REPORT FOR THE UNITED FIREFIGHTERS UNION OF SOUTH AUSTRALIA ON DIESEL PARTICULATES EXPOSURE IN THE SOUTH AUSTRALIAN METROPOLITAN FIRE SERVICE ENVIRONMENT

2020

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1. Executive Summary

Diesel Particulates arising from diesel exhaust emissions are of extreme concern in the general global environment. They are intrinsically more concerning in the confines of the SAMFS Firefighter work environment. To that extent, the following summary outlines these concerns which may be useful in starting to address the negative health effects in a holistic way.

The key points arising from the investigation into diesel particulates in the SAMFS Firefighter work environment are:

1. In June of 2012, the World Health Organisation (WHO) International Agency for Research on Cancer (IARC) confirmed diesel engine exhaust as carcinogenic to humans (Group 1).

2. During the last decade, further research has concluded that Polycyclic Aromatic Hydrocarbons (PAH) are one of the more significant carcinogenic components of DPM. PAH is linked with lung cancer and bladder cancer amongst other adverse health effects.

3. In 2013 the SAMFS commissioned a report to study the air quality in several fire stations selected from a risk assessment previously carried out by the SAMFS. This report concluded that the levels of measured DPM were below the limit of detection and well below the 0.1 mg/m3 for DPM as elemental carbon. On analysis, the currency of the report should be called in to question given that the air monitoring was conducted in 2013 with the report subsequently published in 2014. Safework Australia advises that control measures should be reviewed every 5 years which renders the MFS report on Diesel Particulates carried out in 2013 now redundant. The methodology should also be questioned based on the initial hazard assessment by MFS. The report extract does not immediately make clear what determinants were used to allocate the risk ranking

categories. Given the concerns outlined in the analysis there is a reasonable question about the reliability and currency of the exposure limits and testing results which in turn amplify the question of the extrapolation of such test results to the wider fire station and Firefighter work environment. If the “Precautionary Principle” is applied which deems that substances, such as potential toxicants or contaminants are assumed to be harmful until shown to be harmless, then the supposition above that the risk to employee’s health from inhalational exposure is negligible, **cannot be supported**.

4. In 2019, a survey was conducted prior to Enterprise Bargaining negotiations between the United Firefighters Union of South Australia (UFUSA) and the SA Metropolitan Fire Service. As part of that survey, union members were asked if they agreed or disagreed with the importance of the SAMFS carrying out risk assessments and undertaking testing of exposure rates for Diesel Particulates in Fire Stations. Union members overwhelmingly agreed on the importance of this initiative.

5. **Safework Australia advises that there are currently no Exposure Standards agreed in Australia for Diesel exhaust**. As at the time of writing, the ACTU and the AIOH are seeking a standard of the 0.05 mg/m3 but are yet to obtain agreement.

6. It was recorded in 2015 that 13.8% of Australian workers were substantially exposed to diesel engine exhaust and that the exposure to diesel exhaust is the second highest exposure to a cancer causing agent behind UV.

7. Both short-term (acute effects) and long-term health (chronic) effects arise from the exposure to diesel particulate matter. Short term exposure but in high concentrations may

often cause irritation of eyes, nose, throat and lungs along with light headedness, coughing, phlegm and nausea. Long term (Chronic) effects of diesel particulate matter exposure can adversely impact upon existing respiratory issues such that asthma and allergies stand to be worsened along with an increased risk of heart, lung and bladder cancer due to the carcinogenic nature of diesel particulate components such as the polycyclic aromatic hydrocarbons (PAH).

8. Since 1974, researchers have also been concerned about the connection between parental diesel particulate matter exposure, particularly the PAH component and childhood brain tumours. Additionally, a recent Australian case study documented in 2013 revealed an association between maternal and paternal exposure to diesel particulates prior to childbirth and an increased risk of childhood brain tumours (Cancer Council, March 2017).

9. The stated source of DPM emissions in the SAMFS work environment is very clearly the SAMFS Appliances. There can be no doubt that Appliances are the most significant contributor to DPM in the workplace and consequently PAH emission in the Firefighter and engineering work environment. A significant factor in the DPM emission relates to the Appliance age. The latest available information reveals that in excess of 50% of the total SAMFS Appliance fleet (Metro and Regional) are aged between 10 and 20 years old with a small number in excess of 20 years. In order to reduce the emission of DPM in any meaningful way at the source, the fleet requires renewal with a view to compliance with Euro VI emission standards. The fitting of supplementary exhaust filters on earlier age vehicles may also be worthy of investigation.

10. A holistic strategy is required to mitigate the exposure of SAMFS firefighters to DPM in the work environment which encompasses the total work environment with considerations

such as the installation of Point of Capture (POC) local Exhaust Ventilation (LEV) sytems along with cross flow ventilation of the engine room, positive pressure areas and with PPC, living quarters separated hermetically from contamination areas, education programs to staff, clean cab policy addressing contamination from diesel exhaust and a engine bay use policy. Consideration should be given to developing a transition plan for SAMFS stations to switch from the current extraction ventilation systems to exhaust emission source capture systems.

2. Introduction

This report has been instigated by the Secretary of the United Firefighters Union SA following concerns raised by members regarding adverse health effects associated with diesel exhaust emissions in the workplace and in particular the resultant Diesel Particulate Matter (DPM).

As well as investigating the source and implications of the emissions, this report canvasses many of the issues related to DPM and hopefully provides context for developing strategies aimed at eliminating DPM and/or mitigating the deleterious health effects.

This report does not cover the entirety of the issues specifically concerned with DPM contamination of Firefighter Personal Protective Clothing (PPC) except to the extent of highlighting the need for storage separation of PPC from station engine rooms. The authors are aware at the time of writing that the SAMFS are investigating a total cleaning response to Firefighter PPC contamination.

A number of recommendations are made which may be of assistance to Firefighters and the SAMFS in addressing the complexity of the DPM issue and its adverse health related effects.

Above all else, this report premises its approach on the "Precautionary Principle" which according to an SA Public Health publication is that;

"***If there is a perceived material risk to public health, lack of full scientific certainty should not be used as a reason for postponing measures to prevent, control or abate that risk***."

(SA Health, Public Health Act, Principles, 2013).

And the Work Health & Safety Act 2012

"eliminating exposure to diesel exhaust, so far as is reasonably practicable"

DPM emissions have been recognised as a significant health concern for the global population since 1988, whether in the workplace or indiscriminately through the ambient air. Along with high risk occupations such as underground miners; Firefighters worldwide are one of the most exposed to DPM. After many years of research and evaluation, in June of 2012, the World Health Organisation (WHO) International Agency for Research on Cancer (IARC) confirmed diesel engine exhaust as carcinogenic to humans (Group 1). This determination recognised that there was sufficient evidence to support a causal association between exposure to Diesel Particulate Matter and an increased risk of lung cancer.

During the last decade, further research has concluded that Polycyclic Aromatic Hydrocarbons (PAH) are one of the more significant carcinogenic components of DPM. PAH is linked with lung cancer and bladder cancer amongst other adverse health effects. Lung cancer incidentally is not covered in the presumptive legislation for Firefighters in South Australia.

In 2013 the SAMFS commissioned a report to study the air quality in several fire stations selected from a risk assessment previously carried out by the SAMFS. This report concluded that the levels of measured DPM were below the limit of detection and well below the 0.1 mg/m3 for DPM as elemental carbon. As such the report suggested that the *"risk to employee health from inhalational exposure to DPM appears to be below the limit of detection and negligible."*

Many issues arise from this conclusion, not the least being the use of the "Exposure Standards for Atmospheric Contaminants in the Occupational Environment 2012" as the measuring tool. It is understood that this is the only standard available in Australia to currently deal with DPM as there is currently no Australian standard for DPM emissions. However, the lack of a discrete standard to measure DPM in the work environment is now highly problematic. This is a subject of discussion in this report along with further discussion about the SAMFS Appliances as the source of the DPM emissions.

