MINERALS COUNCIL OF AUSTRALIA

SUBMISSION TO SAFE WORK AUSTRALIA, WORKPLACE EXPOSURE STANDARD FOR DIESEL PARTICULATE MATTER

---

4 JULY 2023

TABLE OF CONTENTS

Table of Contents

1. BACKGROUND

Introduction

On 3 May 2023, Safe Work Australia (SWA) released its consultation paper on *'a proposed workplace exposure standard for diesel particulate matter'* (the Consultation Paper)[1].

The Consultation Paper proposes a Workplace Exposure Standard (WES) for Diesel Particulate Matter (DPM) as an 8-hour time weighted average of 15 µg respirable elemental carbon (REC) per cubic metre.

The Consultation Paper proposes five key questions, with no clear indication of the current SWA position. The Consultation Paper includes the *'Research Report – Workplace Exposure Standard for Diesel Particulate Matter'* (the SLA Report) prepared by SLR Consulting Australia for SWA.[2]

The Minerals Council of Australia (MCA) supports implementing a mandatory WES where appropriate, and risk-based advisory (non-mandatory) exposure standards based on clear, established criteria to ensure they are outcome-focused and flexible to promote continuous improvement, recognise the wide range of different operating environments and ensure standards can be reviewed and updated in a timely manner as required.

The health and safety of our workers is the highest priority of MCA members, and our aim is to reduce the risk of irreversible harm from diesel engine emissions, however, the MCA has concerns for the proposed exposure standard for DPM, as set out in the Consultation Paper. As such, we request that SWA consider the matters raised in this submission, and we would appreciate an opportunity for further consultation with SWA on this topic.

Scope of Applicability to Mining

DPM is a complex mixture of particulate elemental carbon (EC) or soot, particulate and particle bound organic carbon (OC), sulphates and some metals. DPM is produced in mining using diesel-powered plant and because of the combustion process, diesel engines emit DPM, exhaust gases and a small number of metallic compounds, collectively referred to as diesel emissions.

Diesel engines are commonly used in underground coal mines due to requirements for explosion protection and intrinsic safety. They are used as the main workhorse in the mines. Whilst underground metalliferous mines do not have the same restrictions for spark ignition, heavy equipment is still predominantly diesel based due the power load available.

The Australian minerals industry has been working to achieve compliance with an Occupational Exposure Limit (OEL) value of 0.1 mg/ m^3 for DPM, consistent with the value recommended by the Australian Institute of Occupational Hygienists (AIOH) Position Paper (2017).[3]

Unintended consequences

The proposed WES would practically necessitate elimination of diesel equipment underground or create a reliance on low order controls such as respiratory protection, without evidence of what the health benefits to workers would be.

It would be prohibitively expensive to replace entire fleets of mobile plant including load, haul, and support underground equipment. Existing technology does not currently provide the underground mining industry with the means to comply with the proposed limit.

At present Battery Electric Vehicles are not a fit for purpose solution, though research is underway by members to operate fully electronic mines. Increased ventilation rates would add additional challenges for silica exposure controls, and thus introduce further hazards.

[1] Safe Work Australia Submission Document for the Consultation on DPM WES
[2] WES DPM expert report for public consultation
[3] Australian Institute of Occupational Hygienists Diesel Particulate Matter and Occupational Health 2017

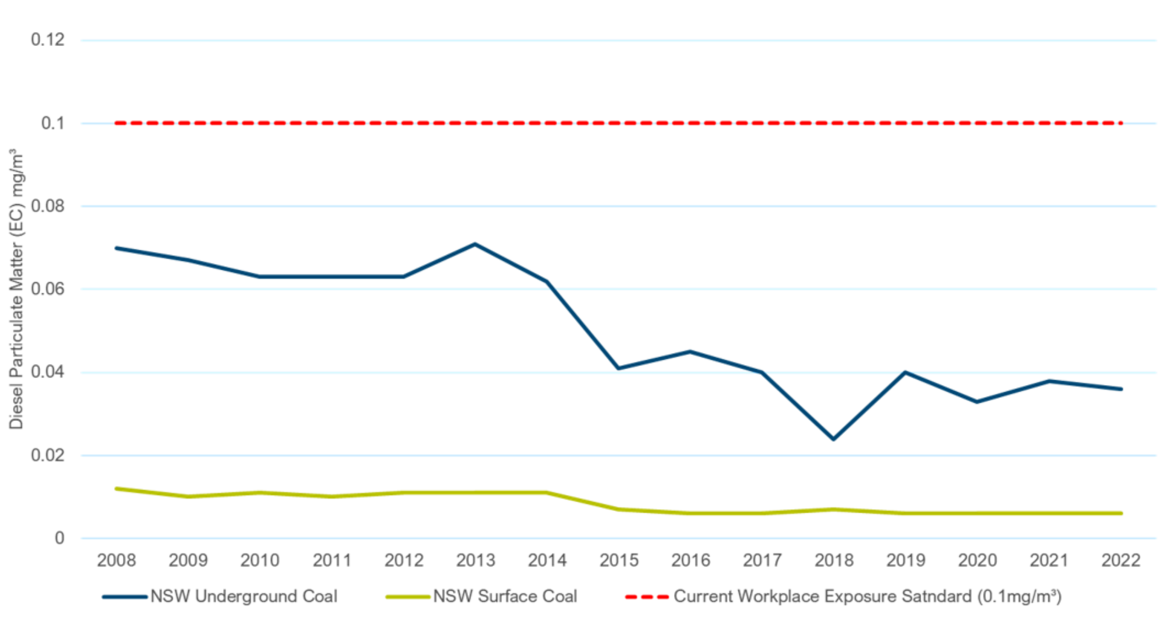
The proposed SWA WES will likely have a significant impact on the minerals industry. It will close many underground coal and metalliferous mines in Australia or impose a mandatory full shift wearing of Powered Air Purifying Respirators (PAPR) for mining, as well as a wide range of other industries.

The highest exposures to diesel engine exhaust (DEE) have been detected in underground mines and tunnel construction sites (i.e., enclosed worksites that use heavy diesel equipment). The mining industry relies heavily on diesel-powered machinery which, until improvements in the performance and cost of alternatives emerge, they will remain essential for the extraction of coal and minerals.

To reduce diesel exposure to below the proposed WES yet still enable certain mines to continue to operate, it is foreseeable that industry may be forced to increase other risks. For example, increasing ventilation flows increases the risk of a spontaneous combustion event (potentially catastrophic explosion of methane) in a coal mine and increases dust lift off and exposure to coal and silica dust.

Executive Summary

- The MCA does not support the SWA proposed exposure standard of 0.015mg REC/m³ for DPM.
- The mining industry has demonstrated ongoing improvements in managing exposure to DEE (see graph below) and is already required to reduce exposures to as low as reasonably practical.



NSW Coal Worker Average Diesel particulate Matter (Elemental Carbon) Exposure 2008 - 2022

- The proposed limits would be almost impossible to comply with in an underground setting. They would result in industry being unable to comply with the legislative requirements and potentially the closure of many underground mines.
- Personal Protective Equipment (PPE) is not the solution - exposure monitoring is of the work environment of the individual, and their exposure is measured independently of the Respiratory Protective Equipment (RPE) that they are wearing.
- Current decarbonisation targets have been set using the recommended (and in some states regulated) DPM WES of 0.1mg/m³. Reducing the WES by such a margin without a long-term implementation strategy will require a re-design and re-commitment of long-term investment plans. A reduction of the WES by such a margin without a long-term implementation strategy will potentially lead to a significant increase in the reliance on RPE for mine workers.

