

TARGETED ASSESSMENT PROGRAM

Worker exposure to diesel exhaust emissions – NSW underground metalliferous mines

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Executive summary

The NSW Resources Regulator started targeted assessments of diesel exhaust emissions in August 2016 as part of its targeted assessment program (TAPs).

To date targeted assessments examining the management of diesel exhaust emissions have been completed at nine underground metalliferous operations and one underground coal mine. These assessments were completed in August 2017 for underground metalliferous mines.

In 2012, the International Agency for Research on Cancer reclassified diesel exhaust emissions as a carcinogen. Consistent with this increased knowledge, legislation has evolved to reflect the seriousness of this hazard.

Previous legislation placed fewer obligations on mine operators compared to current legislation in relation to managing risks related to diesel exhaust emissions, particularly for mines other than coal mines. Underground mine operators were previously required to ensure that diesel exhaust emissions were eliminated or reduced to a level as low as reasonably practicable. Current work health and safety legislation stipulates further requirements. These requirements include having controls that are documented and incorporated within a mine's control plans under the site's safety management system, including a variety of tests, monitoring, maintenance and reviews. On this basis, the decision was made to prioritise the assessment of metalliferous mines.

The targeted assessment is an in-depth examination of the control measures and their implementation for managing diesel exhaust emissions and ventilation management. The assessments are undertaken by a multi-disciplined team of Mine Safety inspectors using both desktop and on-site inspection and assessment.

The main findings of the assessments are grouped into those that were specific to the principal hazard of airborne contaminants (specifically diesel exhaust emissions) and ventilation management, and those that could be more generally applied to all aspects of critical control measure implementation.

General findings include the need to ensure that plans and strategies are developed and implemented; that underlying risk assessments for diesel exhaust emissions are detailed and reference appropriate guidance material and that the safety management system includes an integrated document management process.

The specific findings highlight the need to ensure that baseline testing of diesel equipment is conducted and ongoing monitoring incorporates loaded testing, with all results referenced against baseline readings. Mine operators are required to ensure that there is a system for personal monitoring of underground workers for exposure and those results are communicated to the workers. The use of diesel exhaust treatment devices should be considered and ventilation plans should document quantities of air in locations where diesel engines are used. Mine operators should also implement systems to verify and display air quantities at locations throughout the mine where diesel machines are working.

Targeted assessments are seen as 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 inspection 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 Work Health and Safety (Mines & Petroleum Sites) Regulation 2014 (WHS (M&PS) 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

Involving a multidisciplinary team of inspectors, the scope of the targeted assessment included two elements:

- a desktop assessment of:
 - compliance against legislation with respect to worker exposure to diesel exhaust emissions
 - controls the mine utilises to prevent and mitigate worker exposure to diesel exhaust emissions
 - how the mine monitors the effectiveness of those controls
- a workplace assessment of the implementation of those controls.

The process

The process for undertaking a TAP generally involved the following steps:

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 a two-day 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 that includes interviews of workers, contractors and supervisory staff.
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 emission

Diesel exhaust emissions were classified as probably carcinogenic to humans in 1998. In June 2012, the International Agency for Research on Cancer reclassified whole diesel exhaust as a carcinogen to humans. 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)¹. At this exposure level the irritant effect of exposure is markedly reduced and the risk of cancer may also be reduced.

In June 2013, the Resources Regulator issued Safety Bulletin [Safety Bulletin SB13-03 Diesel emissions in mines](#), which provides guidance on what steps mines should take to control diesel emissions. [MDG 29 Guideline for the management of diesel engine pollutants in underground environments](#), provides industry with guidance on how to manage worker exposure to diesel exhaust emissions.

The WHS (M&PS) Regulation requires a mine operator of an underground mine to ensure that the concentration of diesel emissions in the general body of air in the areas in which people work or travel is as low as is reasonably practicable. In addition, the WHS (M&PS) Regulation requires the mine operator of an underground mine 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 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 August 2016, the Resources Regulator began a targeted assessment program relating to diesel exhaust emissions in underground mines. The TAPs focused on how the mines prevent worker exposure to harmful diesel exhaust emission. 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.