Furthermore, there are many significant concerns which arise from the investigation into DPM exposure and as such, there are a number of areas which require closer attention in order to ensure firefighter and worker health and safety. These include but are not limited to such things as the source of the emissions (the Appliances), the ageing fleet of firefighting appliances, the differing fire station constructs which have differing arrangements of Local Exhaust Ventilation (LEV) systems (presumably some more efficacious than others). There are also discrete matters such as historical cultural work practices such as the "bunkering" of PPC in the engine room. This report spotlights the matters above in the context of building greater awareness of Firefighter Health, Safety and Welfare.

4. UFUSA Member Concerns about Diesel Particulate Matter

The concerns about diesel particulate matter (DPM), its health risks and effects have been historically recorded by firefighters over many years. In 2019, the Secretary and the State Council of the UFUSA recognised the concerns of members who are exposed to DPM by undertaking a range of activities and strategies. These strategies are aimed at identifying and disseminating the contemporary research and knowledge about the issue in order to address the significant health concerns across the UFU membership which includes firefighters and MFS engineering staff in SA.

To that end, a survey was recently conducted prior to Enterprise Bargaining negotiations between the United Firefighters Union of South Australia (UFUSA) and the SA Metropolitan Fire Service. As part of that survey, union members were asked if they agreed or disagreed with the importance of the SAMFS carrying out risk assessments and undertaking testing of exposure rates for Diesel Particulates in Fire Stations. The aggregate response from the survey as revealed in Table 1 below demonstrates significant support from UFU members for the SAMFS to undertake both a risk assessment and exposure testing of Diesel Particulates.

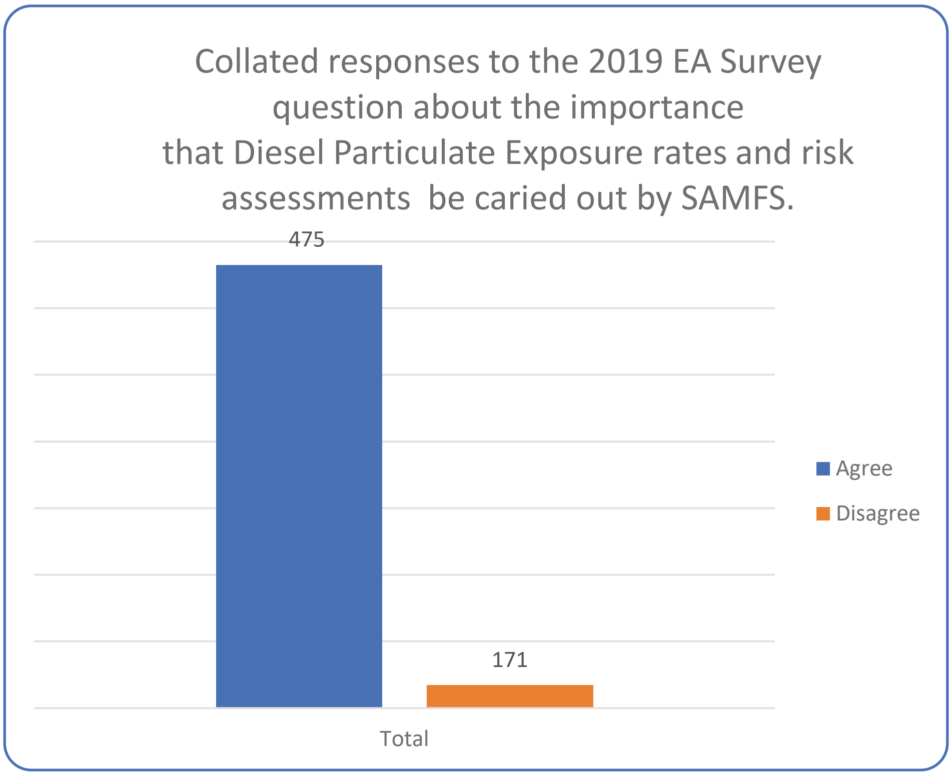
Collated responses to the 2019 EA Survey question about the importance that Diesel Particulate Exposure rates and risk assessments be caried out by SAMFS.
475
171
Agree
Disagree
Total

Table 1

5. Diesel Particulate Matter as exhaust emission– What is it?

Diesel particulate matter (DPM) according to Amann & Siegla (1981), consists mainly of carbonaceous soot deposits which have been generated by combustion processes and to which unburned hydrocarbons (HC) have become attached. In this process there is the formation of both gas and soot. The content of the exhaust gas emissions includes amongst other things, Carbon Monoxide (CO) and Oxides of Nitrogen (NOx) along with nitrogen dioxide (NO2) and Sulphur Dioxide (SO2). Hydrocarbons (HC) are also present and include polycyclic aromatic hydrocarbons (PAH) which exist as a constituent of Elemental Carbon (EC). Polycyclic aromatic hydrocarbon (PAH) has been identified as a carcinogen by the World Health Organisation. Subsequent research has shown further components of the particulate matter to include Organic Carbon (OC), metallic ash and Benzene Soluble fraction (Safework Australia, 2015). It is the Benzene soluble fraction which Sharma and others in 2005 described as a marker for carcinogenicity. That is to suggest a cancer-causing component.

According to Ristovski et al (2011), there are up to 20,000 different chemical compounds in DPM with only about 700 having been identified to the present time. Additional to the chemical components noted previously, there are toxic compounds such as reactive oxygen species (ROS), carbynols, and quinones.

As well as the components listed above, DPM contains sulphates which appear as Sulphuric acid and ammonia sulphate which stem from the Sulphur content of the diesel fuel. However, Ristovski et al report that the contribution of sulphates to respiratory stress since 2009 has decreased significantly as a consequence of much lower sulphur content in the fuel (>1000ppm). This means that the irritant value of sulphur on respiratory health is much more subdued (Ritsoski et al, 2012).

To assist in illustrating the creation of diesel particulate emission, it is perhaps helpful to understand the historical processes through which a diesel engine works. In simple, diesel fuel is injected under high pressure into the combustion chamber or pre/ante chamber of the diesel engine and is then subject to various stages of change which results in the ignition of the fuel. The stages identified by Ricardo as far back as 1929 are; ignition delay; period of uncontrolled burning and the period of controlled burning (Amann & Siegla, 1981).

Vapourisation and combustion are two further necessary functions for the production of diesel particulate matter along with another key element for the ignition of diesel fuel being the correct mixing ratio of air and fuel (called the Stoichiometric ratio). This must be accompanied by very high temperatures which result from the compressive forces of the engine's upward piston movement to achieve combustion.

So, the resulting levels of diesel soot exhaust emission which contain the particulate matter outlined above, is then significantly affected by any variability of these key factors. The consequence of this variability in the key factors such as vapourisation, combustion, temperature and the stoichiometric ratio (air/fuel ratio) can be found to be directly measurable in the total amount of diesel soot (particulate matter) emitted from the exhaust. Resultingly, the amount of diesel gas and soot with its associated constituents of diesel particulate matter, may increase or decrease dependent upon proper combustion.

Diesel particulate matter emission is also significantly affected by the chemical composition of the diesel fuel which can vary widely due to differing regulatory requirements and refining processes (Gong et al, 2003). This further points to the need to ensure optimum performance of the diesel engine if diesel exhaust emissions are to be minimized.

Even with an optimally performing diesel engine using new technology such as common rail fuel injection systems, the resulting diesel exhaust emission is still a problem containing levels of contaminants beyond the regulatory requirements. Thus, the requirement then to install other mechanisms or processes such as diesel particulate filters or use products such as AD-Blue to clean up the exhaust emissions. Ad-Blue liquid Urea is added into the exhaust system after combustion to control NOx emissions which are considered harmful to human respiratory functions. None of these solutions are without their concerns, however. The ADBLUE MSDS for example does reveal possible respiratory inflammation from inhalation.