2. MCA RECOMMENDATIONS

The MCA recommends:

1. A Regulatory Impact Assessment (RIA) of the proposed SWA WES be undertaken to identify the significance of the impacts to the industry.

2. The MCA proposes that an alternative WES of 0.05mg EC/m^3 (as submicron fraction) be adopted with a transitional period of three years to a WES of 0.03mg EC/m^3.

   This will allow for planning and integration of higher order controls, such as elimination or substitution of diesel engines, and additional research and development of electric powered plant to be undertaken.

   This will result in a WES of 0.03mg EC/m^3 (as submicron fraction) at the end of the transition period, at which time a review on updated measurement and testing, research and development, and electric vehicle solutions can be undertaken for the consideration of further lowering of the WES.

3. SWA and State Regulators to confirm their position on:
   - lifetime risk versus single exceedance of a WES, and
   - protected versus unprotected exposure.

4. A compliance strategy should be developed to understand:
   - What is conformance?
   - How, when, and where does industry report excursions or exceedances?
   - What are the consequences for exceedances?
   - What are SWA and State Regulators expectations?

5. Clarification needs to be provided on monitoring and laboratory methodology to understand which particle size is being measured (i.e. respirable elemental carbon or sub-micron elemental carbon)

6. SWA consider continued research into Non-Traditional Diesel Engines (NTDE) and the classification of Traditional Diesel Engines (TDE) with added filtration devices and other engineered solutions that reduce the diesel emissions. The MCA is concerned that the evidence presented in support of the DPM WES in the SLR Report does not consider the modern workplace environment.

7. A Time Weighted Average (TWA) for diesel particulate matter of 15 $\mu g/m^3$ should not be introduced due to the further technical and monitoring limitations presented by application over a 12-hour shift arrangement.

3. CONSULTATION QUESTIONS

Q1. Do you support the proposed workplace exposure standard (WES) for diesel particulate matter (DPM) to protect workers from the adverse health effects of exposure to diesel engine emissions (DEE)?

No.

Q2. What are your reasons for your response to Question 1? Please provide evidence or information to support your response.

The proposed WES of 0.015 mg Respirable Elemental Carbon (REC)/m^3 is so low - 6.6 times lower than the current guidance (and in some states regulated) WES of 0.1 mg/m^3 - that it is likely to close many underground coal and metalliferous mines in Australia or impose a mandatory full shift wearing of PAPR for mining.

Although many underground mines in Australia are already using vehicles with engines that would be considered Non-Traditional Diesel Engines (NTDE), because they have after-treatment technologies fitted, and have a DPM management program, personal DPM exposures are still likely to exceed the proposed WES.

Q3. Is there an alternative WES to DPM as respirable elemental carbon, or additional WES that should be considered to protect workers from DEE? Please provide evidence or information to support your response.

The MCA proposes that an alternative WES of 0.05mg EC/m^3 (as submicron fraction) be adopted with a phased approach to a WES to 0.03mg EC/m^3 over three years.

Gaillard, S, E Sarver & E Cauda (2019) cited typical monitoring procedures for diesel particulate matter (DPM) in mines include the collection of filter samples using particle size selectors.[4] The size selectors are meant to separate the DPM, which is generally considered to occur in the submicron range (i.e., < 0.8 μm), from larger dust particles that could present analytical interferences. However, previous studies have demonstrated that this approach can sometimes result in under sampling, therefore, excluding significant fractions of the DPM mass. The excluded fraction may represent oversized DPM particles, but another possibility is that submicron DPM attaches to supra-micron dust particles such that it is effectively oversized.

To gain insights into this possibility, a field study was conducted in an underground stone mine. Submicron, respirable, and total airborne particulate filter samples were collected in three locations to determine elemental carbon (EC) and total carbon (TC), which are commonly used as analytical surrogates for DPM.

Concurrent with the collection of the filter samples, a low-flow sampler with an electrostatic precipitator was also used to collect airborne particulates onto 400-mesh copper grids for analysis by transmission electron microscope (TEM). Results indicated that, while typical submicron sampling did account for the majority of DPM mass in the study mine, DPM-dust attachment can indeed occur. The effect of exposure to such attached particulates has not been widely investigated.

A three-year transition period will allow for planning and integration of higher order controls, such as elimination or substitution of diesel engines, and additional research and development of electric powered plant to be undertaken, if toxicology of NTDE DEE supports this.

This will result in a WES of 0.03mg EC/m^3 (as submicron fraction) at the end of the transition period, at which time a review on updated measurement and testing, research and development, and electric vehicle solutions can be undertaken for the consideration of further lowering of the WES to 0.015mg EC/m^3.

[4] Gaillard, S, E Sarver & E Cauda (2019) J Sustain Min, 18(2); pp 100-108

The below figure shows average yearly NSW surface and underground coal worker DPM exposure levels from 2008 to 2022. Average results are compared against the following four relevant mining industry DPM workplace exposure standards and guideline limits.

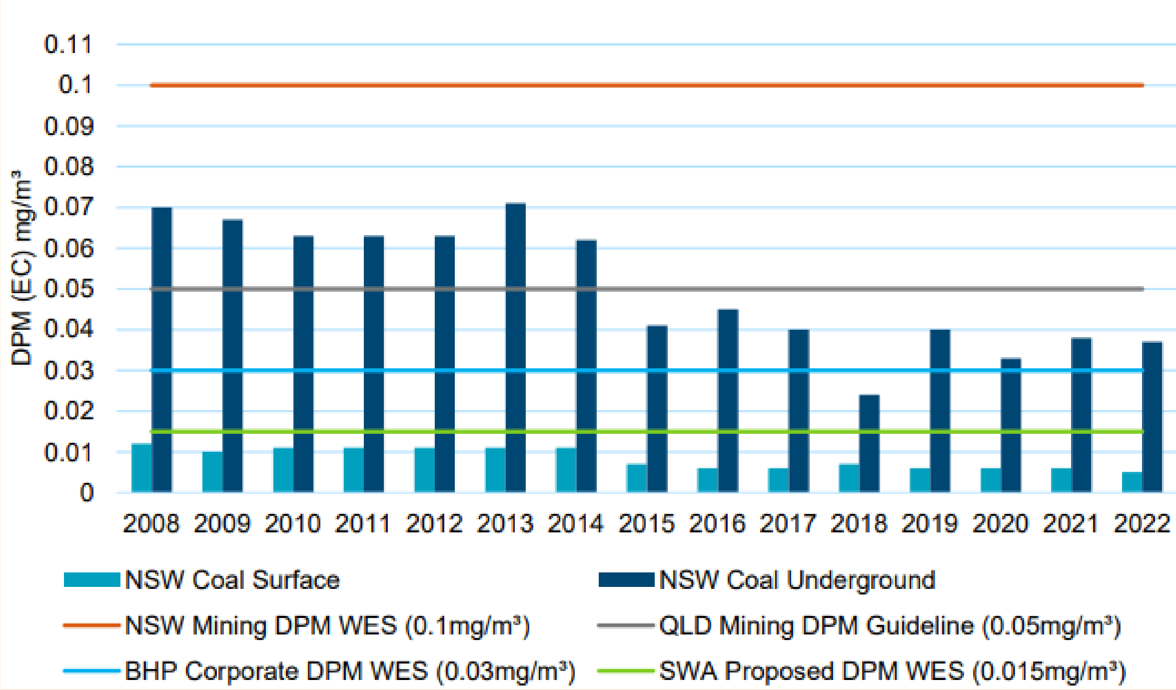


***Figure 1 – DPM WES and Guideline Limits*[5]**

This figure highlights the improvements that have been made across the coal underground mining exceedances in the past ten years, with a continued focus on reducing worker exposures and improving worker health and safety.

