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Technical reference guide

Gas outbursts

Principal hazard management plan

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Date	Version	Amendment
April 2020	1	consultation draft This revised document replaces MDG1004 *Outburst mining guideline*
February 2023	2	Updated references the WHS (MPS) regulation and addressed stakeholder feedback where appropriate

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1. Introduction

This Technical Reference Guide replaces *MDG 1004 Outburst mining guideline*.

This document provides mine operators with guidance on developing and documenting a principal hazard management plan (PHMP) for gas outbursts in underground coal mining operations. The PHMP sets out the overall strategy that mine operators must use for managing their site's health and safety risks for gas outbursts and its integration into the mine's broader safety management system.

This document should be read in conjunction with:

- NSW WHS Acts and Regulations (including Mining and Petroleum Sites)[1]
- NSW codes of practice:
  - Work health and safety consultation, cooperation and coordination
  - How to manage work health and safety risks
  - Safety management systems in mines.
- NSW Resource Regulator's guidance material, for example:
  - Guide - Preparing a principal hazard management plan.
- Australian and International Standards in related fields, for example:
  - AS ISO 31000: 2018 Risk Management — Guidelines
  - AS/NZ ISO 45001: 2018 Occupational Health and Safety Management Systems – Requirements with guidance for use
- The information attached as appendices of this guide.

1.1. Scope and application

This document is intended to apply to underground coal mining operations which may be subject to gas outburst risks. The Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 (the WHS (MPS) Regulation) identifies gas outbursts as a prescribed principal hazard[2] meaning a PHMP must be developed.

This document does not refer to coal burst incidents at a coal operation, however, mine operators when conducting risk assessments for each principal hazard identified must consider the principal hazard individually and cumulatively with other hazards at the mine[3].

2. Fundamentals of gas outbursts

A gas outburst is the sudden ejection of coal and/or rock and a large volume of noxious and/or flammable gas from a coal face and surrounding strata in an underground coal mine. They occur

[1] The NSW WHS laws are:

Work Health and Safety Act 2011 (WHS Act)

Work Health and Safety Regulation 2017 (WHS Regulation)

Work Health and Safety (Mines and Petroleum Sites) Act 2013 (WHS(MPS) Act)

Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 (WHS(MPS) Regulation)

[2] NSW Work Health and Safety (Mines and Petroleum Sites) Regulation 2022. The Regulation defines a principal hazard as any activity, process, procedure, plant, structure, substance, situation or other circumstance relating to the carrying out of mining operations that have a reasonable potential to result in multiple deaths in a single incident or a series of recurring incidents.

[3] Section 27(3(b) WHS(MPS) Regulation

where there is a volume of gas and the pressure exceeds the confining strength of the material being mined, or within seams above and below the active seam. Gas outbursts generally occur at the development face and often, but not always, in the vicinity of geological disturbances, faults and dykes. They do also occur on the longwall face.

Gas outbursts have the potential to affect the health and safety of workers and outcomes can include fatalities, asphyxiation, burial, impact injuries, risk of explosion, equipment, and infrastructure damage, particularly, loss of ventilation, and loss of resource.

It is considered that the following factors play a role in there being a risk of gas outbursts:

- presence of faulting
- structural related thrust or horizontal movements
- seam variations and coal strengths
- coal cleating and jointing
- presence of dykes or cinder coal
- seam permeability
- seam gas content
- gas pressure
- seam gas type and composition, i.e. Methane (CH_4) or carbon dioxide (CO_2.)

3. Developing and documenting a PHMP for gas outbursts

The PHMP for gas outbursts should be developed following the steps detailed in the NSW Resources Regulator's Guide *Preparing a principal hazard management plan*. After initially describing the scope and context of the plan, a comprehensive hazard description should be developed within the context of the risk management approach. The associated risks are then identified, and a control management system is developed that includes planned assurance activities for continual improvement. Workforce representation is an essential element of each of the stages.

It is considered that best practice at mines that may be subject to risk of gas outbursts is the establishment of a gas outburst committee. This committee should typically consist of senior management, a gas drainage engineer, production management, ventilation officer, geologist and any other personnel involved in the implementation of gas outburst controls or supervision at the operation, and the site safety health representative (SSHR).

This section further outlines the types of risk-based tasks and information that should be included in developing and documenting a PHMP for gas outbursts.

Mines typically use the following model for gas outburst management:

- Prediction: The gathering of geological data is comprehensive and robust to quantify the risk of gas outburst. This includes assessing the impacts of identified and unidentified structures, their propensity to gas outburst, gas content, gas composition and gas drainage characteristics.
- Prevention: requires effective drilling and drainage and regular gas content compliance testing. Compliance testing requirements includes gas flow monitoring and core sampling to verify gas drainage effectiveness. Core samples should be undertaken such that the mine has a high degree of confidence that the test location is representative of the area to be mined based on the compliance test.

- Protection: Requires routine training in gas outburst awareness, identification of gas outburst warning signs for workers and mine officials, procedures for inspections, trigger action response plans, and restricted mining and remote mining procedures.

An example of allocation of tasks to personnel responsible for the development, management, and implementation of the gas outburst PHMP in Appendix A.

3.1. Scope and context of the PHMP

An important initial step is to document a clear description of the hazard under investigation. It defines the parameters for the future stages of the plan, including the analyses and risk assessments and the development of the risk control strategy.

Scoping activities consider what locations are in or out, what plant and equipment will or will not be considered, the people and organisational entities to be included or excluded, and the activities and tasks that will or will not be considered.

Establishing the scope and context (and documenting them) for the gas outbursts PHMP should also include:

- identifying objectives for the plan
- reviewing the geotechnical, operational environment or context in which the hazard exists
- exploring the nature of the hazard unique to the mine
- defining how the hazard interacts with other potential hazards on site
- describing how the implementation of control measures under the gas outbursts PHMP will be coordinated with other PHMPs and control plans.

Section 28 of the WHS(MPS) Regulation stipulates what is required to be considered in the preparation of a PHMP. Further information on preparing a PHMP is in the Regulator's Guide *Preparing a principal hazard management plan*.

3.2. Interaction with other plans and overall safety management system

PHMPs form part of the safety management system (SMS) for a mine. For more information about safety management systems see the Safety management systems in mines code of practice.

