NSW GOVERNMENT

NSW Resources Regulator

PLANNED INSPECTION PROGRAM

CONSOLIDATED REPORT: FIRE OR EXPLOSION – ELECTRICAL – UNDERGROUND COAL MINES

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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.

To this end the NSW Resources Regulator 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 15 mines in relation to assessments for the principal hazard of fire or explosion – electrical – underground coal mines conducted during the period from July 2020 to June 2021.

The threats and the critical control assessed for the material unwanted event of fire or explosion – electrical – underground coal mines, are shown in Table 1.

Table 1: Threats and Critical Control for the Material Unwanted Event – Fire or Explosion – Electrical – underground coal mines

THREAT	CRITICAL CONTROL
■ Electrical energy in the presence of fuel	PC1.2 – Electrical protection
■ Electrical energy in the presence of fuel ■ Mechanical energy in the presence of fuel	PC1.5 – Electrical equipment suitable for the atmosphere
■ Natural energy sources in the presence of fuel	PC4.1 – Lightning protective earthing PC4.2 – Remove conductive pathways to fuel

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 the 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

Most mines were found to have well documented control plans and engineering standards that were current and effective. Sites had communicated with workers, who demonstrated a good understanding of the plans. In addition, inspectors spoke with many electrical workers and found their competencies and understanding of the implementation of the electrical control plan well understood.

The inspectors completing the assessment did identify some common themes which applied to several mines in relation to the associated principal hazards.

- Lack of maintenance allowing earth bonds to become heavily corroded at mine portals and switch yards.
- Lack of design records for lightning protection earthing systems or inspections/testing programs were identified at some older mines.
- Some mines had documentation (Risk Assessment, PCP, TARPs etc.) that were found to be not relevant, current, implemented or readily available.
- There were several instances where inspection, maintenance, and repair regimes for electrical installations were not being followed.

The assessments identified several areas where engineering standards could be improved:

- There was a large variation identified between planned and actual timeframes for oil sampling and dissolved gas analysis.
- In several cases, timeframes for high voltage maintenance processes, including relay injection testing, varied. It was unclear how mines determined the timeframes for high voltage maintenance and could not support their nominated timeframe with a risk-based approach.
- Most mines have identified and align with the requirement of AS/NZS3000 hazardous area around surface tube bundle installations.
- Mines were found to have completed arc blast studies; however, a few mines had not yet completed all actions from these studies.
- Mines that have methane present during normal operation were found to have high electrical protection standards and kept reset switches on gas monitoring devices locked.
- Many mines have high voltage switchyards that have recently been constructed to a high standard. Unfortunately, some mines have allowed fuel and vegetation to accumulate.

Recommendations

Recommendations from this planned inspection program include:

- Mine operators must ensure the electrical protection systems are implemented and maintained fit for purpose, so they effectively operate throughout the lifetime of the installation.
- Mines must complete a hazardous area assessment and implement controls for tube bundle installations which must comply with the requirements of AS/NZS 3000 (Wiring Rules) Section 7.7 Hazardous Areas.
- Where mines have engaged specialists to complete assessments such as arc Blast studies, the recommendations should be assessed and implemented in an appropriate timeframe to manage the risks identified.
- Backlog and corrective work-order management should be managed as per the mine maintenance / defect management systems.
- 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.
- Lightning mitigation controls should be periodically inspected and plans of lightning earthing systems must be kept up to date to ensure that they remain effective.
- Mines that still have oil circuit breakers should develop a replacement program to replace them and manage the current risk to as low as reasonably practical.
- 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 clause 17 of the WHS(M&P) Regulation 2014.

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

Introduction

The NSW Resources Regulator's planned assessment programs provide a planned, risk-based and proactive approach to assessing how effective an operation is 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 and controls assessed

Threat:

- Electrical energy in the presence of fuel

Critical control: 0402 - PC 1.2 – Electrical protection.

Control objective: Electrical protection detects and disconnects overloaded or faulty electrical equipment

Performance requirement:

- All electrical equipment that presents a fire or explosion risk is fitted with electrical protection.
- The time / current coordination of the electrical protection ensures it operates before a fire or explosion is initiated.
- Earth faults are detected and cleared before escalating to a multi-phase fault.
- Earth fault currents are limited to prevent escalation to a multi-phase fault.
- The capacity of the disconnection device is sufficient to safely interrupt the available electrical energy.
- Electrical protection reliability sufficient for the level of risk.

This section of the assessment completed by inspectors identified that mines had appropriately documented systems that were supported by a thorough risk assessment.

However, there were issues which were identified during inspections, these included:

- Although all mines have completed arc blast studies a small number of mines were found to have not fully implemented all the actions that had been identified.
- Although all mines identified the importance of high voltage protection relays being tested periodically, it was found that the timeframe for these tests varied significantly and in some cases these timeframes were not supported by risk management. Only one mine was found to have outstanding injection testing that had been rescheduled several times.

