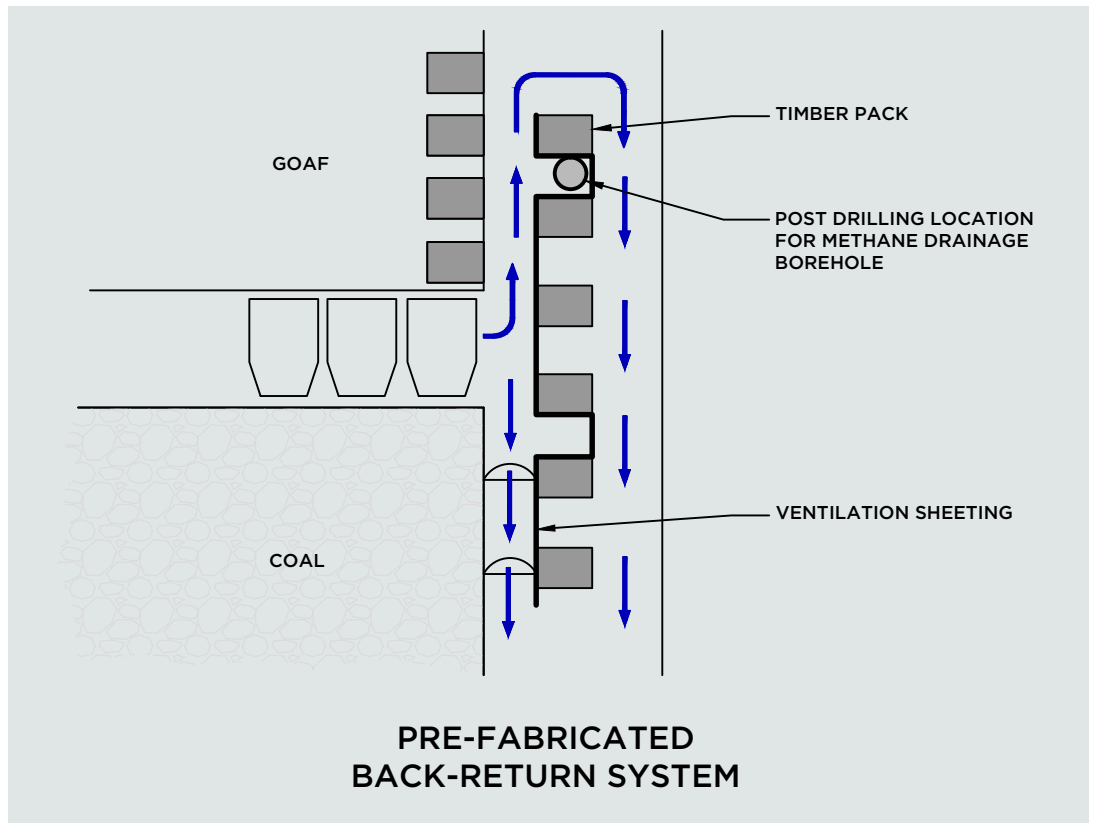


Figure 24 - Methane drainage pre-fabricated back-return system

6.4 Methane drilling

Example of general requirements:

Rig type	Edeco R.S. Triple Ram rig
Length of drill rod	762 mm (2' 6")
Diameter of standpipe	75 mm (3")
Diameter of drill bit:	
Standpipe Stage	115 mm (3")
Production length	76 mm
Length of standpipe	762 mm (2' 6")
Size of gate range	2 x 354 mm (14") i/b 300m of ranges 10"
Size of main ranges	350 mm (14") and 400 mm (16")

- (a) An automatic methane detector will be carried by the methane drillers and hung in a position so that it is visible to them whilst drilling.
- (b) Water will be applied at all times whilst the drill bit is rotating.
- (c) Once the standpipes have been inserted a stuffing box should be used.
- (d) Each hole should be coupled on to the range either by using an orifice unit, or a device used to measure purity and flow, via a flexible hose tightened with Centriflex clips to the valve and the range.
- (e) All the holes should be recorded by the borers on site of the length inclination and angle of the intersections of coal seams.
- (f) Minimum suction available to the new hole should be 1.00 kPa of vacuum.
- (g) If the standpipes become fast in the hole and cannot be moved in or out:
 - (i) They should not be rotated at any time.
 - (ii) The full length of the standpipe should be inserted in order to minimise the effect of having to drill again.
 - (iii) It is not acceptable to achieve half the standpipe distance, as this has proved to be an ineffective borehole. The minimum length to be bored is 60 feet or 18 metres. Failure to achieve this length could result in boring another hole.