6. Health Effects of Diesel Particulate Matter Exposure

As far back as 1982, regulatory standards were being developed in the US for diesel particulate emissions with the contemplation of exhaust particulate filters (Amann & Siegla, 1982). It is important to understand the impact of this path toward "diesel particulate matter" (DPM) emission controls. Some 30 years on from 1982, Dr. Allison Golsby whilst addressing an Australian mining conference suggested that *"DPM history as an emission has not changed"* and that "*diesel…. engines [still] produce heat and emissions"* (Walker, 2014). There was attention drawn to the problematics of diesel particulate matter emissions in confined spaces and the subsequent requirement for better management and reduction of DPM emissions through advancing engine technologies and improved ventilation systems.

But any reduction in the visible DPM levels though is not without its consequences. Recent diesel engine combustion efficiency improvements by incorporating technologies such as common rail injection systems and turbo charging of the air intake system have also resulted in an unwanted outcome.

In a 2013 presentation by Dr Patrick Glynn from the CSIRO, it was reported that DPM emissions now contain an increased number of particulates which on average are more than 50% smaller in size. The consequence of this decrease in particulate size is that whilst the larger (>2.5um) polycyclic aromatic hydrocarbons (PAH) which are a known carcinogen, already have adverse effects upon a portion of the population (such as exposed workers), the now 50% smaller particles (less than 100 nanometres) can cross the lung membrane to the bloodstream with further deleterious effects on human health (Walker, 2014).

It was recorded in 2015 that 13.8% of Australian workers were substantially exposed to diesel engine exhaust and that the exposure rates are only second behind exposure rates to solar UV radiation. Of the estimated 1.2 million workers exposed to diesel particulates in the workplace, about 160,000 (1.8%) of them suffered exposure at a high level (Cancer Council, March 2017). This amounts to a significant public health issue and a significant workplace health issue.

Both short-term (acute effects) and long-term health (chronic) effects arise from the exposure to diesel particulate matter. Short term exposure but in high concentrations may often cause irritation of eyes, nose, throat and lungs along with light headedness, coughing, phlegm and nausea. At the extreme, asphyxiation from carbon monoxide poisoning can result.

Long term (Chronic) effects of diesel particulate matter exposure can adversely impact upon existing respiratory issues such that asthma and allergies stand to be worsened along with an increased risk of heart and lung disease due to the carcinogenic nature of diesel particulate components such as the polycyclic aromatic hydrocarbons (PAH).

The evidence now is very clear and compelling. Diesel exhaust and the particulate matter associated with it is carcinogenic. That it is cancer causing. In June of 2012, the World Health Organization's International Agency for Research on Cancer promulgated a media release classifying *"diesel engine exhaust as carcinogenic to humans (Group 1):* (appendix A) *based on sufficient evidence that exposure is associated with an increased risk of lung cancer"* (IARC media release, 12.06.12). The same body also found that there whilst the evidence was less, there is also an increased risk of bladder cancer associated with diesel exhaust.

Since 1974, researchers have also been concerned about the connection between parental diesel particulate matter exposure, particularly the PAH component and childhood brain tumours. Additionally, a recent Australian case study documented in 2013 revealed an association between maternal and paternal exposure to diesel particulates prior to childbirth and an increased risk of childhood brain tumours (Cancer Council, March 2017). This is clearly an area of significant health concern.

DPM; Respiratory health effects and Lung Cancer

The carcinogenetic attributes of DPM which have been assessed and classified as a Category 1 carcinogen by the WHO in 2012, have been linked by numerous studies to lung cancer.

For example, Xu et al (2018) reports that a large cohort of workers exposed to diesel exhaust in the US workplace in 2008 had an increased risk of mortality from lung cancer. Along with this study, Xu and others reported that a study of trucking company workers in 2012 found a dose-response connection between DPM and lung cancer. Furthermore, Xu et al reports that 2.4% of lung cancer cases in Canada during 2011 were directly attributed to occupational exposure to DPM. Importantly, the results indicated that it was low exposure rates that provided most of the burden, not high rates.

So even with low exposure rates to DPM as above, there is enough available evidence to confirm that harmful respiratory health effects can result. The number, size and surface area of DPM particles as previously discussed are a significant influence upon the absorption of toxic compounds through the respiratory system. Accordingly, nanoparticles of DPM in the size region between 0.4-0.7nm can gain ready access to the alveolar region of the lung and is therefore a crucial element in the creation of adverse respiratory health effects such as lung cancer. There is further information available which describes some of the insidious health effects of DPM to include asthma, chronic obstructive pulmonary disease and pulmonary fibrosis (Reynolds et al, 2011)

Of even further concern is a finding that whilst respiratory health effects caused by DPM are largely by inhalation crossing into the lung region thus increasing the potential risk of lung cancer, there is also primary research which suggests that these ultra-fine particles have been translocated through the olfactory bulb in to other organs such as the brain (Ristovski et al, 2011).

Furthermore, new research by Reynolds et al (2011) suggests that it is not only "fresh" or newly created DPM which constitutes a dangerous health risk from its biological activity; there is also an inherent risk from biologically active "aged" DPM which may have been suspended in the atmosphere for anything up to a decade.

This presents a stark picture of concern about DPM exposure at any level and the subsequent cumulative adverse health effects over extended periods of time.

7. MFS Response to Diesel Particulate Matter

The MFS has been aware of aware of concerns about diesel particulate matter for many years and have undertaken previous activities to investigate the issue. As far back as 2013, a report was commissioned by the MFS to examine the airborne contaminants in selected stations. The extract of the report is embedded below at subheading (a). The report extract concludes that the measured airborne contaminants were less than the Exposure standards of 0.1mg/m3 and was thus interpreted to be;

*"below the limit of detection **for the method of analysis** and well below the recommended guideline of 0.1 mg/m3 for DPM as elemental carbon."*

And further……..

"Therefore, based on the measured positional DPM concentration being typical of the exposure experienced by the fire fighters during the operation of diesel powered fire truck inside the engine room, the risk to employees' health from inhalational exposure to DPM whilst inside the engine room of the fire station appears to be below the limit of detection and negligible."

Given the concerns outlined in the analysis included below in subheading (b), there is a reasonable question about the reliability and currency of the exposure limits and testing results which in turn amplify the question of the extrapolation of such test results to the wider fire station and Firefighter work environment. If the "Precautionary Principle" is applied which deems that substances, such as potential toxicants or contaminants are assumed to be harmful until shown to be harmless, then the supposition above that the risk to employee's health from inhalational exposure is negligible, **cannot be supported**.

In more recent times (2019), the MFS have again been made aware of concerns by further reporting about diesel particulate matter exposure. Such reporting has highlighted concerns about the diesel particulate contamination of Personal Protective Clothing (PPC) where it has been stored in the station engine room environment. Given that the storage of PPC was identified as an issue of concern by the MFS diesel particulate researchers (HSE) as far back as 2013, and given that new research suggests that "aged" DPM can still be biologically active, it is more than profound that the issue still exists as a matter of concern some 6 years on in 2019.

a. MFS Diesel Exhaust Emissions Testing Report 2014

SP26

Internal Memorandum

METROPOLITAN FIRE SERVICE SOUTH AUSTRALIA

To:	WHS Committee
From:	Commander David Mack, Clara Cipriani, Work Health & Safety Officer
Date:	21st January 2014
Subject:	**MFS Diesel Exhaust Emissions Testing**

Situation

The MFS conducted risk assessments at regional and metropolitan stations to determine the stations with the worst conditions for the dissipation and exposure to personnel from suspected diesel emissions. (Risk Assessments are attached to document). As a result of these assessments the MFS, HSW Committee approved the funding of qualitative scientific research to validate any possible associated risks to personnel from the exposure to diesel emissions.