It should be noted that operators of underground mines in NSW are required to comply with clause 62 of the WHS (M&PS) Regulation, requiring that all underground mines have a ventilation control plan to provide for the management of all aspects of ventilation at the mine. The savings and transitional provisions in Schedule 12 of the WHS (M&PS) Regulation gave mine operators until 31 January 2017, to transition to this new requirement. Before this date, mine operators were permitted to rely on compliance with the provisions of the Mine Health and Safety Regulation 2007. This former regulation required ventilation arrangements to be

¹ Generally measured by the NIOSH 5040 method

made, including plans and procedures, but without the formal requirement of a prescribed ventilation control plan.

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

Elimination and control

Clause 9 of the WHS (M&PS) Regulation outlines that mine operators are required to manage risks to health and safety at a mine site, including risks in relation to diesel exhaust emissions. Appropriate control measures to eliminate or minimise those risks are required and more than one control measure may be required to eliminate or minimise worker exposure to diesel exhaust emissions.

Control measures fall into three categories:

- minimising diesel exhaust emissions at the source
- minimising the transmission of airborne emissions throughout the work environment
- minimising exposure to individuals at risk.

Whatever control measures are adopted, clause 53 of the WHS (M&PS) Regulation requires diesel engines to be regularly maintained to ensure that emissions remain as low as is reasonably practicable having regard to baseline emissions, which are the emissions generated when the equipment is new or as-new. Along with scheduled maintenance activities, equipment selection and fuel are an important consideration in ensuring that emissions remain as low as is reasonably practicable.

The design, implementation and operation of ventilation systems also play a critical role in minimising the risk posed by emissions.

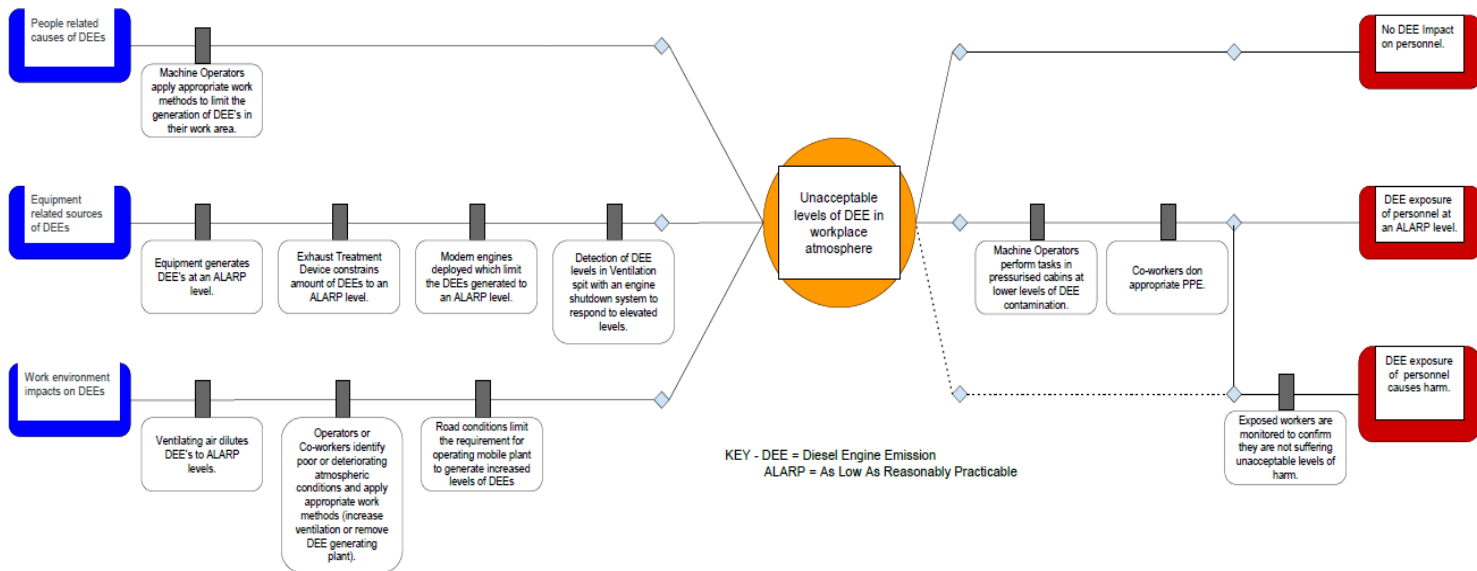
The above methods to control workplace exposure to diesel emissions are readily available, as are commonly employed atmospheric monitoring and health surveillance strategies.