6.5 Stand pipes

- (a) Each stand pipe forming part of a methane drainage system should be securely inserted and sealed in the borehole so that leakage of methane or air around the pipe is minimised; and
- (b) No stand pipe should be joined to a pipe range other than by a flexible connection.

- (c) The standpipes in down holes will be sealed using cement. The cement will be poured into the borehole after the standpipes have been inserted, filling the borehole and the annulus between the standpipes and the surrounding rock. When the cement has cured, the main hole will be drilled.
- (d) Cement-sealing down hole standpipes has the added advantage of being able to resist the high gas-pressure sometimes encountered in down holes in outburst-risk coalmines.
- (e) If the downholes “make” a high outflow of water, water traps will be installed at every downhole, to prevent water entering the degassing system pipeline.

6.6 Pipe ranges

- (a) No pipe range forming part of a methane drainage system should be installed in any shaft or outlet through which air enters the mine; and
- (b) Each pipe range installed should be:
 - (i) Designed and constructed so that samples of the methane flowing through it can be taken and water can be drained from it at intervals along its length;
 - (ii) Adequately supported; and
 - (iii) Painted with a yellow band near every joint in the pipe range.

No pipe should be connected to any pipe range through which methane is flowing, unless it is securely connected in a way that minimises the amount of air drawn into the pipe range.

6.7 Valves

Each valve in a methane drainage system should be painted yellow.

6.8 Exhausters

- (a) No exhauster should be installed in any methane drainage system unless:
 - (i) It is of a type and description approved for use in underground coal mines and designed for the control of methane.
 - (ii) It is constructed and installed so that when it is not working, methane will not be able to flow through it in the reverse direction to that in which it would flow if the exhauster was working.
 - (iii) It and the system are arranged so that when the exhauster is not working, methane will by-pass the exhauster and be allowed to flow freely through the methane drainage system.
- (b) An exhauster should not be used to pump methane unless it is earthed.
- (c) An exhauster should not be installed on the surface unless it is housed in a suitably constructed building used exclusively for the purpose.

- (d) The building where the exhauster is housed should not have any electrical apparatus installed in it unless the equipment is deemed safety critical or flameproof to the same standard as equipment deemed suitable for ERZ1.
- (e) No mine worker should take into or use in the building where the exhauster is housed any light or naked flame, or equipment not identified as being safe to operate inside the building.

6.9 Design requirements

To determine the design parameters for the degassing system a set of calculations that take into account seams and gas horizons are required even when the thickness of such horizons is small (ie less than 200 mm). It is acceptable to group together several small seams provided that the separations are small (ie less than 5 m).

The calculations use an assumed value for the following parameters:

- (a) Age of the workings. The relaxed zones above and below the workings develop over time from the time production commences. The calculation assumes an age of 50 weeks to model the representative gas emission conditions from within a fully-developed relaxed zone. In practice gas emissions usually continue to increase slightly throughout the workings' life as the goaf area increases.
- (b) Since the change of rate of gas emission with depth of burial is not known a depth of 600 m is used in the calculation. The sensitivity in this parameter is less than some others, for example gas content, and therefore can be regarded as a constant.
- (c) The degree of emission from adjacent gas horizons related to their distance from the working seam is derived from the theoretical emission equations published by Airey. For convenience the emission factors are presented in a table at 5 m intervals.
- (d) Inherent gas content. It is known that in some cases the inherent gas content is less than the published figure because of anomalies in the method of determination. If gas contents are not known for the adjacent seams, a gas content gradient is applied.
- (e) Residual gas content. It is acceptable to assume that 60% of the inherent gas is emitted either whilst the coal is being mined or while the coal is travelling along the conveyor.
- (f) Roof and floor coal. Any part of the working seam that is not mined, but instead is allowed to pass into the goaf is assumed to release all its inherent gas into the goaf area.
- (g) Extracted thickness. The effect on adjacent seams is greater for workings extracting a greater thickness of coal.