Health Safety Environment Australia (HSE) was engaged to undertake the research and two specific test projects were developed one for regional stations and one for metropolitan stations. The following are extracts from the methodology and findings regarding each project.

METHODOLOGY

"The Diesel Particulate Matter (DPM) measurements were carried out at a fixed position next to the Fire Truck with the exhaust ventilation system operating while the Fire Truck was in the station before departing and after when the truck was parked.

The monitoring equipment (i.e. air sampling pumps) was inspected prior to commencement and during the monitoring period, to ensure that they were within equipment calibration specifications. Specific testing method is detailed below:

2.1. Diesel Particulate Matter (DPM)

Diesel Particulate Matter (DPM) were collected using respirable dust cyclones, with air drawn through a 25 mm quartz filter at a flow rate of 2.2 +/- 0.1 L/min using calibrated air sampling pumps. Flow rates were checked with a calibrated rotameter prior to, and at the completion of the sampling period.

Samples were analysed by MPL Laboratories, using their in-house thermal optical method for organic carbon / elemental carbon based on the principles of NIOSH Method 5040. The certificate of analysis is provided in Appendix A of this report."

Airborne Contaminant Exposure Standards

The criteria used in the assessment of occupational exposure to airborne contaminants are based on Exposure Standards as listed in Safework Australia's publication 'Exposure Standards for Atmospheric Contaminants in the Occupational Environment' 2012. All exposure standards are based on the personal sampling of chemical substance in the breathing zone of the worker.

These Exposure Standards are defined as airborne concentrations of (individual) chemical substances, which according to current knowledge, should neither impair the health of nor cause undue discomfort to nearly all workers. Unless modified by consideration of any short-term excursion limits, these standards apply to longer term exposures averaged over an 8 hour day, 5 day work week, over a working life.
These standards do not represent 'no effect' levels guaranteeing protection to all workers nor are they fine dividing lines distinguishing between safe and unsafe working conditions; they are best used as guides in the assessment of a working environment.
"Exposure standard" means the airborne concentration of a particular substance in the worker's breathing zone, exposure to which, according to current knowledge, should not cause adverse health effects nor cause undue discomfort to nearly all workers.
The exposure standard can be of three forms; eight-hour time weighted average (TWA), peak limitation or short-term exposure limit (STEL, 15-minute TWA).
The relevant Safework Australia's 8 hour Time Weighted Average (TWA) Exposure Standard is:
***Diesel Particulate Matter** (DPM)*; 0.1 mg/m3 as an 8 hour Time Weighted Average as respirable elemental carbon, (10 micrometers with a 50% cut point of 4.0 micrometers as an equivalent aerodynamic diameter size fraction). The exposure standard is based on the Swiss and German permissible exposure limits, MAK, published by SUVA, using elemental carbon as a respirable dust. Australian Institute of Occupational Hygienists (AIOH) has also recommended guideline value of 0.1 mg/m3 as an 8 hour Time Weighted Average as respirable elemental carbon."
Analysis was conducted independently at MPL Laboratories.

Regional Stations

MONITORING RESULTS

Table 1: Diesel Particulate Matter (DPM) Monitoring Results for 29th November 2013

Sample ID	Monitoring Location	Monitoring Period	Duration (mins)	Measured DPM Conc (mg/m3)
AC27Q	Positional on the exhaust pipe side of the Fire Truck in the engine room area.	1220 -1310	50	<0.027**
Safe Work Australia 8 hr TWA Exposure Standard				0.1*

HSE DISCUSSION AND RECOMMENDATIONS

"As can be seen from Table 1, the measured DPM concentration at the location next to the fire truck in the station engine room during the fire truck starting and running driving out and later reversing into the engine room under the conditions on the 29th November 2013 were found to be below the limit of detection for the method of analysis and well below the recommended guideline of 0.1 mg/m3 for DPM as elemental carbon.
Therefore, based on the measured positional DPM concentration being typical of the exposure experienced by the fire fighters during the operation of diesel powered fire truck inside the engine room, the risk to employees' health from inhalational exposure to DPM whilst inside the engine room of the fire station appears to be below the limit of detection and negligible."

Metropolitan Stations

Monitoring results included six personnel wearing individual monitors as well as environmental monitors that were used in regional stations.

MONITORING RESULTS

Table 1: Diesel Particulate Matter (DPM) Monitoring Results for the 9th to 11th December 2013

Sample ID	Name or Monitoring Location	Date, Monitoring Period	Duration (mins)	Measured DPM Conc (mg/m3)
AC55Q	K Gregory Driver 401	9/12/2013 0750 - 1555	485	<0.003**
AC56Q	S Finney Driver 409	9/12/2013	481	<0.003**

		0755 - 1556		
AC57Q	Positional, centre of St Marys engine room	9/12/2013 0759 - 1600	481	<0.003**
AC66Q	K Gregory Driver 401	10/12/2013 0747 - 1619	512	<0.003**
AC65Q	S Finney Driver 409	10/12/2013 0758 - 1618	500	<0.003**
AC64Q	P Shakeshaft, 409	11/12/2013 0748 - 1553	485	<0.003**
AC63Q	P Scuteri, 401	11/12/2013 0752 - 1556	484	<0.003**
Safe Work Australia 8 hr TWA Exposure Standard				0.1*

HSE DISCUSSION AND RECOMMENDATIONS

As can be seen from Table 1, the measured DPM concentration for the personal and positional samples were all below the limit of detection under the conditions of monitoring on the 9th – 11th December 2013 and well below the recommended guideline of 0.1 mg/m3 for DPM as elemental carbon.

Therefore, based on the measured positional DPM concentration being typical of the exposure experienced by the fire fighters during the operation of diesel powered fire truck inside the engine room, driving and operating the pump, the risk to employees' health from inhalational exposure to DPM appears to be below the limit of detection and negligible."

Conclusion

All tests were less than 3% of the Safe Work Australia 8hr TWA Exposure Standard and exposure was considered 'negligible'. As diesel motor emissions improve with better technology and with improved procedures on how the MFS use engine rooms there is no reason to believe that these results will not deteriorate but in fact improve.

The project did highlight one area that requires rectification and that is a work instruction is required that covers the use of MFS engine rooms. Observations by the investigation team identified that personnel generally started exhaust fans as they left the station but did not start them on their return which is the time they would be subject to exposure. The work instruction needs to consider but not limited to the following points:

- Colocation of South Australian Ambulance Service
- Mutual aid agreements with the CFS where they can be called to standby at MFS stations
- Prior to starting appliances in the engine room ensuring all internal doors shut. This should include reinstating automatic door closers as it was an observation that many doors were wedged open as well as some have closers broken or removed.
- Whenever a motor is running in the engine room at least one external door is to be open and one exhaust fan is to running.

- Review of items and work practices in the engine room. It was noted that some engine rooms had gym equipment in them whist other had PPE, lockers, fridges and other peripheral equipment that may be subject to unnecessary exposure.

Recommendation

Facilities management are to be notified to schedule a program to fix or replace any broken or missing door openers. To replace internal doors, that are missing altogether in engine rooms.

A work instruction is written standardising the use of MFS engine rooms.

