

## **AIOH POSITION PAPER**

### **Diesel Particulate and Occupational Health Issues**

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#### **AUTHORISATION**

This position paper has been prepared by the AIOH Exposure Standards Committee and authorised by the AIOH Council.

A handwritten signature in blue ink, appearing to read 'I. K. A.', is positioned above the title 'President AIOH'.

President AIOH

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## **Australian Institute of Occupational Hygienists Inc (AIOH)**

The Australian Institute of Occupational Hygienists Inc. (AIOH) is the association that represents professional occupational hygienists in Australia. Occupational hygiene is the science and art of anticipation, recognition, evaluation and control of hazards in the workplace and the environment. Occupational hygienists specialise in the assessment and control of:

- Chemical hazards (including dusts such as silica, carcinogens such as arsenic, fibrous dusts such as asbestos, gases such as chlorine, irritants such as ammonia and organic vapours such as petroleum hydrocarbons);
- Physical hazards (heat and cold, noise, vibration, ionising radiation, lasers, microwave radiation, radiofrequency radiation, ultra-violet light, visible light); and
- Biological hazards (bacteria, endotoxins, fungi, viruses, zoonoses).

Therefore the AIOH has a keen interest in the potential for workplace exposures to Diesel Particulate (DP) as its members are the professionals most likely to be asked to identify associated hazards and assess any exposure risks.

The Institute was formed in 1979 and incorporated in 1988. An elected governing Council, comprising the President, President Elect, Secretary, Treasurer and three Councillors, manages the affairs of the Institute. The AIOH is a member of the International Occupational Hygiene Association (IOHA).

The overall objective of the Institute is to help ensure that workplace health hazards are eliminated or controlled. It seeks to achieve this by:

- Promoting the profession of occupational hygiene in industry, government and the general community.
- Improving the practice of occupational hygiene and the knowledge, competence and standing of its practitioners.
- Providing a forum for the exchange of occupational hygiene information and ideas.
- Promoting the application of occupational hygiene principles to improve and maintain a safe and healthy working environment for all.
- Representing the profession nationally and internationally.

More information is available at our website – <http://www.aioh.org.au>

## **Consultation with AIOH Members**

AIOH activities are managed through committees drawn from hygienists nationally. This position paper has been prepared by the Exposure Standards Committee, with comments sought from AIOH members generally and active consultation with particular members selected for their known interest and/or expertise in this area. Various AIOH members were contributors in the development of this position paper. Key contributors included: Brian Davies and Alan Rogers.

## **Twenty-seventh AIOH Council**

President:	Ian Firth (Vic)
Secretary:	Linda Apthorpe (NSW)
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## **AIOH Position on Diesel Particulate and its Potential for Occupational Health Issues**

### **Summary**

Although the adverse health effects of the gaseous fraction of diesel emissions have been known for some time, only in the last two decades has research indicated that the particulate component (DP) of the diesel exhaust has the potential to induce various health effects. In addition, it is associated with non-health aspects such as malodour, visual and nuisance pollution.

Methods to monitor workplace exposures to diesel particulate (capture of the submicron aerosol fraction and analysis as elemental carbon) are now readily available and control technologies have been developed for industries of known elevated exposure (eg underground mining).

Based on some of the animal and epidemiological studies, it is apparent that diesel particulate is a potential carcinogen. However, due to information deficiencies in the literature particularly regarding past exposure conditions, the AIOH has serious concerns as to the degree of potency being assigned to diesel particulates by some regulatory authorities. It is most likely that as with many low potency substances the issue may never be completely defined owing to the lack of sufficient exposure data and control of confounders (eg cigarette smoking) in the studied populations. There is little doubt that this area of the health debate will continue for some time within the scientific and regulatory community.

There is an emerging trend within the occupational hygiene community to take a pragmatic approach to measure and control exposures of the noxious, irritant and malodorous emissions without attempting to define a dose response based exposure standard.

Notwithstanding the lack of a defined dose response relationship, experience has shown that when workplace exposures are controlled below  $0.1 \text{ mg/m}^3$  DP (measured as submicron elemental carbon), irritant effect decreases markedly. AIOH believe that such a level should result in a reduced lung cancer outcome if such a carcinogenic effect is actual for the population.

In the absence of any more definitive data, the AIOH supports the use of an exposure standard of  $0.1 \text{ mg/m}^3$  DP (measured as submicron elemental carbon).