The below figures provide comparison exceedance rates for the key underground and surface worker groups on which coal mines have engaged Coal Services to complete DPM exposure monitoring.

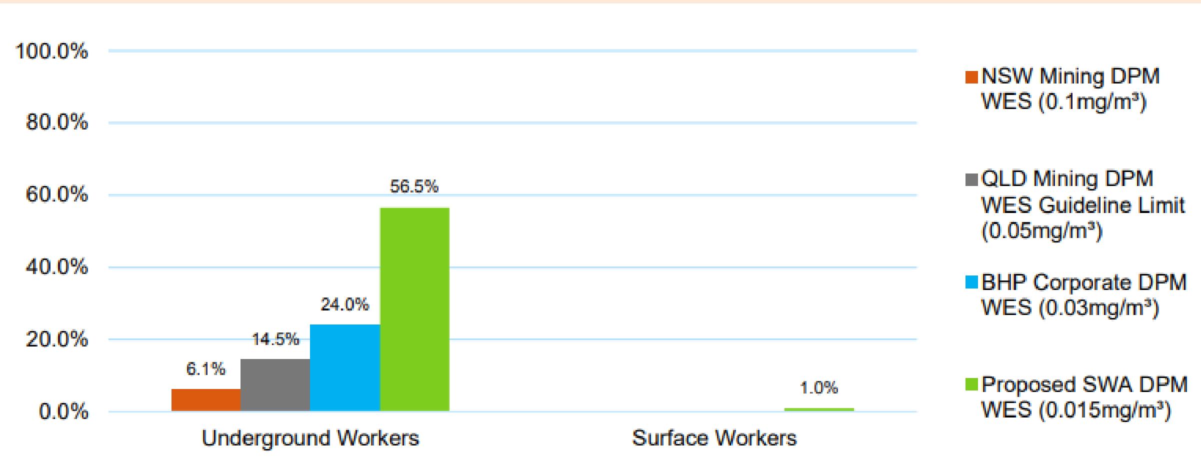


***Figure 2 – comparison exceedance rates for the key underground and surface worker groups*[6]**

[5] The Coal Services NSW Briefing Note: Coal Services Diesel Particulate Matter Exposure Monitoring Information, dated 19 May 2023, Figure 2, page 2

[6] The Coal Services NSW Briefing Note: Coal Services Diesel Particulate Matter Exposure Monitoring Information, dated 19 May 2023, Figure 3, page 3

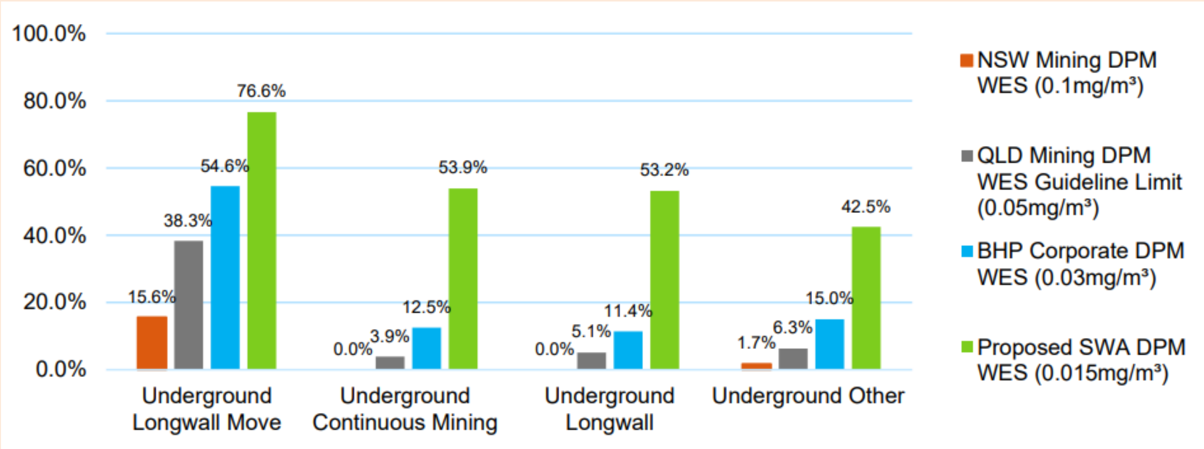


Figure 3 - 2021-2022 NSW coal underground and surface worker DPM WES exceedance rates comparison[7]

There are many initiatives in mining that are currently underway to further develop emission reduction technology and equipment. The following examples reflect the advances that are being made in the industry.

Caterpillar technologies

Caterpillar, and its Australian dealer WesTrac, have rolled out a range of diesel reducing innovations including electric drivetrain machinery which are achieving significant fuel efficiency (up to 31 per cent) and productivity improvements (up to 20 per cent).

They are also partnering with customers to determine how existing fleets can transition to the alternative low carbon fuel such as Hydrotreated Vegetable Oil, which can deliver the same performance and can reduce the carbon footprint of machines by up to 30 per cent.

The most publicised collaboration is the recent trial of Caterpillar's 793 fully electric mining haul truck. The 793 is a prototype to be followed by a range of electric equipment including autonomous vehicles. The 793 electric prototype was demonstrated at its Tucson proving ground in Arizona in late 2022. Mining company customers were able to test the truck on a 7km course and through scenarios equivalent to real life operations.

During the demonstration, the 793 electric's bed was loaded with material from a quarry that needed to be transported to a nearby storage area just like any other heavy truck in normal operations. Fully loaded, the truck achieved a top speed of 60 km/h. It also had to travel one kilometre up a 10 per cent grade at 12 km/h, and then down, capturing the energy that normally would be lost to heat and regenerating the energy to the battery.

Caterpillar developed the truck with support from key mining industry customers, including BHP, Rio Tinto, Newmont, and others.

Caterpillar's focus is initially on introducing four zero emission truck models and they are working with customers to place the trucks, the infrastructure, and the technology on their sites to allow validation of extremes – long haul roads, deep pits, altitude, hot and cold conditions, and achieve the timelines for introduction before 2030.

Komatsu technology

Komatsu, recognising the priority mining is placing on reducing emissions, is developing a truck where the power source can be upgraded over the life of the chassis.

[7] The Coal Services NSW Briefing Note: Coal Services Diesel Particulate Matter Exposure Monitoring Information, dated 19 May 2023, Figure 4, page 3

Komatsu has worked to reduce greenhouse gas emissions in mining for decades. Products such as electric drive haul trucks, electric power shovels, and technologies such as regenerative storage capabilities and fuel saver programs have led to reductions in emissions intensity to-date.

