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TARGETED INTERVENTION PROGRAM

ELECTRICAL SAFETY AT TIER-1 QUARRIES

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Executive summary

In response to significant concerns regarding the testing, inspection and maintenance of electrical equipment identified as part of an incident investigation for a reported electric shock at a quarry, the Chief Inspector of Mines initiated a targeted intervention at Tier-1 quarries across the state, focusing on the management of electrical hazards.

Seventeen sites across New South Wales were identified for assessment, which were conducted by a team of nine electrical inspectors over a period of 14 days.

This report summarises the assessment results, the issues raised and commentary on those issues.

Inspectors issued 84 Work Health and Safety notices in relation to the management of electrical hazards and legislative compliance. This included 23 Section 23 Notices of Concern and 61 Section 191 Improvement Notices.

While all mines that were assessed could demonstrate a risk-based approach to managing electrical risks, issues identified by inspectors included poorly executed risk assessments which failed to include workers, failed to identify all electrical hazards on site and failed to nominate clearly defined risk control measures to eliminate or mitigate the risks.

These failures were reflected within electrical engineering control plans and subordinate documents. These plans did not properly address or communicate minimum requirements for installation, commissioning, maintenance and de-commissioning of electrical plant. Specifically, inspectors noted absent or incomplete electrical commissioning records, inspection and maintenance regimes which failed to ensure electrical risk control remained effective and no documented minimum standards for de-commissioning redundant electrical infrastructure.

Inspectors also identified issues associated with the management of arc blast, lightning protection and management of electric welding equipment.

Further details of the assessment findings are provided later 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 are specific to electrical hazards. Mine operators are encouraged to review these findings and consider how they may apply to their operation.

Introduction

In February 2016, the NSW Resources Regulator published its Incident Prevention Strategy.

A key component of the strategy is the introduction and implementation of a risk-based intervention framework. The framework identifies and confirms risk profiles, verifies risk control measures and allocates resources based on risk priority.

The implementation of the strategy included the development of two operational approaches to regulatory activity. These are:

- targeted assessment programs (TAP): a planned, proactive program that assesses the overall effectiveness of an operator's attempt to control critical risk
- targeted interventions: a response to a specific incident, series of incidents or other intelligence, which assesses how effectively relevant risks are being controlled (see below for further detail).

Background

Targeted interventions provide a systematic response to a critical risk. They can be applied across all sectors of the mining industry. The need to undertake an intervention will be identified through:

- a series of events
- a single significant event, such as a catastrophic failure or fatality
- a change in the operation's risk profile
- data that suggests an emerging issue.

Targeted interventions are typically undertaken by a team of inspectors. The interventions provide an assessment of the:

- operational and management plans and supporting documentation
- implementation of plans and procedures
- effectiveness of control measures
- operator's compliance with relevant legislative provisions.

Scope

The scope of the assessments includes two elements:

- a desktop assessment of:
  - compliance against legislation with respect to the management of risks to health and safety associated with electrical risks at the site
  - controls the mine utilises to prevent and mitigate the risks to health and safety associated with electrical risks
  - the systems the mine utilises to monitor the effectiveness of those controls.
- a workplace assessment of the implementation of those controls.

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 system
- **Specific findings** that should be used to inform and improve an operation's safety management system with respect to electrical risks.

General findings

Risk assessment

Issue	Response
Documented risk assessments were often high-level or generic and did not always represent all the electrical hazards present at the site.	Risk assessments should clearly identify all the electrical hazards applicable to the site and risk controls nominated should be clearly defined and documented within the safety management system. Addressing these areas will assist with improving the integration of identified risk control measures into the electrical engineering control plan, related standards and procedures, and aid in the establishment of performance indicators for the effectiveness of the control measures[1].
For a number of the risk assessments reviewed, it was noted those people who have significant responsibilities for the implementation of electrical risk controls and workers who had substantial site knowledge and experience were not represented (i.e. electricians and plant operators). In some cases, this omission was further compounded by the risk assessment team failing to identify site specific electrical hazards or making assumptions as to the pre-existence of risk controls.	The risk assessment team should include people with knowledge and experience with respect to the hazard being assessed and workers with enough site knowledge to ensure a credible and accurate analyses of the threats and potential risk control measures is carried out[2]. This includes having an appreciation of the potential effectiveness of any identified risk control measures in addressing the risks. At smaller operations, engaging electrical engineering support in the risk assessment process may be prudent.
Assessments at a number of mines identified that risk controls	At the time of the risk assessment it is important to accurately define the specification or intent of the identified

