NSW GOVERNMENT

NSW Resources Regulator

TARGETED ASSESSMENT PROGRAM

# CONSOLIDATED REPORT - MANAGING FIRE OR EXPLOSION RISKS IN UNDERGROUND COAL MINES

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# Contents

# Executive summary

A crucial part of the NSW Resources Regulator's Incident Prevention Strategy involves targeted assessment programs for mines and petroleum sites. This is a focus on assessing an operation's control of critical risks through evaluating the effectiveness of control measures in the mine's safety management system (SMS). It samples specific elements of the system, rather than a holistic, audit-based approach.

This final report summarises assessment results from 18 mines in relation to the hazard of fire or explosion risks in underground coal mines.

While all mines that were assessed demonstrated a risk-based approach to managing fire and explosion hazards, their documented risk assessments often contained poorly defined hazards with all-encompassing management plans, or procedures that were nominated as the risk controls. Some sites failed to include people who had significant responsibilities to implement fire or explosion risk controls in the risk assessment process (i.e. electrical and mechanical engineering managers, ventilation officers). Risk assessments should clearly identify all hazards applicable to the site and nominate clearly defined risk controls. Diligence in this area should also assist to develop verification tasks that accurately reflect the effectiveness of the risk control measures.

Most of the mines assessed were at various stages of implementing a critical control identification and management processes, with corporate-driven verification tasks to confirm the critical control effectiveness. The schedules for these tasks were typically based on a rolling, monthly basis that were, in many instances, high-level risk control implementation assessments. Mines should consider how the routine verification of the critical control effectiveness can be, or already is, embedded in the mine's programmed maintenance and inspection scheme, rather than relying on periodic verification tasks to identify critical risk control failures or absence.

Providing firefighting equipment continues to be driven by the minimum standards in previous prescriptive legislation or mining design guidelines (MDGs). In the absence of any considered analysis of the fuel hazard, this had, in some circumstances, led to poorly positioned or inappropriate firefighting equipment, without considering fuel volatility, fuel load and first responders' safety.

Site inspections noted that firefighting equipment was often poorly sign posted or access was obstructed by stowed plant and equipment. It was also noted that poor housekeeping not only provided a fuel source but provided a fire corridor to mine assets.

Consideration for the early withdrawal of workers in response to carbon monoxide alarms (an early indicator of a fire event) could not be established in risk assessments. Most mines required to physically authenticate the alarm before starting withdrawal procedures and, in some instances, withdrawal procedures were non-existent as an action required in the event of elevated carbon monoxide levels.

Further details of the assessment findings are in this report, with findings grouped into those that could be generally applied to all aspects of the risk management process at the mine, and those that were specific to the hazard of fire or explosion. Mine operators are encouraged to review these findings and consider how these findings may apply to their operations.

# Introduction

The targeted assessment program (TAP) provides a planned, intelligence-driven and proactive approach to assessing how effective an operation is when it comes to controlling critical risk. The TAPs apply the following principles:

- a focus on managing prescribed 'principal hazards' from the WHS (M&PS) Regulation.
- evaluation of the effectiveness of control measures implemented through an organisation's safety management system.
- consideration of the operation's risk profile and the targeting of operations deemed to be highest risk.

The objective of risk profiling is to identify the inherent hazards and the hazard burdens that exist at individual operations in each mining sector in NSW. The information is then used to develop the operational assessment and inspection plans that inform the program.

Each TAP is undertaken by a team of inspectors from various disciplines, such as mining, electrical and mechanical engineering who work together with the operation's management team to undertake an assessment of the risk control measures associated with the relevant hazard and their implementation.

## Scope

The scope of the targeted assessments includes two elements:

1. a desktop assessment of:
   - compliance against legislation with respect to the management of risks to health and safety associated with managing fire and explosion at the mine
   - controls the mine uses to prevent and mitigate the risks to health and safety associated with managing fire and explosion
   - means the mine utilises to monitor the effectiveness of those controls.
2. a workplace assessment of the implementation of those controls.

## The process

The process for undertaking a TAP generally involves the following stages:

- Preliminary team meetings, preparation and review of documents.
- Execution of an on-site assessment involving:
  - a site desktop assessment of relevant plans and processes measuring legislative compliance of the relevant plans
  - the inspection of relevant site operations.
- discussion and feedback to the mine management team on the findings and actions that need to be taken by the mine operators in response.

