

Worker exposure to diesel exhaust emissions in underground coal mines

Targeted assessment program

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Executive summary

This report summarises the findings of assessments undertaken in relation to the hazard of worker exposure to diesel exhaust emissions in underground coal mines. These assessments commenced in October 2017 and to date have been completed at five mines.

A targeted assessment is an in-depth look at the control measures for worker exposure to diesel exhaust emissions and their implementation. Assessments are undertaken by a multi-disciplined assessment team using both desktop and on-site assessment.

The findings of the assessments are grouped into those that are specific to the hazard of worker exposure to diesel exhaust emissions and those that could be generally applied to all aspects of critical control measure implementation.

A general finding was that mine operators are not comprehensively integrating the management of diesel exhaust emissions into their safety management systems.

Specific findings demonstrated that some mines were operating diesel equipment in areas without sufficient ventilation quantities prescribed in clause 71(3) of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014. As a result of this, some mines were issued prohibition notices pursuant to section 195 of the *Work Health and Safety Act 2011*, and the Resources Regulator published the safety bulletin, [SB 17-07 Minimum air quantities for diesel engines in underground coal mines](#).

Another issue identified was defective sealing of diesel particulate filters (DPF) within filter housings on diesel equipment, resulting in the Resources Regulator issuing the safety alert, [SB 18-03 Diesel particulate filter seals critical for effective control of diesel particulate matter](#).

Mine operators are encouraged to review these documents and evaluate their management of the identified issues to ensure compliance with legislation.

Targeted assessments are a valuable process and a powerful analytical tool capable of identifying critical risk control issues not previously uncovered by conventional inspection regimes. This approach also highlights the benefits of using a multi-disciplined assessment team to identify issues across a range of areas through one activity.

Background

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

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

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

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

Scope

The scope of the targeted assessment included two elements:

- a desktop assessment of:
 - compliance against legislation with respect to the management of risks to health and safety associated with worker exposure to diesel exhaust emissions at the mine
 - controls the mine utilises to prevent and mitigate the risks to health and safety associated with worker exposure to diesel exhaust emissions
 - means the mine utilise to monitor the effectiveness of those controls
- a workplace assessment of the implementation of those controls.

Process

The process for undertaking a TAP generally involves four stages.

1. Preliminary team meetings and the preparation of documents.
2. Information and assessment requirements are discussed and supplied to the relevant mine.

3. Execution of an on-site assessment involving:
 - a site desktop assessment of all relevant plans and processes
 - a discussion with the mine management team on the legislative compliance of the relevant plans
 - the inspection of relevant site operations.
4. Discussion and feedback to the mine management team on the findings and actions that need to be taken by the operators in response.

Worker exposure to diesel exhaust emissions in underground coal mines

Diesel exhaust emissions were classified as probably carcinogenic to humans in 1998. The International Agency for Research on Cancer reclassified whole diesel exhaust as a carcinogen to humans in June 2012. This change had implications for the mining industry. A defined universal dose response relationship has not been determined but the Australian Institute of Occupational Hygienists recommends a worker exposure limit of 0.1mg/m³, measured as elemental carbon (EC). At this exposure level, the irritant effect of exposure is markedly reduced and the risk of cancer may also be reduced.

The regulator issued the Safety Bulletin [SB 13-03 Diesel emissions in mines in June 2013](#), which provides guidance on the steps mines should take to control diesel emissions. [MDG29 Guideline for the management of diesel pollutants in underground mines](#) provides industry with guidance on how to manage worker exposure to diesel exhaust emissions.

The Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 (WHS (MPS) Regulation), requires an underground mine operator to ensure that the concentration of diesel emissions in the general body of air in the areas where people work or travel is as low as is reasonably practicable. The regulation also requires the operator to manage risks and implement a range of control measures including:

- implementing a mechanical engineering control plan identifying measures for managing the risks to health and safety from the use of diesel engine systems and the creation of pollutants (clause 26(4))
- implementing a health control plan identifying measures for eliminating or minimising the exposure of workers to airborne and other contaminants (clause 26(3))
- implementing a principal hazard management plan for air quality or dust or other airborne contaminants (clause 24)
- implementing a ventilation control plan to provide for the management of all aspects of ventilation at the mine (clause 62)
- implementing air quality, monitoring and ventilation arrangements to ensure that the concentration of any airborne contaminant is as low as reasonably practicable (clauses 38-42, 54-64)

- managing exhaust emissions through regular sampling and analysis that is measured against baseline comparisons, using good quality fuel and lubricants; using filters and catalysts to treat emissions, training of operators, and maintenance of plant and equipment (clause 53).

