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TECHNICAL REFERENCE GUIDE

VENTILATION CONTROL PLAN

Guide for the development of a ventilation control plan for underground mines

NSW Resources Regulator

Document control

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1. Introduction

1.1. Purpose

This technical reference guide (TRG) provides mine operators with guidance on developing and documenting a Ventilation Control Plan (VCP), which mine operators are required to develop as per clause 62 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 (WHS (MPS) Regulation). Technical detail in the main body of this guide is kept to a minimum and further technical information is signposted throughout this guide. This document is relevant to both underground coal and underground metalliferous mines.

This document should be read in conjunction with:

- NSW WHS Acts and Regulations, including WHS (MPS) Act and Regulation
- NSW codes of practice:
  - Work health and safety consultation, cooperation and coordination (August 2019),
  - How to manage work health and safety risks (August 2019),
  - Safety management systems in mines (February 2015).
- NSW Resources Regulator guidance material, for example:
  - Guide - Preparing a principal hazard management plan (January 2020)
  - Guide – Airborne contaminants principal hazard management plan (July 2018)
- Australian and International Standards in related fields, for example:
  - AS ISO 31000: 2018 Risk Management — Guidelines
  - AS/NZ ISO 45000: 2018 Occupational Health and Safety Management Systems – Requirements with guidance for use.

The requirements for the contents of any VCP are clearly outlined in clause 62(3) of the WHS (MPS) Regulation. This TRG seeks to provide further clarity around what some – though not all – of those provisions require of the mine operator. Some provisions are explicit and clear, for example clause 62(3)(n) requires the VCP to provide a description of *starting procedures for fans*, while clause 62(3)(j) requires the VCP to describe *how close ventilation ducting and brattice lines must be to any face*. Other

provisions require far more detail and consideration, for example the VCP must describe, if applicable to the mine, *the design and operation of the ventilation system, including the standards applying to the placement, operation, maintenance and monitoring of ventilation plant.* It is these provisions that this TRG seeks to provide greater clarity.

Any VCP must be developed with reference to clause 62 of the WHS (MPS) Regulation and not this TRG alone. The VCP also must sit within the overall Safety Management System (SMS) as required by clause 14(1)(c)(iii) of the WHS (MPS) Regulation.

1.2. Glossary and Acronyms

AS:	Australian Standard
Bulkhead:	A bulkhead is usually a solid structure built across a drive or opening that would seal the drive or opening from the effects of an airblast or mitigate the effects of such an airblast from the rest of the mine. A bulkhead can also be known as a stopping or plug. A bulkhead is also used to mitigate the effects of water bodies in underground mines.
CCM:	Critical Control Management
DBR:	Drop Board Regulator
Hazardous Zone:	*At an underground metalliferous mine*, means (for the purposes of this TRG) that area of a mine where conservative application of experience and/or predictive modelling identifies that airblast has the potential to cause injury to persons, damage equipment or seriously disrupt ventilation. At an *underground coal mine*, see definition in clause 3 of the WHS (MPS) Regulation.
ICMM:	International Council on Mining & Metals
ISHR:	Industry Safety and Health Representative
ISO:	The International Organisation for Standardisation
Must:	Indicates that legal requirements exist and must be complied with.
PCBU:	Person Conducting A Business or Undertaking
PCP:	Principal Control Plans
PHMP:	Principal Hazard Management Plan
PPE:	Personal Protective Equipment

QAQC:	Quality Assurance Quality Control
Should:	Indicates a recommended course of action ***Note**: Deviations from recommendations should be provided with a respective management control, shown to provide the same level of safety outcome.*
SMS:	Safety Management System
SSHR:	Site Safety and Health representative
TARPs:	Trigger Action Response Plans
VCD:	Ventilation Control Device
VCP:	Ventilation Control Plan
Ventilation Seal:	Engineered wall used as a VCD in coal mines
Ventilation Bulkhead:	Engineered wall used as a VCD in coal mines
WHS:	Work Health and Safety

1.3. Scope

This guide is for the development of a mine's VCP including how the VCP interacts with other plans to manage other relevant hazards such as gas management, gas inrush, fire and explosion, emergency management, dust and airborne contaminants and heat. It also provides some technical detail around conducting ventilation surveys. It is not exhaustive guidance and mine operators will need to consider additional reference material in the management of their mine's ventilation requirements. This guide is limited to underground mines. It is not intended to be used for the management of ventilation in any other context (e.g. surface mines, confined spaces).

1.4. Application

This guide is for all underground coal and underground metalliferous operations. It is to be used in conjunction with the mine's existing risk assessment and document management practices.