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

[2] Work Health and Safety Act 2011 Part 5 Consultation, representation and participation

nominated in risk assessments were either not in place or ineffective. This could be attributed to poorly defined risk controls or a failure to verify risk control implementation or effectiveness.	control measure to ensure it is properly documented within the safety management system and the risk control owner can effectively implement the control in practice. Mine operators should also satisfy themselves that identified risk control measures are in place and verification tasks, including testing and commissioning procedures, confirm risk control effectiveness[3]. The International Council on Mining and Metals (ICMM) provides guidance on defining control objectives, performance requirements and verification[4].
Site risk assessments often identified proposed additional controls to manage electrical hazards. However, at several sites it could not be verified if the controls were assigned for action or implemented.	Risk assessment should include processes for the documenting and tracking of actions to implement additional controls. For those actions to investigate potential risk controls, clear reason for not adopting a control should also be documented.

Specific findings

Exercising statutory function

Issue	Response
At some of the mines assessed, where a statutory electrical engineer is required (i.e. the connected power at the mine is greater than 1,000 kilowatts or high-voltage is utilised), there was evidence to support a view that the	The statutory functions of the electrical engineer are to develop and review the standards and procedures for the installation, commissioning, maintenance and repair of electrical plant at the mine, and to supervise the installation, commissioning, maintenance and repair of electrical plant at the mine[5]. Safety management systems must detail the responsibilities of each person with a key statutory function in regards to the

[3] Work Health and Safety (M&PS) Regulation 2014 Clause 15 Performance standards and audit
[4] Health and Safety Critical Control Management Good Practice Guide, International Council on Mining & Metals, 2015, p14
[5] Work Health and Safety (M&PS) Regulation 2014 Schedule 10, Clause 33 Electrical engineer

standards and procedures for the installation, commissioning, maintenance and repair of electrical plant and installations at the mine, either had not been determined or had not been reviewed. Field inspections identified inferior installation standards, poorly maintained equipment and, in some cases, accompanying electrical engineers unaware of current site activities.	supervision of workers at the mine or petroleum site[6]. Statutory electrical engineers should have systems in place to ensure standards and procedures are realised and maintained.
Statutory electrical engineers could not always demonstrate a timely review of testing results for new or re-commissioned electrical circuits.	Before a circuit is first energised or is first energised after being recommissioned, the circuit is to be tested in accordance with the Wiring Rules (AS3000) by a competent person and there must be a process in place whereby the operator (or an individual nominated to exercise the statutory function of electrical engineer) can be adequately notified about that testing, as soon as is reasonably practicable after the testing occurs[7].

Electrical engineering control plan

Issue	Response
At some sites it was noted that control measures for electrical hazards, identified within risk assessments, had not been documented within the electrical	In developing the safety management system, the risk assessment process should identify all hazards applicable to the mine and the current and potential risk controls, which should then inform control plans, standards and procedures to facilitate implementation at the mine or quarry site[8].

[6] Work Health and Safety (M&PS) Regulation 2014 Clause 14 Content of safety management system
[7] Work Health and Safety (M&PS) Regulation 2014 Clause 32 Electrical safety
[8] Work Health and Safety (M&PS) Regulation 2014 Clause 26 Principal control plans, (5) Electrical engineering control plan

engineering control plan or subordinate documents.	
At some sites it was noted that electrical engineering control plans and overarching risk assessments were silent on matters to be addressed as prescribed in the WHS (M&PS) Regulation. This has potentially left some sites exposed to risks associated to some electrical hazards (e.g. electrical test equipment, lightning).	The WHS (M&PS) Regulation 2014 nominates matters relating to electrical hazards that must be considered when preparing an electrical engineering control plan. Failure to consider these matters, and where required, identify and implement risk controls, may expose workers to unnecessary risk.[9]
Electrical workers did not always have access to the most recent versions of the electrical engineering control plan, or electrical standards and procedures that were relevant to their work. Some workers were using old document versions or not aware of the existence of relevant standards.	Legislation requires principal control plans to be readily accessible to all workers[10] and mines have an obligation to provide information, training and instruction on the safety management system at the mine before a worker commences work[11].