In managing worker exposure to diesel exhaust emissions operators of underground coal mines must:

- sample and analyse exhaust emissions to monitor and control pollutants from diesel engines (clause 75)
- undertake certain actions if air quality or safety standards are not met, such as withdrawing workers from a place of risk and preventing re-entry (clause 76)
- use only registered diesel engine systems in the underground mine (clause 177)
- ensure that the general body of air in the areas in which persons work or travel has a concentration of diesel emissions (including diesel particulate matter) that is as low as is reasonably practicable (clause 55).

The targeted assessment program relating to diesel exhaust emissions in underground mines focused on how the mines prevent worker exposure to harmful diesel exhaust emissions. Key categories assessed were:

- identification, assessment and risk controls for diesel exhaust emissions hazards
- preventative controls (controlling emissions at the source)
- mitigating controls (controlling exposure to airborne emissions)
- monitoring (worker exposure)
- verification of the effectiveness of controls.

The [NSW Code of practice: Mechanical engineering control plan](#) provides further guidance on ways of complying with the legislative requirements outlined above.

Mine operators should also review [SB17-07 Minimum air quantities for diesel engines in underground coal mines](#) and [SB 18-03 Diesel particulate filter seals critical for effective control of diesel particulate matter](#), published as a result of issues identified during these targeted assessments.

Assessment findings

Assessment activities at underground coal mines to date has highlighted some issues with the implementation of critical controls to manage the hazard and more generally with the process of developing, reviewing and implementing controls. While the highlighted issues were not relevant at all sites assessed, the findings provide some valuable information which should be considered when developing critical controls.

The assessment process highlighted some key issues.

- Coal mines must only operate diesel equipment in areas with sufficient ventilation quantity as prescribed in clause 71(3) of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014. During the targeted assessments, it was identified that some mines were managing diesel equipment based on total ventilation quantity available in the panel rather than the ventilation quantity available at the specific location where the equipment was being

operated. Mine operators should review [SB17-07 Minimum air quantities for diesel engines in underground coal mines](#) for further guidance on this issue. Refer to the *General findings, Ventilation control to manage diesel exhaust emissions* section of this report.

- The operator of an underground mine must ensure that, in any accessible place at the mine, the concentration of any airborne contaminant is as low as is reasonably practicable.¹ During a targeted assessment, defective sealing of diesel particulate filters (DPF) within filter housing on diesel equipment was identified, potentially liberating diesel particulate matter into the underground atmosphere. Mine operators should review [SB 18-03 Diesel particulate filter seals critical for effective control of diesel particulate matter](#) for further guidance on this issue. Refer to the *General findings, Sealing of diesel particulate filter in filter housing* section of this report.

Areas of good practice

Inspectors identified several areas of good practice during the TAP including:

- One mine has established a permanent underground diesel test station with the testing process managed by programmable logic controller (PLC). A unique vehicle identifier is entered into the test station screen enabling the PLC to set the regulator to the air quantity required for testing based on item registration. The screen provides prompts to the operator in relation to engine rpm while gas analysers record emissions. The PLC compares this to statutory limits to provide a pass/fail result for the vehicle, displayed to the operator to enable real-time decision making and disseminated to the diesel fleet coordinator for ongoing management.
- In managing diesel equipment underground, one mine has developed and implemented an electronic tag system to enable live tracking of vehicles. The process involves fitting vehicles with identifying electronic tags that are detected by sensors placed throughout the mine as the vehicle passes, providing real-time notification to the control room of the general location of the vehicle.
- Following these targeted assessments, some mines have begun discussions with Coal Services to broaden 2018 air monitoring programs to include nitrogen dioxide (NO₂), which was not previously included as existing programs focussed on worker exposure to diesel particulate matter (DPM).

The findings of these assessments are grouped into two categories:

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

¹ Clause 54 WHS (MPS) Regulation

General findings

Safety management system

Issue	Response
Some mines could not demonstrate integration of safety management system documentation. Information from risk assessments was omitted from controlling documents including principal hazard management plans, principal control plans and work procedures.	Mine operators must establish a comprehensive and integrated safety management system that addresses all aspects of risks to health and safety in relation to the operation of the mine. ²
Inconsistent information was stated between documents (for example, differences in stated ventilation quantities required for diesel equipment to operate in underground areas of the mine).	In managing risks associated with diesel exhaust emissions, mine operators should ensure an integrated approach between mine management, health, ventilation and maintenance departments, in conjunction with original equipment manufacturers (OEMs). ³