Commander D Mack

STATION	MFS – DIESEL EXHAUST EMISSION - RISK/HAZARD MANAGEMENT ASSES PREPARED BY: Dave Mack, Commander & Clara Cipriani, WHS Ac						
APPLIANCE NO.	**ENGINE ROOM AREA**	**ENGINE ROOM VOLUME**	**MECHANICAL VENTILATION**	**ACTIVATION METHOD**	**FLOW RATE**	**EXTERNAL PENITRATIONS**	**INTERNAL PENITRA**
ST MARYS Two Appliance	165m²	663m³	2 x 600 mm electronic ducted ceiling fans	**Push Button /Auto**	2 x 2800 m³ Restricted by the ducting	4 electronic roller doors 1 external access door	Sliding Pole (Bulk H 7 Internal Personal 1 Personal Access D attached 1 manual door 3 Self Closing Doors 2 Manual Sliding Do
PROSPECT Single Appliance	150m²	750m³	2 x 400 ml electronic ducted ceiling fans	**Push Button / Auto**	2x2800 m³	2 x 3m ridge roof vents 1 self-closing personal access door 4 Electronic Roller Doors	4 Self Closing Doors
CAMDEN/ SAAS Two Appliance	155m²	775m³	2 x 400 ml electronic ducted ceiling fans	**Push Button / Auto**	2x2800 m³	2 x 3m ridge roof vents 1 self-closing personal access door 4 Electronic Roller Doors	4 Self Closing Doors 1 Manual Sliding Do
OAKDEN Two Appliance	195m²	895m³	1 x 600 ml electronic 2 x ducted ceiling fans	**Push Button / Auto**	2800 m³ Restricted by the ducting	2 x 3m ridge roof vents 1 self-closing personal access door 4 Electronic Roller Doors	4 Self Closing Doors
LARGS BAY Single Appliance	155m²	775m³	1 x 600 ml electronic 2 x ducted ceiling fans	**Push Button / Auto**	2800 m³ Restricted by the ducting	2 x 3m ridge roof vents 1 self-closing personal access door 4 Electronic Roller Doors	4 Self Closing Doors
BROOKLYN PARK /SAAS Two Appliance	160²	800m³	2 x 400 mm electronic ducted ceiling fans	**Push Button / Auto**	2x2800 m³	2 x 3m ridge roof vents 1 self-closing personal access door 4 Electronic Roller Doors	2 self-closing (1 dis
PORT ADELAIDE - Rosa Two Appliance	225m²	1125m³	1x 400 mm electronic 3 x ducted ceiling fans	**Push Button / Auto**	2800 m³ Restricted by the ducting	12m ridge roof vents 1 self-closing personal access door 6 Electronic Roller Doors	4 Self Closing Doors (2 doors not closed
APPLIANCE NO.	**ENGINE ROOM AREA**	**ENGINE ROOM VOLUME**	**MECHANICAL VENTILATION**	**ACTIVATION METHOD**	**FLOW RATE**	**EXTERNAL PENITRATIONS**	**INTERNAL PENITRA**
WALLAROO Single Appliance	54m²	216m³	1 x 600 mm electronic	Push Button	2800 m³	2 Manual Personal Access Doors 1 Manual Roller Door 1 External/Sash Window (Broken)	1 Manual Closing 1 Personal access d attached 1 Sliding internal w
MOONTA Single Appliance	80m² Isolated Shed	320m³	1 x 600 mm electronic	Push Button	2800m³	2 Manual Personal Access Doors 2 Manual Roller Doors	Nil
KADINA Single Appliance	65m²	260m³	1 x 600 mm electronic	Push Button	2800m³	4 Manual Sliding Windows 1 Manual Roller Door	3 Manual Personal

PT PIRIE Four Appliance	185m²	470m³	5 x 500mm electronic	Push Button	14000m³	1 Personal Access Door Self Closing 4 Electronic Roller Doors	5 Self Closing Perso 1 Manual Personal was opened to BA I 1 Sliding Window 1 Mechanical Wind
KAPUNDA Single Appliance	47.5m²	166m³	1 x 600 ml electronic	Push Button	2800m³	1 Mechanical Door	1 Personal Access S 2 Manual Access Do

OBSERVATIONS:

- Any mitigation measures to diesel emissions will need to apply to other agencies, this will include South Australian Ambulance Service (SAAS) co location stations and the Country Fire Service (CFS) when back filling MFS resources.
- Currently when Metropolitan appliances are responded from the station the exhaust fans start automatically and the appliance responds. At all other times it is discretionary as to when the fans are on as they activated by manual push button. It is considered that the most important time for fans to be activated is when the appliance returns to the station and the MFS personnel get out into the engine room.
- Pending testing of stations with the highest risk from the survey, the strategy of 'compartmentation' of the engine room from the internal living environment is a practical solution. Many stations have personal access penetrations, some with no doors, some self-closing, some manual closing but whatever the mechanism this should be a uniform outcome where the doors remain closed at all times when an appliance is running in the engine room.
- Regional stations have variety of different appliance access roller doors. Many are manual chain operated doors and it would be considered that these 'must' be open prior to the starting or running of any fire appliance in the engine room area.
- All stations have electronic ventilation systems, for ventilation systems to be effective they need to have a positive and negative flow through effect, in the compartment. Most metropolitan stations have 'ridge vents' that allow for natural air flow but many regional stations had no natural open penetrations for air flow. If testing is indicating there is a risk of diesel emissions build up then a further assessment of the location of natural vents is required to ensure an air flow is generated across the compartment by the fan system.
- There is a variety of sundry items located in engine rooms. Several stations had exercise equipment in these areas and a review of suitable activities and equipment associated in the engine room environment is required.

NOTE: RANKING: the lowest number represents the worst potential station.

b. Analysis of 2014 MFS Diesel Exhaust Emissions report

1. The currency of the report should be called in to question given that the air monitoring was conducted in 2013 with the report subsequently published in 2014. Safework Australia advises that control measures should be reviewed every 5 years which renders the MFS report on Diesel Particulates carried out in 2013 now redundant. As well, Section 19 of the WHS Act 2012 specifies that the conditions in the workplace be regularly monitored by the employer.

2. The methodology should be questioned based on the initial hazard assessment by MFS. The report extract does not immediately make clear what determinants were used to allocate the risk ranking categories which were then presumably used to select the worst potential stations for assessment in the report. What does the term “Worst Potential station” describe? Was the initial risk matrix determined by engine room area and/or manual or automatic activation of exhaust ventilation, a combination of two or more of these assessments as well or some other forms of determinant?

3. The reported methodology and findings are an extract from a more detailed report. The full report was not available at the time of writing.

4. The location of the air monitoring equipment should be questioned based on a fixed location in the air ventilation airstream between the truck exhaust and the ventilation intake. Is that an appropriate location? The testing also included personal monitoring of selected Firefighters. Safework Australia recommend that Occupational Hygienists be consulted about testing for airborne contaminants and that personal monitoring be carried out in the breathing area of the diesel emissions. The report extract does identify a number of firefighters who were involved in personal testing yet the report does not identify the testing regime. Should there also have been alternate monitoring locations that account for particulate deposits on PPC and equipment stored in the engine room? The WHS Regs Division 7 (Managing Risks from airborne substances) apply.

5. The monitoring survey was conducted at a moment in time of course. If we are dealing with vehicle emissions, these can change over time as a result of wear and tear, servicing intervals and vehicle fleet age generally. Again, this may go to the point of currency of the report. There is no mention in the report extract of vehicle specification type or vehicle history relative to the stations tested nor any discussion about the relationship between the emissions being tested and the vehicles themselves.

Importantly Euro standard 5 for heavy vehicle diesel particulate and co2 and nox emissions has been in force in Australia since 2010 with Euro 6 standards now coming online which is more stringent again. So, this has a direct relationship with the work environment being tested. The questions worthy of asking are around the vehicle servicing intervals, maintenance schedules and maintenance content along with most importantly the vehicle fleet age. The report makes no mention of this relationship.

