Are Respiratory Protection Standards Protecting Worker Health Against Ultrafine Diesel Particulate Matter Emissions? An Australian Perspective.

Burton, Kerrie A., Whitelaw, Jane L., Jones, Alison L., Davies, Brian

UNIVERSITY OF WOLLONGONG AUSTRALIA

Background

- Respiratory protective devices are commonly used to protect workers from exposure to ultrafine diesel particulate matter.
- Diesel engine emissions are known to cause lung cancer, cardiovascular and irritant effects.
- Current standards to evaluate penetration through respirator filter media do not consider ultrafine diesel particles.

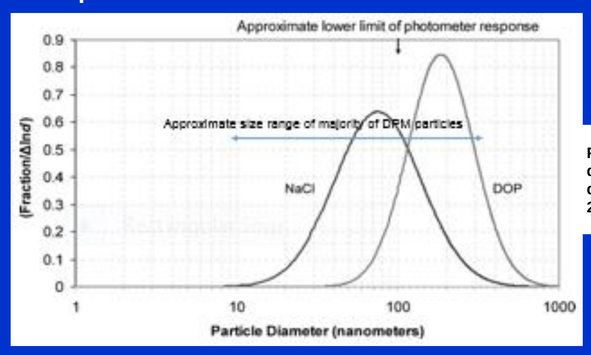

Figure 1: Challenge aerosol particle size distributions (by count) and photometer limit of detection (Adapted From Eninger, Honda et al 2008)

Objective

Evaluate penetration of diesel emissions through a range of commonly used respirators (8 filter models) by:

- mass of Elemental Carbon (EC) and
- particle number count.

Method

- Emissions from a Detroit D706 LTE diesel engine were fed into an experimental chamber
- The respirator filters were mounted inside the chamber.

Figure 2 and 3: Experimental Chamber positioned adjacent to engine, respirator filters mounted inside experimental chamber

- Particle number count was measured using a TSI Engine Exhaust Particle Sizer (EEPS) (5.6 – 560nm).
- Elemental Carbon (EC) was sampled by NIOSH 5040.
- $\text{Penetration} = \frac{\text{Concentration after filter}}{\text{Concentration before filter}} \text{ x } 100\%$

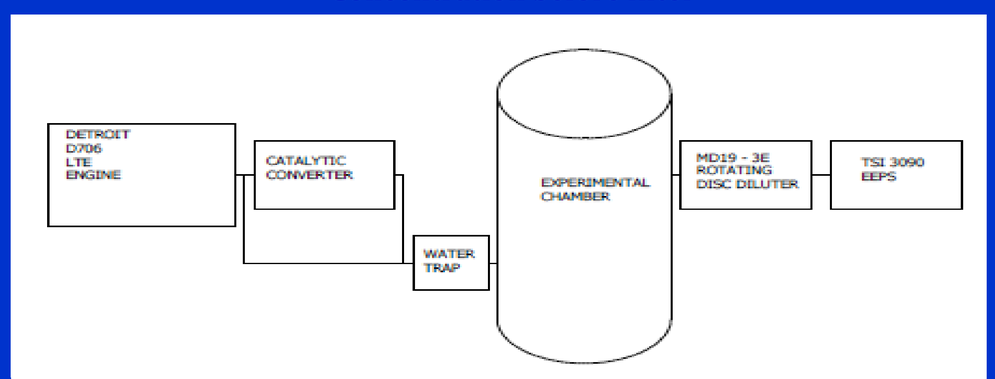

Figure 4: Experimental Setup

Preliminary Results for an example P2 certified filter (AS/NZS1716)

- Pre Filter EC concentration was set at 1 mg/m^3, the rated protection factor of the filter (M=1.6mg/m^3, SD=0.5, 95% UCL=2.3, n=5). Flow rate through filter was 95L/min (the upper limit specified in AS/NZS1716).
- Elemental Carbon penetration averaged 1.1% (SD=0.3, 95% UCL=1.5, n=5).
- Penetration by particle number count (25.5-560nm) averaged 3.1% (SD=0.5, 95% UCL=3.7, n=5).
- AS/NZS1716 specifies that penetration for P2 filters (measured using NaCl as the challenge aerosol) should not exceed 6%.