Protection from direct contact

Issue	Response
During assessments, several areas were identified where the potential for direct	When identifying risk controls for electrical hazards, like overhead high-voltage power lines and buried cables,

[9] Work Health and Safety (M&PS) Regulation 2014 Schedule 2, Clause 3 Electrical engineering control plan
[10] Work Health and Safety (M&PS) Regulation 2014 Clause 103 Duty to inform workers about safety management system
[11] Work Health and Safety (M&PS) Regulation 2014 Clause 105 Duty to provide induction for workers

contact with energised conductors were present. Unimpeded access to live conductors through unsecured electrical enclosures and missing 'pole fillers' in distribution boards are obvious examples. Heavy vehicle parking areas adjacent to high-voltage power lines, unmarked buried cables and unprotected high-voltage trailing cables were also evident. All of which can expose workers to serious risk.

consideration should be given to changing site conditions and possible activities that might diminish the effectiveness of those risk controls. Elimination of the hazard should always be the priority when identifying controls. The realignment of roadways, the introduction of cranes or excavators and changes to mobile plant can all adversely affect risk control effectiveness. Inspection and maintenance regimes should also be in place to ensure risk control measures remain effective throughout the life of plant.

Protection from indirect contact

Issue	Response
Site inspections noted numerous failures to maintain adequate ingress protection (IP Rating) for electrical enclosures and plug socket combinations. Ingress of dust and water provide pathways for electrical tracking and insulation breakdown exposing workers to electric shock hazards.	Electrical equipment installed in wet or dusty environments must have appropriate ingress protection to ensure the electrical insulating properties of the enclosure and fittings are not compromised. When selecting the appropriate IP rating for electrical equipment, foreseeable changes in the environment should be taken into account and guidance sought from Australian Standard AS/NZS3000 Wiring Rules. Inspection and maintenance regimes should also be in place to ensure the ingress protection remains effective and appropriate for the environment.
Reviews of electrical engineering control plans and site inspections noted numerous gaps in the implementation and verification of effective earthing of conductive parts which are not normally live (e.g. metallic enclosures, water pipes and taps, metal buildings and containers)	Australian Standard AS/NZS3000 Wiring Rules requires the effective earthing of exposed and extraneous conductive parts, including water pipes and taps. Earthing systems should be properly installed, verified and maintained to

but may become live under fault conditions. Evidence of routine testing and maintenance, particularly in administrative areas and portable buildings, was often non-existent, with most sites reliant upon the integrity of the initial installation.	ensure workers are not exposed to indirect contact with electricity under faulty conditions.
Some sites responsible for the maintenance and inspection of high-voltage switchyards and transformers could not provide evidence of routine testing or inspection of the main earthing system. Furthermore, site inspections identified corroded earthing attachments, missing equipotential bonds and unidentifiable test points.	Professionally designed earthing systems for high-voltage installations provide significant risk mitigation for step and touch potentials under fault conditions. AS/NZS3000 Wiring Rules mandates compliance to the requirements AS2067 Substations and high-voltage installations exceeding 1 kV a.c. Sites should be able to demonstrate management of the high-voltage earthing system throughout its lifecycle, including design, verification, inspection and maintenance.

Arc faults

Issue	Response
All electrical installations had high fault levels. Despite most sites acknowledging the inherent risks associated with this, the implementation of risk control measures for arc blast were sporadic. Failures to implement controls included not implementing recommended protection settings from fault studies, absent warning labels and failure to make appropriate personal protective equipment readily available.	Sites must identify all electrical hazards including the risks associated with arc blast. Comprehensive modelling of the site's electrical distribution system should identify those areas that pose a risk to workers from arcing faults and identify opportunities to reduce those risks by adjusting protection settings or changes to the distribution system design (e.g. type tested switchboards, fault current limiters). Where the risk cannot be reduced to satisfactory levels when applying the hierarchy of controls, consideration should be given to the use of other risk controls like remotely operated switches and circuit breakers, rated personal protection equipment and warning labelling.