Propulsion technology is developing rapidly as a development platform for power agnostic haulage allowing for changes in the power source going forward.

The engine module is designed such that it can be disconnected and slid out of the front of the machine for easier and faster repair, overhaul, and replacement. This modularity concept approach is driving the innovation to upgrade the power source.

Komatsu is working with major customers to develop its power agnostic truck concept. MCA members BHP, Rio Tinto, Anglo American have joined Vale (Brazil), Codelco (Chile) and Boliden (Sweden) in Komatsu's Greenhouse Gas (GHG) Alliance. Companies will provide site data, analysis and feedback as the truck evolves.

The alliance's initial target is advancing Komatsu's power-agnostic truck concept, with a goal of commercial offering in 2030.

Mining Partnerships

The International Council on Mining and Metals (ICMM) has an initiative for Cleaner and Safer Vehicles (ICSV) and minimising the operational Impact of diesel exhaust by 2025, including a maturity framework. ICMM are also engaging directly with OEMs.

The MCA is working in partnerships Earth Moving Equipment Safety Round Table (EMESRT) and the Australian Coal Association Research Program (ACARP) to engage with OEMs to promote operational and technical innovations to minimise the impacts of DPM in underground operations.

Q4. What changes would you need to make in your workplace (over and above any controls currently in place) to ensure workers and others at the workplace are not exposed to levels of DPM above the proposed WES?

As noted previously, the proposed WES would practically necessitate elimination of diesel equipment underground or create a reliance on low order controls such as respiratory protection, without evidence of what the health benefits to workers would be.

It would be prohibitively expensive to replace entire fleets of mobile plant including load, haul, and support underground equipment. Existing technology does not currently provide the underground mining industry with the means to comply with the proposed limit.

At present battery electric vehicles are not a fit for purpose solution, though research is underway by members to operate fully electronic mines. Increased ventilation rates would add additional challenges for silica exposure controls, and thus introduce further hazards.

Q5. Is there additional evidence or information that you think should be considered?

Existing state regimes and regulators

In September 2022, a DPM WES of 0.1mg/m^3 measured as respirable elemental carbon was adopted in the *NSW Work Health and Safety (Mines and Petroleum Sites) Regulations 2022*.

Clause 50 of the *Work Health and Safety Regulation 2017* requires a person conducting a business or undertaking (PCBU) to conduct air monitoring to determine the concentration of air contaminants to which an exposure standard applies.

Section 42 of the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2022* prescribes the requirement for personal exposure monitoring of workers to diesel particulate matter.

In Western Australia, effective from 5 December 2020, the Government implemented a WES for DPM of 0.1mg/m^3. The WES for DPM must not exceed 0.1 mg/m^3 measured as a timeweighted average (TWA) for an eight-hour exposure period.

The Department of Mines, Industry Regulation and Safety (DMIRS) have analysed 22,120 monitoring results provided by industry since 2003.

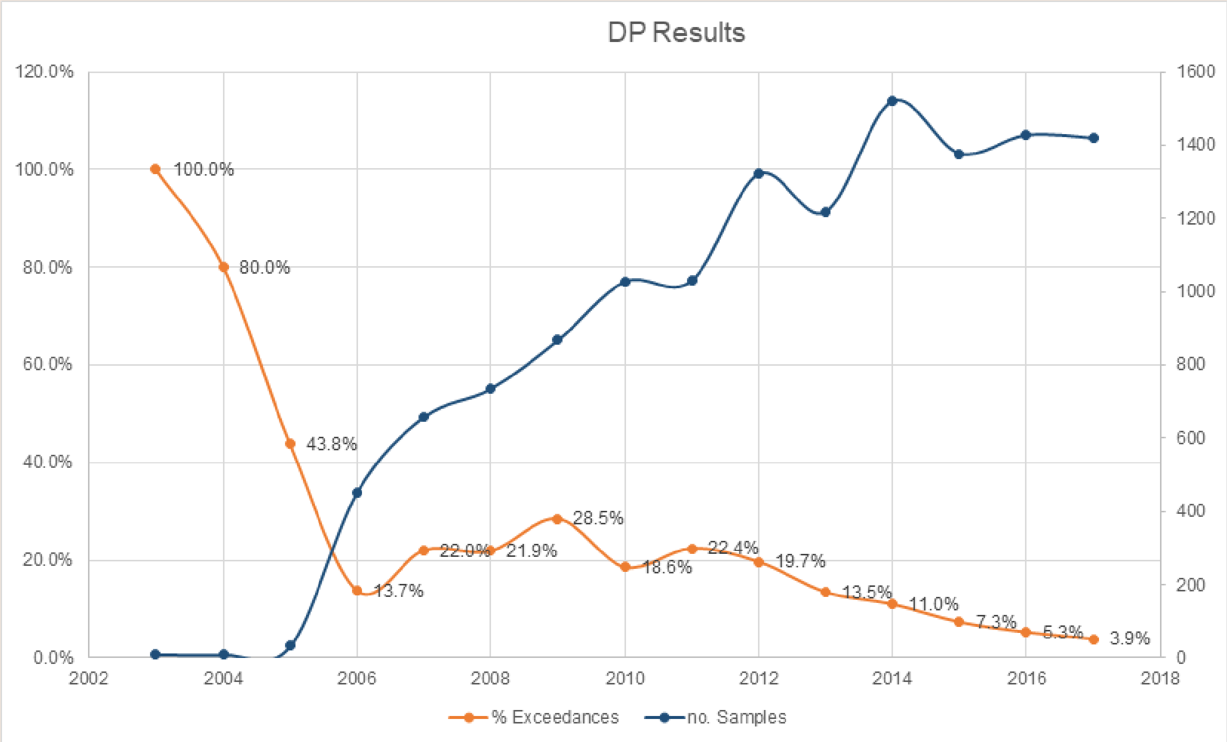


Figure 4 - DMIRS DPM samples compared to exceedances of the adopted guideline of 0.1mg/m3 measured as elemental carbon.[8]

An analysis of the data from 2018 to the present indicates that approximately:

- 98.5 per cent of samples comply with the 100µg/m3 standard
- 70 per cent would comply with a 50µg/m3 standard
- 62 per cent would comply with a 35µg/m3 standard
- 1.2 per cent would comply with a 15µg/m3 standard, and less than 1% when adjusted for a typical 12-hour shift.

The capacity of the regulators to monitor and follow up on exceedance reports must be considered. Reporting of exceedances is designed to inform the regulators where there are failed or omitted controls so action can be taken to ensure worker health. With the projected increase of exceedance reports (as per Figure 1), the regulators are unlikely to have appropriate capacity to ensure thorough review and follow up, which takes significant focus away from where the issues are occurring.

Measurability of the WES

The Coal Services NSW Briefing Note: Coal Services Diesel Particulate Matter Exposure Monitoring Information, dated 19 May 2023, estimated the limit of detection (LOD) outlined in the National Institute for Occupational Safety and Health (NIOSH) 5040 method is 0.3µg per cm². The limit of quantitation (LOQ) is

[8] MSH_TB_History-of-Health-surveillance-and-monitoring power point presentation, slide 13.

approximately 6µg/m^3 with a working range of 6 to 630 µg/m^3 and a LOD of ~ 2 µg/m^3 for a 0.96m^3 air sample collected on a 37-mm filter with a 1.5 cm^2 punch from the sample filter.