- (h) Relative thickness. The ratio of adjacent seam thickness to working seam thickness. The adjacent seam thickness is the clean coal thickness after removal of any dirt bands
- (i) Workings weekly advance. This rate has an effect on gas emission rate and is calculated from the workings dimensions and mean coal production rate.

6.10 Calculation of pipe range diameter

- (a) Assuming that the drainage requires to capture = 800 l/s pure at 50% purity
- (b) The total mixed flow in that range would be = 1,600 l/s
- (c) Say that the pipe length is 1,500 metres long
- (d) Minimum suction at inbye end = 5 kPa
- (e) Minimum outbye end suction = 20 kPa
- (f) Then the pipe range required would be 350 mm or a twin 250 mm range.

6.11 Surface plant

The methane exhauster pumps should be sited in a properly designed, constructed and maintained exhauster house and should be examined (unless any exemption has been granted) every 8 hours by a competent mine worker, appointed by the mine manager.

The mine worker should sign for the state and number of pumps running, the exhauster vacuum, the water level and/or flow, gas temperature and the methane percentage in the range. Monitoring information should be collected and sent back to surface control.

The minimum amount of surface plant monitoring is as follows:

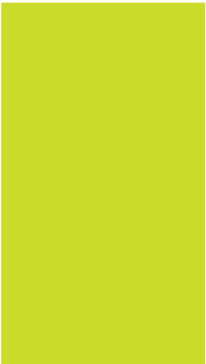
- (a) Low water flow
- (b) Bearing temperature
- (c) Methane purity trip (to trip the exhauster if less than 25% methane available)
- (d) Exhauster vacuum.

6.12 Surface exhauster plant with a remote station

Exhausters should be externally examined at intervals not exceeding 8 hours (unless an exemption is granted by WorkSafe NZ). The minimum requirement for an exemption should be:

- (a) An examination should be made following any stoppage resulting from the operation of any protective device.

- (b) In connection with designated exhausters, there should be provided a suitable place (the Control Room) which is constantly supervised by a competent mine worker appointed for that purpose by the mine manager.
- (c) Continuous systematic monitoring should be provided between the designated exhausters and the Control Room, which, in conjunction with apparatus installed at these sites, should be capable of:
 - (i) Detecting and indicating the methane (which could include ethane, propane, etc) content of the general body of air at the exhausters and giving audible and visual alarm if that content exceeds 0.25% and of automatically cutting off the power supply to all electric motors of the installation if that exceeds 0.5%.
 - (ii) Monitoring the temperature, flow and level of water in any sealing water circuit and giving audible and visual warning if any of these vary outside normal operating ranges and automatically cutting off the power supply to the motors of a designated exhauster if emergency levels set by the Manager are not maintained or exceeded.
 - (iii) Measuring the methane (which could include ethane, propane, etc) content and the inlet and outlet gas pressure in the system and giving audible and visual alarm at high and low values determined by the Manager.
 - (iv) Indicating the state of all inlet, outlet and bypass valves of the designated exhauster installation.
 - (v) Sensing and indicating any developing mechanical fault in any designated exhauster installation.
 - (vi) Indicating the state of the power supply to each of the electric motors of the designated exhauster installation. Controlling each motor with the switch gear designed to automatically cut off the supply at a current level (10%) in excess of the normal maximum and of stopping any individual motor in the installation by means which should be designated to self reveal any failure of the stop circuit.
 - (vii) Apparatus at the surface should be capable of detecting and visibly indicating any fault in the monitoring or warning system.
 - (viii) The designated exhauster should be housed in a suitably constructed building which should be so constructed, treated and maintained to render it fire resistant, as far as reasonably practicable. No flammable materials or oil immersed electrical apparatus should be used within the Exhauster House.