Before writing the PHMP, the mine operator should consider how the PHMP is to be integrated with other plans. It would be expected that the following plans would interact closely with the gas outburst PHMP:

- ventilation control plan
- fire or explosion PHMP
- emergency management plan
- coal burst or rock burst were identified under Section 27 WHS(MPS) Regulation.

3.3. Consultation process

When managing risks, the mine operator must consult with workers and other duty holders at the mine. 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.

4. Identification of gas outburst as a hazard

Mine operators must have processes and controls in place for collection of appropriate information related to risks of gas outburst to reliably predict the likelihood and severity of gas outburst.[4]

Mine operators should have processes in place for:

- determining the total seam gas content and composition of coal to be mined
- evaluating the gas outburst related history of both the mine and any adjacent or earlier operations
- evaluating and recording the geological and geotechnical environment of the mine regarding structures, gas content and composition
- evaluating all available external information
- detecting changes in the environment during mining which may indicate an increased risk of gas outburst.

5. Risk assessing the propensity for gas outburst

It is a requirement of the WHS(MPS) Regulation (Section 27 identification of principal hazards and conduct of risk assessments) that a risk assessment be carried out to identify all aspects of risk to health and safety associated with gas outbursts.

The WHS(MPS) Regulation specifies that a PHMP is to be prepared in accordance with section 28 and Schedule 1. Schedule 1 of the WHS(MPS) Regulation also specifies that the following matters must be considered in developing the control measures to manage the risk of gas outbursts:

- the potential for gas to be released into the working area of a mine, from both natural and introduced sources in a concentration that could lead to fire, explosion, or asphyxiation
- the potential for the accumulation of gas in working areas and abandoned areas of the mine
- the nature of the gas that could be released
- the gas levels in the material being mined
- gas seam pressures
- in the case of a coal mine — AS 3980:2016, Guide to the determination of gas content of coal and carbonaceous material – Direct desorption method.

Mine operators should ensure that the decisions of the gas outburst risk assessment team clearly document their decisions in the PHMP.

6. Control measures

A key component of the gas outburst PHMP is the identification of controls, activities and organisational systems used to manage the risks associated with gas outbursts. Information must

[4] Section 28 WHS(MPS) Regulation

be presented in a way that demonstrates the mine operator is satisfied that they have met the obligations regarding the adequacy of the measures to be implemented in accordance with WHS laws.

In addition, mine operators must comply with any specific controls required by the WHS Regulation or WHS(MPS) Regulation.

The current process for gas outburst management in NSW is focused on:

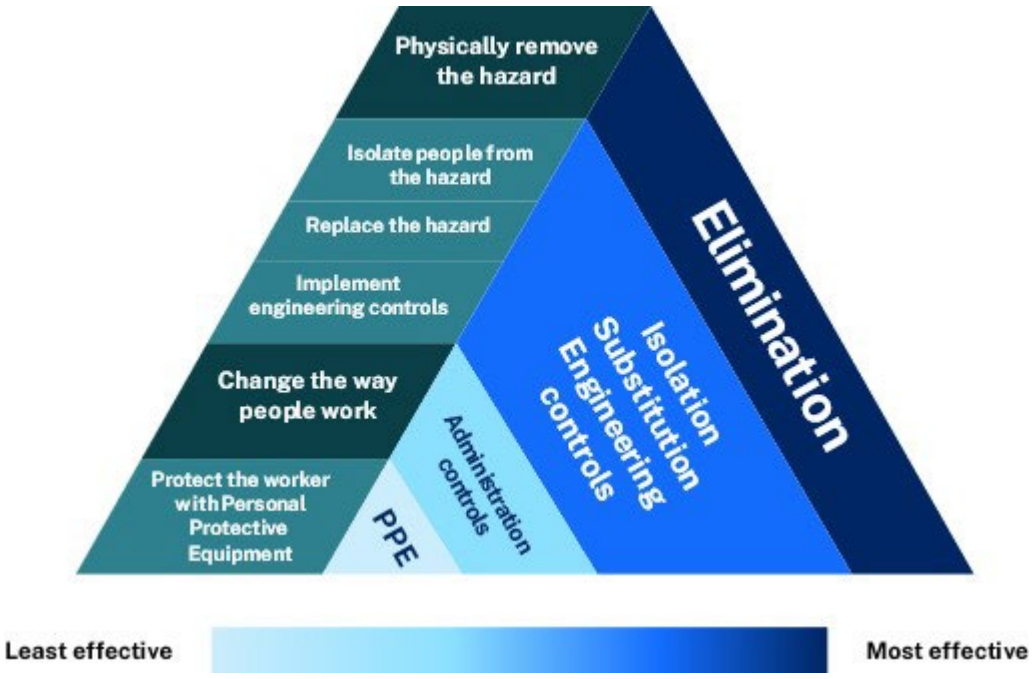
- setting of gas threshold level values (TLVs)
- gas drainage and borehole design
- compliance testing
- inspections.

6.1. The hierarchy of controls

There are many ways to control risks and the various control options must be considered. This may involve a single control measure or a combination of controls that together provide the required level of protection (layers of protection). Sometimes a single control is not adequate on its own to control a risk under all reasonably foreseeable circumstances, or if the reliability of a single control is uncertain.

The hierarchy of risk controls ranks the effectiveness of controls from the highest level of protection and reliability (most effective) to the lowest (least effective), to either eliminate or minimise risks as shown in the figure below. Mine operators and other PCBUs are required to work through this hierarchy when managing risk under the WHS Regulation (refer to clause 36 WHS Regulation). The figure below summarises the hierarchy of risk controls.

Figure 1: Hierarchy of controls



The aim is to eliminate a hazard, which is the most effective action. If this is not reasonably practicable, risk must be minimised by working through the other alternative measures in the hierarchy, as prescribed in Part 3.1 of the WHS Regulation. Risk controls can be classified as either preventative controls or mitigative controls. In most cases, a combination of both preventative and mitigative controls are needed in response to an identified risk.