***Note**: Some of the terminology used throughout this guide may be more applicable to either coal or metalliferous operations. However, the principles underlying the guidance remain relevant and applicable to both sectors.*

1.5. Interaction with the safety management system

The VCP is a principal control plan that must be integrated within a mine operator's SMS. Workers must receive training in the elements of the SMS that are relevant to them. This includes the VCP. All mine

workers should have a working understanding of the VCP and comply with its requirements. The VCP needs to be designed to integrate with the airborne contaminants and heat management plans, as ventilation performs a critical role in managing these hazards on a day to day basis. The mine operator is required to consider, not just the principal hazard, but how the principal hazard interacts with other hazards as per clause 24(3)(b) of the WHS (MPS) Regulation. Further details regarding this can be found in the NSW Resources Regulator's *Guide – Preparing a principal hazard management plan*.

The SMS needs to reference, where appropriate, the relevant documents to satisfy clause 24(3)(b) of the WHS (MPS) Regulation.

For more information about SMSs see the Safety Management Systems in Mines' Code of Practice (2015)[1].

1.6. Consultation

When managing risks, the mine operator must consult with workers and other duty holders at the mine as per clause 121 of the WHS (MPS) Regulation. This includes other persons conducting a business or undertaking (PCBUs) such as contractors. Details are found in the *Guide – Preparing a principal hazard management plan* (section 3.4). Further guidance on consultation, cooperation and coordination can be found in the:

- NSW code of practice: Work health and safety consultation, cooperation and coordination (August, 2019), published by SafeWork NSW
- contractors and other businesses at mines and petroleum sites guide
- consulting workers fact sheet.

[1] https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0008/543941/NSW-code-of-practice-Safety-managment-systems-in-mines.pdf

2. Complying with the legislative requirements

2.1. Legislative requirements

A VCP must be developed by the mine operator, as per clause 62 of the WHS (MPS) Regulation and reviewed upon any changes to the ventilation system per clause 63 of the WHS (MPS) Regulation. The VCP is a principal control plan and must sit within the overall SMS.

The mine operator has a duty to ensure a safe working environment regarding excessive heat or cold as per clause 40(f) of the Work Health and Safety Regulation 2017 (WHS Regulation) and clause 38 of the WHS (MPS) Regulation.

The VCP needs to consider other aspects of legislation, including, though not limited to:

- clause 39 of the WHS (MPS) Regulation – Management of airborne dust; alternatively: Division 4 Specific control measures – all mines and petroleum sites Subdivision 2 WHS (MPS) Regulation - Air quality and monitoring
- clause 45 of the WHS (MPS) Regulation – Management of inrush (if relevant)
- clause 50 of the WHS (MPS) Regulation – Management of the risk of dust explosion
- clauses 54,55,57 and 59 of the WHS (MPS) Regulation – Management of air quality and ventilation infrastructure; alternatively: Division 5 Specific control measures – underground mines Subdivision 2 of the WHS (MPS) Regulation - All underground mines – air quality and ventilation
- clause 60 of the WHS (MPS) Regulation – The monitoring and testing of the ventilation system
- clause 61 of the WHS (MPS) Regulation – Modelling of any changes to the ventilation system
- clause 63 of the WHS (MPS) Regulation – When the VCP is to be reviewed
- clause 64 of the WHS (MPS) Regulation – What needs to be detailed on any mine ventilation plan
- clauses 65-76 of the WHS (MPS) Regulation – Specific to coal mining regarding the management of coal dust and gas; alternatively: Division 5 Specific control measures – underground mines Subdivision 3 of the WHS (MPS) Regulation - Underground coal mines

- Division 5 Specific control measures – underground mines Subdivision 4 WHS (MPS) Regulation - All coal mines
- Division 7 of the WHS (MPS) Regulation – Duty to provide information, training and instruction to workers

The VCP forms a critical part of managing numerous principal hazards and other major hazards in an underground mine and will be referenced in control plans for all these hazards. It is therefore incumbent on the mine operator to consider these issues when developing the VCP.

In addition to this legislation, mine operators should consider the following clauses in the WHS Regulation:

- clause 36 – The duty to use the hierarchy of controls and the highest order control, where reasonably practicable
- clause 37 – Maintenance of control measures
- clause 38 – Review of control measures

2.2. Reasonably practicable

When considering the term “as far as is reasonably practicable” mines must consider clause 36 of the WHS Regulation and the requirement to use the hierarchy of controls when developing controls to manage a hazard. Aspects of legislation that relate to the development of a VCP that include the term “reasonably practicable” include:

- A PCBU must ensure, so far as is reasonably practicable, the ventilation enables workers to carry out work without risk to health and safety, or exposure to extremes of heat or cold, per clause 40(f) of the WHS Regulation and clause 38 of the WHS (MPS) Regulation
- The mine operator of an underground coal mine must determine, so far as is reasonably practicable, the location of all hazardous zones at the mine and ensure that workers are aware of those locations, and ensure that control measures are implemented in respect of each hazardous zone for the management of risks to health and safety associated with the ignition of methane at the mine, as per clause 72 of the WHS (MPS) Regulation
- Level of atmospheric contaminants are kept to as low as reasonably practicable as per clauses 54 and 72 of the WHS (MPS) Regulation.

