CONSOLIDATED REPORT: FIRE OR EXPLOSION – MINING – UNDERGROUND METALLIFEROUS MINES

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Contents

Executive summary

A crucial part of the NSW Resources Regulator's Incident Prevention Strategy involves targeted assessment and planned inspection 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.

To this end, we have developed a bowtie hazard management framework and standardised assessment checklist for each program plan. Under each program plan, the effectiveness of the safety management system at each mine site is assessed against a standard set of control supports and critical controls.

This final report summarises assessment findings from 13 mines in relation to assessments for the principal hazard of fire or explosion, mining – underground metalliferous mines, conducted during the period from December 2020 to June 2021.

The threats, consequences and critical controls assessed for the material unwanted event of fire or explosion, mining – underground metalliferous mines, are shown in Table 1.

Table 1: Threats, consequence and critical controls for the material unwanted event – fire or explosion, mining – underground metalliferous mines

	THREAT/CONSEQUENCE	CRITICAL CONTROL
Threat	■ Electrical energy in the presence of fuel ■ Mechanical energy in the presence of fuel ■ Natural energy sources in the presence of fuel	PC1.4 – Maintain non-explosive atmosphere
	■ Accumulated flammable material, leaks or spills ■ Exothermic chemical reaction	PC4.1 – Hazardous chemical management
Consequence	■ One or more fatalities	MC1.1 – Automatic fire suppression
		MC1.2 – Escape routes

Legislative requirements and published guidance relating to the principal hazard of fire or explosion is listed in Appendix A. Figure 1 presents safety compliance findings for each de-identified mine and critical control assessed for the material unwanted event of fire or explosion. Explanatory notes on the assessment system are also listed in Appendix B.

Key Findings

Although there were some instances of minor oversight, the overall management of this principal hazard was observed to be adequate at the majority of mines assessed. Some of the key findings of the planned inspection program are outlined below:

- Ventilation systems were managed effectively with regular inspections carried out by ventilation engineers or other competent persons. Maintenance was generally in line with scheduled frequencies and there were no major issues observed with the systems implemented.

- Hazardous chemicals that posed a fire risk were identified and their handling and storage was generally in line with site requirements and the manufacturer's recommendations. Chemicals in use were generally diesel fuels, oils and greases. Bunding was adequate, along with signage and labelling. Fire-fighting capacity was commensurate with the type and quantity of the chemical fuel load. However, there were areas of poor management identified, including inadequate segregation and incompatibility of stored chemicals.

- Various automatic fire suppression systems were found to be installed where identified by the mine as a control and these were installed by experienced contractors with the appropriate knowledge. Maintenance was adequate and conducted through scheduled servicing and a defect management system informed by pre-operational checklists. However in some instances, fire extinguishers were highlighted to be either missing, obstructed, or without inspection tags.

- Apart from two instances where poor practice was identified in relation to the escape route locations and a lack of underground fire assessment, escapeways and escape routes were found to be largely well managed, with regular inspections and scheduled maintenance carried out.

- Worker knowledge overall was adequate in relation to the chemicals used, the fire-fighting capabilities, and the location of the nearest refuge chamber or escapeway to their place of work. There were instances identified however, where a lack of fire extinguisher training for workers was identified.

Recommendations

We recommend that all mine operators review their existing controls for the potential of fire or explosion in the underground environment. Areas for improvement were identified and particular attention should be given to associated documentation for this principal hazard and specifically, fire-fighting capabilities, the storage and handling of hazardous chemicals and escapeways through ladderways.

There was an observation where, for example, the principal hazard management plan (PHMP) for fire and explosion was not developed from the fire and explosion risk assessment. A thorough and systematic risk assessment conducted by appropriate personnel experienced with, and affected by, the hazard must then be used to develop and set out all the control measures identified including, information, training and instruction to be provided to workers. Ongoing and periodical reviews should form part of an effective and robust safety management system.

Poor practices were identified and were mainly associated with fire extinguishers. A review of fire extinguishers should be undertaken to ensure they are located in close proximity to designated hot work areas and that they are not impeded by, or totally obstructed with, clutter or other miscellaneous items. Inspection tags should be attached to all fire extinguishers and fire suppression systems and should be stamped when regular maintenance inspections are carried out by competent personnel. Workplace inspections should also be carried out on a regular basis to identify when tags are missing and have them refitted as soon as practicable.