- 
- (ix) All methane outlets from the plant should be protected by the use of suitable flame arrestors to prevent transmission of flame into the Exhauster Plant.
 - (x) Telephone communication should be provided between the Exhauster Plant and the Control Room.
 - (xi) All apparatus intended to automatically cut off the power supply should be designated so that it can reset only at the exhauster site.

A10 Sample TARP for methane control

Document Code:	
Document Title:	Methane Control Goaf Return Road (Cab Point Readout) TARP

Level of response	Normal 0.5% – 1.0% CH ₄	Level 1 1.0% – 1.25% CH ₄	Level 2 1.25% – 2.0% CH ₄	Level 3 >2.0% CH ₄
Operators	<ul style="list-style-type: none"> > Continue production > Work to cutting plan/permit to mine 	<ul style="list-style-type: none"> > Check cutting sequence/ position > Observe gas level trend and inform Deputy 	<ul style="list-style-type: none"> > Stop production > Both primary louvers will be open > Inform supervisor and CRO 	<ul style="list-style-type: none"> > Withdraw from affected parts of the mine
Deputy	<ul style="list-style-type: none"> > Continue production > Work to cutting plan/permit to mine 	<ul style="list-style-type: none"> > Validate the readings > Check cutting sequence/ position > Investigate the root cause and identify any new controls that may be required > Check dilution points, including Dilution Regulator, and adjust as required 	<ul style="list-style-type: none"> > Check ventilation flow. If inadequate, investigate and rectify (Extraction Panel Ventilation TARP may be required) > Ensure that the manual and automatic dilution systems are operating and effective 	<ul style="list-style-type: none"> > Withdraw from affected parts of the mine

Approval

Designation	Signature	Date
Mine Manager		
Underviewer		
Ventilation Officer		

Version No:	Approved Issue Date:	Page 1 of 1
Document Owner:	IBF Component:	

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B/
APPENDIX

Statutory positions and competencies

B1 Health and Safety in Employment Act 1992

B2 Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013

Statutory positions and competencies

B1 Health and Safety in Employment Act 1992

SECTION 19L

19L Interpretation

In this Act,—

mine operator means,—

- (a) *in respect of a mining operation carried out under a permit granted under the Crown Minerals Act 1991,—*
 - (i) *the person appointed by the permit operator to manage and control the mining operation; or*
 - (ii) *the permit operator, if no such person has been appointed:*
- (b) *in respect of a mining operation (not being a mining operation described in paragraph (a)) carried out under a licence or other permission,—*
 - (i) *the person appointed to manage and control the mining operation by the person who holds the licence or other permission to carry out mining operations; or*
 - (ii) *the person who holds the licence or other permission to carry out mining operations, if no such person has been appointed:*
- (c) *in any other case,—*
 - (i) *the person appointed to manage and control the mining operation by the owner of the land where the mining operation is being carried out; or*
 - (ii) *the owner of the land where the mining operation is being carried out, if no such person has been appointed*

mine worker means a person who works in a mining operation, either as an employee or as a self-employed person

site senior executive means the person appointed as the site senior executive by the mine operator

SECTION 19M

19M Meaning of mining operation

In this Act, mining operation—

- (a) *means the extraction of coal and minerals and the place at which the extraction is carried out; and*
- (b) *includes any of the following activities and the place at which they are carried out:*
 - (i) *exploring for coal:*
 - (ii) *mining for coal or minerals:*

- (iii) *processing coal or minerals associated with a mine:*
- (iv) *producing or maintaining tailings, spoil heaps, and waste dumps:*
- (v) *the excavation, removal, handling, transport, and storage of coal, minerals, substances, contaminants, and wastes at the place where the activities described in subparagraphs (i) to (iv) are carried out:*
- (vi) *the construction, operation, maintenance, and removal of plant and buildings at the place where the activities described in subparagraphs (i) to (iv) are carried out:*
- (vii) *preparatory, maintenance, and repair activities associated with the activities described in subparagraphs (i) to (iv); and*
- (c) *includes—*
 - (i) *a tourist mining operation:*
 - (ii) *a tunnelling operation; but*
- (d) *does not include—*
 - (i) *exploring for minerals:*
 - (ii) *an alluvial mining operation:*
 - (iii) *a mining operation wholly on or under the seabed on the seaward side of the mean high-water mark:*
 - (iv) *a quarrying operation.*