6. **Safework Australia advises that there are currently no Exposure Standards agreed in Australia for Diesel exhaust**. It suggests that some of the individual components of diesel exhaust may be able to be monitored such as carbon monoxide, carbon Dioxide, and inhalable or respirable dust. According to the Victorian Trades Hall, people working where diesel engines are running indoors or in enclosed spaces, such as bridges and tunnels, engine maintenance, garages, carparks, underground mines, and **fire stations** have some of the highest exposures to the exhaust, and are at increased risk for illness.

The report prepared for MFS by Health Safety Environment Australia utilised the 2012 Exposure Standards for Atmospheric contaminants in the Occupational Environment in which they refer to monitoring being based on the personal sampling of chemical substances in the breathing zone of the worker. In fact, along with a range of further prescriptions, Safework Australia's "GUIDANCE ON THE INTERPRETATION OF WORKPLACE EXPOSURE STANDARDS FOR AIRBORNE CONTAMINANTS" states that;

"*Where monitoring of airborne contaminants is used to estimate a worker's exposure compared to the exposure standard, the monitoring **must** be conducted in the breathing zone of the person, also known as 'personal monitoring'."*

7. The following is an extract from the HSE report of 2013:

"Therefore, based on the measured positional DPM concentration being typical of the exposure experienced by the fire fighters during the operation of diesel powered fire truck inside the engine room, driving and operating the pump, the risk to employees' health from inhalational exposure to DPM appears to be below the limit of detection and negligible."

Given the immense variability evident in the Firefighter work environment and the immense variability in the Appliance age and type, along with the numerous variants of fire station structures in existence, it is incomprehensible that the 2013 report authors are then able to extrapolate a conclusion which typifies levels of DPM concentration and exposure and the subsequent risk to employee's health as being negligible.

8. The report makes recommendations about several matters in the conclusion including automatic door separation from engine rooms to other quarters, and PPC storage along with automatic door operation for access and egress etc. These recommendations should be questioned about their current status. For example, Oakden was being modified back in March so it would be a benchmarking exercise to assess the modifications of the Oakden station against the

report recommendations. Given the time lapse from the 2013 report to now 2019, the recommendations should be revisited to assess whether any of these mitigation measures have been implemented and what the efficacy of such measures has been.

9. The authors of the HSE report also presume that; *"As diesel motor emissions improve with better technology and with improved procedures on how the MFS use engine rooms there is no reason to believe that these results will not deteriorate but in fact improve".*

This conclusion by the HSE report authors is arguably flawed. The statement reflects many assumptions about the status of the SAMFS work environment and the SAMFS appliances if one was to even simply consider the average age of the appliances being between 10 and 20 years of age along with an inherently slow appliance replacement process.

10. Lastly, the conclusion recommendations refer to work instructions (SOP) being developed. This shift of responsibility from MFS to Firefighters is highly problematic. Was there a consultative process with the UFU that commenced before this report and before the recommendations for the development of those work instructions? Moreover, it would be more than informative to clarify any mitigating actions arising from the 2013 report which the MFS may have undertaken.

8. Diesel Particulate Matter Exposure Standards

Legislation and Exposure standards for airborne contaminants have been available for several years now. However, when it comes to Diesel Particulate Matter Exposure limits, there is still work to be done in that field. Much of the work with Exposure Standards for DPM has been the province of the Mining Industry and particularly underground mining, which suffers some of the most debilitating health issues from DPM exposure.

However, as a graphic example, **Safework Australia advises that as of 2019, there are currently no Exposure Standards agreed in Australia for Diesel exhaust**. At the time of writing, there are currently discussions being had within Safework Australia and the ACTU regarding the issue of a specific Exposure Standard for Diesel Particulate Matter. These discussions were due to have taken place during 2019 but most recent advice is that the discussions will be delayed until 2020. The Exposure level being proposed is still in contention but there is a view that an Exposure level of 0.05mg/m3 of DPM be used.

Safework Australia does suggest that some of the individual components of diesel exhaust may be able to be monitored such as carbon monoxide, carbon Dioxide, and inhalable or respirable dust. Furthermore, people working where diesel engines are running indoors or in enclosed spaces, such as bridges and tunnels, engine maintenance, garages, carparks, underground mines, and **fire stations** have some of the highest exposures to the exhaust, and are at increased risk for illness.

Of note, the most used exposure standard when addressing Diesel Particulate Matter emission is "The 2012 Exposure Standards for Atmospheric contaminants in the Occupational Environment". This was the Exposure Standard used by HSE when undertaking the Diesel Particulate Exposure report for SAMFS in 2013. It seems clear that in the absence of a specific measure for Diesel Particulate exposure, the more generalised 2012 Exposure Standards for Airborne Contaminants represent the best possible measure exposure until such time as a specific standard is developed and legislated.

Importantly, Safework Australia advise that;

They ….[The Exposure Standards]… ***do not represent a fine dividing line between a healthy and unhealthy work environment. Natural biological variation and the range of individual susceptibilities mean that a small number of people might experience adverse health effects below the exposure standard.***

The Australian Institute of Occupational Hygienists (2016) also state that;

Any recommended exposure value should not be viewed as a fine line between safe and unsafe exposure. They also do not represent quantitative estimates of risk at different exposure levels or by different routes of exposure. Any recommended exposure value should be used as a guideline by professionals trained in the practice of occupational hygiene to assist in the control of health hazards.

Safework Australia's guide for the implementation for these standards also advise that;
Exposure standards represent the airborne concentration of a particular substance or mixture that must not be exceeded. There are three types of exposure standard: a) 8-hour time-weighted average; b) peak limitation; or c) short term exposure limit. Exposure standards are based on the airborne concentrations of individual substances which, according to current knowledge, should not cause adverse health effects nor cause undue discomfort to nearly all workers.

8-HOUR TIME WEIGHTED AVERAGE (TWA) EXPOSURE STANDARD
Eight hour time-weighted average exposure standards are the average airborne concentration of a particular substance that is permitted over an eight-hour working day, and a 5 day working week. These are the most common types of exposure standards. Note: 8-Hour TWA exposure standards may require adjustment where work shifts exceed 8 hours or for greater than a 5 day working week. Refer to Chapter 4 of this Guide.

SHORT TERM EXPOSURE LIMIT (STEL)
Short term exposure standards are the time weighted average airborne concentration of a particular substance that is permitted over a 15 minute period. Some substances or mixtures can cause intolerable irritation or other acute effects upon brief exposure, although the primary toxic effects may occur with long term exposure through accumulation of the substance or mixture in the body or through gradual health impairment with repeated exposures. The short term exposure limit (STEL) provides limits for the control of short term exposure. These are important supplements to the eight-hour TWA exposure standards which are more concerned with the total intake over long periods of time. Generally, STELs are established to minimise the risk of: intolerable irritation irreversible tissue change narcosis to an extent that could precipitate workplace incidents STELs are recommended where there is evidence either from human or animal studies that adverse health effects can be caused by high short term exposure.

PEAK LIMITATION
Peak limitation exposure standards are a maximum or peak airborne concentration of a particular substance determined over the shortest analytically practicable period of time which does not exceed 15 minutes. For some rapidly acting substances and mixtures the averaging of the airborne concentration over an eight-hour period is not appropriate. These substances may induce acute effects after relatively brief

exposure to high concentrations and so the exposure standard for these substances represents a maximum or peak concentration to which workers may be exposed.

In a more recent development, the Australian Institute of Occupational Hygienists in 2018 writes that;

"Elemental carbon (EC) is a surrogate for DPM, as it provides the best fingerprint of diesel particulate emissions, is relatively free of interferences and is chemically stable, unlike the adsorbed organic carbon fraction.
Notwithstanding the lack of a well-defined universal dose response relationship, experience has shown that when workplace exposures are controlled below 0.1 mg/m3 DPM (measured as submicron EC), irritant effect decreases markedly."