6.2. Prediction of gas outbursts

6.2.1. Prediction indices

The earliest stage to predict whether a coal seam has a propensity to gas outbursts would be at the surface to coal seam exploration period. The information from each sample core taken can be used to predict the geology, gas content, coal strengths and geological structures within that coal seam as indicators of what may lie ahead. This will assist in determining the follow up requirements of mine design, inseam drilling and other methods to determine structures within the working areas and may include:

- gas desorption rates
- gas reservoir modelling
- gas composition
- gas pressures.

Many indices have been developed to predict gas outbursts. Different indices are used in different countries. The methods used to determine these indices are discussed in the Australian Coal Association Research Program (ACARP) Outbursting Scoping Study report C4034, March 1996.

6.2.2. Geology

Geology plays an especially important role in the manifestation of gas outbursts. Seams having complex geological structures are more prone to gas outbursts if high gas conditions are prevalent.

The processes for identifying the geological environment may include:

- surface mapping
- seismic surveys
- other geophysical methods
- drill logs
- cores
- borehole video cameras.

The following points need attention when geological factors are being considered:

- any structure related to horizontal movement of beds within the coal seams, presence of soft coal beds in the seam(s) and the thickness
- presence of thrust faulting, thickness of the gouge and width of the fracture zone
- gas outbursts have occurred in seams of varying thickness including seams as thin as 0.5m
- normal faults which have a throw greater than the seam thickness may result in complete stoppage of gas flow (gas trap). Strike slip faults generate more gouge than thrust faults and gouge thickness is lower on the normal faults
- the presence of cleat in coal, particularly shearing of the cleat and presence of fine sheared material between the cleat surfaces (Wood and Hanes, 1982) is an indication of high stresses and deformation to which the seam is subjected

- Surrounding strata may affect the gas outburst potential of an area. For example, seams surrounded by sandstone have a higher probability of shearing compared to seams surrounded by shale or softer rocks
- micro-porosity and coal strengths may affect the gas outburst proneness of the seam
- determination of the presence of structures such as faults, dykes and sills is a widespread practice in general geological investigation. Sheared zones due to folding and faulting may have sintered coal (a brownish and weak formation known as Mylonite). This needs to be investigated carefully
- gassy seams with a low coal strength are highly liable to outburst (Lama & Bodziony, 1996). A valid measure of coal strength should be used.
- when a coal bearing area is split into two areas with a major fault, it is essential that both these areas be examined separately. It is possible that the two areas may have quite different conditions related to gas regime.

6.2.3. Mine details relevant to gas outburst

Information may include:

- Regional overview – including proximity to other mines, regional infrastructure, and support resources, as well as information on any limitations to access to the surface above the mine.

  Geotechnical information related to the mine – this identifies any factors that may influence the inherent gas outburst risk.

7. History of gas outburst events at the mine and in the region

It is important to recognise the characteristics of past events at the mine or other mines within the region.

Information may include:

- particular locations – working faces including longwalls, drift driveage and developments
- factors that increase/decrease the likelihood of such events at the mine in comparison to past events such as changes in mining methods, monitoring systems, ventilation systems, geological environment, the in-situ gas content, and composition.

7.1. Known controls for the prevention or mitigation of gas outbursts

Elements of mine design aimed at preventing gas outbursts include:

- seam thickness
- roadway, pillar, and extraction panel design
- gas drainage systems, surface to seam and in seam
- determination of threshold limits for all mining methods
- pre-drainage of coal seams
- borehole surveying and drill logs.

A range of reactive/mitigating controls for gas outbursts include:

- development of a trigger action response plan (TARP)
- monitoring of carbon dioxide and methane gas levels
- monitoring seam gas pressure and content
- ventilation requirements
- gas drainage lead time and dewatering times
- strata de-stressing
- remote mining methods and procedures (including gunching and shot firing)
- compliance testing
- gas drainage and hole spacing
- pre-drainage of coal seams
- in-seam drainage and post drainage.

To ensure new risks are not introduced, it is important to repeat hazard identification and assessment processes when selecting control measures.

A control checklist must be compiled to enable a site to validate that a control has been properly implemented and is functioning as designed. These checks must be carried out at a sufficient frequency to ensure the controls are remaining effective.

7.2. Gas threshold limit values

Gas threshold limits are set by the mine to determine how mining can take place. A mine may operate with one or more threshold levels. The threshold limit values (TLVs) may be set as follows:

- A maximum limit for normal mining operations take place. As total gas content trends towards TLVs additional controls should be implemented, which may include review of gas drainage design, addition of flank holes, reduction of borehole spacing and increased compliance testing
- A range of limits above normal mining operations where restricted mining can take place. Restricted mining is where advance rates, per shift or day, are limited to allow for the strata to release enough seam gas to adequately lower the likelihood of a gas outburst occurring to an acceptable level
- A limit above restricted mining operations where only remote mining can take place
- A limit above remote mining where no mining takes place.

Additional to those TLVs, there may be separate TLVs for structured ground (the presence of faults, dykes, etc.) and unstructured ground for each of the above TLVs with lower TLVs with increased compliance testing for structured ground.

Each TLV may also be on a sliding scale depending on gas composition with lower TLVs for areas that are rich in CO_2 compared to the areas that are rich in CH_4.

7.3. Gas drainage

Gas drainage is used to lower the seam gas to below the relevant TLV.

Removal of gas from the coal seam and surrounding strata is an effective method in reducing or eliminating gas outbursts.

The benefits of gas drainage are:

- Reducing the gas content of coal to a level that prevents a gas outburst event.
- Gas given off from the virgin coal is reduced so that gas percentage in intake airways and at working faces are kept within statutory limits and coal production rates are not governed by gas emission rates. This is achieved by degasification of coal prior to mining, i.e. pre-drainage.
- A reduction in the intensity of gas outburst.

In coal deposits with high gas content beyond threshold limits, gas drainage can be carried out by drilling boreholes. Drainage by borehole drilling can be carried out either from the surface or from underground. In either case the drainage of gas should be carried out prior to mining to reduce the risk of gas outbursts.

The extent of the borehole density, drill pattern and fan orientation with respect to the panel direction is dependent upon the coal permeability, coal gas make, gas composition, ground principal stress direction, coal cleat orientation, geological environment, geographical access, and lead time until mining.