### **What is Diesel Particulate?**

Over the past 115 years the invention of a compression ignition engine by Rudolph Diesel in the 1890's has contributed significantly to the productivity of many nations, owing to the widespread use of larger diesel powered equipment in most industrial activities. The down-side in terms of occupational health has been the exposure of a large number of workers to the complex mixture of toxic gaseous, adsorbed organics and particulate components found in the raw exhaust emissions.

The gaseous phase of diesel exhaust consists largely of the same gases found in air, such as nitrogen, oxygen, carbon dioxide and water vapour.

The particulate fraction of diesel exhaust consists mainly of very small particles (typically 15-30 nm diameter) which rapidly agglomerate together to form “chains” or clumps of particles which are themselves typically <1 µm aerodynamic size. High resolution electron microscopy has demonstrated that the basic diesel particulate particles consist of an irregular stacked graphitic structure, nominally called elemental carbon.

The graphitic nature and high surface area of these very fine particles means they have the ability to absorb significant quantities of hydrocarbons (the organic carbon fraction) originating from the unburnt fuel, lubricating oils and the compounds formed in the complex chemical reaction during the combustion cycle.

In terms of health outcome, the very small particle size of diesel particulate (DP) is important as this means it can reach the deep parts of the lungs. Particulate overload rather than chemical composition is thought to be the major mechanism leading to toxic effect

### **How do we Measure it?**

Methods for the quantification of employee exposure to diesel particulate have been developing over approximately 30 years. The most advanced and specific method involves capturing the submicron fraction of the workplace aerosol and then determining the amount of the core component of diesel particulate (elemental carbon; EC). Recent commercial developments provide ease in routine submicron sampling using a single use impactor cassette fitted into a respirable aerosol cyclone which is necessary when sampling in dusty atmospheres to prevent clogging of the cassette impactor holes. Sample analysis on the captured aerosol is best conducted using NIOSH method 5040 (NIOSH 2003) for determination of carbon species (especially elemental carbon), however care needs to be exercised to minimise errors due to sampling, blank filter interpretation and instrument operating parameters (Davies & Rogers, 2004).

### **Hazards Associated with Diesel Particulate**

In 1988 the US National Institute of Occupational Safety and Health (NIOSH) published Criteria Bulletin No. 50 (NIOSH 1988) which proposed a potential link between occupational exposure to diesel exhaust and lung cancer. The NIOSH finding was based on the consistency of toxicological studies in rats and mice and limited epidemiological evidence, mainly from the railroad workers.

The International Agency for Research on Cancer (IARC) evaluation 2A (probable human carcinogen) is based on limited evidence in humans and sufficient evidence of carcinogenic risk in animal studies (IARC, 1989).

The Health Effects Institute (HEI, 1995) undertook a review of the toxicological studies including acute and chronic effects. It also included the 30 epidemiological studies of workers exposed to diesel emissions in occupational settings for the period 1950 – 1980. About half of these epidemiological studies indicated an increase risk of lung cancer and the remainder showed no increase in lung cancer risk. HEI after examining the positive outcome studies concluded that the epidemiological data indicated weak associations between exposure to diesel exhaust and lung cancer with a relative risk of 1.2 – 1.5. They issued a note of caution indicating that all the studies lacked definitive exposure data for the populations

studied and most had an inability to determine the influence of confounding factors, such as tobacco smoking.

Mines Safety and Health Administration (MSHA, 2001) reviewed 47 epidemiological studies and determined that in 41 studies there was some degree of association between occupational exposure to diesel particulate matter and an excess prevalence of lung cancer. However, some of these studies had limited statistical power either because they included relatively few workers or had an inadequate allowance for latency or follow-up period. MSHA then concluded based on the studies with positive lung cancer outcomes and implied estimates of historical exposure levels that exposure at a mean concentration of  $0.64 \text{ mg/m}^3$  DP for a period of 45 years would result in a relative risk of 2.0 for lung cancer.

The United States Environmental Protection Agency (US EPA) conducted a health assessment for diesel engine exhaust (US EPA, 2002). They concluded that acute effects with respect to health, such as eye, throat and bronchial irritation, light-headedness, nausea, cough and phlegm were evident. With respect to chronic non-cancer respiratory effects they suggested, from animal studies, the potential for chronic respiratory disease in humans. The EPA also concluded that lung cancer was evident in occupationally exposed groups but could not define sufficient dose-response data to produce a quantitative risk assessment.