Worker information, training and instruction

Issue	Response
Mines did not have site personnel with training in basic occupational hygiene practices and relied entirely on the expertise of external service providers to administer air monitoring programs.	It is recommended that mine operators provide training to key site personnel in basic occupational hygiene to enable closer oversight of air monitoring programs administered by external service providers. Training should be of a sufficient standard to enable mine operators to identify places of risk through undertaking preliminary monitoring and analysis to provide baseline data and to increase site understanding of similar exposure groups (SEGs). Additionally, the training should enable mines to monitor, review and trend air monitoring results.
Some interviewed workers did not have a clear understanding of the composition of diesel exhaust emissions, site risk controls or the health consequences of exposure to diesel exhaust emissions.	Mine operators must ensure that workers are provided with suitable and adequate information, training and instruction in relation to hazards associated with the work being carried out by the worker and the implementation of control measures. ⁴

² Clause 13(6) WHS (MPS) Regulation

³ SB13-03 Diesel emissions in mines

⁴ Clause 39 WHS Regulation and clause 104 WHS (MPS) Regulation

Monitoring and review of risk control measures

Issue	Response
<p>In managing diesel equipment, underground mines used diesel tag board or electronic spreadsheet systems that rely substantially on human factors to implement the risk control. However, mines were unable to produce evidence of audits or verifications of the implementation and effectiveness of the risk control.</p>	<p>Mine operators must ensure that the safety management system for the mine includes performance standards for measuring the effectiveness of all aspects of the safety management system and must have a system for auditing the effectiveness of the safety management system against the performance standards.⁵</p> <p>Mine operators must review and, as necessary, revise control measures to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety.⁶</p>

Specific findings

Air monitoring for diesel exhaust emissions

Issue	Response
<p>Mines relied entirely on external service providers to develop, implement and manage air monitoring programs for diesel exhaust emissions and were unable to demonstrate active oversight of programs or produce a formal documented agreement outlining the roles and responsibilities of each party.</p>	<p>In managing risks to health and safety, it is recommended that mine operators develop a formal documented agreement with the service provider that clearly outlines roles and responsibilities of each party. The agreement should demonstrate how the air monitoring program manages the risks through a site risk based program that considers all work areas and tasks undertaken at the mine and includes all workers who are subject to the hazard.⁷</p>

⁵ Clause 15 WHS (MPS) Regulation

⁶ Clause 38 WHS Regulation and clause 10 WHS (MPS) Regulation

⁷ Clause 9 WHS (MPS) Regulation

Issue	Response
<p>Air monitoring programs for diesel exhaust emissions were focussed on monitoring for diesel particulate matter (DPM) and did not consider diesel exhaust gases including nitrogen dioxide (NO₂), carbon monoxide (CO) and carbon dioxide (CO₂).</p>	<p>In undertaking air monitoring for diesel exhaust emissions, mine operators should determine a baseline for worker exposure to NO₂, CO and CO₂ and ensure that these gases are included in air monitoring programs. It is recommended that mining supervisors who use hand-held gas monitors for daily inspections in areas where diesel equipment operates include capability to measure NO and NO₂.</p> <p>Air monitoring programs should determine the cumulative effect of worker exposure to NO₂, CO, and CO₂ and should be adjusted based on shift length including for extended shifts.</p>
<p>Some mines did not consider environmental risks in relation to the quality of intake air including undertaking a baseline analysis.</p>	<p>Mine operators must ensure that the ventilation system for the mine provides air that is of sufficient quality to ensure that the general body of air in the areas in which people work or travel has a level of diesel exhaust emissions that is as low as reasonably practicable⁸. Mines should refer to MDG29, which recommends a maximum workplace exposure limit of 0.1 mg/m³ measured as elemental carbon for diesel particulate matter⁹. MDG29 also provides guidance in relation to the maximum permissible exposure limits for common diesel engine gaseous emissions based on time weighted average (TWA), and short-term exposure limit (STEL).¹⁰</p> <p>In managing risks associated with intake air, it is recommended that mine operators consider routine monitoring of surface intake air for diesel exhaust emissions to determine a baseline and undertake monitoring at mine exhaust to quantify the impact of diesel equipment on the underground atmosphere.</p>

⁸ Clause 55(2) WHS (MPS) Regulation

⁹ Section 2.3.5, MDG29 Guideline for the management of diesel engine pollutants in underground environments

¹⁰ Section 2.2.9, MDG29 Guideline for the management of diesel engine pollutants in underground environments