3. Risk Management

A critical control is a control that is crucial to prevent an event, or mitigate the consequences of an event, such that its absence or failure would significantly increase the risk despite the existence of the other controls[2]. They are considered important enough to warrant additional monitoring and reporting to ensure they are implemented and maintained to high levels of effectiveness.

The critical control approach to risk management is now the process recommended by the International Council on Mining and Metals (ICMM). Ventilation is likely to be identified by mine operators as the critical control to the management of a number of hazards in underground mines.

3.1. Hazard identification

Due to the infrastructure required to install primary ventilation systems, it is incumbent on mine operators to consider ventilation at the earliest stages of the mine planning process. In the mine planning process, the mine operator should consider:

- Virgin rock temperatures – Geothermal rock temperature and how it is likely to increase heat in the mine.
- Ground water – Excess water can be added to the air, increasing humidity, restricting roadways with water accumulations, and altering pressure differentials around the mine.
- Mining fleet – All mines are to have adequate ventilation for the fleet size and type selected for the mining operation in the areas of the mine that this equipment will operate.
- Gas levels – Gases can be produced from several sources including strata, diesel exhaust, the use of explosives, battery charging, spontaneous combustion or fires. They can displace oxygen and create toxic, irrespirable or explosive atmospheres. Ventilation is critical to the dilution of gas. Adequate ventilation is required to dilute gas to below the limits prescribed in the legislation.

[2] In 2015 the International Council on Mining and Metals (ICMM) released their good practice guide “Health and Safety Critical Control Management” that described how mining and metals industries’ risk management outcomes could be improved by focussing on those controls that are most critical for health and safety. A number of subsequent ICMM documents have described the CCM framework, including the “Critical Control Management: Implementation Guide” (ICMM, 2015a) and the “Good Practice Guidance on Occupational Health Risk Assessment” (ICMM, 2015b)

- Adiabatic expansion – the process by which air expands as mining depth increases, which causes the air to increase in temperature.
- Circuit resistance – Each shaft driveway, heading, ventilation bag or brattice that is being used for primary ventilation creates resistance to the flow of air according to Atkinsons formula. This needs to be carefully considered in the planning stages so that the area of any ventilated pathway is adequate to supply the appropriate amount of air, without inducing too much resistance and that the resistance is matched by the appropriate fan type.
- Dust management – Typically any airspeed over 7 metres per second will cause dust to liberate excessively, so airspeeds in working areas need to be managed. Ventilation is also critical for removing airborne contaminants such as diesel particulates and coal dust.
- Matching Fans – The mine operator should select fans that are appropriate for the amount of air required and the resistance in the circuit.
- Mining depth – The deeper mining the more heat that will be added to the intake air due to virgin rock temperature and adiabatic expansion. Psychrometry can be used to predict air temperatures when sources of heat are known.
- Mining Method – Different mining methods have differing ventilation requirements. This should be considered when modelling any ventilation circuit.
- Geotechnical – If airways are compromised due to a fall of ground adding or reducing resistance in the circuit.
- Recirculation – Recirculation where dirty air is recirculated into other work areas and not directly ventilated out of the mine.
- Secondary/auxiliary ventilation – Secondary/auxiliary ventilation needs to be appropriately installed, and appropriately maintained
- Emergency – In the event of an emergency it is likely that mine ventilation will be affected or play an important role in the evacuation of workers. Mine operators need to consider mine ventilation in their emergency plans.
- Fan shutdown – The mine operator needs to have a system of work in place – typically in the form of a trigger action response plan.
- Mine water balance – by not maintaining the mine water balance, airways may fill with water, adding resistance to the circuit or cutting off an airway entirely.

- Monitoring – Monitoring is a major component of managing any ventilation system. Monitoring includes regular primary surveys. Sites should conduct a ventilation survey when there is a change made to the ventilation system. A risk assessment should be undertaken to determine the need for heat monitoring. Where necessary, it should occur continuously, particularly for mines with higher air temperatures. This is typically undertaken by operators and supervisors. Worker training becomes critical in the management of heat. Other monitoring systems include the monitoring of secondary ventilation for rips, tears and quality of install, monitoring of fan performance and monitoring Ventilation Control Devices (VCD)s to ensure they are performing as intended.