	Sites should have inspection regimes in place to ensure these risk control measures are in place and remain effective.

Lightning

Issue	Response
Site assessments found numerous instances where risk assessments and electrical engineering control plans did not identify hazards and risk controls associated with lightning. Subsequent interviews with workers identified minimal awareness of any site protocols for responding to thunderstorm activity.	The WHS (M&PS) Regulation requires the impact of lightning on a mine site[12] to be considered. Ignition of explosives or explosive atmospheres, electric shock or burns and unintended operation of electrical systems are some of the hazards associated with lightning. Risk assessments should also consider workers operating fixed and mobile plant in open areas, who have a high exposure to any lightning activity. Australian Standard AS/NZS1768 Lightning protection provides guidance on the assessment and management of lightning hazards. Workers exposed to lightning hazards should be made aware of site protocols, including trigger action response plans (TARPs) that are in effect during lightning storms.

Commissioning

Issue	Response
At some sites it was noted that electrical workers were unaware of the minimum requirements for electrical testing and commissioning of electrical equipment prior to energising for the first time or	The WHS (M&PS) Regulation requires new or recommissioned electrical circuits to be tested in accordance with the Wiring Rules (AS3000) by a competent person[13]. The Wiring Rules (AS3000) prescribe the mandatory tests required prior to placing electrical equipment into service following construction, alteration or repair. Electrical engineering

[12] Work Health and Safety (M&PS) Regulation 2014 Schedule 2, Clause 3(f) Electrical engineering control plan
[13] Work Health and Safety (M&PS) Regulation 2014 Clause 32 (2) Electrical safety

returning to service after repair. There was also evidence of poor record keeping when testing was carried out.	control plans should describe the minimum electrical testing and commissioning requirements and prescribe the form in which records should be made and the process for reviewing test results.

De-commissioning

Issue	Response
At several sites, decommissioned electrical plant and wiring systems were not readily discernible from operational equipment. Interviews with site electrical workers often revealed a lack of clarity on the minimum requirements for isolation and marking of redundant electrical cables and plant.	Incidents involving the inadvertent energising of redundant cabling and plant can be averted using robust decommissioning standards that ensure electrical circuits are securely isolated from their source and, where necessary, properly insulated, short-circuited and/or earthed. Indelible labelling of decommissioned circuits or plant and the timely disconnection and removal (where possible) should further ensure hazardous situations do not arise.

Signage

Issue	Response
Site inspections often identified illegible, obscured, inappropriate or missing safety signage designed to warn of the presence of a hazardous situations, including the presence of buried cables, arc flash hazards, overhead power lines and hazardous voltages.	Risk assessments often identify the use of warning signs as a risk control to warn workers of a hazard. Mines have an obligation to ensure risk control measures are maintained and remain effective[14] and should have systems in place to verify this effectiveness.

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

Welding equipment

Issue	Response
Site inspections identified numerous defects for electric welding equipment. Unprotected welding outlets (earth leakage), modified earth pin on a three-pin plug, damaged clamps and cabling can all increase the risk to workers.	Mine operators should have robust systems for the inspection and maintenance of welding equipment by competent personnel, including 'test and tag'. Documented pre-use inspections of welding equipment and the welding environment can increase operator awareness of the hazards associated with electric welding.

Compliance

Below is a summary of notices issued by inspectors in response to identified compliance issues and concerns.

Notice	In relation to
Improvement notices, Section 191 Section 191, *Work Health and Safety Act 2011*	• At a floating concentrator, it was noted that floating metal access walkway pontoons, supporting the wet plant's 22KV trailing cable power supply, were not equipotential bonded to the mine's earthing system. • It was identified that several contractor-managed electrical installations did not meet the requirements of AS/NZS 3000 Wiring Rules. • Numerous high-energy, low-voltage switchgear and bus enclosures did not have arc flash category rating signage affixed and arc flash PPE had been removed from its storage location within a switch room. • Process not in place to make the statutory electrical engineer aware of all electrical test reports for re-commissioned or newly commissioned electrical circuits. • There was no evidence the nominated statutory electrical engineer had reviewed the installation and commissioning documentation. • Electrical engineering control plans not reviewed. • The document layout, format and content of an electrical engineering control plan had not been set out in a way that is readily understandable by workers who use it. • Installations (i.e. demountable buildings, shipping containers, water pipes, hot water system and water filter systems) that had no equipotential earth bonding of extraneous conductive parts as part of the electrical installation to these buildings. • No documented process outlined in the electrical engineering control plan for the testing of new /altered electrical installations before first energised.