# Managing fire or explosion risks in underground coal mines

Managing the risk of fires and explosions is particularly important at underground coal operations because of the hazardous nature of the environment. Fires and explosions are identified in the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 as a principal hazard that has a reasonable potential to result in multiple deaths in a single incident or a series of recurring incidents (clause 5(a)).

The WHS (MPS) Regulation requires mine operations to identify principal hazards and conduct a risk assessment that involves a comprehensive and systematic investigation and analysis of all aspects of risk to health and safety associated with the principal hazard (clause 23) and prepare a principal hazard management plan for each principal hazard (clause 24).

Additionally, the Work Health and Safety Regulation 2017 prescribes the requirement to manage the hazards associated with flammable gas, vapour, mist or fumes and combustible dust (clause 51).

In developing the control measures to manage the risks of fire or explosion, Schedule 1, clause 6 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 requires that the following matters must be considered:

- The potential sources of flammable, combustible and explosive substances and materials, both natural and introduced, including gas, dust, ores, fuels, solvents and timber.
- The potential sources of ignition, fire or explosion, including plant, electricity, static electricity, spontaneous combustion, lightning, light metal alloys, hot work and other work practices.
- The potential for propagation of fire or explosion to other parts of the mine.

- The potential sources of flammable material with a flash point of less than 61° Celsius, including materials on the top of any shaft, outlet or well at the mine.
- Arrangements for the management and control of the transport and storage of combustible liquids.
- Arrangements for the prevention of fires, including the types and location of systems for the early detection and suppression of fires.
- The equipment for fighting fire at the mine.
- The arrangements for the management and control of volatile or hazardous materials in underground mines.
- Procedures to be used for carrying out hot work at the mine.

A list of additional guidance material on managing risks associated with fire or explosion is included in Appendix A.

# Assessment findings

The assessment findings are grouped into two categories:

- General findings that can be used to inform all aspects of an operation's safety management and provide valuable information and insight across all sectors and operation types.
- Specific findings that should be used to inform and improve SMS's to address this principal hazard.

# General findings

## Risk assessments

***Issue:*** While all mines demonstrated a risk-based approach to managing fire and explosion hazards, the documented risk assessments were often at a high level and did not always provide clarity on the hazard being assessed and the actual preventative and mitigating control measures that were identified to manage the risk. Poorly defined hazards, or threats, often included lists of equipment types grouped as single line items, with controls listed as all-encompassing management plans, or procedures that make the discovery of the actual risk control challenging.

***Response:*** Risk assessments should clearly identify all hazards applicable to the site and risk controls nominated should be clearly defined and documented within the SMS.

Addressing these areas will help to improve the integration of identified risk control measures into the PHMP, related control plans and procedures and help establish performance indicators for effective control measures[1].

***Issue:*** For several fire or explosion risk assessments reviewed, it was noted that the position holders, who had significant responsibilities for implementing fire or explosion risk controls, were not represented (i.e. electrical and mechanical engineering managers, ventilation officers). In some cases, this omission was further compounded by the risk assessment team making assumptions about the pre-existence of risk control measures for a particular hazard that could not be substantiated at the time of assessment.

***Response:*** The risk assessment team should have sufficient knowledge and experience about the hazard being assessed to ensure a credible and accurate analysis of the threats and potential risk control measures. This includes appreciating how effective any identified risk control measure is in addressing the risks. At the time of the risk assessment, it is also important to accurately define the specification or intent of the identified control measure, to ensure it is properly documented in the SMS. The risk control owner can then effectively and practically implement the control.

***Issue:*** Assessments at several mines identified that risk controls nominated in risk assessments were either not in place or ineffective. This could be attributed to poorly defined risk control performance requirements or failing to truly verify risk control implementation or effectiveness.

***Response:*** Mine operators should satisfy themselves that identified risk control measures are in place and verification tasks, including commissioning procedures, confirm risk control effectiveness[2].

The International Council on Mining & Metals (ICMM) provides guidance on defining control objectives, performance requirements and verification[3].

[1] Work Health and Safety Regulation 2017 Clause 37 Maintenance of control measures

[2] Work Health and Safety (M&PS) Regulation 2014 Clause 15 Performance standards and audit

[3] Health and Safety Critical Control Management Good Practice Guide, International Council on Mining & Metals, 2015, p14

## Critical controls

***Issue:*** Most mines that have implemented a critical control focus rely on corporate-driven verification tasks to confirm the critical control effectiveness. The schedules for these tasks were typically based on a rolling monthly basis which were, in many instances, high-level assessments of risk control implementation.