3.2. Risk controls

3.2.1. Hierarchy of controls

As discussed in section 2.2the mine operator must consider the hierarchy of controls (clause 36 WHS Regulation) when selecting controls for particular hazards. Mines should implement controls that are of the highest order in the hierarchy, unless it is not reasonably practicable to do so.

3.2.1.1. Elimination

Automated systems of work provide a way for workers to be removed from an area, eliminating their exposure to ventilation risks.

3.2.1.2. Substitution

As mining technologies continue to improve it is incumbent on mine operators to assess ways in which processes can be substituted for other processes. For example, airleg rising mining vs raiseboring. This reduces the risk to workers by substituting a system of work that exposes workers to a far greater ventilation hazard with one that poses a smaller ventilation hazard.

3.2.1.3. Isolation

Many of the hazards that are typically found with ventilation are managed through a mixture of isolation and the use of engineering controls. In order to isolate workers, numerous engineered structures are used. This includes:

- ventilation doors
- bulkheads

- ventilation brattice
- escapeways
- refuge chambers

Details around the construction and management of these controls is discussed further in section 3.2.2.

3.2.1.4. Engineering

Ventilation systems are primarily driven by plant and structures. This includes:

- secondary fans
- primary fans
- ventilation bags
- ventilation brattices
- VCDs
- constructed shafts, roadways and old workings
- dust suppression systems
- ventilation system design
- inertisation
- gas drainage
- overcasts, underpasses and air crossings
- ventilation seals
- ventilation bulkheads

3.2.1.5. Personal Protective Equipment

Personal Protective Equipment (PPE) to manage ventilation systems includes:

- respiratory protection equipment (RPE)
- eye protection

3.2.1.6. Administration

There are a number of important administrative controls used to manage ventilation:

- heat and ventilation monitoring
- worker positioning
- worker training
- physical maintenance of fans and VCDs
- operation of dust and airborne contaminants suppression systems
- maintaining VCDs in their correct state
- reconciliations of ventilation monitoring results with modelled results
- use of TARPs
- maintaining equipment or manning restrictions in certain work areas
- worker training. This is a critical control support to ensure ventilation controls are effectively enacted. Minor ventilation changes: Details on the management of each of these controls is discussed in Section 3.2.5

3.2.2. Preventative controls – Engineering

3.2.2.1. System design

For a mine ventilation system to be both efficient and reduce the risks mine ventilation poses to workers, ventilation should be considered at the beginning of the mine planning process. This was discussed in Section 3.1. Clause 61 of the WHS (MPS) Regulation requires the mine operator to model significant changes in the ventilation system, while the VCP is required to detail the design and operation of the ventilation circuit as per clause 62(3)(a) of the WHS (MPS) Regulation. The VCP should therefore detail all the relevant factors used in the development of any ventilation model, this should include:

- diesel fleet and air volumes required for each piece of fleet
- primary fans, their settings and relevant fan curves
- mine plan on which design is based upon

- any relevant assumptions (for example: adiabatic expansion, resistance factors maximum or minimum airspeeds for declines/drifts, drives and shafts, designed recirculation and how much dilution will occur)
- any systems of work that are required for the designed ventilation plan to be implemented (e.g. limited production rates from certain mine areas, disused stopes that need to remain filled or empty, water mass balances maintained)
- reference any third-party reviews or reports conducted on the mine's ventilation system
- detail where any electronic files that the plan is based upon are stored.

Any model that is developed should be constantly updated according to the latest mine plan and be reconciled with the latest ventilation survey. This is to ensure the mine operator manages the risk of the model being inaccurate and satisfies the prescribed requirements in accordance with clause 55 of the WHS (MPS) Regulation.

Ventilation design incorporates the following activities:

- determining ventilation system requirements
- developing, maintaining and verifying a model of the ventilation system
- predictive computer modelling of any major or minor ventilation changes or ventilation failure anticipated
- routine survey including pressure, quantity, temperature, moisture and gas
- incorporating findings from pressure, gas, health and hygiene monitoring
- incorporating findings from the mine inspection plan to verify the status of VCDs and ventilation system effectiveness.

The design of the ventilation system must address the quantity and quality of airflow required to meet prescribed requirements and any additional production or operational activities at a mine. Production and operational activities include:

- development or longwall operations ventilated by separate air splits
- removal or dilution of seam gasses
- auxiliary ventilation arrangements including booster or auxiliary fans
- personnel and vehicle access

- airborne dust removal or dilution
- heat and humidity control.

The ventilation system must provide adequate volumetric flow and pressure within all safely accessible parts of the mine to ensure air quality and air safety standards are achieved.