Notice	In relation to
	• Site's certificate of compliance did not outline what mandatory testing is required in accordance with AS/NZS3000 Wiring Rules. • Electrical risk assessment and electrical engineering control plan risk assessment not developed or reviewed in consultation with site electrical workers. • Electrical risk assessment and electrical engineering control plan risk assessment did not detail the control measures implemented to eliminate or minimise the risks that were identified through the risk assessment. • Electrical engineering control did not address specific procedures for the use of electrical test instruments, which must be taken into account when developing control measures for the electrical engineering control plan. • The mine operator failed to take into account control measures with respect to the rating and design of plant for the prospective electrical fault level, electrical load and arc fault control as per the requirements of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 Schedule 2 (3)(3)(b). • Multiple examples of electrical equipment plugged into 240 volt socket outlets with out-of-date test tags, no tags or tags that were blank. • An unused ducted air conditioner/ heating system with electrical power still applied via a 240 volt socket outlet that was not maintained and was not properly decommissioned. • A pad mount kiosk transformer had one of two locks removed on both the high and low voltage end doors compromising transformer security, allowing the doors to be pulled out at the bottoms and also compromising their sealing/ IP rating and their ability to keep out the fine product dust. The holes where the locks once were allowed access by vermin (arc blast risk). • Touch, step and transfer voltages not assessed and documented.

Notice	In relation to
	• The earthing system for the mine not documented - there was no earthing arrangement diagram available at the time of inspection. Earth connection points were unable to be inspected for the kiosk transformer. • Equipotential bonding between metal portable buildings (that are easily bridged) was not evident. • The effects of lightning had not been taken into consideration. • Bunding/ demarcation of the pad-mounted transformer considered inadequate to prevent impact with mobile machines. • An arc flash risk assessment had several actions identified that could not be verified as being completed or assessed for suitability. • A risk assessment did not have any signoff for people who attended and did not have a date identifying when it was completed. • The electrical engineering control plan and associated documents were unable to be accessed on the mine's document control system. • Electrical engineering control plan documents were only available on the personal drives of the mine manager or statutory electrical engineer. • Electricians maintained hard copies of the electrical engineering control plan within the workplace which were not current, controlled versions. • The mine's electrical engineering control plan did not fully address the requirements of Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 (cl 32) and schedule 2 (cl 3). • The electrical engineering control plan did not identify key competencies for electrical workers or high-voltage work on site, did not contain a protection philosophy or protection register, did not have a formalised system for sign-off of new

Notice	In relation to
	electrical works, did not have procedures in place for isolation of electrical equipment. • Heavy mobile plant were being parked at a designated 'go-line'. The 'go-line' was located directly below an energised high-voltage power line (corridor) and equipment parked in this area had the ability to raise (tip) the body which may bring the plant within an unsafe distance of the overhead lines. • The mine's safety management system lacked the statutory electrical engineer's responsibilities regarding the supervision of workers. • Switchboards were not locked or secured, allowing access to the energised components by unauthorised people. • The arc flash analysis study drawing was different to the field components. The data used in the modelling was different to what was actually installed in the field. • There was no electrical maintenance strategies for earthing infrastructure, switch rooms, switch boards, motors and other electrical apparatus able to be viewed at the time of inspection. • There was no equipotential earth bonding of extraneous conductive parts (demountable buildings, water pipes, hot water system and water filter systems), as part of the electrical installation to these buildings. • The mine has not completed an arc flash study for the mine. • Recommended actions within the protection study report appeared to be uncomplete. Since the completion of the report, another switch room and associated electrical apparatus had been added to the mine's electrical infrastructure without consideration to load and fault levels. • Electrical installations at the quarry's processing plant did not meet the requirements of the Wiring Rules (AS3000). • A welder generator was in poor condition and was not maintained in accordance with the mine’s electrical engineering control plan, which requires compliance to

