Resources Regulator
Department of Regional NSW

Consolidated report

Fire or explosion – electrical

Metalliferous mines and tier 1 quarries

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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.

The Regulator has 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 report summarises the assessment findings from 28 mines in relation to assessments for the hazard of fire or explosion - electrical, conducted during the period from April 2021 to October 2022.

The threats, consequence and critical controls assessed for the material unwanted event (fire or explosion - electrical) are shown in Table 1.

Table 1: Threats, consequences and critical controls for the material unwanted event (fire or explosion – electrical – metalliferous mines and tier 1 quarries)

Program Sector	Threat	Critical control
Surface	Electrically generated heat	PC 1.1 – Electrical protection
Surface and Underground	Electrical energy in the presence of fuel	PC 1.2 – Electrical protection PC 1.5 – Electrical equipment suitable for the atmosphere
Surface and Underground	Natural energy sources in the presence of fuel	PC 4.1 – Lightning protective earthing
Surface and Surface and Underground	Explosive atmosphere	PC 6.2 – Explosion protected equipment

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 ground or strata failure. Explanatory notes on the assessment system are also listed in Appendix B.

Most mines were found to have well documented control plans and engineering standards however, implementation of documented site standards was generally considered less than adequate. Inspectors completing the assessment identified common themes which applied to several mines in relation to the associated principal hazard. This resulted in a total of 59 notices (including notices of concern, improvement notices, and prohibition notices) being issued throughout the inspection program.

Key findings

Resource Regulator inspectors were able to share information from other mine sites of work that was being done well to manage the hazards associated with fire or explosion, as well as any incidents that had occurred within the mining industry and what controls were applied to prevent a similar type of incident from reoccurring.

Some general findings from the inspection program are listed below, as well as some specific findings for each of the critical controls assessed.

General findings:

- Understanding and management of electrical hazardous areas as defined in AS/NZS 3000:2018 Section 1.4.15 was considered inadequate by the assessing inspectors.
- Removal and restoration of power procedures were not well understood by workers and documented practices were not being adhered to.
- Most of the inspected mine's removal and restoration of power procedures did not specifically address earth fault lock out (EFLO) trips.
- Oil filled switch gear at some mines had not been appropriately risk assessed and suitable inspection and maintenance controls were not implemented.
- Hazardous area maintenance practices had not been developed with consideration for conditions contained within the relevant explosion protected equipment certificates of conformity.

Critical control: PC1.1 – Electrical protection

- Most sites had suitable electrical protection installed.
- Protection and arc flash studies exist at most sites capturing required settings of protection devices.
- Settings of protection devices inspected generally aligned with site protection studies.
- Some sites failed to identify the requirement for fire detection and/or suppression devices in electrical installations.
- High voltage maintenance findings at one mine suggested that the high voltage electrical protection systems installed in the 66/11kV switchroom and switchyard may not be fail safe. Scenarios potentially exist where the protection would not operate in the event of a fault.
- Removal and restoration of power procedures were not developed with consideration of a risk assessment.
- Most of the inspected mines removal and restoration of power procedures did specifically address earth fault lock out (EFLO) trips.
- Redundant cables were observed unterminated and without any protection against moisture ingress.
- At some mines, arc flash labelling had not been implemented.
- Some mines had not recently completed maintenance and testing of oil filled switchgear.
- Oil filled switchgear at some sites was not fitted with remote switching facilities and no specific guidance existed for safely switching power.
- Remote switching facilities installed on some oil filled switch gear was not operational.

Critical control: PC1.2 – Electrical protection

- Restoration of power procedures at multiple mines allowed reclosure of supply after an earth leakage fault and/or earth fault lock out (EFLO) trip without the requirement to first electrically test the installation. This process was not risk assessed at any of the referenced sites.
- Electrical equipment observed underground allowed workers access to earth leakage and earth fault lockout reset buttons without the need for a key. This was despite locked reset switches being identified as a control for managing restoration of power.
- Access steps and landing structures around electrical switchgear were found not equipotential bonded to the mine's earthing system.
- Some mines had not completed an earthing study.
- Mine personnel were unaware of any specific requirements limiting cable lengths for trailing cable installations.

Critical control: PC1.5 – Electrical equipment suitable for the atmosphere

- Mines inspected generally had a poor level of understanding of hazardous area classification.
- A lack of signage to identify hazardous areas.
- Lack of procedures for the controlled intermittent use of non-explosion protected equipment within defined hazardous areas.
- Hazardous area maintenance practices had not been developed with consideration for conditions contained within the relevant explosion protected equipment certificates of conformity.

Critical control: PC 4.1 – Lightning protective earthing

- Lightning management practices observed appeared sufficient for the level of risk.
- Mines were able to demonstrate testing had been carried out to confirm site earthing integrity.
- Earthing studies existed for most sites inspected.

Critical control: PC 6.2 – Explosion protected equipment

- A lack of signage to identify hazardous areas.
- Lack of procedures for the controlled intermittent use of non-explosion protected equipment within defined hazardous areas.
- tradespersons interviewed were unaware of specific maintenance considerations for working on explosion protected equipment.
- electrical personnel required to work on explosion protected equipment had not received training in hazardous areas (EEHA).
- most mines did not have procurement systems in place to ensure replacement of explosion protected electrical equipment is like-for-like.
- some mines inspected did not receive and review maintenance work orders for site hazardous areas that are completed by contractors.