Air quality and air safety standards for an underground mine other than an underground coal mine are:

i. the oxygen level specified in clause 55(1)(a) of the WHS (MPS) Regulation
ii. a dust level referred to in clause 55(1)(b)(ii) of the WHS (MPS) Regulation
iii. an exposure level referred to in clause 55(2)(b) of the WHS (MPS) Regulation.

Air quality and air safety standards for an underground coal mine are:

i. the oxygen level specified in clause 55(1)(a) of the WHS (MPS) Regulation
ii. a dust level referred to in clause 55(1)(b)(ii) of the WHS (MPS) Regulation
iii. an exposure level referred to in clause 55(2)(b) of the WHS (MPS) Regulation
iv. the concentration of methane referred to in clause 72(1)(b) of the WHS (MPS) Regulation.

3.2.2.2. VCD designs

As per clause 62(3)(k) of the WHS (MPS) Regulation the VCP must detail the arrangement in place for the installation of all VCDs. The VCP should provide specific technical detail to assist the mine operator when considering the design and installation methods of any VCD, including bulkheads, ventilation doors, brattices, fire resistant anti-static (FRAS) material (coal mines) and seals.

The mine operator needs to take a risk assessment approach to the design of any VCD, in general, the greater the risk associated with the VCD, the more consideration needs to be given to the design and construction of any VCD. For example, VCDs that barricade the goaf or protect workers from an airblast risk need to be designed and constructed with reference to engineering principals and have strong QAQC throughout their construction. These VCDs are critical to preventing immediate harm to workers. However, a VCD to regulate secondary ventilation airflow does not require the same level of design and consideration.

The Regulator considers VCDs to represent a critical control in the management of a ventilation system and that without VCDs there would be a catastrophic risk posed to workers. The VCP needs to detail the types of VCDs used at the mine and the design criteria behind them, model the circuit before they are installed and test the circuit when they are installed to check they are performing as intended. Any settings on a VCD need to be described in the VCP, along with how the devices will be maintained.

The VCP should also describe who can make adjustments to any VCDs and any worker training that is required for their use.

3.2.2.3. Inrush and outburst management

Gas inrush and outburst represents a significant risk to underground coal mines. The mine ventilation system is a critical control to the management of the principal hazards of inrush, inundation and outburst.

Gas from strata that can impact the mine ventilation system exists as both free gas and adsorbed gas. The degree of saturation, pressure and permeability can affect the amount of gas that may enter a mine's atmosphere. The adsorption and desorption of gas can be described by an isotherm and changes with gas composition. Gas from strata adjacent to the mine forms part of the total gas reservoir that can impact the mine ventilation system.

The VCP needs to consider this risk and closely reference the inrush PHMP. Any requirements of the ventilation circuit to manage inrush or outburst events need to be detailed in the VCP, for example:

- when firing a stope, blast overpressure may damage a VCD How this risk is managed should be detailed in the VCP.
- the ability to ventilate an outburst of gas which informs any gas outburst TARP.

Mine gas extraction systems with the use of pre and post gas drainage can be used to remove gas from strata or coal, to reduce gas pressure and reduce the gas load on the mine ventilation system. Mine gas extraction systems require assessment of lifecycle and performance criteria prior to procurement and installation.

System control limits should be identified and understood with appropriate monitoring set to alarm at levels that allow for anticipatory action to be taken prior to system failure.

When considering the design of the gas extraction systems, potential failure modes and redundancy should be assessed with effective controls established and maintained. Examples of controls which may be applicable include:

- strategic monitoring type and locations
- variable flow and liquid ring pumps
- flame traps and venting requirements
- fuel rich concentrations within the gas extraction systems network

- network ring mains.

Modelling of the mine gas extraction systems is required to assist planning and operational requirements. Modelling used to assist planning and operation should consider:

- different operating conditions and the system configuration
- pressure relative to mine ventilation system
- flowrates, velocities, type of flow, gas make and concentration
- dewatering and monitoring requirements
- infrastructure and mine access.

3.2.2.4. Ground and strata management

The ground and strata PHMP must consider mine infrastructure and how it will be supported, monitored and maintained. Mine shafts, declines, passes, return air drives, fresh air drives and old workings can all be used as pathways for the mine's primary air. The mine operator must ensure that where such infrastructure is relevant to the mine's ventilation system that the risk of ground or strata failure is considered.

In addition, geotechnical failure, both planned and unplanned in the mining process can affect the mine's ventilation circuit. For example:

- if a goaf is designed to be ventilated and the ground is far more competent than planned, a larger volume than planned will need to be ventilated
- once a brow is cracked open when bogging a stope, air can short-circuit through the stope

The hazard identification process, as discussed in section 3.1 needs to consider all the risks to the ventilation circuit a particular mining method poses.

