NSW GOVERNMENT

NSW Resources Regulator

DISCUSSION PAPER

DIESEL PARTICULATE EXPOSURE STANDARD FOR NSW MINES

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Foreword

The NSW Resources Regulator is seeking feedback from mining industry stakeholders regarding the potential introduction of a diesel particulate workplace exposure standard for mines in NSW. The information in this discussion paper is shaped by a report written by Mr Alan Rogers, commissioned by the Resources Regulator in March 2019. Mr Rogers is a Certified Occupational Hygienist and Fellow of the Australian Institute of Occupational Hygienists, whose work in the field of researching issues associated with diesel particulate matter is internationally recognised.

The adverse health impacts of diesel exhaust emissions are well known, and research indicates the particulate component of diesel exhaust can contribute to acute and chronic health conditions. However, there is currently no legislated national workplace exposure standard. Regulatory authorities and many mine operators have adopted the exposure value recommended by the Australian Institute of Occupational Hygienists (AIOH). It states that a worker's exposure to diesel particulate matter should be controlled to below 0.1 mg/m^3, measured as submicron elemental carbon. The Resources Regulator considers this level to be technically achievable and within acceptable limits.

The NSW Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 requires that, unless otherwise specified, mine operator's comply with Safe Work Australia's (SWA) Workplace Exposure Standards for Airborne Contaminants (WESFAC). However, the WESFAC does not currently include an exposure limit for diesel emissions. While SWA has publicised its intention to consider including diesel exhaust emissions in the WESFAC it has not proposed a value to date or a timeline for this consideration.

While there is currently no maximum exposure limit for diesel exhaust emissions specified in the WESFAC, the Regulation still imposes an obligation on mine operators to reduce emissions to as low as reasonably practicable. To provide guidance on 'as low as reasonably practicable', Mining Design Guideline (MDG) 29 recommends a maximum workplace exposure (mine atmosphere) for diesel particulate of 0.1 mg/m^3 measured in the elemental carbon fraction.

Have your say

You are invited to respond to the Resources Regulator's proposal to:

- prescribe an exposure limit on NSW mine and petroleum operators of 0.1 mg/m^3 limit measured in the elemental carbon fraction for diesel exhaust emissions (either through the Workplace Exposure Standard for Airborne Contaminants or a specific regulatory provision)

- have any such exposure limit take effect within 12 months of the decision to impose the standard
- update MDG 29 to provide guidance on the requirements of a principal mining hazard management plan, specific to the operation of diesel engines underground, assessment and testing of compliance with the plan, and actions required, should the assessment reveal temporary and/or long-term deficiencies.

In providing a response you may also wish to make comment on any the impact of implementing a monitoring plan to enable compliance with the proposed limits.

You can make an individual submission or contribute to a joint submission through your employer, union, professional association, work health and safety group or committee or another forum.

Please provide your submission to rr.feedback@planning.nsw.gov.au by 11 October 2019. Submissions on this discussion paper will be considered by the Resources Regulator.

Submissions or summaries may be published on the Resources Regulator's website. Please advise us if you do not want your submission to be published or if you wish to keep parts of your submission private, such as your name and contact details.

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1. Exposure standards

While there has been increasing awareness of the risks associated with diesel emissions since the 1980s, especially for the mining industry, an exposure standard for diesel particulate matter has not yet been legislated through federal or state WHS laws.

Historically in Australia, the development of an exposure standard for diesel particulate matter has been contentious because of conflicting epidemiological studies, gaps in historical quantitative exposure data and the potential carcinogenic risk. Internationally, Germany and Canada have adopted exposure standards for diesel emissions, the United Kingdom and South Africa do not have exposure standards and the United States has been attempting to introduce an exposure standard since 1988.

Australian Institute of Occupational Hygienists

In 2007, the Australian Institute of Occupational Hygienists (AIOH) stated that based on the available information, it believed that worker exposure to diesel particulate levels should be controlled to below 0.1 mg/m^3, measured as submicron elemental carbon. AIOH noted that at this level, irritation should decrease significantly, and other adverse health effects may be controlled.

This position was updated in 2012 to note that while there are differences of opinion regarding the degree of carcinogenic potential, it strongly encourages precaution in the management of diesel emissions. It also noted that an exposure value of 0.1 mg/m^3 (submicron elemental carbon) is technically achievable.