Some issues were also found with the handling, storage and labelling of chemicals. A chemicals register should be developed. In particular, incompatibility of chemicals and segregation distances should be clearly identified and accounted for. Incompatible chemicals must never be stored together because of the potential to react to cause a fire, explosion, harmful reaction or evolution of flammable, toxic or corrosive vapour. Where cabinets are used to store flammables, the location of the cabinets should take into account the proximity to ignition sources such as computer equipment or other electrical apparatus. Correct signage and labelling, including placarding, should be in line with the Globally Harmonised System (GHS) of labelling and spill kits should be readily available, labelled appropriately and maintained.

Escapeway and ladderway locations should be reviewed and properly assessed from any effects from the potential for propagation of a fire or explosion to other parts of the mine. This should be done taking into consideration the venting of any smoke through exhaust rises and how it may impact workers under an emergency evacuation using the ladderways.

Introduction

The NSW Resources Regulator's planned assessment programs provide a planned, risk-based and proactive approach to assessing how effective an operation is when it comes to controlling critical risk. These programs apply the following principles:

- a focus on managing prescribed 'principal hazards' from the Work Health and Safety (Mines & Petroleum Sites) Regulation 2014

- evaluation of the effectiveness of control measures implemented through an organisation's safety management system and

- consideration of the operation's risk profile.

The objective of risk profiling is to identify the inherent hazards and the hazard burden 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.

Scope

Planned inspection programs include two assessment types:

- targeted assessments, incorporating:

  - desktop assessment of:

    - compliance against legislation with respect to the management of health and safety risks associated with fire or explosion – see Appendix A for details

    - the definition of the controls the mine utilises to prevent and mitigate the risks to health and safety associated with fire or explosion.

  - a workplace assessment of the implementation of those controls through the inspection of plant and worker interviews.

- planned assessments, which involve a workplace assessment of the implementation of controls through the inspection of plant and worker interviews only.

The process

The process for undertaking an assessment under a planned inspection program generally involves the following stages:

- preliminary team meetings, preparation and review of documents

- execution of an on-site assessment involving:

    - an on-site desktop assessment of relevant plans and processes measuring legislative compliance of the relevant plans (targeted assessments only)

    - the inspection of relevant site operations (both targeted assessments and planned inspections).

- discussion and feedback to the mine management team on the findings and actions that need to be taken by the mine operators in response.

Assessment findings

Threats, consequences, and controls assessed

Threats:

- electrical energy in the presence of fuel

- mechanical energy in the presence of fuel

- natural energy sources in the presence of fuel.

Critical control: PC 1.4 – Maintain non-explosive atmosphere.

Control objective: Minimise the accumulation of flammable gas or airborne dust.

Performance requirement:

- The atmosphere is free from explosive mixtures of gas or dust.

The purpose of this critical control assessment for metalliferous mines was to examine the ventilation system ensuring it was monitored, inspected, maintained and was generally adequate in diluting any airborne contaminants.

The results of this control identified all mines as having a good level of oversight of the ventilation system. Main ventilation fans had good levels of monitoring through electronic/computer systems and were inspected regularly and maintained in-line with the scheduled frequency. Ventilation engineers or other site-competent personnel were completing regular ventilation assessments to ensure adequate air flow to the underground workings. There were a small number of isolated instances also observed that included a damaged secondary ventilation bag and the reliance on a visual indicator to determine when the primary ventilation fan was operating.

- accumulated flammable material, leaks or spills

- exothermic chemical reaction.

Critical control: PC 4.1 – Hazardous chemical management.

Control objective: Hazardous chemicals are safely contained and used in a manner that prevents fires or explosions.

Performance requirement:

- Hazardous chemicals are safely contained.

- Hazardous chemicals are handled and used in a manner that prevents fires or explosions.

Overall, the majority of mine operators had an adequate system of management of hazardous chemicals. This was achieved through good storage and handling practices, available fire-fighting capabilities and workers with adequate knowledge and training to deal with the chemicals used.

Chemicals which mainly consisted of diesel fuel, oils and greases were generally stored appropriately in accordance with site and manufacturer's requirements. This included being bunded and labelled correctly. Safety data sheets (SDS) were available and the provision for spillage was managed through available spill kits.

Firefighting capabilities were generally adequate with correct types of extinguishers located appropriately, fire suppression systems on mobile plant and electrical switch-rooms, and deluge systems around fuel bays.

Interviews and discussions with workers identified adequate knowledge about the chemicals used, along with proper storage and handling. Knowledge on fire-fighting requirements, along with appropriate training, was also demonstrated.

Areas for improvement were also identified including some instances of inadequate signage and labelling being observed, especially around manifest quantities of combustible fuels and instances of incompatible hazardous chemicals being stored together.

Consequence:

- one or more fatalities.