3.2.2.5. Mobile Equipment

Mine operators are required to limit diesel particulate to 0.1mg/m^3 as per clause 39 of the WHS (MPS) Regulation. In developing their VCP, mine operators should consider engineering controls on mobile equipment to reduce the amount of diesel particulate emitted by diesel-powered equipment. Manufacturers have a number of options available to filter out diesel particulate and these engineered controls should be assessed during the risk assessment process.

Mine operators also need to consider clause 54 of the WHS (MPS) Regulation and any other airborne contaminant that may be introduced into the ventilation circuit such as NOx and SO_2 gases from mobile equipment. MDG 15 *Mobile and transportable plant for use on mines and petroleum sites* details that mine operators in metalliferous mines should have a minimum of $0.05m^3$/sec/KW of diesel engine power, while clause 71(3) of the WHS (MPS) Regulation requires coal mines to have $0.06m^3$/sec/KW of diesel engine power and a minimum of $3.5m^3$/sec of air for any diesel motor.

The VCP should describe or reference the fleet size and the minimum air volumes required to ventilate it. It should also describe any restrictions on equipment movement to ensure MDG 15 and clause 71(3) of the WHS (MPS) Regulation are satisfied.

Mobile equipment can also liberate dust from walls/ribs and the road. Mine operators should also consider this in the development of any VCP and the procurement of mobile equipment.

3.2.2.6. Dust and airborne contaminant suppression

Separate to the use of mobile equipment there are numerous other processes, items of fixed plant, chemicals and systems of work in underground mines that generate dust and airborne contaminant. With reference to the hierarchy of controls, where reasonably practicable to do so, mine operators should seek to supress dust and airborne contaminants at their source and limit their liberation into the ventilation system.

On 1 July 2020 the workplace exposure standard (WES) for respirable crystalline silica reduced to a maximum time weighted average (TWA) of 0.05 mg/m^3. Clause 128(5)(r) of the WHS (MPS) Regulation requires a mine operator to notify the regulator of the detection of an atmospheric concentration of crystalline silica that exceeds the WES TWA of $0.05mg/m^3$.

Mine operators need to consider the generation of dust and airborne contaminant at the earliest stages of the mine planning process, so that appropriate air velocities and volumes are used and infrastructure is installed to satisfy both clause 39 and clause 54 of the WHS (MPS) Regulation. When a control is considered, any additional hazards associated with this control need to be considered. For example, if water sprays are to be used to supress dust, this will add humidity to the air, which increases the risk of heat exposure to workers. This ultimately needs to be considered in the ventilation system design and discussed in the VCP.

Sources of dust and airborne contaminant can emanate from (though not limited to):

- Production / working faces
- haulage
- drill and blast

- crushing
- conveyor systems
- chemical and explosives stores
- any hot work, such as wielding, thermal lancing, grinding
- stone dusting
- dust liberated from drive walls, backs/roof, floor or shafts
- chemical reactions such as applying water to fibrecrete emitting ammonia.

The risk assessment process must be documented, and the mine operator should conduct a wide-ranging investigation into all the controls available to supress dust and airborne contaminants, with reference to the hierarchy of controls.

Once the mine has satisfied itself that it has done all it reasonably practicably can to supress dust at its source, the remainder of the dust will enter the ventilation system. Any practices to limit worker exposure to dust such as the use of respiratory protection equipment (RPE) in certain areas or the use of airlock doors should be detailed within the VCP and these practices integrated into the SMS.

Infrastructure where dust and airborne contaminants are going to be generated, such as fuel/chemical stores, magazines and hotwork workshops should have direct access to a return air rise and be appropriately designed to limit the exposure of workers to as low as reasonably practicable. Any magazine design and ventilation requirements should be developed with reference to AS 2187 as per clause 31(2) of the WHS (MPS) Regulation.

3.2.2.7. Monitoring

Monitoring is a control support to the critical control of VCDs in the ventilation circuit. Due to the dynamic nature of mining any ventilation circuit requires constant monitoring. Clause 62(3)(b) of the WHS (MPS) Regulation requires the VCP to detail “arrangements for inspecting, monitoring, maintaining and testing the ventilation system,” while clause 60 of the WHS (MPS) Regulation requires the mine operator to conduct ventilation monitoring. Monitoring must occur at intervals that satisfy clauses 55 and 59 of the WHS (MPS) Regulation. In other Australian states this time period is prescribed as a minimum of four times a year, or whenever there is a significant change made to the circuit for metalliferous mines. For coal mines clause 71(6) of the WHS (MPS) Regulation requires the ventilation plan to be reviewed monthly as a minimum.