B2 Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2013

Site Senior Executive

7 Appointment of site senior executive

- (1) *The mine operator of a mining operation must appoint a site senior executive for that mining operation.*
- (2) *Subject to regulation 10, a mine operator that has more than 1 mining operation may appoint a person to be the site senior executive for more than 1 mining operation.*

8 Competency requirements for appointment as site senior executive

- (1) *The mine operator and the site senior executive must ensure that the site senior executive holds a current certificate of competence as a site senior executive and any other certificate or competency required by subclause (2).*
- (2) *In addition to the requirements of subclause (1),—*
 - (a) *if appointed for an underground coal mining operation, the site senior executive must hold a current certificate of competence as—*

REG 7

REG 8

- (i) *a first-class coal mine manager; or*
- (ii) *if not more than 5 mine workers ordinarily work underground at the underground coal mining operation at any one time, a coal mine interviewer:*
- (b) *if appointed for an underground metalliferous mining operation, the site senior executive must hold a current certificate of competence as—*
 - (i) *a first class mine manager; or*
 - (ii) *if at least 3 but not more than 10 mine workers ordinarily work underground at the underground metalliferous mining operation at any one time, an A-grade tunnel manager; or*
 - (iii) *if fewer than 3 mine workers ordinarily work underground at the underground metalliferous mining operation at any one time, an A-grade tunnel manager or B-grade tunnel manager:*
- (c) *if appointed for a tunnelling operation, the site senior executive must have successfully completed any additional competencies prescribed by WorkSafe under regulation 34(d) for a site senior executive of a tunnelling operation.*
- (3) *Subclause (2)(a) does not apply during any period of time where the only activities at the mining operation are those described in regulation 16(2).*
- (4) *If there is disagreement between the mine manager and the site senior executive in relation to any operational matter at the mining operation, the manager's view prevails if the site senior executive does not hold a relevant certificate of competence as a manager or holds a lower certificate of competence than the manager (of the relevant certificates of competence in regulation 35(b) to (j) applicable to the particular type of mining operation).*
- (5) *Nothing in subclause (4) limits or affects the application of the Act to any matter arising at the mining operation.*

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

The mine operator must ensure that the site senior executive has sufficient resources and authority to perform his or her functions, duties, and powers under the Act and these regulations.

Manager**REG 13****13 Manager of mining operation**

The mine operator of a mining operation must appoint a person to—

- (a) *manage the mining operation; and*
- (b) *supervise the health and safety aspects of the mining operation on every day on which any mine worker is at work.*

REG 16

16 Manager must hold certificate

- (1) *The mine operator or, as the case may be, the quarry operator or alluvial mine operator, and the manager must ensure that the manager holds a current certificate of competence specified in regulations 17 to 22 for the kind of mining operation or quarrying operation or alluvial mining operation to which the manager is appointed.*
- (2) *Subclause (1) does not apply to—*
 - (a) *any operation in which any activity is carried out pursuant to a prospecting licence or an exploration licence granted under the Mining Act 1971 or a coal prospecting licence granted under the Coal Mines Act 1979 or a prospecting permit or an exploration permit granted under the Crown Minerals Act 1991, being in each case a licence or permit in force; or*
 - (b) *any operation in which any exploratory activity is carried out by machinery for the purpose of ascertaining whether a mine or quarry may be worked.*

Other safety-critical roles

REG 26

26 Electrical superintendent

- (1) *The site senior executive of a mining operation must appoint an electrical superintendent for the mining operation if an electrical engineering principal control plan is in place, or required to be put in place, at the mining operation.*
- (2) *The site senior executive and the person appointed as an electrical superintendent must ensure that the person holds a current certificate of competence as an electrical superintendent.*

REG 27

27 Mechanical superintendent

- (1) *The site senior executive of a mining operation must appoint a mechanical superintendent for the mining operation if a mechanical engineering control plan is in place, or required to be put in place, at the mining operation.*
- (2) *The site senior executive and the person appointed as a mechanical superintendent must ensure that the person holds a current certificate of competence as a mechanical superintendent.*