Safe Work Australia

Safe Work Australia's WESFAC list contains about 700 individual chemical exposure standards that are mandatory under the model Work Health and Safety (WHS) laws. To comply with these laws, individuals conducting a business or undertaking must ensure that no person is exposed to airborne concentrations of a chemical above the exposure standard in the workplace. The WESFAC does not list exposure standards for all chemicals or agents. There is currently no exposure standard for diesel exhaust. In SWA's diesel particulate matter guidance material, it states that mining regulators in several jurisdictions and the AIOH recommend that exposure to diesel particulate matter is kept below of 0.1 mg/m^3 time-weighted average over eight hours (measured as sub-micron elemental carbon). It notes that this recommendation is based primarily on minimising the irritant effect of diesel particulate matter.[1]

[1] SafeWork Australia (2015) *Guide to Managing Risks of Exposure to Diesel Exhaust in the Workplace* https://www.safeworkaustralia.gov.au/doc/guidance-managing-risks-diesel-exhaust.

SWA published its intention to consider including diesel engine emissions on the WESFAC list as part of its WESFAC Review 2018. It notes that additions to the WESFAC list will be based on external consultation and data from trusted sources.

2. Diesel particulate matter in mining

Diesel reached peak usage in NSW mines in the mid-1980s, with many workers exposed to the toxic particulate components in diesel exhaust emissions. Many Australian mine operators, and most state-based mining jurisdictions, have voluntarily adopted/recommended a diesel particulate matter exposure value of 0.1 mg/m^3 sub micron elemental carbon for the last 15 years. This guidance value, along with keeping exposures as low as reasonably practicable, is based on a pragmatic approach to measure and control exposures of the noxious and malodorous emissions without attempting to define a dose-response based exposure standard.[2,3] However, both personal and static (area) monitoring results and their statistical and trend analysis are inconsistent, as are the actions taken by mines when exceedances occur.

New South Wales

In the 1990s, the NSW mining industry voluntarily adopted a value of 2 mg/m^3 organic particulates using the respirable combustible dust internal analysis method. In 1999, the NSW Minerals Council proposed an industry best practice exposure standard of 0.2 mg/m^3 sub-micron diesel particulate matter (equivalent to 0.16 mg/m^3 submicron total carbon or 0.1 mg/m^3 submicron elemental carbon) and suggested that worker exposure levels to diesel particulate should be reduced to as low as reasonably practicable.

In 2008, the NSW government published Mining Design Guideline 29 including the recommended eight-hour time-weighted average exposure standard of 0.1 mg/m^3 (as submicron elemental carbon, by NIOSH 5040) in underground environments. The NSW Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 requires that an operator of a mine identify risks, assess the extent of the risk, prepare and implement a management plan for that risk, and control the risk but does not currently list a diesel particulate matter exposure standard.

[2] Australian Institute of Occupational Hygienists (2017) *AIOH Position Paper Diesel Particulate and Occupational Health Issues* https://www.aioh.org.au/resources/publications1/epublications/aioh-position-paper-diesel-particulate-matter-and-occupational-health

[3] Rogers, A and Davies, B (2005) *Diesel Particulates – Recent Progress on an Old Issue*, The Annals of Occupational Hygiene, Volume 49, Issue 6, August 2005, Pages 453-456, https://academic.oup.com/annweh/article/49/6/453/177045

Davies, B and Rogers, A (2004) *A Guideline for the Evaluation and Control of Diesel Particulate*, Australian Institute of Occupational Hygienists https://www.aioh.org.au/resources/publications1/publications/a-guideline-for-the-evaluation-control-of-diesel-particulate

Queensland

In 2012, Safety Bulletin 127 recommended that the limit of 0.1 mg/m^3 be adopted in all coal and metalliferous mines

In 2014, Queensland Mines Inspectorate issued a Guidance Note (QGN21) outlining the legislative obligations to manage risk at a mine as far as reasonably practicable, including that the hierarchy of controls must be applied to exposure to diesel particulate matter. The Guidance Note lists an eight-hour time-weighted average exposure limit of 0.1 mg/m^3 (measured as sub-micron elemental carbon), to be shift adjusted where necessary.

Western Australia

In 2013, the Department of Mines and Petroleum in Western Australia (WA) issued a guideline on diesel emissions stating that the accepted time weighted average exposure limit for mine workers in WA mines is 0.1 mg/m^3 of elemental carbon, based on AIOH guidance. It noted that the risks from diesel emissions should be assessed and controlled to an acceptable standard and that data submitted by industry indicated that compliance with 0.1 mg/m^3 for diesel particulate matter is achievable and reasonably practicable for underground mines.