Critical control: MC 1.1 – Automatic fire suppression.

Control objective: Fire suppression systems automatically detect, alarm and where necessary suppress a fire to facilitate escape.

Performance requirement:

- Fires are detected and alarms are activated to warn workers of the presence of a fire.

- Fire suppression systems facilitate worker escape from the workplace.

- Fire detection, alarm and suppression systems operate when required.

- Workers respond to fire alarms.

Nearly all mine operators had automatic fire suppression systems installed.. Automatic fire suppression systems of various types were generally installed on mobile plant, fuel bays, workshops and electrical switch-rooms. The systems had been supplied and installed by specialist contractors knowledgeable with the operation and performance of the systems. With these installations came good maintenance regimes underpinned by the mine operator's computerised maintenance management system (CMMS) and commonly undertaken by contractors. An adequate defect management system was also observed, whereby defects were rectified in a timely manner, whether they were identified through a pre-operational checklist or through scheduled maintenance.

Workers interviewed demonstrated good knowledge of the fire alarms and warnings and the required response. Warnings were generally audible and visual alarms, along with stench gas release and radio communications across all areas.

Critical control: MC 1.2 – Escape routes.

Control objective: Escape routes are available to provide safe passage from fire.

Performance requirement:

- Escape routes are identified where a fire or explosion hazard exists.

- Escape routes are implemented and maintained.

- People use escape routes to escape from fires.

For this critical control, the majority of mine operators managed escape routes adequately.

Under emergency conditions, escape routes identified generally consisted of escape ladderways, cages mounted to production shaft conveyances, and refuge chambers strategically placed in the underground workings. These were found to be inspected regularly by competent personnel and maintained in accordance with site requirements.

Workers interviewed demonstrated a good knowledge of the escape routes in their immediate work areas, including the location of their nearest refuge chamber locations.

The areas for improvement were mainly concerned with ground conditions and debris impeding access. Poor ground conditions were observed leading to the ladderways from the access drives and in the immediate vicinity around the ladderway itself. Clutter and debris included a disused ventilation bag, sections of mesh and other consumables strewn around, making it difficult to quickly and safely access the ladderway.

Findings by mine

Figure 1 presents aggregate assessment findings by critical control, providing a summary view of the status of each mine's hazard management processes. Importantly, the system recognises the value of fully implemented and documented controls by awarding an additional point if both elements were assessed as present. More details explaining the assessment system are found at Appendix B.

Figure 1: Assessment findings for the planned inspection program – fire or explosion –mining – underground metalliferous mines

	Threat		Consequence	
	1. Electrical energy in the presence of fuel 2. Mechanical energy in the presence of fuel 4. Natural energy sources in the presence of fuel	3. Accumulated flammable material, leaks or spills 4. Exothermic chemical reaction	One or more fatalities	
	PC1.4	PC4.1	MC1.1	MC1.2
	Maintain non-explosive atmosphere	Hazardous chemical management	Automatic fire suppression	Escape routes
Mine A	Green	Red	Green	Green
Mine B	Green	Yellow	Green	Red
Mine C	Yellow	Green	Green	Red
Mine D	Green	Yellow	Yellow	Green
Mine E	Yellow	Green	Green	Orange
Mine F	Green	Yellow	Green	Green
Mine G	Green	Yellow	Green	Green
Mine H	Green	Green	Green	Green
Mine I	Green	Green	Green	Green
Mine J	Green	Green	Green	Green
Mine K	Green	Green	Green	Green
Mine L	Green	Green	Green	Green
Mine M	Green	Green	Green	Green

- Green (=100%)
- Yellow (>= 80% and <100%)
- Orange (>= 65% and <80%)
- Red (<65%)

Notices issued

Of the 13 sites assessed under the inspection program, each individual mine received notices relating to the principal hazard of fire or explosion, while some mine operators received notices in relation to other matters. For the purposes of this report, contraventions related to other matters have been removed from the analysis. The notices issued for fire or explosion were examined in detail and Table 2 below lists the notices issued by type and details.

Table 2: Notices issued for the planned inspection program – fire or explosion –mining – underground metalliferous mines

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.195 prohibition notice	2	2
s.191 improvement notice	16	8
s.23 notice of concerns	14	11
Total	**32**	**13**

Of the combined 32 notices issued, there were some common themes which were apparent throughout the program plan. Table 3 summarises the type of contraventions, and also outlines the total occurrences encountered. These themes can be related back to the critical controls outlined earlier and identify some trends which are of concern.