***Response:*** Mine operators should consider how routinely verifying critical control effectiveness can be, or already is, embedded in the mine's programmed maintenance and inspection scheme, rather than relying on periodic verification tasks to identify failed or absent critical controls. Mines should also satisfy themselves that verification tasks are a true measure of the risk control effectiveness.

The International Council on Mining and Metals (ICMM) provides guidance on the implementation of critical control management systems. This guidance advises that 'a successful CCM process will have monitoring and reporting components embedded into business-as-usual operations. This includes integrating scheduled verification activities and reporting into current maintenance and inspection systems'.[4]

## Training and competence

***Issue:*** Risk assessments either make an initial assumption that workers are trained and competent or they specifically identify training as a risk control measure for a hazard. However, assessments often found mines were not maintaining their training refresher schedules or worker interviews indicated the frequency of refresher training may not be sufficient for them to retain important information.

***Response:*** The mine's training and competence management schemes must describe the process for reassessment, to ensure ongoing safe performance of a task or skill[5]. When considering the process for determining the interval between reassessments, the mine should be mindful that in many instances training and competence is identified as a significant risk control measure and the effectiveness of this risk control should be subject to periodic review and any identified deficiencies addressed.

[4] Critical Control Management Implementation Guide, International Council on Mining & Metals, 2015, p50
[5] Coal Services Guideline for Order 34

# Specific findings

## Carbon monoxide (CO) alarms

***Issue:*** It was identified that mine procedures for responding to carbon monoxide (CO) alarms, an early indicator of a fire event, focus on validating the alarm before initiating withdrawal procedures for workers.

***Response:*** Mine operators must ensure that procedures for the response to carbon monoxide alarms allow the timely withdrawal of workers from the mine to provide the best possible opportunities for self-escape. Mines should consider a staged withdrawal, withdrawing workers to the outbye side of the potential fire location while an appraisal is made of the fire threat.

***Issue:*** In compliance with clause 73 WHS(M&PS) Regulation, mines have used carbon monoxide (CO) sensors on the return side of conveyor drives. However, inspections revealed that in many instances, the effectiveness of these sensors may be compromised because of dilution from converging airstreams or positioning them away from the air flow over the conveyor drive.

***Response:*** Mine operators should formalise their approach to the provision and positioning of carbon monoxide (CO) sensors and satisfy themselves that sensors are positioned to maximise the likelihood of detection. Consideration should be given to the use of smoke tubes to verify the effectiveness of the installation.

## First response

***Issue:*** Mines continue to maintain an approach to the provision of firefighting equipment based on the minimum standards prescribed in previous prescriptive legislation or mining design guidelines (MDGs). Failing to challenge this approach through a risk-based process has, in some circumstances, led to the provision of inappropriate firefighting equipment and the failure to recognise the hazard exposure to first responders.

***Response:*** When developing control measures, mine operators must consider the equipment and arrangements for preventing, suppressing and fighting fires, and must ensure the provision of adequate firefighting equipment.[6] Mines should adopt a risk-based approach to providing firefighting equipment, considering fuel volatility, fuel load, safety of first responders and published guidance material.

[6] Schedule 1(6) WHS (MPS) Regulation, Clause 359 WHS Regulation

***Issue:*** During the site inspection, it was noted that firefighting equipment, emergency isolation points (LPG) and emergency communication equipment was not always clearly or strategically located, or sign posted. Access to several hydrants and fire extinguishers was often obstructed by stowed plant or equipment or signs that were missing or damaged.

***Response:*** The mine's maintenance and inspection scheme should take a holistic approach when assessing the readiness for duty of firefighting equipment. Firefighting equipment must not only be installed, tested and maintained, but needs to be readily accessible in an emergency. Some guidance may be sought from Australian Standard AS2444 when determining the type, strategic placement and accessibility of firefighting equipment[7] and emergency isolation points.

## Conveyors

***Issue:*** Most mines identified real-time temperature and, in some cases, vibration monitoring for rotating components of critical plant (i.e. pulleys, gearboxes, motors) as a preventative control for equipment fires. However, the method for determining what components should be monitored, and the specification and functionality of the monitoring devices could not be verified.