Threat:

- Electrical energy in the presence of fuel
- Mechanical energy in the presence of fuel

Critical control: 0402 - PC 1.5 – Electrical equipment suitable for the atmosphere

Control objective: Management of diesel or electric-powered plant prevents ignition of explosive atmosphere

Performance requirement:

- Areas that may contain an explosive atmosphere are identified.
- Installed or introduced electrical and mechanical equipment is appropriate for the hazardous area classification.
- Installed or introduced electrical or mechanical equipment is removed or de-energised if atmosphere changes.
- Explosion-protected electrical equipment, both installed and introduced is maintained in an explosion protected state.
- Atmospheric monitoring of mechanical equipment is installed and is maintained in an explosion-protected state.
- Non-explosion protected equipment is prevented from entering an area classified as hazardous.

Specific findings for this critical control included:

- Several mines have oil circuit breakers in use underground. All mines have identified these as an arc blast risk and some have implemented operating devices that allow the operator to remotely close them.
- Mines have tube bundle installation that analyses mine atmospheres and gases at a central location on the surface that is mainly located in an enclosed building. Most mines have recognised that these areas are required to be assessed as per the requirements of AS/NZS 3000 (Wiring Rules) Section 7.7 Hazardous areas. Some mines have not completed hazardous area assessments and implemented controls.

- Several electrical installations both on the surface and underground were found to be obstructed with non-electrical plant making access in an emergency difficult and provided a fuel source for fires.
- The assessments identified that some mines have work practices used in the field that did not align with the electrical engineering control plan, for example, fitting of locks to electrical protection of CH_4 reset devices.
- Redundant cables and electrical plant have been the cause of several electric shocks in recent years and the assessments identified that mines have addressed this in their management plans. However, in a few cases inspectors found installations that did not align with the site standards.
- Oil sampling is a proven method of predicting premature failure of electrical plant. Mines are using oil sampling and dissolved gas analysis to predict issues with electrical plant. The inspectors identified that there was a vast difference in the timeframes these tests were conducted.

Threat:

- Natural energy sources in the presence of fuel

Critical control: 0402 - PC 4.1 – Lightning protective earthing.

Control objective: Lightning energy is diverted away from underground parts of the mine.

Performance requirement:

- Earthing arrangements for lightning dissipation to ground are in place.

This assessment identified that most mines had completed lightning protection studies for the current operational arrangements around mine portals, boreholes, and MIA areas. Two key areas that were identified that required improvement were:

- Lack maintenance of the earth bonds allowing earth bonds to become heavily corroded.
- A lack of design records for lightning protection earths or inspections/test programmes

Critical control: 0402 - PC 4.2 – Remove conductive pathways to fuel.

Control objective: Lightning energy is separated from underground fuel source.

Performance requirement:

- Conductive pathways are insulated from underground fuel sources
  (e.g. steel bore cases, piezometers, air & water pipelines, conveyors, rails, etc)

Most mines had assessed and managed the effects of lightning, with high standards of maintenance and good documentation. At a few older mines, the assessment found maintenance practices around lightning installations had allowed the installations to deteriorate over time. More specifically, these included:

- lack of electrical plans of lightning earth grids
- no evidence could be provided for maintenance of lightning earths, eg. corroded connection points.

Findings by mine

Figure 1 presents aggregate assessment findings for the 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 – Underground coal mines

	1. Electrical energy in the presence of fuel	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	
	PC1.2	PC1.5	PC4.1	PC4.2
	Electrical protection	Electrical equipment suitable for the atmosphere	Lightning protective earthing	Remove conductive pathways to fuel
Mine A	Red	Yellow	Red	Red
Mine B	Green	Orange	Red	Red
Mine C	Green	Green	Orange	Red
Mine D	Green	Green	Yellow	Red
Mine E	Orange	Green	Green	Orange
Mine F	Green	Yellow	Yellow	Green
Mine G	Green	Green	Yellow	Green
Mine H	Green	Green	Yellow	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
Mine N	Green	Green	Green	Green
Mine O	Green	Green	Green	Green

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

Notices issued

Of the 15 sites assessed under the inspection program, 12 separate mines received notices relating to the principal hazard of fire or explosion, 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 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 – Electrical – Underground coal mines

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.191 improvement notice	38	9
s.23 notice of concerns	14	10
Total	**52**	**12**

Of the combined 52 notices issued, there were some common themes which were apparent throughout the program plan. Table 3 summarises the type of contraventions 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
Maintenance of electrical plant throughout the life cycle not being completed in line with scheduled maintenance programmes
Incomplete protection and earthing studies, with a failure to implement appropriate controls
Poor housekeeping of electrical installations, preventing safe access and operation of electrical equipment
Work practices did not reflect what is documented in sites control plan
Control plan not periodically reviewed against the appropriate risk assessment

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 of fire or explosion

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

Work Health and Safety (Mines and Petroleum Sites) Regulation 2014:

- Clause 32 - 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 2290.1 - Electrical equipment for coal mines - inspection and maintenance
  - 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
- SA20-10: Anti-static materials in underground coal mines
- SB18-13: Alternators and IS equipment

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.

[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