In the absence of any more definitive data, the AIOH supports the maintenance of DPM levels (measured as submicron EC) as low as reasonably practicable (ALARP) below an 8-hour TWA ***guidance exposure value of 0.1 mg/m3, with the provision of applying a TWA value of 0.05 mg/m3 as an action level which triggers investigation of the sources of exposure and implementation of suitable control strategies"*** (Australian Institute of Occupational Hygienists, Published August 2017).

The Australian Institute of Occupational Hygienists also suggest that;
"There is no formal biological limit for exposure to PAHs. However, the UK HSE has introduced a Biological Monitoring Guidance Value (BMGV) for biological monitoring for PAHs based on measurement of end-of-shift urinary 1hydroxypyrene concentrations, while in France a guidance value based on the end of the last workday shift urinary 3-hydroxybenzo(a)pyrene concentration is recommended. The level of 4 μmol/mol creatinine (cr) and 0.4 nmol/mol cr has been recommended, respectively."

Safe Work Australia also states that;

"A person conducting a business or undertaking *has the primary duty to ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking.*

This duty includes eliminating exposure to diesel exhaust, so far as is reasonably practicable."

9. Vehicle Fleet and Emissions

The stated source of DPM emissions in the SAMFS work environment is very clearly the SAMFS Appliances. There can be no doubt that Appliances are the most significant contributor to DPM in the workplace and consequently PAH emission in the Firefighter and engineering work environment. Whether in Metropolitan and Regional Fire Stations, in the Angle Park Engineering Workshop or other areas such as learning and Development, the levels of DPM in each particular work environment will vary depending upon the particular appliance/s in use and the apparent variations in mitigation methods for each workplace. Still, the common aspect to DPM emissions in the workplace are the SAMFS appliances in all their manifestations.

Variations in DPM emission from each Appliance are related to many factors such as the age and wear of the appliance, the service and maintenance history, any SCR [selective catalytic reduction] system such as AdBlue, operational use and the type of fuel used. However, none of these factors should be taken in isolation when attending to DPM emissions. It is of interest that exhaust additives such as AdBlue are targeted at reducing Nitrous Dioxide (NO2) emissions and do not of themselves reduce PAH levels in Diesel emissions.

A significant factor in the DPM emission relates to the Appliance age. The latest available information reveals that in excess of 50% of the total SAMFS Appliance fleet (Metro and Regional) are aged between 10 and 20 years old with a small number in excess of 20 years.

Vehicle age is relevant here because Australian Design Rules (ADR) vary year by year and specify levels of exhaust emission which are generally more stringent commensurate with the ADR's of a particular year. For example, Euro V standard for exhaust emissions on heavy vehicles was adopted as ADR 80/03 in 2010 and specifies a PM level of 0.03 Transient cycle (eg. working cycle), a decrease in emission from Euro III which was 0.16 in 2002 for Australia.

<u>Euro VI is the most recent standard but at the time of writing is still yet to be adopted into Australian design rules.</u>

Euro VI emission standards were introduced in Europe by Regulation 595 in 2009 well over a decade ago. The new emission limits became effective from 2013/2014. The Euro VI standards also introduced *particle number* (PN) emission limits.

Of interest, a recent news article stated that in 2016 the Victorian MFB took delivery of Euro 6 compliant Scania trucks for building into heavy pumpers, Ultra Pumper and Bronto aerial platform.

The rationale according to the Fleet Development Manager of MFB Stuart Collis was that the MFB has both an Occupational Health and Safety obligation as well as a social and community responsibility. He is quoted as saying that;
"Every day, the trucks are driven inside buildings, which are uniquely both work-places and residences for the MFB's operational men and women. The health and welfare of fire-fighters is taken seriously at all times. [and] *Reduced particulates and the cleaner exhausts offered by Euro 6 compliance are better for everyone in our community."*

The rationale is a valid one. The same rationale could and should be transposed into the SAMFS environment such that the attention to WHS regulatory requirements for cleaner and healthier workspaces along with significantly less exposure to DPM will be greatly assisted by the ongoing replacement of Appliances with Euro 6 compliant vehicles thereby reducing the source of the emissions (the Appliances) in the first instance.

As a point of contention, the issue of the Appliance exhaust configuration was canvassed with the SAMFS Engineering workshop to better understand the complexities of installing Point of Capture (POC) LEV systems in the engine rooms of SAMFS stations. These discussions revealed that there are **<u>at least 5 different Appliance exhaust configurations</u>**. This level of complexity provides a difficulty in capturing exhaust emissions on individual appliances at different stations which result from appliance change-over and rotations.

As can be seen in the following section, there is an inherent obstacle to a “one size fits all” approach to exhaust capture. This is not to say that a well-designed POC system cannot be universal; rather the emphasis should be on “well-designed and appropriate for its function”.

10. Mitigation Measures and Controls

The following images demonstrate the significant deficiencies in the current mitigation systems in the selected SAMFS stations of St Mary's and Oakden. As can be seen from these images, figure 1 shows the diesel soot deposition upon the ceiling surface at St Mary's and is a direct result of poorly configured and mismatched exhaust extraction location along with what appears to be a grossly inadequate extraction air flow in the first instance. Figures 2,3, and 4 also show a design failure at Oakden which has the exhaust pointing toward a wall which is opposite to the ventilation duct at the centre of the engine room. Again whether the ventilation airflow is adequate is a serious question which needs to be assessed.

The issue of "bunkering" of PPC within the engine room is highly problematic given the exposure to DPM. More prudent methods of PPC storage should be investigated and implemented which will lead to healthier outcomes.

Figure 1. Diesel Particulate contamination of ceiling at St. Mary's Station December 2019

Figure 2. Oakden Station January 2020

Figure 3.Figures 2, 3 and 4 identify that the Appliance Exhaust configuration and Local Exhaust Ventilation (LEV) system are substantially mismatched. Diametrically opposite configurations allow for diesel exhaust contamination of work environment and surfaces.

Figure 4. Identifying the inadequacy of the LEV system.

A further significant issue is that of PPC "Bunkering" in the external work environment which also provides for DPM contamination of PPC.

Figure 5. Mt Barker Station January 2020. The Point of Capture LEV system may provide for reduction in DPM but the efficacy of the system requires assessing to ensure appropriate design, flexibility in Appliance exhaust configuration and adequacy.

The Australian Institute of Occupational Hygienists suggest that;

"The most effective means of restricting PAH absorption is by controlling exposure.

The hierarchy ofcontrols must be utilised when determining the appropriate controls to be utilised; for example: "

- ***provision of improved enclosure and ventilation to capture vapour, fume and particulate,***
- ***good housekeeping,***
- ***provision and use of change room facilities for scrupulous personal hygiene,***
- ***no eating or smoking in PAH-contaminated areas,***
- ***administrative controls (e.g. limits on overtime),***
- ***education and***
- ***use of protective clothing and appropriate respiratory protection.***

Additionally, Safework Australia advise that ;

Engineering controls are the most effective strategy for minimizing worker exposure to DE/DPM. A combination of controls is often required. Examples include:

- ***Performing routine preventive maintenance of diesel engines to minimize emissions,***
- ***Installing engine exhaust filters,***
- ***Installing cleaner burning engines,***
- ***Installing diesel oxidation catalysts,***
- ***Using special fuels or fuel additives (e.g., biodiesel),***
- ***Providing equipment cabs with filtered air, and***
- ***Installing or upgrading main or auxiliary ventilation systems, such as tailpipe or stack exhaust vents to capture and remove emissions in maintenance shops or other indoor locations***

