AIOH Submission

Consultation on:
Proposed Workplace Exposure Standard for Diesel Particulate Matter

[redacted]
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Summary of our Submission

We would like to thank Safe Work Australia for the opportunity to provide a submission in support of this important work.

The Australian Institute of Occupational Hygienists (AIOH) maintains its position stated in its 2017 Diesel particulate matter and occupational health issues - Position Paper (AIOH 2017) i.e. an 8-hour time-weighted average (8-h TWA) workplace exposure standard (WES) of 0.1 mg/m³ sub micron elemental carbon and an action limit of 0.05 mg/m³ sub micron elemental carbon (as a trigger for additional controls); this will ensure that worker mid and long-term exposure will be less than 0.05 mg/m³. The currency of this position holds as there has been no new epidemiological studies and no new relevant toxicological evidence to change the AIOH's stance.

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)?

◉ Yes

○ No

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

The Australian Institute of Occupational Hygienists (AIOH) maintains its position stated in its 2017 Diesel particulate matter and occupational health issues - Position Paper (AIOH 2017), i.e. an 8-hour time-weighted average (8-h TWA) workplace exposure standard (WES) of 0.1 mg/m³ sub micron elemental carbon and an action limit of 0.05 mg/m³ sub micron elemental carbon (as a trigger for additional controls); this will ensure that worker mid and long-term exposure will be less than 0.05 mg/m³. The currency of this position holds as there has been no new epidemiological studies and no new relevant toxicological evidence to change the AIOH's stance.

The proposed WES of 15 µg/m³ respirable elemental carbon (REC) applicable to diesel exhaust emissions (DEE) exposures has been developed as the result of the failure of the extensive array of epidemiological studies involving exposed workers mostly assembled more than 20 years ago, to provide a sound technically valid and consistent quantitative dose response health risk estimate (endpoint for lung cancer).

This is essentially due to the latency of the disease (time from first exposure to the positive diagnosis) being typically 30-40 years, combined with the absence of suitable historical exposure assessments from the preceding decades, further confounded by exposure profiles involving the complex and changing mix of chemical constituents in workplace DEE (AIOH 2017).

Due to the above deficiencies, the WES of 15µg/m³ proposed in the 2022 SLR research report – Workplace Exposure Standard for Diesel Particulate Matter (the SLR Report) becomes heavily reliant on indeterminate outcomes from short-term findings from animal experiments and small-scale human exposure experiments examining irritant effects. These short-term irritant factors have been relied upon in the proposed WES to extrapolate via various proposed mechanisms; the extent and risk of long term (40 year working lifetime of exposure) health outcomes from DEE exposures experienced by the Australian workforce.

A further issue of disagreement and uncertainty raised in the SLR Report is the reliance on the measured parameter of respirable elemental carbon (REC) which opens the problems associated with interference from other carbon species found in the occupational environment. The correct exposure parameter is sub-micron elemental carbon as captured with a specific sampling head which excludes the larger size interfering organic carbon aerosols found in many workplace environments (Rogers 2005).

In addition, and of considerable importance, is the fact that the authors of the SLR Report do not acknowledge that a WES for DEE (8-h TWA 0.1 mg/m^3 or 100 µg/m^3 submicron elemental carbon EC) is already gazetted and successfully implemented into the mining regulations and is part of the routine assessment of miners' exposures in the main mining states of NSW, Qld, and WA. This WES has also been routinely implemented in exposure assessment and control strategies in mining and other industries across Australia since the 1990's, thereby providing a contemporary exposure database for epidemiological assessment.

There is very limited consideration in the presented documentation of the technical aspects of the health implications arising from exposure to and control of DPM and DEE emissions as addressed in existing Australian publications (AIOH list documents + JCB/BHP mine research projects and regulatory COP's and University theses).

A point that was raised within the SLR Report and then discarded, is the difference between traditional diesel engines (TDEs) and new technology diesel engines (NTDEs). TDEs are generally referred to as pre-2007, and NTDE are those manufactured post-2007. The key features of NTDEs include a focus on 'in cylinder' combustion processes and associated electronic control management of engine parameters.