In the context of first workings boreholes are typically drilled in advance of the working face often from adjacent gate roads or main headings to dewater and degas the coal over time. The coal gas is drained off the coal either by its natural gas pressure or with the aid of vacuum pumps.

Where boreholes are drilled from adjacent gate roads across future longwall panels, they may drain the area of the longwall panel they intersect. Where fan drill patterns are used often borehole distance will increase in areas across the longwall panel.
When assessing a longwall panel for gas drainage requirements, consideration should be given to:

- The extent of borehole coverage for all areas of the panel
- The presence of geological structure
- The compliance testing requirements to ensure the mine has a high degree of confidence that the test location is representative of the area to be mined based on the compliance test.

7.4. Compliance testing

Compliance testing is carried out to confirm the TLV of the area to be mined and therefore the appropriate type of mining to take place. The mine should specify the maximum spacing and location of where compliance tests are to be taken. The spacing should be at a distance that the mine has a high degree of confidence that the test location is representative of the area to be mined based on the compliance test.

The spacing of the compliance tests should be reduced in structured ground with test locations selected to cover each side of any structure.

Where compliance tests cannot be carried out due to issues such as boggy ground where a core cannot be obtained then it should be assumed that the gas threshold levels have been exceeded and only remote mining should be carried out. In all other cases mining should only occur where compliance testing has been carried out at the relevant spacing in accordance with the PHMP. This should apply to longwalls as well as development.

7.5. Inspections

Face inspections are particularly important in monitoring for changes that may indicate increased risk of gas outburst occurring. There is a real potential for changes to the geological and gas environment not being identified during the exploration processes used by the mine to determine the risk of gas outburst. Trigger action response plans (TARPs) should be developed for gas outburst face inspections to guide the person carrying out the inspections on the appropriate actions to be taken based on the inspection results.

Inspections should cover an assessment of:

- faults
- dykes and cinder
- Mylonite
- pressure bumps
- increase or decrease of gas levels over short time frames
- coal spitting
- coal abnormally hard or abnormally soft
- abnormal geological features
- calcite bands
- increased frequency of joints or changes in direction of joints
- any site-specific indicators of increase gas outburst risk or unexpected change.

7.6. Trigger action response plan (TARP)

Trigger action response plans (TARPs) can be a useful tool for mining operations. A TARP defines the minimum set of actions required by workers in response to a deviation from normal working conditions.

TARPs can be used to demonstrate the relationship between conditions in:

- a normal environment
- an abnormal environment (e.g. mining in an area with an unidentified structure)
- an emergency.

They define the required actions relevant to each situation. TARPs should:

- be simple and robust
- be adequately resourced in terms of personnel and equipment, including monitoring systems
- focus on prevention and control through early detection
- set triggers through detailed knowledge of what is normal
- be regularly reviewed and revised as necessary
- be based on the best available on-site and off-site advice.

See Appendix B for an example of a TARP for gas outburst.

7.7. Training and supervision

The WHS Act (section 19) and the WHS(MPS) Regulation (sections 106-107) impose specific obligations on mine operators relating to the health and safety of workers, and to provide information, training, and instruction to ensure that workers can safely carry out their duties at the workplace.

Training on the applicable controls must be completed by all workers involved in any activity that might give rise to the risk of gas outburst.

All workers should have sufficient training so that they can safely and effectively carry out their duties and understand the following:

- gas outburst awarness (change detection)
- normal mining provisions and remote mining procedures
- roles and responsibilities
- identification of gas outburst signs during drilling or mining
- competency assessments for those classes of employees
- appropriate use of personal protective equipment
- use of self rescue equipment
- first response rescue equipment and procedures
- gas drainage related tasks in outburst control zones is a high risk activity
- fit for purpose equipment with appropriate worker protection from flying coal/debris.

Standard operating procedures should be readily available to all workers so that they are fully knowledgeable about the gas outburst risks and type(s) of controls that they may encounter in their workplace.

Additional training should be provided where there are changes to gas outburst risks and controls. Refresher training should be provided to workers commensurate with the level of risk. Records of training must be kept.

Mine operators must ensure that workers are provided with suitable and adequate information, training, and instruction, and are provided with appropriate supervision based on their experience and qualifications.

7.8. Authority to mine (ATM)

Mining should only proceed after:

- evaluation of all information, prediction, prevention, and protection has been reviewed by the gas outburst committee
- development of a documentary form of authorisation to verify the evaluation is issued
- determining the type of mining system for the area is stated - being development or longwall
- the documentation (i.e. the ATM) has been approved by the Mining Engineering Manager and other personnel specified by the gas outbursts PHMP. This may include a gas drainage engineer and person responsible for the production area such as longwall or development manager

- identifying only those personnel with adequate competency to be allowed to proceed in remote mining crews, drilling crews or as contractors performing work under the control of the gas outbursts PHMP
- identifying and documenting the threshold values for operating under gas outburst conditions when the following is taking place:
  - normal mining practice
  - restricted mining or remote mining practices
  - no mining to take place
  - showing influencing structures
  - pre drainage and core sampling gas content.

7.9. Performance standards and auditing

Performance standards provide a reference comparison designed to enable mine operators to determine how effective the planning, execution, and implementation of the gas outburst PHMP risk management approach is and continues to be.

Section 20 of the WHS(MPS) Regulation sets out the performance standards and auditing requirements for the mine's SMS and must include:

- performance standards for measuring the effectiveness of all aspect of the SMS that:
  - are sufficiently detailed to show how the operator will ensure the effectiveness of the SMS, and
  - include steps to be taken to continually improve the SMS.
- the way in which the performance standards are to be met
- a system for auditing the effectiveness of the SMS for the mine against the performance standards, including the methods, frequency, and results of the audit process.

When preparing the PHMP, mine operators should include triggers for shutdown, review or investigation and ensure that any actions required for absent or ineffective controls are documented.

7.10. Monitoring and review

Reviewing the gas outburst PHMP will determine whether controls continue to be suitable, consistent with current good practice and effective in managing the risks associated with gas outbursts.