Based on their interpretation of the toxicological and epidemiological data, regulatory authorities in USA, Europe and Canada have concluded that sufficient evidence exists to indicate that diesel particulate presents an increased risk of lung cancer, although the absolute quantification of potency remains unclear. On the other hand, the UK HSE believes there is insufficient evidence for diesel exhaust emissions to be classed as a carcinogen (Dabill, 2004). A NSW Coal Industry cancer surveillance study has shown no significant cancer risk for underground workers exposed to high levels of diesel particulate (SMR of 0.85 all cancers, 0.74 for lung cancer) (Brown *et al.*, 1997).

While the epidemiological outcomes associated with exposure to diesel particulate remains unclear, and is unlikely to be resolved in the near future, there is no doubt as to the irritant nature of diesel emissions (including particulate) in confined atmospheres including that found in mines. On this basis the control of such emissions to minimise irritation in workplaces may in turn reduce the potential for any long-term health effects below that which is detectable.

### **Major Uses / Potential for Exposure (in Australia)**

Potential for exposure to DP exists whenever workers are in close proximity to operating diesel equipment. In many cases the fact that the equipment is operating in the open environment significantly reduces the potential for excessive exposures. Exposure assessments conducted aboard diesel locomotives have ranged from  $<0.001$  to  $0.045 \text{ mg/m}^3$ , with a geometric mean of  $0.0037 \text{ mg/m}^3$  (as EC) (Liukonen *et al.*, 2002).

Conversely, where diesel equipment is operating in confined areas (eg underground mines, ships' holds, cool rooms) there is a significant risk of exposure. Levels in Australian underground coal mines have been measured at  $0.01$  to  $0.37 \text{ mg/m}^3$  (as EC) (Joint Coal Board, 1999), although levels up to  $2.2 \text{ mg/m}^3$  have been measured, depending on job type and mining operation (Pratt *et al.*, 1997). Levels in Australian underground metalliferous mines have been measured at  $0.01$  to  $0.42 \text{ mg/m}^3$  (as EC) (Rogers & Davies, 2001). For surface mining operations, forklift operators have been found to be the highest exposed group

(Dabill, 2004). Levels for forklift operators have ranged from 0.007 to 0.40 mg/m<sup>3</sup>, with a median of 0.075 mg/m<sup>3</sup> (as EC) (Groves & Cain, 2000).

### **Risk of Health Effects**

While there has been (and continues to be) debate as to the carcinogenic potential of DP, there is sufficient evidence to indicate over-exposure will give rise to irritation and potentially other non-malignant adverse health effects.

The risk of lung cancer is less clear, however some statutory authorities maintain that this is probable.

### **Available Controls**

Over the past 15 years considerable research has taken place to develop suitable control technologies, especially for vehicles operating in confined areas (eg underground mining).

Proven control technologies include:

- Low emission engines
- Low emission fuel
- Ventilation
- Engine maintenance
- Exhaust filtration systems
- Air conditioned (filtered) operators' cabins
- Operating practices
- Driver and workforce education
- Personal protective equipment

Experience has shown that no one single simple solution exists and that individual operations need to explore which of the above control technologies best fit their circumstances. The North-American Diesel Emissions Evaluation Program (DEEP), available at <http://www.deep.org>, provides good examples of control methods for DP.

### **Current Applicable Legislation and Standards**

Legislation for the control of DP is in its early stages of development and implementation. On 2 February 2007 the NSW Department of Primary Industries issued a gazettal notice which picked up sections of their Mine Design Guideline (MDG29) and thus also picked up an exposure standard of 0.1 mg/m<sup>3</sup> (as submicron EC) for NSW coal mines.

Legislation is currently in place in the USA, Canada and Europe to control DP exposures in mining and tunnelling. Effective January 2007, MSHA in the USA reduced their exposure limit (PEL) to 0.35 mg/m<sup>3</sup> (as total carbon, equivalent to 0.31 mg/m<sup>3</sup> as EC). By January

2008, the final PEL will be 0.16 mg/m<sup>3</sup> (as total carbon, equivalent to 0.12 mg/m<sup>3</sup> as EC). Germany has an exposure standard for underground non-coal mines of 0.3 mg/m<sup>3</sup>, and 0.1 mg/m<sup>3</sup> for all other activities measured as whole diesel particulate.

### **AIOH Recommendation**

Based on the available information, the AIOH believes that worker exposure to DP levels should be controlled to below 0.1 mg/m<sup>3</sup> measured as submicron elemental carbon. At this level irritation should decrease significantly and other adverse health effects may be controlled.

### **References and Sources of Additional Information**

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