***Response:*** When developing control measures, mine operators must consider the potential sources of ignition, fire or explosion, including plant.[8] When systems are identified as risk controls, consideration should be given to the specification of the system to ensure the expected risk control effectiveness is achieved. These considerations should include accuracy, reliability, alarm and trip levels and operator response to alarm trip and failure modes. Mine operators should also consider guidance provided in AS/NZS 4024.3611 Conveyors[9] with respect to fire detection.

***Issue:*** Most mines acknowledged that, other than reviewing inspection reports, there was no formal process in place to audit the effectiveness of conveyor inspections as a risk control. These failings were often further compounded by the confusion of workers about the classification of conveyor defects and the expected response when defects were identified.

Competency and training requirements for workers carrying out inspections also varied considerably across sites.

[7] AS2444-2001 Portable fire extinguishers and fire blankets-selection and location
[8] Schedule 1(6) WHS (MPS) Regulation 2014
[9] AS/NZS 4024.3611:2015 Safety of machinery: Conveyors—Belt conveyors for bulk materials handling Clause 2.8.2.7

***Response:*** Mine operators must manage risks to health and safety associated with operating belt conveyors at the mine.[10] Mines should implement rigorous processes to verify the effectiveness of all risk controls, including conveyor inspections. For example, mines should consider independent inspections of conveyor systems to provide assurance that the minimum standard of routine inspections are being met.

Mines should also consider developing a comprehensive training package for workers who undertake conveyor inspections that clearly defines minimum requirements and triggers for action for defects including idler wear, alignment, clearances and housekeeping. Consideration should be given using photographs to illustrate minimum acceptable standards.

## Hot work areas

***Issue:*** Mines controlled risks associated with hot work through designated hot work areas in or near workshops, and for all other areas, permit systems were in place. At some sites, inspections and interviews identified there was some confusion about the extent of designated hot work areas and the minimum standards required to be maintained within those areas.

***Response:*** When developing the control measures to manage the risks of fire or explosion, mine operators must consider hot work.[11] Mine operators should ensure that the minimum requirements, including firefighting equipment and housekeeping standards for designated hot work areas, and the actual site locations, are documented within the safety management system. Designated hot work areas should be clearly sign posted and defined and housekeeping standards maintained (i.e. removing rags, packaging, oil spills, aerosol cans and safe access and egress).

## Potential for propagation

***Issue:*** Some mines could not demonstrate appropriate consideration in safety management system documentation of the potential propagation of fire or explosion throughout the underground parts of the mine, including arrangements for rapid sealing and segregation of roadways.

[10] Section 44A WHS (MPS) Regulation
[11] Schedule 1(6) WHS (MPS) Regulation

***Response:*** When developing control measures to manage the risks of fire or explosion, mine operators must consider the potential of propagating fire or explosion into other parts of the mine[12], and must ensure that procedures are in place for emergency sealing all or part of the mine from a safe place (including from a place out of the direct line of any potential blast).[13]

Providing pre-installed rapid sealing arrangements at mine entries and in strategic positions underground can assist to mitigate a fire event. Remotely operated sealing devices also provides an additional level of safety for emergency response crews.

***Issue:*** Surface areas of underground coal mines were often overlooked when mines considered the propagation of fires to other areas. The maintenance of fire breaks from bushland area was often compromised by poor housekeeping with respect to rubbish, leaf litter and stored combustible materials, which create a fire corridor to mine infrastructure, plant and equipment.

***Response:*** When assessing mine surface areas, risk assessments should address the potential for fires, originating from both within and outside of the mine boundary, spreading to mine assets. Providing and maintaining segregation between buildings, stored plant and equipment and coal stockpiles should be considered.

## Underground refuelling bays

***Issue:*** Most mines use transportable diesel fuel pods and underground refuelling bays. However, despite risk assessments identifying refuelling bays as a potential fire hazard, and controls generally being bunded fuel containers and providing firefighting equipment, many sites have not identified or documented minimum installation standards for underground refuelling bays. This was often evident, with mines failing to provide adequate ventilation, floor roof and rib treatment and strategically positioned firefighting equipment.

***Response:*** Risk control measures, adopted from risk assessments, must be clearly documented within the safety management system[14]. A clearly documented installation standard for underground diesel refuelling bays should provide clear instruction on the minimum requirements for access, ventilation, bunding, treating roof, rib and floor and firefighting equipment arrangements. A documented standard also provides an audit tool for auditing the effective implementation of the risk controls[15].