TABLE 3. Notices issued - prevalence of categories of concern

IDENTIFIED CONCERN CATEGORY	TOTAL OCCURRENCES IN NOTICES
Emergency equipment (e.g. firefighting, first aid, chemical spills) is not readily available, maintained, fit for purpose or located appropriately	11
Poor standard of storage or separation of hazardous chemicals and materials that could react in an explosion or fire	10
Information relating to hazardous chemicals (e.g. signage, SDS, register/manifest, labelling, exposure standards) not available, current, maintained or outdated	10
Ignition sources (e.g. exposed wiring, static electricity, hot surfaces, sparking, friction) not identified or managed	9
Opportunities for minimising and/or isolating hazardous substance or chemicals exposure to workers not adequately addressed or implemented	6
Fuel sources (e.g. vegetation, rubbish, poor housekeeping, oils, fuels, chemicals) not identified or managed	5
Documentation relating to controls for fire or explosion (e.g. risk assessment, PHMP, TARPs) not relevant, current, or readily available	3
Poor standard of storage or separation of hazardous chemicals that could result in the production and exposure to workers of harmful airborne dusts or gases	2
Workers not trained adequately on permits to work, hot work equipment, firefighting, emergencies (TARPS).	2
Documentation relating to controls for emergencies (e.g. risk assessment, PCP, TARPs, escape plans) not relevant, current, or readily available	1
Gas monitoring devices either not positioned or installed as per site standards	1
Safety equipment used for hot work insufficient, inadequate or outdated	1

Further information

For more information on safety assessment programs, the findings outlined in this report, or other mine safety information, please contact the NSW Resources Regulator:

CONTACT TYPE	CONTACT DETAILS
Email	cau@planning.nsw.gov.au
Incident reporting	To report an incident or injury call 1300 814 609 or log in to the Regulator Portal
Website	https://www.resourcesregulator.nsw.gov.au/
Address	NSW Resources Regulator 516 High Street Maitland NSW 2320

Appendix A. Legislative requirements and published guidance relating to the principal hazard fire or explosion

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.

WHS (Mines & Petroleum Sites) Regulation 2014:

- Division 2 Principal hazard management plans

- Schedule 1, Part 6.

WHS Regulation 2017:

- Division 8 – Hazardous atmospheres

- Division 9 – Storage of flammable or combustible substances

- NSW Code of Practice: Mechanical engineering control plan

- Technical Reference Guide – Hot Work (Cutting and welding) at mines and petroleum sites.

Australian and New Zealand Standards:

- AS/NZS 1850 - Portable fire extinguishers - Classification, rating and performance testing

- AS 1851 – Routine service of fire protection systems and equipment

- AS 1940 - The storage and handling of flammable and combustible liquids

- AS 2444 - Portable fire extinguishers and fire blankets - Selection and location

- AS 4332 – The storage and handling of gases in cylinders

- AS 5062 – Fire protection for mobile and transportable equipment.

Appendix B. Assessment system explained

We use a bowtie framework to proactively assess how mine sites manage their principal hazards. Bowties are a widely used risk management tool that integrates preventative and mitigating controls onto threat lines that relate to a material unwanted event.

As part of program planning, controls were categorised in accordance with the ICMM handbook. Only controls deemed critical[1] are assessed under a planned inspection program. For a control to be assessed as effective, each of its control supports must be in place and operational.

Assessment findings results calculation

During the program, each control support assessed at each mine was rated and the findings recorded. Points were awarded depending on whether there was evidence that the control support had been documented and / or implemented. Importantly, the system recognises the value of fully implemented and documented controls by allocating four points if both these elements were present.

For finding outcomes, points were awarded for each control support identified within a critical control. An overall assessment result for the critical control was then calculated as a proportion of the maximum possible points for that critical control. For example, if a critical control comprises 10 control supports and five were assessed as fully implemented ('documented and implemented') and five were found to be 'not documented and not implemented' then the overall assessment result for that critical control would be 50%.

Table 3: Finding outcome and points

FINDING OUTCOME	POINTS
Documented and implemented	4
Implemented but not documented	2
Documented but not implemented	1
Not documented and not implemented	0

Critical control calculations also took into account instances where control supports were not applicable to the mine being assessed or when control supports were not able to be assessed during a site visit.

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[1] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.

The overall assessment result for each critical control has been assigned a colour based on the assessment bands presented in the table below. The colour band results are then used to identify industry focus areas requiring improvement.

Table 4: Assessment results and colour code

CRITERIA	COLOUR
An assessment result of 100% of possible points	Green
An assessment result of > 80% but < 100% of possible points	Yellow
An assessment result of > 65% but < 80% of possible points	Orange
An assessment result of < 65% of possible points	Red