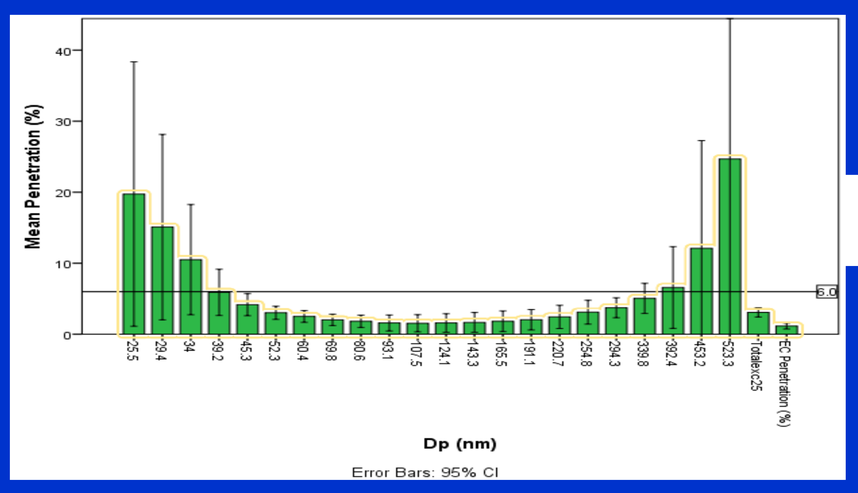

Figure 5:Percentage Penetration by particle count and Elemental Carbon (Note reference line at 6% AS/NZS1716 certification requirement)

- Penetration by mass of elemental carbon significantly different from penetration by particle number count, using a paired samples t-test ($t(4)=19.789$, $p=<0.001$).

Conclusions

- Mean penetration measured as both elemental carbon and particle number count was below 6% for the example filter.
- These results vary dependant on filter model tested.
- Initial data demonstrates that for some commonly used respirator filters penetration may exceed 6% at selected particle diameters, for some filter models.
- This may lead to inhalation of these particles by exposed workers.
- These small particles may contribute to increased cardiovascular mortality and morbidity associated with diesel engine emissions (Martinelli, Olivieri & Girelli 2013), as well as other adverse health impacts.
- The absence of an occupational exposure guideline with respect to particle number count requires further investigation to determine whether the study results pose an additional health risk to workers.

Limitations and Future Work

- Further investigation is required to understand the variation in penetration results for some particle diameters. This may be due to differing sampling conditions for example temperature and humidity levels inside the experimental chamber.

Acknowledgements

This research was supported by grants to the University of Wollongong provided by WorkCover and Coal Services Health and Safety Trust. The experimental chamber was constructed by ERP Engineering.

Contact Details

Kerrie Burton, PhD Candidate
kab843@uow.edu.au

Selected References

Burton, KA, Whitelaw, JL, Jones, AL & Davies, B 2016, 'Efficiency of Respirator Filter Media against Diesel Particulate Matter: A Comparison Study Using Two Diesel Particulate Sources', *The Annals of Occupational Hygiene,* vol.60, no.6, pp. 771-779.

Eninger, RM, Honda, T, Reponen, T, McKay, R & Grinshpun, SA 2008, 'What does respirator certification tell us about filtration of ultrafine particles?', *Journal of Occupational and Environmental Hygiene*, vol. 5, no. 5, pp. 286-95.

Martinelli, N, Olivieri, O & Girelli, D 2013, 'Air particulate matter and cardiovascular disease: A narrative review', *European Journal of Internal Medicine* vol. 24, no. 4, p. 295.

Standards Australia International Ltd & Standards New Zealand 2012, *Respiratory protective devices*, AS/NZS 1716:2012, SAI Global Limited / Standards New Zealand, Sydney / Wellington.

World Health Organisation 2012, *IARC Diesel Exhaust Carcinogenic Press Release #213*, International Agency for Research on Cancer.