NSW Coal Services reports a LOD ~ 2µg/filter as determined experimentally, with measurement uncertainty of +/- 5 per cent. This is in alignment with Safety in Mines Testing and Research Station (SIMTARS), QLD, who have collaborated with NSW Coal Services in DPM analysis quality assurance processes.

Limit of detection (LOD) can be defined as '*the lowest concentration of the analyte present in a sample that can be detected, using a given measurement procedure, with a specific level of confidence*'.[9]

The limit of quantitation (LOQ) can be defined as *'the lowest level of analyte that can be determined with acceptable performance'*.[10]

The accuracy and reliability of DPM exposure assessments is also dependant on uncertainties relating to the sampling process. Some of the factors that can impact sampling accuracy include:

- Conformance of the sampling device to the respirable particle collection efficiency curve
- Impact of high dust environments on the sampling device and capture medium
- Variations in flow rates, durations, and associated measurements
- Handling and transportation of samples

As collected samples approach the LOD, uncertainty in the result increases. It is therefore important that the WES for a contaminant is not too close to the LOD. To address this potential issue the European Commission states that measurement techniques should be able to assess exposure at 0.1 times (or 10 per cent of) the WES for an 8-hour TWA.[11]

The DPM WES proposed by SWA is an 8-hour average, which means it is based on an exposure to the worker of 8 hours a day, 5 days a week. Deviations from this traditional shift pattern are a normality within the mining industry. Under guidance from the Department of Mines, Industry Regulation and Safety (DMIRS), the WA resources sector carries out shift-length adjustment using the *Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST)* method. This adjustment is in accordance with the DMIRS Guidance Adjustment of atmospheric contaminant exposure standards. This guide requires that a specialised approach called the Québec model is used for the adjustment of exposure standards for extended shifts (>8hrs).[12]

Applying the IRSST method for shift adjustment to the proposed DPM WES for a typical resources sector shift pattern, results in a 12-hour TWA limit of 10µg/m3 (1.0mg/m^3).

Measurability of the action level

An action level (if the exposure reaches the action level, the employer must act and implement exposure control measures to reduce the exposure potential) is typically half of the WES.
Based on the measurement technique requirements, measuring an action level of 7.5µg/m^3 (i.e. half of the proposed WES of 10µg/m3) is not achievable or reliable. This effectively creates a 'no exposure limit'.

A 'no exposure limit' would always classify every worker in the workplace as 'at-risk' and given the inability to accurately measure at such low levels, this would mandate respiratory protective equipment for all workers. Not only would this have significant cost implications, but the mandating of RPE also introduces further workplace hazards and puts an emphasis on lower order controls.

[9] Eurachem Guide (2014). The Fitness for Purpose of Analytical Methods – A Laboratory Guide to Method Validation and Related Topics, B. Magnusson and U. Örnemark (eds.) (2nd ed).
https://www.eurachem.org/images/stories/Guides/pdf/MV_guide_2nd_ed_EN.pdf

[10] Definition NIH

[11] European Commission (2017). Methodology for derivation of occupational exposure limits of chemical agents - The General Decision-Making Framework of the Scientific Committee on Occupational Exposure Limits (SCOEL), Luxembourg: Scientific Committee on Occupational Exposure Limits

[12] Department of Mines, Industry Regulation and Safety [WA]: Adjustment of atmospheric contaminant exposure standards – guide; page 5

Given that personal exposure testing currently has an uncertainty value of 10µg, the testing facility would need to be much more accurate to be reliable and considered 'measurable'.

Reporting of exceedances

Any exceedance of the DPM exposure standard is reportable in NSW to the NSW Resources Regulator as a high potential incident (HPI) under section 124 (5)(q) of the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2022*. It is also reportable in WA.

Without a compliance strategy, there will be confusion (particularly where a WES is already regulated) on what conformance (and non-conformance) might look like. Industry must be able to understand when exceedances are required to be reported, who the exceedances are reported to, what the consequences are, and what the process will be once reported.

There must also be a clear understanding of SWA and State Regulator expectations in relation to reporting and investigation processes to ensure businesses can prepare and appropriately comply.

Risk-based approach

The MCA supports the national model of a *risk-based approach* to reduce DPM workplace exposures. An effective approach must, however, be able to distinguish between industries based on their risk level and existing control measures, where those measures are effective.

Introduction of further hazards to comply with the proposed WES

Additional ventilation in an underground environment, to further reduce diesel exhaust, would be energy intensive, cost prohibitive and would add additional challenges for silica exposure controls as more air movement would cause roads to dry out more quickly and keep particulate airborne longer, resulting in higher levels of respirable crystalline silica (RCS).

One MCA member identified that in one underground mine alone, the PAPR requirements would go from 40 individuals to 400 individuals (being the entire workforce for that mine) even with existing exhaust after controls, ventilation, and fuel management. Mandating PAPR introduces additional hazards, including:

- Complications for workers who have existing respiratory illnesses (such as asthma)
- Obstructed vision
- Musculoskeletal impacts from the weight of the PAPRs

Controls being implemented in mining

DPM filters - Diesel Particulate Filters (DPF) and Disposable Diesel Particulate Filters (DDEF)

DPF and DDEF are used in the exhaust pathway on diesel equipment to capture the solid portion of the exhaust. They can be retrofitted, or purpose-built into the machines, and are either reusable and regenerating, or disposable. These have been shown to have a high efficiency rating for filtering DPM from the exhaust of engines, providing filter housing and filter systems are well maintained. Different filters have different efficiencies.

Ultra Low Sulphur Fuel (ULSF) and alternative fuels

ULSF is used to help reduce gases and the particulate amount within diesel exhaust emissions. This is achieved by reducing the number of nuclei for diesel particulate to form on. Various types of low sulphur fuels are available. These include fuels that are aliphatic based which reduce the odour, and eye and respiratory irritation to workers.

One Australian fuel supply company has a focus on underground DPM emissions and is currently supplying an alternative fuel for trial in an underground mine. Initial and early feedback suggests that DPM is almost eliminated through the use of the alternative fuel.

At the conclusion of the transition period, the MCA would encourage SWA to consult with Industry on the developments and movement of electronic technology available. The mining industry is committed to net zero by 2050.

Diesel Tag Boards

Tag boards can be used as a visual aid to show the amount of air available, and the amount of air required for diesel equipment to enter areas. This is based on equipment exhaust calculations and the statutory airflow requirements. These boards use a tag system, with each vehicle assigned a certain number of tags depending on the amount of air required to sufficiently dilute the exhaust to a statutory level. It provides a physical representation for all staff to easily see both the mine capacity and the number of vehicles in use.

Wet Scrubber Systems

Wet scrubber systems are commonly found within diesel engine systems in the underground coal mining industry as this helps reduce the temperature of the emitted exhaust. Their primary role is for spark suppression. They assist in reducing the amount of particulate matter by up to 10 per cent.

Vehicle Maintenance and Emissions Based Maintenance Testing

Vehicle maintenance and emissions based maintenance testing engine exhaust and providing regular emissions-based maintenance in addition to original engine manufacturer (OEM) requirements improves the efficiency of the engine. It reduces emissions from the vehicles as well as providing cost savings by using less fuel and filters. The testing improves productivity by having a more reliable fleet and improves health to workers by exposing them to lower emissions.