The WHS(MPS) Regulation states when a PHMP must be reviewed (section 29). For further information on reviewing a PHMP, refer to the Regulator's Guide *Preparing a principal hazard management plan.*

A mine operator should:

- review the control measures to determine the effectiveness of the performance standards in the Gas outburst PHMP
- conduct regular auditing of inspections reporting from the defined areas prone to gas outbursts
- ensure physical and other circumstances are being adequately catered for in the plan

- conduct reviews to ensure that all personnel deployed are:
  - sufficiently trained in identifying changes in the workplace
  - understand the gas outburst procedures and indicators, and
  - are trained in emergency procedures.

7.11. Notification and changes

Mining in outburst control zones is a high-risk activity under section 35 of the WHS(MPS) Regulation. The mine operator is required to notify the regulator of their intention to carry out this activity. The notification must include the relevant parts of the safety management system for the mine that describes the systems, procedures, plans and other control measures that will be used to control risks to health and safety associated with carrying out the activity. This would include the gas outbursts PHMP.

Section 35 of the WHS(MPS) Regulation also requires that the activity be carried out in the manner specified in the notification, although it also allows for an amendment to be submitted for how the activity is to be carried out. This means that if there is a change to the gas outbursts PHMP that changes how mining in outburst control zones is carried out, or the control measures for the activity are changed, the mine operator should submit a new high risk activity notification or an amendment to the existing notification.

Section 190 of the WHS(MPS) Regulation defines when a gas outburst is a dangerous incident which requires immediate notification and site preservation in accordance with sections 14 and 17 of the WHS(MPS) Act, respectively.

8. Reference information

8.1. Acronyms

Name	Definition/detail
ACARP	Australian Coal Industry's Research Program
AS	Australian Standard
ICMM	International Council on Mining and Metals
ISHR	Industry safety and health representative
ISO	International Oganisation for Standardisation
PCBU	Person conducting a business or undertaking
PCP	Principal control plan
PHMP	Principal hazard management plan
SMS	Safety management system
SSHR	Site safety and health representative
TARPs	Trigger action response plans
WHS	Work health and safety

8.2. Definitions

Term	Meaning
gas threshold level	Measurement of seam gas content and composition used for dtermining the method of mining. For this document, all reference of threshold levels must be based on total content measurement.
normal mining	Mining below the gas outburst mining threshold.
gas outburst	A sudden release of gas and material from the working place. Can vary in magnitude.
gas outburst conditions	Those conditions (gas level, presence or likelihood of structures, other outburst potential signs) under which mining must only proceed as per the principal hazard management plan.
gas outburst mining	Mining in an outburst control zone is defined in Schedule 3 of the WHS (MPS) Regulation.
gas outburst mining procedures	The total of measures, including, but not limited to, such things as worker machine protection, mining and coal loading sequence, and personnel movement constraints, put in place for the purpose of reducing the effect of any outburst on personnel.
gas outburst mining threshold	The gas threshold level above which only gas outburst or remote mining may be permitted to proceed.
gas outburst-prone area	Any area in which the measured gas content level is above the mining threshold.
gas outburst-prone structure	Any discontinuity in the worked coal seam which has associated levels of seam gas and in-situ stress which may give rise to an outburst when mined, or has a history of gas outbursts when previously mined.
remote mining threshold	The gas threshold level above which mining may only proceed by remote means which do not expose personnel to risks arising from a gas outburst.
total gas content	The gas content measured from a coal sample in accordance with AS3980 or an approved method. For this document, all reference of gas content must be interpreted as a reference to total gas content.

8.3. Australian and International Standards

AS 3980:2016 Determination of gas content of coal and carbonaceous material – Direct desorption method.

AS/NZS ISO 45001:2018 Requirements with guidance for use - Occupational health and safety management systems – Requirements with guidance for use.

AS ISO 31000:2018 Risk management – Guidelines.

AS 3745:2010 Planning for emergencies in facilities.

8.4. References

Australian Coal Association Research Program (ACARP) Outbursting Scoping Study report C4034, March 1996.

Wood, J H, Hanes, J, 1982. Development of protection techniques for mining the outburst prone Central Bowin Basin, NERDDC Project 80/0223, Final Report.

Lama, R D, Bodziony, J, 1996. Outbursts of gas, coal, and rock in underground coal mines, edited by R D Lama and Associates, Wollongong.

8.5. ACARP reports

The following reports are available from the http://undergroundcoal.com.au/ website developed by the University of Wollongong as part of ACARP Project C14015 Development of Web-Based Underground Coalmine Gas Outburst Information Management System.

Strategic Review of Gas Management Options for Reduced GHG Emissions - 1 May 2010

Review of Inseam Drilling Practice - 1 December 2009

ACARP Gas and Outburst Workshop - 28 August 2004 (download)

Gas and Outburst Workshop - 22 November 2003 (download)

Outburst Scoping Study - John Hanes (download)

Real Time Return Gas Monitoring for Outburst and Gas Drainage Assessment – July 1997

Outbursting Scoping Study - March 1996 (Lama & Bodziony)

Outburst Symposium - March 1995

Coal Mine Outburst Mechanism, Thresholds & Prediction Techniques - Ian Gray

Further reports available from ACARP

Numerical Modelling of Outburst Mechanisms and the Role of Mixed Gas Desorption – ACARP C9023 – X Choi 2002

Laboratory Study of Coal Properties & Outburst Simulation - Application to Gas Drainage, Outburst Prediction, Control & Management – ACARP C13012 - X Choi 2009

Validation and Application of a Numerical Outburst Model as a Tool for Outburst Management Through Field Studies – ACARP C16016 X Choi 2014

Control and management of outburst risk – ACARP C26055 D Black 2019

8.6. Case studies

Case Study Outburst & Gas Management, P. Eade, GHP Billiton – *Illawarra Coal*
Case Study Management of Outburst Risk at Tahmoor Colliery, P. Wynne - *Austral Coal*

Case study: High performance longwall operations in areas with high gas emissions – Australia, L W Moreby_Belle.pdf
Review of coal and gas outburst in Australian underground coal mines, Dennis J. Black, 2019

Outburst at NSW underground coal mine December 2022 (NSW Resources Regulator)

8.7. Further information

Resources Regulator Targeted Intervention Program Consolidated report – *Gas outburst risks in longwall mining*, September 2017

International Council on Mining & Metals (ICMM) *Critical Control Management Implementation Guide*.