Notice	In relation to
	AS1674.2. The issues identified included welding leads with exposed conductors, connection lugs crimped with incorrect tool, earth stake connected held on with water clamp, no earth leakage was provided on the welder for the 240V outlets. • A mine had 22kV supplied to the site from the supply authority and the mine utilised high-voltage infrastructure. The mine had not nominated an electrical engineer. • Electrical load flow, arc flash and fault studies were not able to be produced. An earthing study was not able to be produced. • No specific procedures could be produced for welding activities outside of the workshop hot work area. • No specific procedures for the use of electrical test instruments could be produced.
Notices of concern, Section 23 Section 23, *Work Health and Safety (Mines and Petroleum Sites) Act 2013*	• Remote operation facilities for 22kV and 415V switch gear were installed directly adjacent the arc flash energy sources and potentially within the nominated arc flash boundaries. • Caddy welders stored in the tool store were found to be not in a fit-for-service state and did not have an out of service tag fitted. • Inspections identified unprotected (corrosion protection) earth bonds and equipotential bonds, faded signage around HV switch rooms, use of moulded non-ip56 plugs within the lab wet area and pole fillers were missing within a distribution board within the main switch room. • Reviews of a mine's electrical broad-brush risk assessment (BBRA) have not included a cross-section of relevant workers. • Risk assessment actions were recorded within a spreadsheet but there was no record or tracking of completion. • Some risk control measures identified in a mine's BBRA had not been mapped to the electrical engineering control plan. • A mine did not appear to have a trigger action response plan (TARP) for lightning. All workers interviewed had a poor

Notice	In relation to
	understanding of the mine's control measures in relation to lightning. • Lack of documented entry-to-site processes for cranes or excavators to ensure the controls associated with overhead powerline and buried services hazards were implemented. • Site procedures did not demonstrate a process whereby the statutory electrical engineer was adequately notified of the testing of new or recommissioned electrical circuits. • A mine's documented live work and live testing requirements appeared confusing and this was reflected in interview responses from electrical tradesmen. • A mine did not have specific requirements for the decommissioning of electrical plant or circuits. • A mine's maintenance and inspection regime did not have a system for the verification/ confirmation for the equipotential bonding arrangements for conductive parts of equipment and extraneous conductive parts associated with administrative buildings. • A Caddy welder in a workshop was found with a 15A plug which had the earth pin ground down and defective earth return clamp. • Switch boards (crib rooms, bath houses, administration buildings) were not locked allowing non-trained people to reset circuit breakers after a fault, without an electrician completing any testing/ investigation into the incident. • Workers interviewed had a poor understanding of the mine's lightning procedures (i.e. how they would be notified and where to seek refuge in the event of lightning activity). • Injection/ functional testing of electrical protection relays had not been conducted since 2013. • Workers interviewed had a poor understanding of the arc flash PPE requirements for the incident energy category ratings displayed on distribution boards.

Notice	In relation to
	• The procedure for first aid specific to electrical work indicated transport to hospital for electric shock victims by ambulance as an option. This may put people at risk if an adverse reaction occurs during transport. • There were numerous instances of illegible or temporary safety warning signage for electrical hazards.

Next steps

The Resources Regulator routinely completes an assessment of all reported electric shock incidents, and will initiate a major investigation if it is considered that a mine operator does not have the appropriate resourcing to complete such an investigation; if there are specific concerns in relation to the reported circumstances of the incident, or if the person involved in the incident suffered serious injuries (or there was a high potential that serious injuries may have resulted).

Electrical inspectors also routinely examine the effectiveness of electrical risk controls when attending mine sites as part of planned assessment activities, regardless of the principal hazard being assessed.

A planned inspection program specifically examining electrical risk controls in the extractives sector has commenced in the last year, and this will continue. All planned inspection programs for the prescribed principal hazards are scheduled to recur, subject to the ongoing review of industry risk profiles for all prescribed principal hazards.

Further targeted interventions may be initiated, subject to the findings of planned inspection programs, and the frequency and circumstances of electric shock incidents into the future.

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Issued by

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Further information

For more information on targeted intervention programs, the findings outlined in this report, or other mine safety information, please contact us. You can find the relevant contact details below.

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