Recommendations

The planned inspection program identified varying levels of control implementation and effectiveness across all the sites assessed. This highlighted several practices that could be improved to assist in protecting the health and safety of workers when exposed to this hazard. Based on the assessments completed, the recommendations are as follows:

- Potential hazardous areas should be identified through risk assessment conducted in consultation with suitably qualified and competent people.
- Mine operators must complete a hazardous area assessment and implement controls for any relevant installations which must comply with the requirements of AS/NZS 3000 (Wiring Rules) Section 7.7 Hazardous Areas.
- Mine operators should ensure that workers are provided training and instruction of site restoration of power procedures.
- To ensure compliance with site restoration of power procedures engineering controls should be considered for controlling worker access to reset functions on electrical equipment.
- Where mines have engaged subject matter experts to complete assessments such as arc blast, earthing and protection studies, the recommendations should be assessed and implemented in an appropriate timeframe to manage the risks identified.
- Mine operators must ensure that electrical protection systems are implemented, maintained, and remain fit for purpose so they effectively operate throughout the lifetime of the installation.

- High voltage maintenance should be planned by taking a risk-based approach and scheduled at appropriate timeframes to prove the reliability and effectiveness of protection relays.
- Mines should audit their work practices in the field against what is documented in their electrical engineering control plans.
- A system should be developed for the periodic review of electrical engineering control plans and associated documents in line with Section 22 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022.

It is recommended that mine operators, upon reading this consolidated report, review their site's relevant risk assessments, principal hazard management plans and associated documents to manage electrical risks associated with fire or explosion that are unique to their site. During the review process, mine operators should also consider the relevance of these recommendations as well as the guidance published within Appendix A

Findings by mine

Figure 1 presents aggregate assessment findings by threat/consequence and 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 – electrical – metalliferous mines and tier 1 quarries – surface

		Threat	
		Electrically generated heat	Explosive atmosphere
		PC1.1	PC6.2
		Electrical protection	Explosion protected equipment
Surface	Mine A	Yellow	Red
	Mine B	Orange	Orange
	Mine C	Green	Red
	Mine D	Red	Green
	Mine E	Green	Yellow
	Mine F	Green	Green
	Mine G	Green	Green
	Mine H	Green	Green
	Mine I	Green	Green
	Mine J	Green	Green
	Mine K	Green	Green
	Mine L	Green	Green
	Mine M	Green	Green
	Mine N	Green	Green
	Mine O	Green	Green

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

Figure 2: Assessment findings for the planned inspection program – fire or explosion – electrical – metalliferous mines and tier 1 quarries – surface and underground

		Threat			
		Electrical energy in the presence of fuel		Natural energy sources in the presence of fuel	Explosive atmosphere
		PC1.2	PC1.5	PC4.1	PC6.2
		Electrical protection	Electrical equipment suitable for the atmosphere	Lightning protective earthing	Explosion protected equipment
Surface and Underground	Mine AA				
	Mine AB				
	Mine AC				
	Mine AD				
	Mine AE				
	Mine AF				
	Mine AG				
	Mine AH				
	Mine AI				
	Mine AJ				
	Mine AK				
	Mine AL				
	Mine AM				

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

Notices issued

Of the 28 sites assessed under the inspection program, 23 separate mines were given notices relating to the principal hazard of fire or explosion - electrical, while some mines 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 fire or explosion - electrical 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 – electrical – metalliferous mines and tier 1 quarries

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.195 prohibition notice	4	4
s.191 improvement notice	34	18
s.23 notice of concerns	21	20
Total	59	

Of the combined 59 notices issued, there were some common themes which were apparent throughout the program plan. Table 3 summarises the type of contraventions and 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:	OCCURRENCES:
Site restoration of power procedures not being followed	7
Potential hazardous area not classified	5
Inadequate management of classified hazardous areas	6
Failure to implement arc flash controls	2
No earthing study	1
Issues relating to oil filled switchgear	3
Inadequate electrical engineer supervision	3
Welder issues	3

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	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 - electrical

The following is a list of certain legislative requirements for the management of ground or strata failure risks referred to in this report, as provided by the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 and Work Health and Safety Regulation 2017.

Work Health and Safety (Mines and Petroleum Sites) Regulation 2022:

- Clause 34 - Electrical Safety

Work Health and Safety Regulation 2017:

- Part 4.7 General electrical safety in workplaces and energised electrical work

Relevant published guidance:

- NSW code of practice: Electrical engineering control plan
- Australia and New Zealand Standards:
  - AS/NZS3000 - Electrical installation 'Wiring Rules'
  - AS/NZS3800 - Electrical equipment for explosive atmospheres - repair and overhaul
  - AS/NZS 60079.0 - Explosive atmospheres - equipment general requirements
  - AS/NZS 60079.17 Explosive atmospheres – electrical installation inspections and maintenance
  - AS/NZS 4761.1 Competencies for working with electrical equipment for hazardous area

Appendix B. Assessment system explained

The NSW Resources Regulator uses 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 by the NSW Resources Regulator's Mine Safety inspectorate 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 ten 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.

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

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