Coal Services *Mines Services Incident Command and Control System (ICCS) Guide.*

University of Wollongong Resource Operators Conference - Coal mining outburst papers

Gas and Outbursts seminars Wollongong – Mining Science and Technology (miningst.com)

Appendix A: Plan implementation - roles and responsibilities

Statutory and other roles

The table below provides an example of the allocation of tasks to people responsible for the gas outburst PHMP. It may be used as a guide for this process.

Role	Accountabilities for the PHMP
Mine operator	• establish the development and implementation of the PHMP for gas outbursts • monitor the effectiveness of this PHMP • provide appropriate resources to implement this PHMP • specify functions and responsibility and provide training.
Mining engineering manager	• own, approve, and administer this PHMP • monitor the effectiveness of this PHMP • approve changes to this PHMP, and associated standards and procedures • monitor performance of persons in carrying out responsibilities under this PHMP • approve all final driveage layouts before submission to the Regulator for approval • review gas outburst conditions in conjunction with life of mine plan and annual budget • perform any duties specifically required by this PHMP • establish that all individuals with functions and responsibilities under this plan are trained and competent to carry out those responsibilities — establish that all workers are aware of, and understand their responsibilities as stated in the plan, and that these responsibilities are included in their position descriptions — establish that training material is developed and provided for all functions of the plan — establish that any systems and procedures are developed and implemented in accordance with the requirements of the plan — establish that the plan is monitored and audited. The plan must be reviewed at intervals not exceeding three years, or if a specific event occurs as defined in the plan. Any changes should be conveyed to the workforce — establish that all risk-assessment processes are formally documented

Role	Accountabilities for the PHMP
	— verify that any corrective action undertaken has been conducted. • co-ordinate remedial action necessary in the event of any emergency occurring underground • sign off on the panel reviews as soon as practicable • establish that enough resources are allocated • comply with any other requirement of the PHMP for gas outburst for this function.
Gas drainage coordinator	• plan and schedule gas drainage activities to meet the requirements of this plan • maintain a database of gas drainage information • participate in risk assessments, reviews, audits, and monitoring of the gas outbursts PHMP as required • develop training packages, in association with the training department, for gas drainage workers and supervisors • review ATMs to ensure gas drainage information contained within the document is correct • liaise with the Mine Surveyor to ensure gas drainage information on mine plans is correct.
Mine geologist	• determine the nature and location of geological structures • plan and schedule geological activities to meet the requirements of this plan • maintain a database of virgin coal gas content • maintain a geological prediction model • participate in risk assessments, reviews, audits, and monitoring of the gas outbursts PHMP as required.
Ventilation officer	• set high and low alarms to monitor gas levels • direct the installation of appropriate monitoring of gas levels and air quantities • maintain knowledge of current industry standards for gas outburst conditions • monitor the effectiveness of this PHMP • recommend changes to this PHMP • monitor performance of procedures required under this PHMP • liaise with the mine planning engineer and statutory officials with respect to gas outburst issues • update training packages as required • provide advice on gas outburst matters to mine officials as required • report to mining engineering manager any relevant matters that the ventilation officer cannot remedy.

Role	Accountabilities for the PHMP
Shift undermanager	• participate in review of this PHMP as required • assess effectiveness of this PHMP • monitor performance of persons in carrying out responsibilities under this PHMP • monitor performance of procedures required under this PHMP • monitor for indications of gas outburst • report to the ventilation officer any relevant matters that undermanager cannot remedy • document in the undermanager's reports any abnormal or unusual conditions which may be relevant to mine ventilation, mine monitoring or gas outburst and bring such details to the attention of the ventilation officer • perform any duties specifically required by this PHMP • check the installation of monitoring stations is in accordance with the PHMP for gas outburst • check the strata support is installed in accordance with the mine support plans • ensure corrective action for the above if required • respond to alerts from section mining supervisors • record details and notify appropriate supervisors of any gas outburst with the potential to injure people or cause significant downtime.
Technical services manager	• facilitate the implementation of the PHMP for gas outburst and ensure it is updated and modified as necessary: • assist the Mining engineering manager in identifying the resources required to meet the requirements of this plan • liaise with the technical experts such as geologists and geotechnical workers regarding any additional information or investigation that may be warranted for the compilation of the hazard plans • review the system before the mining of any new section of the mine along with a review at the completion of the section • oversee intermediate reviews as required • determine the nature, location, and frequency of monitoring • organise internal/external reviews • comply with any other requirement of the PHMP for gas outburst for this function. • ensure short term and long-term planning adequately considers gas outburst risk • report to the ventilation officer and mine planning engineer any features that may affect gas outburst risk • ensure surface boreholes are sealed to standard and supply a list of locations of boreholes to the ventilation officer and surveyor • provide appropriate resources to implement this PHMP

Role	Accountabilities for the PHMP
	• perform any duties specifically required by this PHMP.
All supervisors (e.g. deputies)	• participate in review of this PHMP as required • monitor for indications of gas outburst in area of responsibility • report to undermanager and/or ventilation officer any relevant matters deputy cannot remedy • participate in training as required • perform any duties specifically required by this PHMP • check the installation of monitoring stations is in accordance with the PHMP for gas outburst • facilitate corrective action for the above if required • respond to alerts from section workers • record details and notify shift supervisor of any gas outburst with the potential to injure people or cause significant downtime.
Electrical engineering manager	• participate in review of this PHMP as required • monitor performance of persons in electrical department in carrying out responsibilities under this PHMP • monitor performance of electrical related procedures required under this PHMP • oversee the procedures for maintenance and calibration of the gas and ventilation monitoring systems are carried out • ensuring the monitoring system has an automatic fail-safe alarm system • report to the ventilation officer any relevant matters that the electrical engineer cannot remedy.
Control room officer (CRO)	• participate in review of this PHMP as required • respond appropriately and promptly to any gas monitoring warning level or alarm, other ventilation alarm, or failure of part of the monitoring system • comply with applicable procedures as required under this PHMP • report to the ventilation officer any relevant matters that the CRO cannot remedy • participate in training as required • perform any duties specifically required by this PHMP.
Mine surveyor	• maintain plans of surface and underground boreholes • ensure surveying of underground roadways and longwall workings is undertaken • check that the roadways are driven to design and in relation to orientation and dimensions

Role	Accountabilities for the PHMP
	• ensure surveys are carried out and transferred onto suitable plans for filing and reference purposes and roadways are plotted as constructed • ensure all boreholes are shown on section hazard plans • comply with any other requirement of the PHMP for gas outbursts for this function.
Training coordinator	• assist in developing relevant training modules, including CROs • deliver training as required for gas outbursts • maintain records of training.
All employees and contractors	• report suspected gas outburst indicators to a mining supervisor • comply with procedures to minimise risk of gas outburst • participate in training as required • perform any duties specifically required by this PHMP.