[12] Work Health and Safety (M&PS) Regulation 2014 Schedule 1(6)
[13] Work Health and Safety (M&PS) Regulation 2014 Clause 88 and Schedule 7(5)
[14] Work Health and Safety (M&PS) Regulation 2014 Clause 14 Content of safety management system
[15] Work Health and Safety (M&PS) Regulation 2014 Clause 15 Performance standards and audit

## Post incident monitoring of mine atmosphere

***Issue:*** Although mines have acknowledged requirements to establish post incident monitoring arrangements, safety management system documentation was often found to be limited on detail for the arrangements around ongoing monitoring of the mine atmosphere, following an event that required the withdrawal of workers.

***Response:*** Mine operators must ensure that arrangements are developed and implemented to monitor, so far as is reasonably practicable, the atmosphere of the mine, following a fire or explosion that leads to the withdrawal of workers from, and the cutting of the supply of power to, all or part of the mine.[16]

Strategically placed real time monitoring with uninterruptable power supplies and tube bundle monitoring points can provide valuable information on the nature of the mine atmosphere after a fire or explosion event. This information can assist incident management teams to make decisions on the risks associated with re-entry or recovery of the mine. Mines should not assume that all monitoring will be damaged or destroyed in a fire or explosion.

# Areas of good practice

While most mines had started to implement a critical control management strategy to manage risks associated with fire or explosion, this approach appeared initially as a 'bolt on' process that was poorly understood by site personnel. During the assessment program, there was evidence that mines were continuing to evolve with the integration of critical controls. These controls were being clearly documented and defined within their principal hazard management plans and in some cases, acknowledged as existing controls in workplace risk assessments.

Many mines were plagued by poor signs or workers failing to follow the directions of the signs, however some mines had prominently displayed signs giving clear direction to the workforce about the required standards, emergency equipment location or safe egress pathways.

[16] Work Health and Safety (M&PS) Regulation 2014 Clause 77

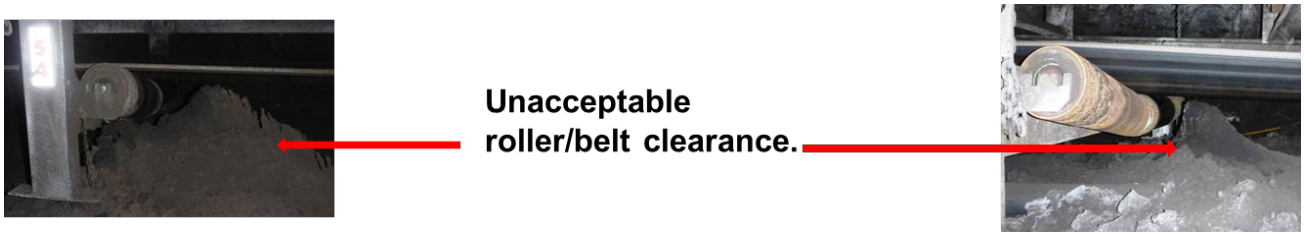
Figure 1 & 2: Signage at mine sites



Regularly inspecting conveyor belts is a regulatory requirement and acknowledged as a significant control in the prevention of conveyor fires. However, maintaining acceptable inspection standards appeared to be problematic for some mines with varying opinions about what was acceptable or not.

Some mines introduced training packages for workers, that carry out conveyor inspections, providing clear pictorial guidance on the acceptable limits for conveyor defects.

Figure 3: Pictorial guidance provided in worker training



# Compliance

Assessment teams issued notices in response to the following identified compliance issues.

| Notice | In relation to: |
|---|---|
| Prohibition notices<br><br>Section 195, *Work Health and Safety Act 2011* | ■ Conveyor system issues, including build-up of coal fines, seized and defective rollers and belt tracking issues with inoperable tracking aids causing friction and belt fibres. |
| Improvement notices<br><br>Section 191, *Work Health and Safety Act 2011* | ■ No documented response to increasing carbon monoxide (CO) levels on the underground conveyor system.<br>■ No formal arrangements for positioning carbon monoxide (CO) gas detectors inbye of conveyor drives to maximise the likelihood of detection.<br>■ Training records indicated significant numbers of workers escape refresher training and second egress familiarisation training elapsed.<br>■ There were a significant number of expired skills recorded for refresher training for various items including conveyor inspections, first aid and equipment operator.<br>■ Ventilation recirculation identified at underground auxiliary fan installations.<br>■ Alarm levels for gases monitored in main airways were set at the upper legislated limits and did not provide for the early detection of abnormal mine conditions.<br>■ Conveyor inspections failed to identify defects requiring immediate corrective action (i.e. missing guarding, failed idlers, poorly adjusted tracking switches and inadequate clearances).<br>■ Explosion barriers not compliant to documented site standards. |
| Notices of concern | ■ Defects with automatic fire detection and suppression equipment, identified by third party contractors, were not being entered into |

Section 23, *Work Health and Safety (Mines and Petroleum Sites) Act 2013*

the mine's computerised maintenance management system and addressed in a timely manner.