DPM is a key risk when developing new mines where the ventilation system is still being developed and is therefore limited in its capacity. All vehicles must have exhaust filters and exhaust emissions that meet regulatory requirements.

Respiratory Protection Equipment (RPE)

Diesel exhaust is thermally generated and have a minimum requirement for RPE of a P2 respirator as per AS1716.

Fuel Active Systems in QLD

Two mines are currently trialling a fuel active system. This system takes fuel from the top of the tank (as opposed to bottom with residues) with a 5µm filter, trials seeing a 10-20 per cent reduction in DPM levels.

Q6. Are there any additional comments you would like to make?

The MCA agrees that, in addition to a WES for DPM, there should also be WESs for other potential DEE exposures, such as NO_2, to control and/or minimise such exposures. However, we note that Australian underground mines will likely also have difficulties in complying with the proposed WES of 0.2 ppm NO_2.

4. GENERAL COMMENTS

Relevant feedback on the SLR Report

The SLR Report does recognise that compliance with its recommended WES may prove difficult in certain workplaces where traditional diesel engines (TDEs) are still prominently used.

The SLR Report provides a comprehensive review of the relevant independent, peer reviewed research and literature on the health effects of exposure to diesel engine exhaust (DEE), recommending an 8-hour time-weighted average (8-h TWA) of 0.015 mg REC/m³. This was the approximate midpoint of toxicological data-derived candidate WES values (ranging from 7.5µm/m³ to 25µm REC/m³). It was considered that these candidate WES values would also likely be protective of lung cancer from PAH exposure, considering the potential for PAH content being adsorbed to DPM.

Landwehr (2020)[13] also recently reviewed research findings relevant to setting an appropriate WES, focusing specifically on newer engines and after-treatment technologies.[14] However, it proposed a WES of an average diesel exhaust concentration below 0.05 mg/m³ of total DPM, 0.035 mg REC/m³, being appropriate to limit health effects. It noted that this value is below the acute exposure concentrations where effects were still found in asthmatics and also below the exhaust concentrations that found the highest lung cancer risks.

The MCA does not support the SWA proposed WES of 0.015 mg REC/m³ for DPM to protect workers from the adverse health effects of exposure to DEE. While the MCA acknowledges the importance of minimising worker exposure to DEE, we believe that the proposed limit is set at an unreasonably low level, making it prohibitive for the mining industry, particularly underground mining, to comply using available technology.

Consistent with SWA position in 2019, the SLR Report notes that:

> *DEE is made up of a complex mixture of hundreds of chemicals consisting of gaseous, adsorbed organics and particulate components found in the exhaust emissions from diesel engines… the composition of this mixture varies depending on engine type, operating conditions, fuel, lubricating oil, and whether an emission control system is present.*[15]

As was noted by the AIOH (2017) Position Paper, the SLR Report also notes that:

> *…engine technology has evolved from older 'traditional diesel engines' (TDE) to 'Non-Traditional Diesel Engines' (NTDE). With the application of sophisticated emission control devices in NTDE, emissions of particulates and other constituents are >90per cent lower than in TDE exhaust. TDE engines are generally considered to be any engines manufactured before 2007 and not equipped with after-treatment devices.*[16]

The SLR Report also found that '*the critical health effects associated with exposure to DEE include lung irritation, which upon long-term exposure, can progress to an inflammatory response and lung cancer.'*[17] This is consistent with the AIOH (2017) Position Paper and past MCA response to SWA.

The SLR Report concluded that there is insufficient information to recommend a WES for DEE. Instead, a WES derived using DPM (expressed as respirable elemental carbon, or REC) as an indicator compound in DEE should be used, keeping in mind that exposures to other constituents of potential concern in DEE (i.e. NO_2, PAHs and aldehydes) should also be managed. REC is considered the best surrogate for measuring diesel exhaust particulate, consistent with the AIOH (2017) Position Paper and CAREX Canada (2020)

[13] Landwehr, K.R.; Mead-Hunter, R.; O'Leary, R.A.; Kicic, A.; Mullins, B.J.; Larcombe, A.N. Respiratory Health Effects of In Vivo Sub-Chronic Diesel and Biodiesel Exhaust Exposure. *Int. J. Mol. Sci. 2023*

[14] Landwehr, K.R, A.N., Reid, A. *et al*. Critical Review of Diesel Exhaust Exposure Health Impact Research Relevant to occupational Settings: Are We Controlling the Wrong Pollutants? *Exposure and Health 13*

[15] Safe Work Australia Research Report Workplace Exposure Standard for Diesel Particulate Matter, December 2022, page 3, para 3.

[16] Safe Work Australia Research Report Workplace Exposure Standard for Diesel Particulate Matter, December 2022, page 3, para 4.

[17] Safe Work Australia Research Report Workplace Exposure Standard for Diesel Particulate Matter, December 2022, page 3, para 7.

opinions.[18] Several international jurisdictions have proposed or adopted OELs based on measurement of REC.

Other aspects, such as carcinogenicity of DEE, engine type exhaust toxicity, and whether a threshold or non-threshold concentration response is operable for DEE. This is important in deriving a health-based DPM TWA-WES value.

Carcinogenicity of DPM

There is still much conjecture as to the carcinogenicity or otherwise of DEE, particularly for Non-Traditional Diesel Engine (NTDE) DEE exposures. However, given the differing views as to the carcinogenicity of DEE:

- the likelihood that NTDE DEE exposure is less toxic than TDE DEE exposure and that after-treatment devices also reduce DEE toxicity and that most diesel engines currently used in Australian underground mines are likely 'equivalent' NTDEs, and
- the likely existence of a threshold level for DPM carcinogenicity it is likely that the candidate WES lies more at the high end of the range of approximate epidemiological exposure estimates that have been associated with an increased risk of lung cancer (8µg to 67µg REC/m^3).

It is therefore likely that the health-based candidate WES lies between 25µg REC/m^3 and 67µg REC/m^3. It may even be higher for NTDE DEE exposures.

In addition, it is common for estimated health-based calculated occupational cancer risk values derived from epidemiological studies to be based on 40 years of work exposure. In Australia at least, 40 years of work at the same job is no longer common. A shorter work duration is more common; hence the calculated limit value will be higher (e.g. changing from 0.013 mg/m^3 to 0.05 mg/m^3).

The International Agency for Research on Cancer (IARC) classified DEE as a human carcinogen (Group 1).[19] This decision was primarily based on the findings of the National Cancer Institute (NCI) / National Institute for Occupational Safety and Health (NIOSH) epidemiological 'Diesel Exhaust in Miners Study' (DEMS) which only looked at exposures to TDE DEE.

There are however differing views as to the carcinogenicity of DEE, which are presented in both the SLR Report and the AIOH (2017) Position Paper.