Appendix B: Example TARP for gas outburst

LEVEL OF RESPONSE	NORMAL (Green)	LEVEL 1 (Yellow)	LEVEL 2 (Orange)	LEVEL 3 (Red)
Trigger Levels	No outburst indicators or structures on normal mining ATM.	**Increased awareness** Mining through areas of known structure as indicated on the normal mining ATM	**Potential for outburst** Outburst indicators observed at face (not identified on the normal mining ATM, or unexpected for area being mined)	**Outburst (emergency)** Outburst has occurred
Responsibilities	**ACTIONS**	**ACTIONS**	**ACTIONS**	**ACTIONS**
All Employees	1. conduct mining as per ATM 2. attend refresher training as required 3. inspect face area for outburst indicators and structures.	1. continue mining as per ATM 2. inspect face area for outburst indicators and structures with heightened awareness around change in conditions 3. if geological structures and associated change in conditions are present upon inspection that are not on the ATM then elevate to level 2	1. cease mining, retreat from face and contact mining supervisor until face has been inspected by mining supervisor	1. evacuate face area to a place of safety and follow further instruction
Control Room Operator	1. routine monitoring	1. routine monitoring	1. routine monitoring	1.I initiate mine emergency response procedures
Mining Supervisor	1. review ATM with crew at start of shift 2. conduct mining as per ATM 3. continue inspections as per inspection plan 4. monitor the face for changing outburst indicators	1. as per normal, and 2. inspect face area for structures and record on statutory report 3. record on statutory report structures intersected and any associated change in conditions noted upon inspection 4. monitor the face for changing	1. inspect face area for structures and outburst indicators. Record findings on statutory report and complete event report. 2. notify undermanager of findings. Production to	1. account for personnel in crew 2. no road the area 3. notify undermanager and confirm actions moving forward 4. notify control to assist in coordinating first response rescue

		outburst indicators (e.g. more than usual bumping, change in gas make). If noted elevate to level 2	remain ceased until directed from MEM and undermanager.	efforts if required 5. gather witness statements
Undermanager	1. continue inspections as per inspection plan 2. review and countersign statutory reports, action to rectify if required	1. as per normal, and 2. verify that any structures intersected are in the location specified by the ATM 3. if outburst indicators are reported that are not on the ATM then instruct to cease mining until inspection is undertaken. Elevate to level 2	1. verify mining supervisor's inspection and inspect face 2. notify MEM if outburst indicators are present but not indicated on the ATM 3. contact geologist/geotech for inspection of face if outburst indicators are present (not identified on the ATM or are unexpected for the area) 4. consult gas drainage superintendent to discuss / review data 5. in consultation with MEM review all data and specialist advise, remove, or reinstate ATM as required	1. notify MEM 2. initiate mine emergency response procedures. 3. provide mining supervisor with instruction moving forward 4. consult with MEM and give instruction to stop mining in other areas and withdraw to surface 5. gather witness statements and commence investigation 6. ensure mining in all other production panels is ceased
Geologist	1. member of the outburst risk review team (OCI) 2. assess ATM area and provide geological comments and advice	1. as per normal, and 2. if increased outburst indicators are reported then undertake inspection	1. inspect the face as required by the undermanager or MEM to clarify outburst indicators 2. issue strata advice to development superintendent, MEM, gas drainage superintendent and undermanagers 3. as part of the OCI determine requirements to recommence mining 4. provide recommendations and projections to	1. act as required by the IMT managing the incident

			determine extend of structure and determine any additional drilling requirements 5. participate in OCI team meeting / discussion to determine drilling requirements	
Gas Drainage Superintendent	1. convene the outburst risk review team meetings as per gas outbursts PHMP 2. compile ATM information and prepare for issue as per gas outbursts PHMP checklist	1. as per normal	1. consult with MEM and discuss re convening OCI to re-assess core regime for the ATM if the ATM has been withdrawn 2. consult with undermanager to consider if current gas drainage is still adequate and effective to maintain current ATM, consider if structure will interrupt gas drainage design and effectiveness. If issue identified, undermanager to remove ATM. 3. issue drill plans as required (if drilling necessary)	1. Act as required by the IMT managing the incident
Development Superintendent/ Coordinator	1. member of the outburst risk review team 2. participate in issuing of ATM, complete checklist for authorisation as per gas outbursts PHMP checklist.	1. as per normal, and 2. accompany inspection if required by MEM	1. Accompany inspection of face if required by MEM. If further OCI meetings are required, participate in these to further determine further core requirements 2. If the ATM has been withdrawn issue a communication to the workforce	1. act as required by the IMT managing the incident

Mining Engineering Manager	1. member of the outburst risk review team 2. authorise mining of areas in accordance with ATM process	1. as per normal	1. consult with UM, review all reports and data, remove, or reinstate ATM as required 2. initiate reconvening of OCI members to determine new coring arrangements based upon geotechnical/ geological recommendations if ATM has been withdrawn	1. provide direction for IMT 2. notify Regulator 3. address workforce (or delegate with appropriate information) 4. suspend mining, review all other ATMs

Appendix C: Example gas outburst report

1. Location

Mine:	Panel:
Roadway location:	Coordinates: N: E:

2. Timing

Date:		Day of week:
Time:	am/pm	Shift:

3. Health and Safety

Injuries:
Fatalities:

4. Geology

Presence of structure:		Type of structure:
Fault type: Normal / reverse / thrust / slipstrike		
Throw: mm	Dip:	Dip direction:
Dyke: Thickness:		Hardness:
Stress direction:		
Frequency and direction of jointing:		
Mylonite (gouge evident):		Thickness: mm
Changes in coal properties:		
Changes in roof:		
Changes in floor:		
Water:		
Seam gas Methane: %	Carbon Dioxide: %	Content: m/tonne
Drill log: Comments:		

5. Ventilation

Air quantity: m^3sec	Location:
Gas readings:	

1. Location

Before o/b: CH_4	%	CO_2	%	
After o/b: CH_4	%	CO_2	%	
Variations detected:				

6. Mining details

Outburst mining method in use: Yes / No			
Method of mining: Cont. Miner / Road Header / Shearer:			
Mine layout: Heading / Cut-through / Pillar / Split:			
Distance driven: On-shift: m	Last 24 hours: m	Last 72 hours: m	
Face description: Cut out LHS	Cut out RHS:	Undercut:	Face square:

7. Incident details

Nature of discharge:	Lump coal:			
	Fine coal:			
	Roof stone / coal:			
Location of outburst:	Face centre:	Face LHS:	Face RHS:	
	Left rib:	Right rib:		
Quantity discharged:	tonnes			
Distance solids thrown:				
Gas liberated:	CH_4 %	CO_2 %	CH_4 m^3	CH_4 m^3
Coning evident:	Haze:	Brown / red colouring:		
Effective on machinery: Trip-outs:	Distance dislodged:			
Comments:				

8. Observed

Audible signs:	
Rumble / bumping / knocking:	Loud / soft:
Visible signs:	
Coal spitting / slabbing / mass ejection / surging:	

8. Observed	
Sensed signs: Air warming / air cooling / smell:	
9. Written reports (attached)	
Witnesses:	
Deputy:	
Undermanager:	
Inspector:	
ISHR:	
Others:	
10. Plans	
Mine location (1:10000) Panel location (1:2000) Gas drainage (1:50)	
11. Sign off	
Prepared by (name):	Position:
Signed:	Date:
Authorised / countersigned (name):	Position:
Signed:	Date:

Resources Regulator
Department of Regional NSW

Appendix D: Extract from safety alert

Department of Industry
Resources Regulator
Mine Safety

SAFETY ALERT

Gas outburst on longwall face

INCIDENT

Two gas outbursts occurred on the longwall face at Metropolitan Colliery, south of Sydney, on 23 December 2016 and again on 4 January 2017. The first event resulted in the release of a volume of carbon dioxide, and evidence of a small gas outburst cavity high in the longwall face.

The second event resulted in the release of a large volume of carbon dioxide and the violent ejection of coal from the longwall face resulting in the obstruction of the passage across the face.

No injuries were reported in either incident.

Figure 1: Maingate view of gas outburst. Supplied by Metropolitan Colliery.

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Figure 2: Tailgate view of gas outburst. Supplied by Metropolitan Colliery.

CIRCUMSTANCES

At the time of the second incident, the longwall was on production and the shearer was mining toward the maingate. A slip-strike fault had been intersected and was present in the face at support 63. Face conditions were reported as good, with no evidence of weighting on the face. The shearer had just passed the faulted zone when operators reported hearing a loud noise and there was a subsequent ejection of coal and carbon dioxide from the longwall face directly over the shearer.

The shearer driver and support operator were positioned on support 38 and were covered in fine coal dust. The gas detector units they were carrying alarmed due to the carbon dioxide.

A minor gas outburst event was reported to the NSW Resources Regulator on 23 December 2016. The NSW Resources Regulator directed Metropolitan Colliery to undertake a review of the control measures associated with gas outburst hazards and, subsequent to the review the mine implemented additional control measures to limit worker exposure to any potential gas outburst risk. This included:

- applying an exclusion zone that extended 20 m on the maingate side of the shearer and all points inbye including the return roadways that supported the longwall ventilation split;
- the carrying of gas detectors by face workers; and
- a restriction on the number of workers accessing the longwall face.

INVESTIGATION

Following the second incident the NSW Resources Regulator issued a S195 notice prohibiting longwall production at Metropolitan Colliery. Metropolitan Colliery is undertaking several activities to comply with the directions in this notice.

Evidence indicates the gas outburst travelled about 35 m towards the maingate, which went beyond the previously determined exclusion zone.

RECOMMENDATIONS

A gas outburst is a well understood hazard in underground coal mines. Although gas outbursts on longwall faces are rare, there was a previously recorded event at West Cliff Colliery in 1998 (see Safety Alert SA98-02 on the Resources Regulator website) and the phenomenon has been reported at longwall operations overseas.

Mine operators are required under the Work Health and Safety Regulation 2011 Part 3.1 to identify hazards and control measures taking into consideration the hierarchy of controls and then implement those control measures.

In managing the risk of a gas outburst, the following principles should be considered:

- prediction
    - core sampling and geotechnical assessment of potential structures should be undertaken to identify the gas outburst potential
- prevention
    - gas drainage of the seam to below a gas outburst threshold limits should be undertaken before extraction.

Underground coal operations should assess the potential for gas outburst on the longwall face. This assessment should include:

- a geological assessment of the longwall block
- taking core samples to determine the gas content of the longwall blocks to be mined
- the assessment of the appropriate and effective methods required to reduce gas content to below gas outburst threshold limits
- the methods of testing required to ensure that gas drainage has been effective, particularly in and around geological structures.

Where the gas outburst risk cannot be eliminated mine operators should isolate workers from the hazard, that is, remove workers from the area of risk. This has been achieved through the implementation of remote mining methods.

NOTE: Please ensure all relevant people in your organisation receive a copy of this Safety Alert, and are informed of its content and recommendations. This Safety Alert should be processed in a systematic manner through the mine's information and communication process. It should also be placed on the mine's notice board.

Issued by

Garvin Burns
Acting Chief Inspector of Mines
Appointed pursuant to Work Health & Safety (Mines and Petroleum Sites) Act 2013

View more safety alerts and search our safety database at http://www.resourcesandenergy.nsw.gov.au/miners-andexplorers/safety-and-health/incidents. If you would like to receive safety alerts by email, enter your contact details on our signup page.