Ventilation control to manage diesel exhaust emissions

Issue	Response
Some mines managed the operation of diesel equipment based on total ventilation quantity available in the panel, rather than ventilation quantity measured at the specific location where the diesel equipment was operating. A specific example included one mine using ventilation quantity measured in the return airway of a multi-intake panel to manage diesel equipment access to the panel.	Mine operators must ensure that diesel equipment is only operated in areas with sufficient ventilation quantity as prescribed in clause 71(3) of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014. Mine operators should review SB17-07 Minimum air quantities for diesel engines in underground coal mines for further guidance.
Most mines did not include underground diesel workshops and refuelling areas in regular ventilation measurements undertaken by mining supervisors to ensure that ventilation quantity was sufficient for diesel activities required in the area.	Mine operators should ensure that ventilation quantity in underground diesel workshops and refuelling areas is measured regularly to ensure there is sufficient ventilation quantity available to comply with clause 71(3) of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.
Some mines conducted weekly general body testing for diesel exhaust emissions in areas of high ventilation quantity not representative of areas where the diesel equipment normally operates.	Mine operators should ensure that weekly general body diesel emissions testing is carried out in a roadway in which the diesel engine normally operates ¹¹ and where ventilation quantity is consistent with the minimum prescribed ventilation quantity for the diesel equipment being tested.

Sealing diesel particulate filters in filter housing

Issue	Response
Some mines did not ensure adequate sealing of diesel particulate filter (DPF) within the housing on diesel equipment, potentially resulting in diesel particulate matter bypassing filtration and being directly emitted into the mine atmosphere.	Mine operators of underground mines must ensure that in any accessible place at the mine, the concentration of any airborne contaminant is as low as is reasonably practicable. ¹² For guidance on this issue mine operators should review SB 18-03 Diesel particulate filter seals critical for effective control of diesel particulate matter .

¹¹ Section 5.5.1.1, MDG29 Guideline for the management of diesel engine pollutants in underground environments

¹² Clause 54 WHS (MPS) Regulation

Where to now

Targeted assessments provide an account of the issues observed at sites at a point in time. Some of the findings resulted in notices being issued including notices of concern under section 23 of the WHS (MPS) Act, improvement notices under section 191 of the WHS Act and prohibition notices under section 195 of the WHS Act.

The matters addressed by the notices reflect the findings of the inspectors. The findings are summarised in the table below.

Notice	In relation to
Prohibition notices, s 195	Operation of diesel equipment in areas with insufficient ventilation quantity as prescribed in clause 71(3) of Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.
Improvement notices, s 191	Diesel particulate matter (DPM) identified as a risk to workers in safety management system documents However, no DPM monitoring program was implemented at the mine. No baseline exposure established for diesel exhaust emissions, including DPM and diesel exhaust gases.
Notices of concern, s 23	Used diesel particulate filters disposed of unbagged in site waste. Underground diesel workshop not included in regular ventilation measurements taken by mining supervisors.

The TAP process identified many common issues around the approach taken by the sites to manage the hazard of worker exposure to diesel exhaust emissions. It also highlighted broader issues that are common across mine sites associated with the process of developing, implementing and reviewing the risk assessments, management plans and procedures.

The regulator expects that all underground mines will review their procedures and practices in consideration of the findings of this summary.

The requirement for principal hazard management plans to comply with legislative requirements, reduce risk to as low as reasonably practicable and consider the implementation and management of critical controls apply at all types of mining operations.

Issued by

Garvin Burns
Chief Inspector
NSW Resources Regulator
NSW Department of Planning and Environment

Further information

Please contact the Resources Regulator for more information on targeted assessment programs, the findings outlined in this report or other mine safety information.

Type	Contact details
Email	cau@planning.nsw.gov.au
Phone	1300 814 609
Incident reporting	To report an incident or injury call 1300 814 609
Website	resourcesandenergy.nsw.gov.au/safety
Address	Resources Regulator 516 High Street Maitland NSW 2320

Appendix A: Legislative requirements

This appendix provides a list of legislative requirements referred to in the findings of this report as identified in the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 and Work Health and Safety Regulation 2017.

Legislation, section/clause	Legislative requirements
WHS (M&PS) Regulation, clause 9	Management of risks to health and safety
WHS (M&PS) Regulation, clause 10	Review of control measures
WHS (M&PS) Regulation, clause 13	Duty to establish and implement safety management system
WHS (M&PS) Regulation, clause 15	Performance standards and audit
WHS (M&PS) Regulation, clause 54	Air quality—airborne contaminants
WHS (M&PS) Regulation, clause 55	Air quality—minimum standards for ventilated air
WHS (M&PS) Regulation, clause 104	Duty to provide information, training and instruction
WHS Regulation, clause 38	Review of control measures
WHS Regulation, clause 39	Provision of information, training and instruction