Scientific Committee on Occupational Exposure Limits (SCOEL), in its 2016 opinion paper, states that TDE DEEs are carcinogenic 'SCOEL Group B' (genotoxic carcinogens with no clear critical exposure threshold, based on epidemiological studies) or 'SCOEL Group C' (genotoxic carcinogens with a mode of action-based threshold, based on toxicological and pathobiological information from animal studies).[20]

Engine Type Exhaust Toxicity

As noted in the AIOH (2017) Position Paper, the most modern diesel engine assessed in the epidemiology studies that were used to derive an OEL for DPM was built in 1983. This means that the vast majority of considered exposure in those studies came from diesel engines produced in the 1970s and earlier. This is no longer a valid methodology as the exhaust produced by NTDEs is totally different to that from old engines (TDEs).[21]

The SLR Report notes that a vast amount of primary and secondary literature has been published on the composition and toxicity of DEE, many of these focused on DEE from the older TDE technology. Only a few of the more recent reviews concentrate in part on NTDE exhaust.

The SLR Report cites research of Taxell & Santonen, (2017) that suggests that NTDE and after-treatment technologies may decrease the genotoxic potency of DEE, which is likely attributable to the significant

[18] Carex Canada Diesel Engine Exhaust Profile

[19] IARC: Diesel Engine Exhaust Carcinogenic

[20] SCOEL/OPIN/403 Diesel Engine Exhaust Opinion from the Scientific Committee on Occupational Exposure Limits, K217030ENN_002, page 10.

[21] AIOH (2017) Position Paper, 6.1, page 17

reduction of particulate matter (and therefore adsorbed PAHs) in the exhaust.[22] They also cite a systematic review by [Weitekamp *et al* (2020)] that included treatment groups of filtered and unfiltered (whole) diesel exhaust. They found that most statistically significant effects on health-related endpoints were in response to exposure to both filtered and whole diesel exhaust.[23] Given that the primary difference between these treatment groups is the filtering of particulate matter, the gaseous fraction of diesel exhaust may have been the primary driver of the observed effects.

An important limitation is that none of the studies that met their inclusion criteria (i.e., studies that directly compared the health effects of filtered to whole diesel exhaust) reflect 2010-compliant diesel engines with manufacturer built-in catalysed filters, which greatly reduce emissions of oxides of nitrogen (NO_x). Weitekamp *et al* (2020) conclude that a more complete understanding of the contributions of all individual components within DEE will be important for human risk assessment.

The SLR Report states:

> *These data provide tentative support for the conclusion that DPM from TDE is not likely to be in principle of different toxicity to DPM from NTDE. The lower concentration of DPM in NTDE appears to reduce the toxicity of DPM, however the concentrations of gaseous compounds such as NO_2 and aldehydes may increase compared with TDE.*[24]

In not distinguishing between TDE and NTDE exhaust toxicity, the SLR Report also observes that most diesel engines currently used in underground mining in Australia are pre-2007 older technology transitional engines (Tiers 1-3), and thus do not contain exhaust after-treatment devices. While there are a **minority** of mines still using pre-2007 TDE's, these machines **would not have the original engine**. Machinery typically has a 5–6-year (or 10000-15000 hour) life. It is likely that any machine in operation manufactured pre-2007 now has a NTDE.

The Queensland DNRME (2019) 'Best Practices and Recommendations' document used for managing DPM in underground coal mines notes that only just over 25 per cent of the operating fleet was older than 10 years and that all mines use DPM filters during longwall moves.[25] Additionally, most of the mines use DPM filters routinely.

One MCA member stated that while they use Tier 3 or older equipment that does not have OEM exhaust treatment, most underground equipment has been modified after market, with heavy use equipment being generally fitted with a DPF, and that support equipment will have at least a diesel oxidation catalyst (DOC). DPFs can be problematic with support equipment, as often they do not operate on a heavy enough duty cycle to regenerate the filter, leading to clogging.

The presumption by the SLR Report that older diesel engines with no exhaust after-treatment devices are most common in Australia underground mines is not correct. Tier 1 to 3 engines can be retrofitted with DPFs (including high-efficiency catalysed filters), which will substantially reduce REC DPM. DPFs can remove approximately 90 per cent by mass of particulate matter.

It can be concluded that NTDE DEE exposure is substantially less toxic than TDE DEE exposure and that after-treatment devices also reduce DEE toxicity. The SWA WES review and the SLR Report have not considered how this would affect the WES and how it should be reflected.

Epidemiological Studies – Importance for Exposure Limit Derivation

The SWA (2018) WES review was to be based on the available toxicological and epidemiological data. Traditionally, epidemiological data has been considered the 'gold standard' for developing an OEL.[26]

---

22 Taxell, Piaa & Santonen, Tiina; Diesel Engine Exhaust: Basis for Occupational Exposure Limit Value. *Toxicol Sci. 2017*

23 Weitekamp CA, Kerr LB, Dishaw L, Nichols J, Lein M, Stewart MJ. A systematic review of the health effects associated with the inhalation of particle-filtered and whole diesel exhaust. *Inhal Toxicol. 2020*

24 Safe Work Australia Research Report Workplace Exposure Standard for Diesel Particulate Matter, December 2022, page 54, para 3.

25 Department of Natural Resources, Mines and Energy QLD; Diesel Emissions Management in Underground Coal Mines – Best Practices and Recommendations, page 7, box 3

26 https://www.safeworkaustralia.gov.au/doc/wes-review-recommending-health-based-workplace-exposure-standards-and-notations

The SLR Report explored several approaches for establishing a health-based 8-h TWA-WES for DPM, including epidemiological studies. However, it derived its candidate WES values (range of 7.5-25 µg REC/m³) using an acute or chronic 'point of departure' from controlled human exposure studies and using a chronic No-Observed-Adverse-Effect Concentration (NOAEC) from experimental studies in rats (i.e., only toxicological data).

Regarding epidemiological studies, the SLR Report notes

> …*there is considerable debate in the scientific community as to the strengths and utility of the exposure-response relationships for lung cancer risk from occupational epidemiological studies with DEE. Qualitatively, the studies do support a statistically significant association between DEE exposure and lung cancer risk. However, from a quantitative assessment perspective, the extrapolation to low exposures and apparent nonmonotonicity of the relationship (which is not supported by the hypothesised mechanisms for DEE-induced lung cancer) arguably limits the utility of the information for deriving a WES. It is also somewhat concerning that various reanalyses of the same dataset have resulted in vastly different quantitative estimates, highlighting the uncertainties inherent in any retrospective exposure assessment and application of statistical models of best fit.'*[27]

SLR therefore does not use the epidemiological data in deriving candidate WES values, simply noting that its recommended 8-h TWA of 0.015mg REC/m³ is at the low end of the range of approximate epidemiological exposure estimates that have been associated with an increased risk of lung cancer (0.008 to 0.067mg REC/m³).

In addition, the report also notes that when using the exposure metric of cumulative REC to inform an average WES, it is dependent on the exposure duration of each of the individual workers in the various cohorts. For example, a cumulative REC exposure of 0.5 mg/m³.yrs could be represented by 40 years of exposure at an average REC concentration of 0.0125 mg/m³ but could just as well be represented by 10 years of exposure at a concentration of 0.05 mg/m³. SLR thus conclude that the occupational epidemiological information on its own is not considered to be sufficient for quantitative use in derivation of a WES.

It is worth noting that, in Australia, 40 years of work at the same job is no longer common. Shorter periods of employment seem to be more the norm. Data from the Australian Bureau of Statistics state that of the 13.4 million people employed in February 2022, only one in ten people (11 per cent) had been in their current job for 20 years or more. Over half (55 per cent) had been employed in their current job for less than 5 years and about one in five (21 per cent) had been in their job for less than 1 year.