- At the surface areas of the mine, the access to fire hydrants was often impeded by randomly placed items of plant or equipment.
- Signs designating the location of emergency equipment including fire extinguishers, emergency fuel isolation points and fire hydrants were often missing, illegible or obscured to facilitate prompt identification.
- There were no signs warning of the presence of the explosion vents on the main vent fans.
- There was some confusion about the correct adjustment of flow control valves and the correct calibration procedure for gas monitoring panels at main vent fans.
- Unmanaged vegetation provided a fire corridor from bushland to mine infrastructure.
- During desktop assessments, it was noted that the electrical 'Load Flow and Fault Study', which supported the electrical protection scheme, had not been updated to reflect the current mining environment.

# Where to now

Moving forward, the Regulator's targeted assessment program has been integrated with its other proactive assessments, and will be executed as part of a single program with a clearer focus on the risk controls.

In developing the assessment tools for the new programs, we have initiated a series of internal bowtie workshops for the principal mining hazards, which include the identification of critical controls using a process aligned with the guidance provided within the ICMM Critical Control Management documents.

Each of the programs are developed with two assessment levels; a desktop assessment to examine how risk controls are identified and defined within the documented safety management system and a site assessment, to observe how risk controls are implemented and maintained where workers are most exposed.

Our assessment tools will not be a definitive list of the critical controls that must or may exist at a mine or quarry, but a series of targeted questions designed to assist us to identify deficiencies within the sites safety management system for managing a particular hazard. The results of these assessments will be recorded in a format that will assist dependable data analysis, to inform the ongoing program and provide constructive feedback to industry.

**Issued by**

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NSW Resources Regulator
NSW Department of Planning, Industry and Environment

# Further information

For more information on targeted assessment programs, the findings outlined in this report, or other mine safety information, please contact the NSW Resources Regulator. The contact details are below.

| Type | Contact details |
|---|---|
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| Incident reporting | To report an incident or injury call **1300 814 609** |
| Website | resourcesregulator.nsw.gov.au |
| Address | NSW Resources Regulator<br>516 High Street<br>Maitland NSW 2320 |

# Appendix A: Legislative requirements and published guidance relating to the management of fire or explosion risks

The following is a list of certain legislative requirements for the management of fire or explosion risks referred to in this report as provided by the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 and Work Health and Safety Regulation 2017.

Table 1: Legislative requirements for the management of fire or explosion risks

| Legislation, section/clause | Legislative requirements |
|---|---|
| WHS (MPS) Regulation, clause 9 | Management of risks to health and safety |
| WHS (MPS) Regulation, Clause 44A | Operation of belt conveyors |
| WHS (MPS) Regulation, clause 77 | Post incident monitoring |
| WHS (MPS) Regulation, clause 88 | Duty to prepare emergency plan |
| WHS (MPS) Regulation, Schedule 1, clause 6 | Schedule 1 Principal hazard management plans—additional matters to be considered |
| WHS (MPS) Regulation Schedule 7, clause 5 | Schedule 7 Matters to be included in emergency plan |
| WHS Regulation, clause 36 | Hierarchy of control measures |
| WHS Regulation, clause 359 | Fire protection and firefighting equipment |

The following published guidance material may assist mine operators to manage risks associated with fire or explosion:

Code of practice: Managing risks of hazardous chemicals in the workplace (Safe Work Australia)

MDG 1032 – Guideline for the prevention, early detection and suppression of fires in coal mines (NSW Resources Regulator)

Safety Bulletin SB17-02 Mines and preparing for fires (NSW Resources Regulator)

Safety Bulletin SB13-05 Too many underground fires (NSW Resources Regulator)

Safety Alert SA18-04 Workers withdrawn after methane frictional ignition (NSW Resources Regulator)

Fire and Rescue NSW - Guidelines and general information (Fire and Rescue NSW)

Fire or explosion in underground mines and tunnels (Worksafe New Zealand)

Critical control management (International Council on Mining and Metals (ICMM))