Mining companies

Some Australian mining companies have adopted their own internal company exposure standards. For example, BHP Billiton listed exposure limits (HSEC Procedure No P09 August 2003) for diesel particulate of 0.2 mg/m^3 as diesel particulate or 0.1 mg/m^3 as elemental carbon and sampled in the submicron fraction and analysed as per NIOSH Method 5040 (1994).[4] More recently, it is understood that BHP has set an interim requirement to manage exposures to 0.03 mg/m^3 elemental carbon, recognising that this will require the use of respiratory protection equipment for its higher-exposed work groups.

3. Health and epidemiological studies

The adverse health effects of the gaseous parts of diesel emissions, as well as smell and pollution, have been known for some time. Complaints of eye, throat and bronchial irritation and neurophysiological symptoms such as headache, light headedness, nausea, vomiting and numbness and tingling of the extremities have been associated with exposure to diesel exhaust emissions.
The first widespread alert on lung cancer was released by the US National Institute of Occupational Safety and Health (NIOSH) in 1988. In the following years, toxicological and epidemiological studies have

[4] BHP Billiton (2005) *Diesel Emissions Management*

demonstrated a link between occupational exposure to diesel exhaust and an increase in the risk of lung cancer.

In 2012, the International Agency for Research on Cancer classified diesel particulate extract as carcinogenic to humans, based on evidence from human and animal studies.

Australian studies in underground coal and metalliferous mines have noted that the level of eye and upper respiratory tract irritation is significantly reduced at diesel particulate matter exposure concentrations of 0.2 mg/m^3 or less (approximately 0.1 mg/m^3 submicron elemental carbon).

In June 2019 the Western Australia Department of Mines, Industry Regulation and Safety (DMIRS) released reports on a research project which focused on evaluating the physical-chemical aspects of diesel exhaust emission. Curtin University, the Chemistry Centre and the University of Western Australian conducted the research in collaboration with DMIRS and Mineral Research Institute of Western Australia. The reports suggest more stringent exposure standards for diesel exhaust emissions may need to be adopted, and question the feasibility of using particle mass-based limits, especially ones based on elemental carbon alone, when diesel particulate filters are used. It suggests alternative methods of measuring exposure to diesel exhaust should be explored, including particle number and nitrogen oxides (NOx):

https://www.dmp.wa.gov.au/Safety/Reports-16199.aspx

4. Monitoring and sample analysis methods

4.1. Diesel particulate – formation and composition

Char or soot particles are the main component of diesel exhaust emissions, with the potential for causing cancer and irritation to eyes and upper respiratory tract. Diesel particulate aerosol consists of small particles with a high surface area. This means they can absorb large amounts of organic carbon fraction from unburnt fuel, lubricating oils and chemical compounds. Contemporary diesel engines produce less diesel particulate matter, so there is less potential for organics to be absorbed, resulting in an increase of micro and nano droplets.

4.2. Analysis of carbon species

Since the early 1980s, trace carbon species analysis has been used to track and determine the mix and sources of air pollutants from fixed and mobile emission sources. The thermal-optical technique for analysing the carbonaceous fraction of diesel particulate is more precise and has a very low detection limit, compared with other analytical methods. Carbon speciation analysis uses a punched section of

quartz fibre filter from a field sampling cassette in an oxygen free helium atmosphere flow furnace. As the gas mixtures flow through the furnace and over the sample, the furnace delivers various oxidation and temperature conditions to the sample. Distinct carbon species react differently to these conditions and software calculates the concentration and ratio of dissimilar carbon species in the air sample (NIOSH Analytical Method 5040).

4.3. Sub-micron sampling for diesel particulate matter

Personal monitoring of workers can be done using a modified version of the sampling train used for respirable coal and silica dust monitoring in accordance with AS 2985-2004. A modified sampling head is connected to the personal sampling pump, air from the mine is drawn into the sampling head and split into the sub-micron and super-micron fractions. The sub-micron fraction deposits on a quartz fibre filter which is analysed in the laboratory using NIOSH 5040.

4.4. Sub-micron dust sampling and analysis in coal mines

The species of elemental carbon determined by NIOSH 5040 is useful for measuring exposure to diesel particulates in coal mines because it is subject to less interference than other carbon species or combinations using organic carbon. Studies in NSW coal mines have shown that interference from the presence of sub-micron size coal dust is minimal at a level of 1 mg/m^3 respirable coal dust.

4.5. Sub-micron sampling in mines

Measurement of worker exposure to sub-micron diesel particulate matter has been conducted in Australian underground mines since around 1990, initially reported as sub-micron mass and later as sub-micron elemental carbon and total carbon.