The VCP needs to detail when monitoring is to occur, where monitoring stations are located and who is responsible for what aspects of monitoring. Any devices used to monitor the ventilation circuit should be detailed or referenced in the VCP along with how they are to be maintained and calibrated. Monitoring also includes the physical inspection of VCDs fans and secondary ventilation ducting/bratticing. As these items can be affected on a day to day basis clear responsibilities for both their monitoring and the process through which any changes to these devices is made should be detailed in the VCP.

It is helpful to workers to clearly sign any VCD and the state it is expected to operate in. For example, drop board regulators (DBR) may be signed with how many boards are expected to be in the regulator and doors clearly labelled if they are required to be open or closed. This allows the wider workforce to monitor some VCDs and raise a concern if the VCD is not in its displayed state.

The VCP should clearly describe who is able to conduct any monitoring and what training they are to receive before being tasked with monitoring.

As the ventilation circuit affects temperature and worker exposure to dust and airborne contaminants, the mine operator may also choose to discuss the monitoring of this in the VCP. The Regulator recommends that the statutory ventilation officer liaise closely with the worker(s) who are responsible for any dust or airborne contaminant testing. It is also recommended that the ventilation officer work closely with maintenance staff regarding the performance of primary and secondary fans and any changes to the mobile fleet. If the changes represent a change to what is prescribed in the VCP, then the VCP needs to be reviewed and updated, as discussed in section 3.2.4.

3.2.2.8. Worker Training

As both primary and secondary ventilation is throughout an underground mining operation, mine workers will interact with parts of the system as a regular part of their roles. From the management of VCDs decline/drift dust suppression sprays, monitoring for temperature (particularly for hot mines) to maintaining secondary ventilation in drives, a wide spectrum of the workforce is expected to manage parts of the mine's ventilation system.

The VCP should detail roles and responsibilities for the installation, maintenance, operation and monitoring of all elements of the ventilation system and what training that individuals assigned to these roles require. This training and responsibilities should then sit within the overall SMS. At a minimum, all workers should receive familiarisation as to how the mine's ventilation system – both primary and secondary – works and any relevant operational restrictions the system has, for example only one loader on a working level or only three trucks below a certain level.

All workers also need to be trained in any TARPs or systems of work for the management of a loss of power to one or more fans as per clause 62(3)(e) of the WHS (MPS) Regulation.

Worker training is an important control to the management of the ventilation circuit and therefore needs to be appropriately detailed in the VCP as per clause 62(3)(i) of the WHS (MPS) Regulation.

3.2.3. Mitigating controls

When monitoring systems identify that the ventilation system is not performing to the required standard, mitigating controls need to be enacted to ensure the health and safety of workers. This is often in the form of a TARP, where for example temperature monitoring reveals conditions are not fit for normal systems of work, therefore systems of work are modified, depending on the temperature.

The VCP also interacts with any emergency plan, particularly for inrush, outburst and fire events. Therefore, it is important that the VCP consider these events in its development and training of workers. For example, it is recommended that all escapeways be in fresh air, so that in an emergency any second means of egress can still be traversed.

Mitigating controls for the management of the day to day aspects of maintaining adequate ventilation are often underpinned by administrative controls. If monitoring either via a device such as an anemometer or thermometer or by observation (such as observing ventilation ducting or brattice is not an adequate distance to the face) reveals conditions are outside those prescribed in the VCP, the mine must have a system in place to ensure the non-compliance is rectified. The VCP or the overall SMS should describe how such defects, when identified are to be actioned.

The need for constant observation of the ventilation circuit reinforces the need for all workers to be trained in the basic operation of the mine's ventilation circuit, to monitor and to report any defects they may observe.

3.2.4. Review of controls

The VCP must be reviewed in accordance with clause 17 of WHS (MPS) Regulation.

The mine operator of an underground coal mine must ensure that the effectiveness of the ventilation system and the ventilation control plan for the mine are audited at least once every 12 months by an individual nominated to exercise the statutory function of ventilation auditor at the mine. The mine must review control measures if a deficiency has been identified in an audit of the VCP in accordance with clause 10 of the WHS (MPS) Regulation.

When controls are identified and installed, these controls need to be continually reviewed to measure their effectiveness. This requirement is largely satisfied through the monitoring program described in section 3.2.2.7 and 3.2.3 for the ventilation circuit itself. Any deterioration of VCDs should be identified during routine inspections undertaken by the mine operator.

Note: *The mine operator must maintain VCDs in accordance with clause 37 of the WHS Regulation.*

In underground metalliferous mines it is recommended that periodic reviews of the ventilation system be conducted by independent third parties to test underlying assumptions and practices to ensure the circuit is running as efficiently as possible when maintaining ventilated air to workers.