Bow-tie risk assessment

When developing this targeted assessment program, the regulator team completed a bow-tie risk assessment on diesel engine emission. This exercise confirmed with the assessment team the critical controls that would typically be required to prevent unacceptable levels of diesel exhaust emissions in a mine's atmosphere, for inclusion in the assessment template.

The bow-tie risk assessment was facilitated by a competent external facilitator, and involved both Resources Regulator inspectors, and external representatives from coal services and others with appropriate technical knowledge.

Bow-tie risk assessment – outcome



Assessment findings

The targeted assessments of workers' exposure to diesel exhaust emissions identified some issues associated with the management of worker exposure and more generally with the process of developing, reviewing and implementing the controls. While the highlighted issues were not relevant at all of the sites assessed, the findings provide some valuable information which should be considered when developing critical controls.

The assessment process highlighted that:

- most mines had initiated systems to manage diesel exhaust emissions; however integration into the safety management system and implementation at the working face required improvement
- workers and contractors lacked knowledge on the health risks of diesel exhaust emissions.

The findings of this assessment 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.

General findings

Development and implementation of a plan

Issue	Response
Mine operators did not have a documented principal hazard management plan to control diesel exhaust emissions that was integrated and implemented within the safety management system for the mine.	As defined in the NSW Work Health and Safety Regulation 2017 (WHS Regulation), a contaminant is any substance that may be harmful to health or safety. Airborne contaminants, whether naturally occurring or introduced, are considered a principal hazard at mines and mine operators must prepare a principal hazard management plan in accordance with clause 24 of the WHS (M&PS) Regulation. In developing a principal hazard management plan for air quality, dust or other airborne contaminants, mine operators must consider the risks associated with diesel exhaust emissions. This includes identifying controls to manage these risks and incorporating these controls into the principal hazard management plan.

Risk assessment

Issue	Response
Lack of a detailed risk assessment and supporting documentation with regards to the management of the hazard and risk exposure.	Mine operators must conduct a risk assessment that involves a comprehensive and systematic investigation and analysis of all aspects of risk to health and safety associated with the principal mining hazard in accordance with clause 23 of the WHS (M&PS) Regulation. Controls must be implemented in accordance with the hierarchy of controls and industry best practice.
Risk assessments undertaken by the mine did not adequately consider recommendations made in the department's Safety Bulletin SB13-03 Diesel emissions in mines .	Areas and tasks where workers may be exposed to diesel exhaust emissions should be identified and effectively controlled through risk assessment. Factors that may increase the risk should also be considered. These factors include the type of work being carried out, ventilation, use and number of diesel engines in the same ventilated area, the number of people exposed and the duration of the exposure.

Document management system

Issue	Response
Mine operators did not maintain an integrated document management system.	The safety management system must set out how records will be kept, as well as how records and documents are managed to ensure compliance with various duties under WHS laws. This may involve consideration of whether records are to be stored electronically or in hard copy and how access to documents will be provided. Mine operators should consider the guidance in the NSW code of practice - Safety management systems in mines .