[27] Safe Work Australia Research Report Workplace Exposure Standard for Diesel Particulate Matter, December 2022, page 48, para 1.

5. GLOSSARY OF TERMS

ACES	Advanced Collaborative Emissions Study Cooperative multi-party effort to characterize emissions and possible health effects of new advanced heavy-duty engine and control systems and fuels in the market 2007 – 2010
DEE	Diesel Engine Exhaust
DPF	Diesel Particulate Filters A DPF is a device designed to remove diesel particulate matter (DPM) or soot from the exhaust gas of a diesel engine.
DPM	Diesel Particulate Matter Particulate matter, as defined by most emission standards, is filterable material sampled from diluted and cooled exhaust gases. This definition includes both solids, as well as liquid material that condenses during the dilution process. The basic fractions of DPM are carbonaceous solids and heavy hydrocarbons derived from the fuel and lubricating oil. In cases where the fuel contains significant sulphur, hydrated sulphuric acid can also be a major component. DPM contains a large portion of the polycyclic aromatic hydrocarbons (PAHs) found in engine exhaust. DPM includes small solid primary soot particles of diameters below 40 nm and their agglomerates of diameters up to 1µm as well as nucleation mode of particles consisting almost entirely of condensed liquid.
DOC	Diesel Oxidation Catalysts DOCs are catalytic converters designed specifically for diesel engines and equipment to reduce carbon monoxide (CO), hydrocarbons (HCs) and particulate matter (PM) emissions. DOCs are simple, inexpensive, maintenance-free, and suitable for all types and applications of diesel engines.
EC	Elemental Carbon Carbon that is present in atmospheric particulate matter can be classified into three basic forms: carbonate carbon, organic compounds, and EC. Carbonate carbon comprises the salts of the carbonate ion (CO_2^{2-}) and the bicarbonate ion (HCO_3^-), whereas organic carbon comprises hundreds to thousands of organic compounds. EC is pure carbon, of which there are two types (graphite and diamond). EC is frequently used as a surrogate for measuring concentrations of diesel particulate matter. While both organic carbon and EC are present in diesel engine exhaust, there are many other sources of organic carbon such that atmospheric concentrations of it cannot be stated, with any reliability, as being solely from diesel engine exhaust. However, respirable EC generally has only one source in the workplace: exhaust. EC consists of carbonaceous airborne particle species formed from incomplete combustion of carbonaceous fuel and is linked with possible human health impacts.
HPI	High Potential Incident As defined in section 17 of the *Coal Mining Safety & Health Act 1999 QLD* a high potential incident at a coal mine is an event, or a series of events, that causes or has the potential to cause a significant adverse effect on the safety or health of a person.
LNT	Linear No-Threshold The linear no-threshold model (LNT) is a dose-response model used to estimate health effects such as radiation or chemical induced cancer, genetic mutations, and teratogenic effects on the human body. The model statistically extrapolates effects of radiation or a chemical from very high doses (where they are observable) into very low doses, where no

	biological effects may be observed. The LNT model lies at a foundation of a postulate that all exposure to ionizing radiation or carcinogens is harmful, regardless of how low the dose is, and that the effect is cumulative over lifetime.
LOD	Limit of Detection The lowest concentration of an analyte present in a sample that can be detected, using a given measurement procedure, with a specific level of confidence.
LOQ	Limit of Quantitation The lowest level of analyte that can be determined with acceptable performance.
mg/m^3.yrs	Milligrams Per Cubic Metre Years This is a cumulative measure of an exposure concentration over a specific duration, in this case number of years. The number of years over which the exposure is accumulated must be stated.
NOAEC	No Observed Adverse Effect Concentration The greatest concentration or amount of a substance at which there are no statistically and/or biologically significant changes in the frequency or severity of adverse effects between the exposed population and its appropriate control. Some effects may be produced at this level, but they are not considered as adverse, nor immediate precursors to specific adverse effects. In an experiment with several NOAECs, the assessment focus is primarily on the highest one for a given critical effect, leading to the common usage of the term NOAEC as the highest exposure without adverse effect.
NO_x	Nitrogen Oxides NO_x is a generic term for the nitrogen oxides that are most relevant for air pollution, namely nitric oxide (NO) and nitrogen dioxide (NO_2).
NO_2	Nitrogen dioxide
NTDE	Non-Traditional Diesel Engines These engines were developed in the mid-2000s and involve use of inbuilt emission control measures (e.g. DPFs, DOCs) to minimise emissions to air (particularly DPM and NO_x) from the diesel combustion process. NTDE exhaust is defined as diesel exhaust from post-2006 and older retrofit diesel engines that incorporate a variety of these technological advancements, including electronic controls, ultra-low-sulphur diesel fuel, oxidation catalysts, and wall-flow DPFs.
OEL	Occupational Exposure Limit The OEL typically represents a regulatory limit for airborne contaminants that must not be exceeded. It is synonymous with the Workplace Exposure Standard (WES) used in Australia, but the terminology ‘OEL’ has been used more broadly in this report when referring to international versions of these values.
OEM	Original Equipment Manufacturer
PAHs	Polycyclic Aromatic Hydrocarbons PAHs are a class of chemicals that occur in coal, crude oil, and gasoline. They are also produced when coal, oil, gas, wood, garbage, and tobacco are burned, as well as in combustion of diesel. Several PAHs are carcinogenic.
PAPR	Powered Air Purifying Respirator

	Respirators that protect the user by filtering out contaminants in the air and use a battery-operated blower to provide the user with clean air through a tight-fitting respirator, a loose-fitting hood, or a helmet.
REC	Respirable Elemental Carbon This is EC measured by a size selective device conforming to a sampling efficiency curve which has an approximate 50per cent cut-point of 4μm, as defined by ISO 7708. This is also the mass fraction of inhaled EC that penetrates to the unciliated airways (i.e., the gas-exchange region of the lung).
SEG	Similar Exposure Group
STEL	Short-Term Exposure Limit This is the time-weighted average maximum airborne concentration of a substance calculated over a 15-minute period. Under the model WHS laws, the STEL must not be exceeded at any time during an 8-hour working day, even if the exposure during the full day is less than the TWA. Exposures at the STEL must not be longer than 15 minutes and must not be repeated more than 4 times per day. There must be at least 60 minutes between successive exposures at the STEL.
TDE	Traditional Diesel Engines These are engines that are not considered NTDE. Increasingly stringent emissions standards (1988–2010) for particulate matter and nitrogen oxides (NOx) in diesel exhaust have helped stimulate major technological advances in diesel engine technology and diesel fuel/lubricant composition, resulting in the emergence of NTDE. Traditional Diesel Engines are any engines that are not NTDE.
TWA	Eight-hour Time-Weighted Average This is the maximum average airborne concentration of a substance when calculated over a specific timeframe. Under the model WHS laws, this is an 8-hour working day, for a 5-day working week. With respect to a TWA, during periods of daily exposure to an airborne contaminant, exposure above this value is permitted for short periods, if compensated for by equivalent exposures below the exposure standard during the working day.
WES	Workplace Exposure Standard In Australia, under the model WHS laws, a WES for a particular chemical sets out the airborne concentration limit of that substance or mixture that must not be exceeded. WESs are not intended to represent acceptable exposure levels for workers, and do not identify a dividing line between a healthy or unhealthy working environment.