REG 28

28 Mine surveyor

- (1) *The site senior executive of an underground mining operation or tunnelling operation must appoint a mine surveyor for the operation.*
- (2) *The site senior executive and the person appointed as a mine surveyor at an underground mining operation must ensure that the person holds a current certificate of competence as a mine surveyor.*

REG 29

- (3) *The site senior executive and the person appointed as a mine surveyor at a tunnelling operation must ensure that the person holds a current certificate of competence as a mine surveyor or is a licensed cadastral surveyor.*
- (4) *In considering any appointment of a mine surveyor, the site senior executive must consider—*
 - (i) *the education, knowledge, and experience of the person, having regard to the type and size of the mining operation and the nature and complexity of the technology used at the mining operation; and*
 - (ii) *the fitness and capacity of the person to exercise the skills required as a mine surveyor.*
- (5) *Unless expressly authorised by WorkSafe, no underground mining operation or tunnelling operation may operate for longer than 28 days without a person holding the position of mine surveyor.*

29 Ventilation officer

- (1) *The site senior executive of a mining operation must appoint a ventilation officer for the mining operation if a ventilation control plan is in place, or required to be put in place, at the mining operation.*
- (2) *The site senior executive and the person appointed as a ventilation officer must ensure that the person holds a current certificate of competence as a ventilation officer.*

REG 30

30 Underviewer

- (1) *The site senior executive of an underground coal mining operation must appoint an underviewer for each production shift at the mining operation.*
- (2) *Subject to subclause (3), the site senior executive and the person appointed as an underviewer must ensure that the person holds a current certificate of competence as a first-class coal mine manager or an underviewer.*
- (3) *WorkSafe may at any time give notice to the site senior executive that the person appointed as underviewer must hold a current certificate of competence as a first-class coal mine manager.*
- (4) *The site senior executive must ensure that an underviewer is present at each production shift at the mining operation.*

REG 31

31 Supervisor

- (1) *The site senior executive of a mining operation other than an underground coal mining operation must appoint a supervisor for each production shift.*

- (2) *The site senior executive and the person appointed as a supervisor of an underground metalliferous mining operation must ensure that the person holds a certificate of competence as a B-grade tunnel manager, an A-grade tunnel manager, or a first-class mine manager.*
- (3) *The site senior executive and the person appointed as a supervisor of a tunnelling operation must ensure that the person holds a current certificate of competence as a B-grade tunnel manager or an A-grade tunnel manager.*
- (4) *The site senior executive and a person appointed as a supervisor of an opencast coal mining operation must ensure that the person holds a current certificate of competence as a B-grade opencast coal mine manager or an A-grade opencast coal mine manager.*
- (5) *The site senior executive and a person appointed as a supervisor of an opencast metalliferous mining operation must ensure that the person holds a current certificate of competence as a B-grade quarry manager, an A-grade quarry manager, or a first-class mine manager.*
- (6) *Despite subclauses (2) to (5), WorkSafe may at any time give notice to the site senior executive that the person appointed as supervisor must hold a certificate of competence of one of the kinds described in regulation 35(b) or (d) to (j).*
- (7) *The site senior executive must ensure that a supervisor is present at each production shift at the mining operation.*

32 Other workers required to hold certificates

The site senior executive of a mining operation must take all practicable steps to ensure that a worker required to carry out the duties normally associated with a coal mine deputy or a winding engine driver holds a current certificate of competence issued in accordance with these regulations.



C/
APPENDIX

- C1** Definitions
 - C2** Chemical symbols
 - C3** Standards
 - C4** References
 - C5** Further resources
-

C1 Definitions

Adsorption – the process in which atoms, ions or molecules from a substance (it could be gas, liquid or dissolved solid) adhere to a surface of the adsorbent.

Blackdamp – defined in BS 36182 as a mine atmosphere containing carbon dioxide and nitrogen in excess of the normal percentage and in which a naked flame will not burn owing to a deficiency in oxygen (16%). However, it is more usefully considered as the actual percentage of nitrogen and carbon dioxide in excess of that associated with the oxygen in the sample in the same ratio as in fresh air. The gases that can be present in mine air and cause suffocation are methane and blackdamp (which is a mixture of carbon dioxide and nitrogen).