These and other advancements in engine combustion and improvements in fuel types have altered the chemicals commonly found in diesel exhaust from engines pre-2007 to post-2007. Advances in diesel engine technology and fuel have resulted in reductions in emissions, chiefly particulate matter, oxides of nitrogen and hydrocarbons. Therefore, the emission profile of diesel exhaust differs between NTDE and TDE (McClellan et al. 2012). Particle mass of DPM in new engines (i.e., post-2007) has been reduced by an order of magnitude, although the number of smaller particles has increased with NTDE (Hesterberg et al. 2011; Kittelson 1998; Matti Maricq 2007; McClellan et al. 2012). It remains uncertain how a shift to smaller particles size will affect the toxicity of NTDE compared to TDE and more research is required (Landwehr et al. 2019). Substantial reductions have also been reported for carbon monoxide, non-methane hydrocarbons, formaldehyde, benzene, acetaldehyde, and polycyclic aromatic hydrocarbons (McClellan et al. 2012).

Most epidemiological studies to date are based on estimated exposure data from older technology diesel sources. The Advanced Collaborative Emissions Study (ACES) aimed to evaluate the hypothesis that emissions from a 2007 compliant on-road diesel engine "...will not cause an increase in tumour formation or substantial toxic effects in rats and mice at the highest concentration of exhaust that can be used … although some biological effects may occur" (McDonald et al. 2012). Results from the study indicated that exposing rats to DPM did not cause identifiable differences in mortality and morbidity rates, nor generate other significant differences (Costantini et al. 2016). Some statistically significant effects, such as early signs of lung changes and oxidative stress, were evident at the high exposures (McDonald et al. 2012). The high exposures that had been routinely seen pre-2007, are generally not seen now. Although some sites certainly continue to operate TDE, they are generally fitted with exhaust after treatment at the very least, with particulate filters and catalytic converters regularly in place in addition to using better quality diesel fuel. Therefore, the delineation between TDE and NTDE is blurred with many TDE being closer to a NTDE rather than a TDE in terms of DEE.

Particulate matter from post-2007 engines is dominated by sulphates (53%) and organic carbon (30%) with an EC content of approximately 13% compared to 40-90% in TDE (Hesterberg et al. 2011). Studies by Biswas et al (2009) and Liu et al (2005) also support a significant reduction in elemental and organic carbon and particle-phase and semi-volatile organic compounds present in diesel engine exhaust. Research indicates this is not only due to the new engine design and operating characteristics, but also exhaust aftertreatment and changes in fuel constituents (Biswas et al. 2009; McClellan et al. 2012; McDonald et al. 2012).

Diesel fuel has changed and improved over time within Australia. Eromanga Underground Mining Fuel® (Eromanga) is diesel fuel produced at the Eromanga Refinery, Australia. It is a premium aliphatic based low emission diesel fuel used in many underground mining operations within Australia. Eromanga has been used in the mining industry since the 1980s due to its low aromatic content and particulate output. This fuel in not available to be used on the open road as it exceeds the sulphur content limits that is permitted in over-the-road diesel fuel, however other commercially available, over-the-road fuels are also suitable for use underground, albeit with slightly higher constituents. In 2013, Queensland University of Technology (QUT) conducted studies on Eromanga and three other commercially available diesel fuels to determine the difference in emissions between each product (Wang et al. 2013). The testing included determining the carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), PM2.5, particle number and particle size distributions between the fuels. The results showed that CO_2, CO, NO_x, and numbers of particles were lowest with Eromanga. However, diesel fuel quality generally has improved in Australia over the last two decades. Prior to 2000, diesel fuel was largely unregulated, however the Fuel Quality Standards Bill 2000 was introduced to reduce pollutants and emissions arising from the use of fuel that may cause environmental, greenhouse and health problem; facilitate the adoption of better engine and emission control technologies; and allow the more effective operation of engines. Fuel Quality Standards (Automotive Diesel) Determination 2019 replaced the Fuel Standard (Automotive Diesel) Determination 2001 which sets out the specification for the chemical and physical parameters of fuel supplied as automotive diesel and is a further improvement again on the previous regulation. These improvements in fuel are expected to equate to an improvement in potential health outcomes, however, epidemiology is not available with the recent fuel changes to support this with data, as all human studies have taken place on older fuel types and engines.