For any PHMP that relies on the ventilation system as a control, or that can affect the ventilation system, mine operators must review these as per clause 25 of the WHS (MPS) Regulation. In the review of these documents the mine operator should consider the ventilation circuit and if the mine determines that changes have been made – for example the ground and strata PHMP – may determine that a particular open stope that is being used for the primary ventilation circuit needs to be backfilled. As this would affect the ventilation circuit, the VCP would need to be updated and a new circuit designed and modelled.

3.2.5. Ventilation changes

The VCP should incorporate processes to determine:

- varying levels of ventilation changes
- who is authorised to make each type of ventilation change
- what actions are required prior, during and after each ventilation change is made
- the notification of affected workers from each proposed ventilation change, including workers who may be affected if a negative outcome was to occur, and the controls in place.

Mines should incorporate a 3-tiered process for determining what involvement of the site's management team are required to be involved in ventilation changes, some examples below are:

Minor ventilation change:

EXAMPLE	MANAGEMENT TEAM SIGN-OFF
Panel stopping being built in a gate-road development panel	Deputy/UG Supervisor Ventilation Officer to issue instruction
Installation of temporary stoppings (brattice) in a mains development unit	Deputy

Moderate ventilation change:

EXAMPLE	MANAGEMENT TEAM SIGN-OFF
Longwall goaf seal installed	Ventilation Officer to issue instruction
Installation of an overcast, regulator, machine doors (not yet commissioned)	Ventilation Officer to issue instruction

Major ventilation change:

EXAMPLE	MANAGEMENT TEAM SIGN-OFF
Regulator adjustment	Ventilation Officer Mining Engineering Manager
Commissioning new development panel, Commissioning overcast, changing panel quantities etc.	Ventilation Officer Mining Engineering Manager

3.2.6. Effectiveness of controls

Mine operators should regularly review communications issued by the Regulator i.e. safety alerts and incorporate recommendations into the site's review processes. This approach encourages mines to proactively review the effectiveness of their respective control measures.

Monitoring process should largely determine the effectiveness of controls. However, it is incumbent on mine operators to remain up to date on changing standards and improved controls. For example, the change in respirable silica dust from 0.1mg/m^3 to 0.05mg/m^3 which took effect in July 2020 will likely mean the effectiveness of current dust controls at mines will need to be reviewed for their effectiveness. Whenever a control is considered in the risk assessment process, mine operators are required to assess its effectiveness as part of clauses 9 and 23 of the WHS (MPS) Regulation.

As new technologies emerge which provide greater risk controls associated with ventilation, the mine operator is required to review the site's existing control measures using the hierarchy of controls, so far as is reasonably practicable. For example, as dust suppression systems of underground crushing units improve to provide greater suppression and suspension of airborne contaminants, mine operators should consider these advancements in the available controls.

3.2.7. Documentation and records management

All air monitoring records are required to be kept for a minimum of seven years as per clause 58 of the WHS (MPS) Regulation. Clause 14(1)(c)(iii) of the WHS (MPS) Regulation requires the mine operator to have a well-documented SMS that includes the VCP. The Regulator recommends that mines adopt an integrated, computerised document management system, so that the risk assessment and controls identified within it, along with all the assumptions relevant to the VCP, are easily identifiable. By having a clear flow of documents and references to how each is developed, the mine operator makes any review process more efficient to ensure the VCP is based on the latest mine plan and risk assessment.

Such a system can provide alerts and assign responsible people when changes are made and can reference relevant documentation from OEM's relevant modelling, or third-party consultants. Due to the importance of the VCP in managing a host of hazards in an underground mine, effective document management will be critical to the VCP being used effectively and the mine operator satisfying clauses such as 23(3)(b) of the WHS (MPS) Regulation which requires mines to consider principal hazards both individually and cumulatively.

3.2.8. Information and training

The primary ventilation circuit is required to be displayed prominently to the workforce, with the latest set of testing results as per clause 71(2)(j)(iv) of the WHS (MPS) Regulation for coal mines. While the regulations have no such requirement for metalliferous mines, operators of these mines should also adopt this practice as part of the mine's duty to provide information and training to workers.

As workers are constantly interacting with the ventilation system and rely on the system to have a respirable atmosphere, the types of training required for workers should always be considered in the risk assessment process and this training be provided to workers as part of the mine's SMS. Incidents have been reported where workers tampered with ventilation control devices, typically to improve primary airflows in their level, without them understanding how such actions affect the primary circuit. Clear expectations around the use of the ventilation system such as the requirement to maintain VCDs in their prescribed state should be given to workers.