Specific findings

Regular testing and analysis

Issue	Response
<p>Mine operators did not ensure that diesel exhaust emission test results were consistently assessed and monitored against baseline emission results.</p>	<p>A consistent approach to testing and maintenance is required. Documentation should show the requirement to test diesel particulate and gaseous emissions in consideration of the guidance contained in section 6 of MDG 29 Guideline for the management of diesel engine pollutants in underground environments and section 4.5.7.3 of the NSW Code of practice: Mechanical engineering control plan.</p>
<p>Mine operators did not determine a baseline for diesel particulate matter and gaseous emissions at engine loads specified by the original equipment manufacturer.</p>	
<p>Mine operators' testing may not be frequent enough to determine engine deterioration in a timely manner, resulting in the potential to expose workers to higher levels of emissions.</p>	

Personal monitoring of underground workers

Issue	Response
<p>Mine operators failed to adequately determine the risk to workers from diesel exhaust emissions and their response to exposure limits being exceeded was inadequate.</p>	<p>Mines require an integrated approach to determine the risks and implement appropriate control measures for diesel exhaust emissions using ventilation records and results from hygiene monitoring and mechanical maintenance testing. A system for personal monitoring of underground workers using similar exposure groups is recommended. Mines should have trigger action response plans (TARPs) to respond to exposure limits being exceeded.</p>
<p>Lag time from monitoring and laboratory reports reduces opportunity for the timely investigation of exceedances.</p>	<p>Real time monitoring devices are available and their use is recommended to provide indicative exposure levels and provide a tool for ongoing workplace hazard assessment and investigation of exceedances.</p>

Communicating monitoring results to underground workers

Issue	Response
Monitoring results were not communicated to workers at all underground mines.	Mine operators should take a proactive approach to communicating the results of personal monitoring results to workers. Mine operators should review their communication methods to ensure effective communication with workers.

Information, training and instruction

Issue	Response
Workers were uninformed about the risks of diesel exhaust emissions.	Mine operators must provide information, training and instruction on workplace hazards in accordance with clause 104 of the WHS (M&PS) Regulation. Safety Bulletin SB13-03 Diesel emissions in mines and MDG 29 Guideline for the management of diesel engine pollutants in underground environments provide appropriate data to educate the mine workforce and contractors.
Mine operators could not provide formal training records of maintenance workers that conduct emission testing and fault finding to manage diesel equipment underground.	Mine operators must ensure that workers are trained, and competent in basic risk management techniques used at the mine having regard to the nature of the work carried out by the worker in accordance with clause 104 of the WHS (M&PS) Regulation and that records of training provided to a worker under clause 104 are kept in accordance with clause 108 of the WHS (M&PS) Regulation.

Exhaust after treatment devices on diesel engines

Issue	Response
Mine operators could not provide evidence demonstrating consideration being given to applying or not applying an appropriate after-treatment device on diesel engines to reduce diesel exhaust emissions underground.	In order to achieve a concentration of diesel emissions that is as low as is reasonably practicable, mine operators should have a strategy for the use of exhaust treatment devices on diesel engines. The method for selecting and the justification for not applying the exhaust treatment device for particular diesel engines should be documented.

Ventilation monitoring

Issue	Response
<p>Mine operators did not document air quantity measurements in the respective areas of the underground mine where diesel emissions were produced.</p> <p>Mine operators did not quantify the ventilation against engine size and/or number of diesel engines used.</p>	<p>The mine's ventilation plan should record the measurements of air quantity for the different working areas of the underground mine and accurately record diesel engine flow requirements.</p>
<p>Ventilation monitoring had not been undertaken to demonstrate that the level of diesel emissions was as low as is reasonably practicable.</p>	<p>Mine operators must implement a ventilation monitoring system that ensures that the ventilation system for the mine provides air that is of sufficient volume, velocity and quality to ensure the general body of air in the mine has a concentration of diesel emissions that is as low as is reasonably practicable in accordance with clause 55 of the WHS (M&PS) Regulation.</p>

Procurement standards

Issue	Response
<p>Procurement standards did not include a benchmark for the purchase of new diesel plant and equipment.</p>	<p>Mine operators should review industry best practice with a view to setting new site guidance benchmark for procurement of new diesel plant and equipment. Consideration should be given to making replacement engines part of the procurement specification to avoid missing the opportunity to upgrade to lower emission engines where reasonably practicable.</p>

Where to now

Targeted assessments provide an account of the issues observed at particular sites at a particular time. Some of the findings resulted in notices being issued, including notices of concern, under section 23 of the *Work Health and Safety (Mines & Petroleum Sites) Act 2013*, and improvement notices, under section 191 of the *Work Health and Safety Act 2011*.