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.

YES. There is an alternative and existing WES and monitoring method. It is important to note that the SLR's document does not acknowledge that a WES for DEE (8-h TWA 0.1 mg /m^3 or 100 micrograms/m^3 submicron elemental carbon EC) is already gazetted and successfully implemented in mining regulations in NSW, Qld, and WA, and have been voluntarily adopted by mining companies in other states.

This WES has been routinely implemented in exposure assessment, control strategies, and compliance testing in mining and other industries across Australia since the 1990s. The adoption and application of the TWA of 0.1 mg /m^3 submicron elemental carbon value has been extremely successful in reducing daily exposures and the long-term average exposures of the workforce to much less than 0.05 mg/m^3 across the Australian mining and quarrying industry. The result being that the long-term extrapolated risks such as risk of lung cancer associated with the cumulative exposures is predicted as very low if not zero, aa level of risk which is not detectable in real world measurement or epidemiological studies.

This DPM control limit has been subject to detailed documentation and rational risk decision making and has proven application to Australian industry and mining activities. The DPM control limit has been promoted in documents and seminars to mines and industries in most states by the mining regulators and adopted as a means of compliance with the various state regulations.

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?

Please include in your response:

a) **a description of the control measures currently in place at your workplace(s) to minimise exposure of workers and others to DEE.**

In the preparation of this response, the AIOH sought input from members currently working in DEE risk management, they have provided the following commentary.

As there has not previously been a mandated exposure standard for DPM, outside the mining industry, many workplaces (particularly within small business) have not sought guidance from occupational hygienists and hence may not have considered exposure risks, undertaken exposure monitoring, or implemented exposure controls. Improvements to controls would include replacement or upgrade of diesel-powered plant, relocation of diesel-powered plant or exhaust outlets, use of local exhaust ventilation, or general ventilation, redesign of workplace layout and processes, investment in exposure monitoring programs, and investment in education and awareness for staff (both management and workers). Further, small businesses may not have the knowledge and/or financial resources to identify, assess and control exposure risks. Support for small business should include the provision of a control banding system (backed up by sufficient exposure data) to allow quick and simple identification of exposure risks and application of suitable controls.

Within the rail transport industry, many older locomotives remain in use – significant investment would be required to replace these machines. Examples of activities which place rail workers at risk of exposure include:
evacuation when trains are stuck in tunnels (caused by mechanical issues with the train or external track faults) consecutive trains passing through tunnels; and full load testing as part of routine maintenance schedules. This work can be undertaken outside but also occurs within enclosed sheds/workshops, often with no LEV or extraction.

Within commercial construction (for example high-rise and warehouse construction) – the use of diesel-powered plant (including concrete pumps, generators, high-pressure water blasters, forklifts, and trucks) in enclosed areas may be required (due to the building design and construction methods used). It is not always possible to relocate plant to outdoor areas, and alternative plant and equipment may not exist (for example concrete pumps and concrete delivery trucks). Examples of common controls used to minimise risk of exposure in these situations (where substitution or relocation is not possible/practical) include local exhaust and/or general mechanical ventilation. For infrastructure construction across Australia, particularly for road, rail and service tunnelling activities, the use of diesel-powered equipment is extensive (including road headers, tunnel boring machines, trucks, generators, and heavy plant such as excavators).

The use of these plant and equipment do not fall under the jurisdiction and/or regulatory authority which specifies requirements for use of diesel-powered equipment in underground applications. i.e., the equipment is not/may not be specifically designed for reduction of DEE, and they may not be capable of using diesel fuel which is specifically designed to generate low DEE.

Underground mines in Queensland, NSW and WA have implemented many controls including new generation low-emission engines. The gaseous coal mines are not currently, nor in the future, likely to be in the position to have battery operated vehicles. Mines are purchasing vehicles with the cleanest engine packages available at the time. These plants have low emission profiles, that are designed specifically for underground mining.