Blind heading – a single entry roadway or tunnel with no exit.

Continuous miner – usually an electric/ hydraulic machine used to cut and load out coal in the development of roadways in coal mines.

Desorption – changing from an adsorbed state on a surface to a gaseous or liquid state, usually associated with the release of methane from coal.

Firedamp – the most commonly encountered flammable gas in coal mines. The main element of firedamp is methane but it also contains a small amount of other hydrocarbon gases, such as ethane and propane. *In this document, the term 'methane' is used in the generic sense to represent a range of highly flammable gases, mainly methane. In other publications the term 'firedamp' may be used. In the context of this document, the terms are intended as being interchangeable.*

Gas fast – a heading, district or tunnel where the concentration of methane in the general body exceeds 2%; or there is a layer of methane at a concentration greater than 5%, at least 30cm thick and at least 10m in length.

Goaf – an area of a mine where the coal or ore has been mined or extracted and no ground support has been installed.

Impellor – the revolving wheel or pumping element of a centrifugal fan or pump.

Inbye/Outbye – from any point in the mine, inbye of that location is in the direction of the working face, and outbye of that location is in the direction away from the working face, typically heading 'out of the mine'.

l/s – litres per second.

MDAs (Multi Discriminating Alarms) – used to differentiate between transient peaks caused by diesel engines and genuine increase in CO caused by fire and spontaneous combustion.

m³/s – cubic metres per second.

m/s – metres per second.

Pa or kPa – pascal or kilopascal.

Pantehnicon – generally, a large steel structure used to carry the electrical and mechanical support equipment used in the operation of a longwall operation that is linked and moves on wheels or monorails as the longwall panel is advanced or retreated.

ppm – parts per million.

Regulator – a device used to control ventilation volume in an underground operation.

Seal – a permanent structure used to seal off abandoned workings in a mine. An explosion proof seal is a double-walled construction with the cavity between the two walls filled with a cementitious material (usually gypsum). In a metalliferous mine, the term '**bulkhead**' is used to describe a seal.

Seal (Coffin) (or Mousetrap) – a device that allows a conveyor belt to pass from the intake to the return airways (or vice versa) with minimal loss of ventilation.

Stopping – a single or double walled structure constructed from blocks, bricks or sandbags, or from substantial boarding attached to tight roof supports, for the purpose of separating intake and return airways.

Stopping (Temporary) – a light structure erected from brattice cloth or boarding, which will not withstand any significant pressure difference, and which is intended to be replaced with a permanent stopping as the mining operation advances.

Swilley – a low point in a roadway, typically where water can collect.

TBM – Tunnel Boring Machine.

Wet Bulb/Dry Bulb hygrometer – a device used to determine the humidity content of the underground workings.

C2 Chemical symbols

CH₄ - Methane

CO - Carbon Monoxide

CO₂ - Carbon Dioxide

H₂ - Hydrogen

H₂S - Hydrogen Sulfide

N₂ - Nitrogen

O₂ - Oxygen

SO₂ - Sulphur Dioxide

C3 Standards

AS 4368-1996 “Mine plans – Preparation and symbols”

AS/NZS ISO 31000:2009 “Risk management – Principles and guidelines”

BS 6164:2011 “Code of Practice for health and safety in tunnelling in the construction industry”

LINZS25000 “Standard for New Zealand Geodetic Datum 2000”

MDG 1010:2011 “Minerals industry safety and health risk management guideline”

MDG 29:2008 “Guideline for the management of diesel engine pollutants in underground environments”

SA/SNZ HB 89:2013 “Risk Management – Guidelines on risk assessment techniques”

SA/SNZ HB 436:2013 “Risk Management Guidelines”

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C5 Further resources

Standards

AS 4774.1-2003 “Work in compressed air and hyperbaric facilities – Part 1: Work in tunnels, shafts and caissons”

AS/NZS 1715:2009 “Selection, use and maintenance of respiratory protective equipment”

AS/NZS 1716:2012 “Respiratory protective devices”

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