4.5.1. Existing monitoring programs in Australian mines

New South Wales

From 2017 to 2018, Coal Mines Technical Services collected 401 individual diesel particulate matter samples from underground coal mines in NSW, an increase of almost 30 per cent on 2016/2017. These samples included personal exposure monitoring and static positional monitoring, covering most NSW underground coal mines and some open-cut coal operations.

However, as the monitoring was undertaken on a commercial basis the Resources Regulator is unable to access the specific results. Further, as there is currently no mandated exposure limit there is no requirement for mine and petroleum operators to report monitoring data directly to the Resources

Regulator. As such, the Resources Regulator does not presently have data on which it can directly model the potential exceedance rate at the proposed limit of 0.1 mg/m^3

However, the Resources Regulator has undertaken a targeted assessment program (TAP) relating to the hazard of worker exposure to diesel exhaust emissions in 19 underground coal mines and 9 metalliferous mines. A copy of the findings from the TAP program can be found on the Resources Regulator's website.[5]

Queensland

The Queensland Mines Inspectorate requested personal diesel particulate matter monitoring results from all Queensland underground coal mines from 2004 to 2007, 2010 and 2011 to 2012. As of 2013, 3,472 suitable results of individual personal exposure measurements were provided by 14 mines. Looking at the results for all the years combined, 21 per cent of samples were equal to or greater than the guideline exposure limit of 0.1 mg/m^3 elemental carbon. Between 2014 and 2016, 10 per cent of samples exceeded the exposure limit across similar exposure groups. Longwall moves accounted for 44 per cent of exceedances, development 23 per cent and underground maintenance six per cent. The database now includes 7,228 diesel particulate matter exposure samples collected from 13 underground sites between 2005 and 2017.

In January 2005, the Queensland Government's Safety in Mines Testing and Research Station (SIMTARS) commenced a diesel particulate matter monitoring program of underground metalliferous mines, collecting 275 samples across 12 similar exposure groups at nine sites. Results indicated 18 per cent of samples exceeded the 0.1 mg/m^3 elemental carbon. Nearly 3,000 samples from the last five years have been obtained and will be assessed against similar exposure groups and control factors.

Western Australia

Diesel particulate matter levels have been monitored in WA mining since 2003.

Until 2015, CONTAM (the system for monitoring and managing airborne contaminant and hazardous substance exposure) held 8,666 personal monitoring results for submicron elemental carbon. An analysis of 347 diesel particulate samples reported in 2006 from 36 sites, mainly underground gold and nickel mines, found 25 per cent of samples exceeded the occupational exposure levels. Between 2009 and 2014, CONTAM results showed 36 per cent exceeded 0.1 mg/m^3 elemental carbon. In the 2014 data, no exceedances recorded.

[5] https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0018/1152423/TAP-Consolidated-report-Diesel-exhaust-emissions-UG-Coal.pdf

WA has since changed to a risk-based system of occupational hygiene management involving identification and investigation of exceedances and monitoring data to determine the effectiveness of controls arising from changes in mining operations.

4.5.2. Diesel particulate matter monitoring programs

All mines should have monitoring programs to test the level of exposure and potential risk of diesel exhaust emissions. The monitoring program should cover routine operations and engineering controls, such as ventilation and machinery usage. The program should also monitor the degree of exposure that occurs during abnormal mining operations, which may result in the workforce being subjected to unusually high exposures. Records of personal monitoring results should be held by the mine for 30 years and both personal and static (area) monitoring results and actions taken.

5. New technology and future developments

The introduction of on-road and non-road emission standards for diesel engines has resulted in electronic fuel injection and combustion controls, exhaust gas recirculation, mandatory fuel quality standards and after-treatment technologies for capturing particles. This has reduced the quantities of toxic gases, diesel particulate matter and organic chemicals found in diesel exhaust emissions. Research has found the concentrations of particulate matter and toxic air pollutants emitted from new diesel engines have more than 90 per cent lower mass of particulate matter and are 90 per cent lower in soluble volatile organics than emissions from traditional diesel engines.[6] Nitrogen oxide and particulate matter emissions were significantly reduced in 2010 engines. Toxicological studies from contemporary diesel engines found that lifetime exposure did not induce tumours or pre-cancerous changes in the lungs of rats, in contrast to findings from studies of pre-2007 diesel engines.