The matters addressed by the notices reflect the findings of the Resources Regulator inspectors. In summary, these findings are:

Notice	In relation to
Improvement notices, s 191	<ul style="list-style-type: none"> • Ventilation monitoring to ensure compliance against WHS (M&PS) Regulation Clauses 54, 55, 56, 57, 58, 59, 60, 62 and 64. • Detailed risk assessment with regards to the management of the hazard, documentation for the control of the hazards and risk exposure to be set out with details in procedures, plans or other control measures. • Records for the provision of information, training and instruction of workers or supervisors with regards to the hazard of diesel exhaust emissions. • Ventilation monitoring to be undertaken in a systematic and effective manner to demonstrate that the ventilation system provides air in the underground workings that meets the minimum standards for ventilated air when diesel equipment is being operated. • The mine ventilation plans to show the direction, course and volume of air currents and the position of all air doors, regulators, fans (including auxiliary fans) and other ventilation plant and structures and monitoring devices. • A principle mining hazard management plan to be developed with controls to consider the matters identified in the WHS (M&PS) Regulation Schedule 1(5) "Air quality or dust or other airborne contaminants".
Notices of concern, s 23	<ul style="list-style-type: none"> • Monitoring of diesel engine exhaust against baseline emissions. • Quantifying ventilation based on engine size or number of engines. • Recording air quantity for the different working areas of the underground mine in the ventilation plan. • Recording engine flow requirements accurately in the ventilation plan. • communication of personal monitoring results to workers • Trigger action response plans to respond to personal monitoring exceedances. • A documented plan to control diesel exhaust emissions that is integrated and implemented within the safety management system. • The gas monitors used by underground personnel were not "bump" tested, calibrated or appropriately maintained to provide competent management of the ventilation monitoring. Kestrel for the measurement of ventilation flows and temperature were not readily available to the underground supervisors.

All mine operators involved in this targeted assessment indicated that they would respond to the notices and other issues identified through the inspections. Where significant issues were identified, these will be followed up with the individual mines.

The TAP process identified many common issues around the approach taken by the sites to manage the risk 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 metalliferous mines will review their procedures and practices in consideration of the findings of this summary.

This assessment program will continue in the underground coal sector in 2017-18.

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

Issued by

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Further information

For more information on targeted assessment programs, the findings outlined in this report, or other mine safety information, please contact the Resources Regulator’s Mine Safety branch. You can find the relevant contact details below.

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Address	Resources Regulator 516 High Street Maitland NSW 2320

Appendix A: Legislative requirements relating to worker exposure to diesel exhaust emissions

The appendix provides a list of certain legislative requirements for the management of airborne contaminants including diesel exhaust emissions referred to in this report, as provided by the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.

Legislation, section/clause	Legislative requirements
WHS (M&PS) Regulation, clause 9	Management of risks to health and safety
WHS (M&PS) Regulation, clause 13	Duty to establish and implement safety management system
WHS (M&PS) Regulation, clause 23	Identification of principal hazards and conduct of risk assessments
WHS (M&PS) Regulation, clause 24	Preparation of principal hazard management plan
WHS (M&PS) Regulation, clause 25	Review
WHS (M&PS) Regulation, clause 26	Principal control plans
WHS (M&PS) Regulation, clauses 38-42	Air quality and monitoring
WHS (M&PS) Regulation, clause 53	Exhaust emissions and fuel standards
WHS (M&PS) Regulation, clauses 54-64	All underground mines - air quality and ventilation