All underground mines have ventilation to provide clean air and cooling to workers and disperse naturally occurring gas build up and plant emissions. Mine ventilation is designed considering the numbers and size of vehicles operating in the mine and in ventilation districts, with the use vehicle tag boards to limit the number and size of diesel engines operating in an area. Underground mobile plant has exhaust treatment devices such as wet scrubber systems, regenerative ceramic filters, disposable diesel exhaust filters (DDEF) and exhaust dilution–dispersal systems.

The mobile plant fleets also have maintenance programmes that include specific exhaust emissions, and regularly undertake diesel exhaust emissions analysis to as part of preventive and restorative maintenance. The emissions testing ensures that irregularities are quickly found and mitigated. Additionally, the operators’ cabs are air conditioned and pressurised to 30 pascals and supplied with filtered air (these have risen in prominence since improved awareness around silica and asbestos issues and with ISO 23875).

The proposed reduction in the WES, however, would place an undue burden on the underground coal mining and tunnelling industries who have effectively and steadily reduced worker exposure using the above controls. Existing technology does not currently provide the industry with the means to comply with the proposed WES. At present Battery Electric Vehicles are not a fit for purpose solution. Battery Electric Vehicles for underground coal mines are not available for most use cases due to the explosive atmosphere risks and would require a long lead time to adequately design, test, register and construct vehicles that will allow compliance with the proposed levels.

Underground mine ventilation is designed to ensure safety and health in the underground environment , including air circulation and cooling; considering the management of diesel emissions alone, underground mines currently ventilate the operation at a rate of 0.05 m^3/kw/s – in the absence of zero emission plant, a dilution rate to achieve 15% of the current levels is required at 0.34 m^3/kw/s Significant infrastructure development including the sinking of additional ventilation shafts will be required. The cost of operating the ventilation fans will be prohibitive, increasing by a factor of approximately 2000 (operating cost increase = $(100/15)^4$ = 1975), rendering continued operation unviable.

b) details of any costs to implement the WES for DPM

The AIOH membership advises and services a wide range of industry including mining, construction, manufacturing, transport, infrastructure, and retail, and hence has wide experience in the variety and effectiveness of control methodologies. In general, the control solutions are implemented where necessary in a practical manner but most often are associated with large scale projects and hence often have considerable timelines and associated costs.
In the case of capital purchases of new plant, anecdotal evidence from the mining industry indicates that production of mobile plant has been pre-purchased for the next three years on the back of COVID production limitations, expansion of overseas operations and the implementation of WES in other jurisdictions.

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

Whilst the Australian Institute of Occupational Hygienists (AIOH) is not a standard setting body, we bring together the practical technical expertise of its 1,300 professional members to provide advice to its members, workers, industries, and regulators on the best practice in assessing exposures, implementing control strategies, and reducing risks associated with workplace exposures to chemical, physical and biological agents in the workplace so as to prevent or minimise ill health.
AIOH members are the primary professionals who carry out exposure monitoring and analysis to ensure compliance with WESs and assess the

effectiveness of exposure control measures. The AIOH is also relied on by Australian safety regulators to advise on suitable WES and control mechanisms for inclusion in state-based work health and safety regulations, codes of practice and guidance materials.

Several senior AIOH members have been involved in advising and supporting the implementation of chemical, dust, heat, and diesel exhaust emission exposure control limits to limits to Regulators, including state-based mining regulators; transport, construction and general industries (e.g., agriculture and manufacturing); and it is best practice to seek out their knowledge and experience relating to assessment and control of diesel exhaust emissions. The assessment of exposure and control of DPM is only one area of provision of professional advice which Occupational Hygienists, including Certified Occupational Hygienists can provide.

Are there any additional comments you would like to make?

The correct exposure parameter is sub-micron elemental carbon as captured with a specific sampling head which excludes larger sized interfering organic carbon aerosols and carbonaceous materials found in many workplace environments.

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