Fuel quality

The introduction of national fuel quality standards, and the increase of on-road diesel vehicles, has resulted in an improvement in the quality of diesel fuel. In NSW underground mines, the use of diesel fuel that meets the national fuel standard for automotive diesel is mandatory and any fuel or fuel additives used at the mine must not increase the health and safety risks to workers at the mine.[7]

Engine and exhaust system maintenance is a major factor in controlling diesel particulate matter at the source. Guidelines on management and control of diesel emissions have been published in several

[6] Health Effects Institute (2015*) Advanced Collaborative Emissions* Study (ACES) https://www.healtheffects.org/publication/executive-summary-advanced-collaborative-emissions-study-aces

[7] Clause 52 Work Health and Safety (Mines and Petroleum Sites) Regulation 2014

Australian documents.[8,9] A recent project conducted in an underground coal mine in NSW found an overall reduction 30 to 50 per cent in diesel particulate matter and nitrogen oxide exposures in the test mine which conducted detailed maintenance work, compared with that from a control mine site. As well as early detection and prevention of engine faults, a 15 per cent saving on fuel usage was achieved.[10]

6. Mining Design Guideline (MDG) 29

MDG 29[11] provides guidance for the management of diesel engine pollutants in underground environments and forms the basis for guidelines in other states.[12] [13] It is prescriptive and provides technical direction to meet legislative obligations. It lists the recommended maximum workplace exposure for diesel particulate as 0.1 mg/m^3 in the elemental carbon fraction, when expelled from a diesel engine. Mine operators are required to develop and implement a site-specific risk management plan.

It is proposed that MDG29 be updated to provide an outline of the requirements of a principal mining hazard management plan,[14] including operation of diesel engines underground, assessment and testing of compliance with the plan, and actions required should the assessment reveal deficiencies. Technical details relating to specific areas of risk assessment and testing should be included as appendices.

7. Summary and recommendations

Despite known health effects, including its 2012 categorisation as carcinogenic to humans, there is no national exposure standard for of diesel particulate matter. A workplace exposure standard of 0.1 mg/m^3 submicron elemental carbon has been recommended by AOIH and is broadly recommended in the safety and mining industries but is not legislated through state or federal WHS laws.

[8] NSW Minerals Council (1999) *Diesel Emissions in Underground Mines – Management & Control*

[9] Pratt, S. et al. (1995) *Evaluation and Control of Employee Exposure to Diesel Exhaust Emissions in Underground Coal Mines*, ACARP Research Project C3080 https://www.acarp.com.au/abstracts.aspx?repId=C3080

[10] Hines J (2018) *Linking Diesel Maintenance Personnel to Occupational Hygienists to Improve Worker Health* (presentation at AIOH Annual Conference Melbourne, December 2018)

[11] NSW Government (2008) *MDG 29 Guideline for the Management of Diesel Engine Pollutants in Underground Environments* https://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0011/419465/MDG-29.pdf

[12] Queensland Department of Natural Resources and Mines (2014) QGN 21 Guidance note for management of diesel engine exhaust in metalliferous mines, p26 https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0019/240364/qld-guidance-note-21.pdf

[13] Government of Western Australia, Department of Mines and Petroleum, Resources Safety (2013) *Management of diesel emissions in Western Australian mining operations — guideline*, p37 http://www.dmp.wa.gov.au/Documents/Safety/MSH_G_DieselEmissions.pdf

[14] NSW Resources Regulator (2018) *Guide - Airborne Contaminants Principal Hazard Management Plan – Guidance for the NSW mining and petroleum industries*, https://www.resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0003/823422/Airborne-Contaminants-PHMP-Guide.pdf.

Mines need to implement monitoring programs to assess the risks of diesel particulate matter and must establish and apply controls to ensure worker safety. The WHS laws require that a mine operator identify risks, assess the extent of the risk, prepare and implement a management plan for that risk, and control the risk. It instructs that diesel engines used underground must have a concentration of diesel emissions that is as low as is reasonably practicable. To provide guidance on what is considered 'as low as reasonably practicable', MDG 29 recommends a maximum workplace exposure for diesel particulate of 0.1 mg/m^3 elemental carbon fraction. This is considered technically achievable, particularly given that contemporary diesel engines and fuels produce significantly less particulate matter and noxious fumes than traditional engines.

The Resources Regulator is proposing to:

- support the introduction of 0.1 mg/m^3 limit measured in the elemental carbon fraction into the WESFAC through SWA's review process. This would mandate the exposure standard through clause 49 of the Work Health and Safety Regulation 2017.
- prescribe a limit of 0.1 mg/m^3 limit measured in the elemental carbon fraction in the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014, if SWA does not include diesel emissions in the WESFAC or proposes a higher limit
- have any such exposure limit take effect within 12 months of the decision to impose the standard
- update MDG 29 to provide guidance on the requirements of a principal mining hazard management plan specific to the operation of diesel engines underground, assessment and testing of compliance with the plan, and actions required should the assessment reveal temporary and/or long-term deficiencies.