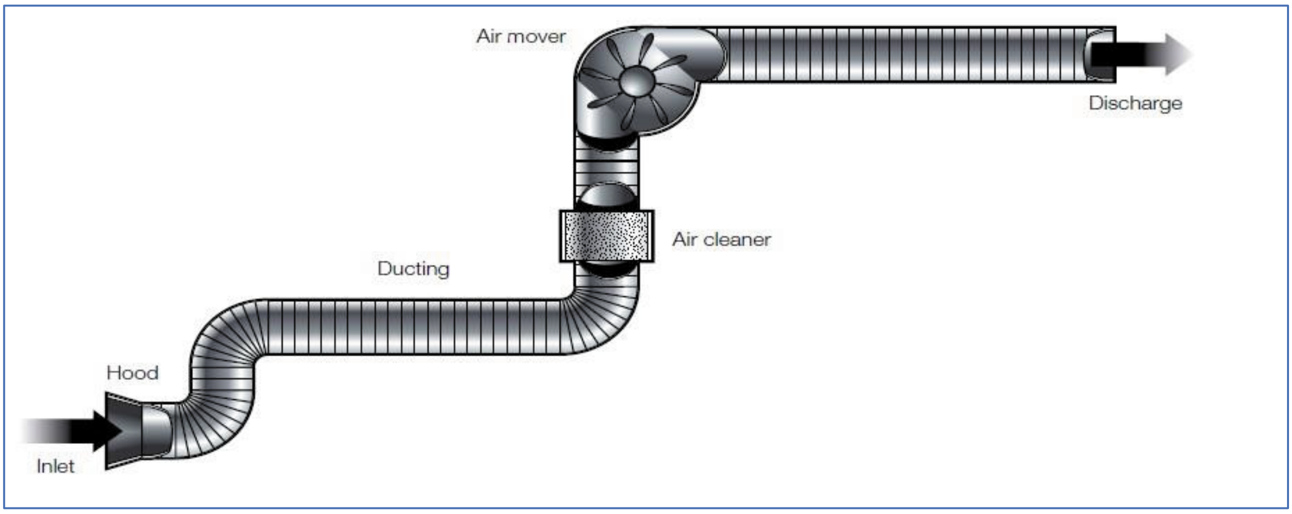

Figure 6 A schematic of a basic Local Exhaust Ventilation (LEV) system.

LEV taken directly from the Safe Work Australia Guide to Managing Risk of Exposure to Diesel Exhaust in the Workplace.

The elimination and mitigation of DPM in the work environment of SAMFS Firefighters should not be solely reliant upon stand-alone measures such as a Point of Capture local exhaust ventilation system, more refined start up pre check work procedures or variations in work routines and methods. As stated earlier, there is a need to adopt a holistic approach to the issue of DPM exposure as listed above but which also includes the SAMFS appliances as the source of the emissions.

11. Other Fire Service Environments and Responses

The Victorian MFB and the Queensland Fire Service have previously conducted assessments on the work environment of Firefighters exposure to DPM. Both the MFB and Queensland Fire Service reports make a series of recommendations which are more than worthy of consideration in the context of the SAMFS work environment.

The following is an extract of the Executive Summary from the MFB report prepared by Australasian Safety Services Pty Ltd in 2017;

Executive Summary

Australasian Safety Services Pty Ltd performed a Diesel Particulate Matter Exposure and Management Project (the Project) across four Western District sites of the Metropolitan Fire and Emergency Services Board (MFB). This report details the results of the project conducted in May 2017 by Australasian Safety Services Consultant, David Jowett.
The Project was performed in accordance with the requirements of Chapter 4, Part 4.1, Division 3 of the Victorian Occupational Health and Safety Regulations 2007, with guidance from *AS2985-2009*
Workplace atmospheres—Method for sampling and gravimetric determination of respirable dust.
The Project indicated that, under the working conditions encountered on the days of the assessments, DPM concertation levels at the monitored locations were well below the relevant guideline exposure standard. Workers would be unlikely to receive exposures in excess of the recommended guideline limit of 0.1mg/m3
To assist in further minimising exposures for fire fighters to DPM in the future, the following recommendations are provided:

1. Strong consideration should be given to preparing a transition plan for stations to switch from the current extraction ventilation to exhaust emission source capture systems. This will seek to further reduce and control exposures to DPM as far as reasonably practicable, as recommended by the world's leading workplace health and safety agencies, with aim of targeting a world's best practice of zero emissions within fire station engine bays.
2. Until such time that source capture systems could be installed, the following alterations should be considered for existing ventilation systems:

- Increase the run time of the systems before the auto-shut off from 10 minutes to a minimum of 15 minutes, preferably 20 minutes.
- Ensure all stations have a manual override switch for the ventilation that prevents the auto-shut off from occurring for when pre-start checks are occurring.
- Ensure bugs such as the issue at Sunshine, whereby staggered opening of the front

doors results in the second door turning off the ventilation, are fixed across all sites.

- Undertake a system check at all stations to ensure all installed fans are operating correctly.

3. Consider investigating the option of fitting exhaust filters to further reduce DPM being emitted from appliance exhausts.
4. Review any documented procedures relating to the operation of the ventilation to ensure they are up to date and that the existence of and requirement to follow the procedures are communicated to all fire fighters in the interests of protecting their health and well-being.
5. If possible, undertake extended pre-start checks that require the engine to run outside to increase the effects of dilution ventilation.
6. During pre-start checks, only run the engine for as little time as required to complete the check.
7. Consider providing information to all fire fighters on potentially hazardous nature of DPM and the increased risk of adverse health effects subject to duration of exposure and ways to limit exposure.
8. Ensure the MFB has a policy in place for future appliance purchases that includes a commitment to reduced engine emissions. This could be by way of engines that have a lower emission profile, using low emission fuel, or by looking at alternative technologies for items of plant that require diesel power engines.
9. Ensure all diesel engines are regularly maintained to help reduce exhaust emissions.

……

The following is an extract from the Queensland Fire and Rescue Service Report prepared by the Queensland Fire and Rescue Service Scientific Branch in 2010;

The four most obvious functional arrangements to consider include:
1. Doors from the engine bay to the station proper- construction and operation;
2. Ventilation within the engine bay – natural ventilation through grilled doors;
3. Storage of PPE-, location, storage and ventilation; and
4. Engine performance.

The QFRS should consider developing a risk based tool to assess the four arrangements above. The tool will take into account factors such as those listed above. The results will assist determine priority items to improve when refurbishing fire stations across Queensland. In the specific case of engine performance QFRS Technical Services should consider the information about identifying vehicles outside the scope of current regulatory framework for diesel emissions and consider the benefit of retro-fitting ceramic disks to the exhaust systems. It has been shown ceramic disks can reduce particulate emissions by more than 95%.

General recommendations to consider for future QFRS fire stations
The design of new fire stations provides an opportunity to incorporate several performance requirements to address the following issues:
_ Air movement between the engine bay and station proper- construction and operation of doors and windows;
_ Ventilation within the engine bay – natural ventilation through grilled doors; and
_ Storage of PPE-, location, storage and ventilation.
In the context of the risk control hierarchy it is likely engineering controls are the most reasonable element to apply. There are many factors to also consider as outlined above and perhaps the greatest is the future appliance fleet as it changes to match the evolving emissions regulatory environment.
The design should consider improvements to minimise air movement from the engine bay to the station proper without hindering the movement of fire fighters. Approaches may include:
_ automatic opening/closing and/or self-closing doors between the engine bay and work areas;
_ open air passageways and/or positive pressure airlock between the engine bay and station proper with self closing doors either side;
_ positive pressure within the station proper *c.f* the engine bay;
_ air conditioning/station exhausting to comply with AS1668; and
_ air conditioning inlets away from the engine bay and station proper,
The design should consider improvements to ensure natural ventilation occurs within the engine bay and enhances the dispersal of engine emissions. Approaches may include:
_ engine bays doors with grills encompassing the lower third of the door-back and front; and
_ time delays closing of doors after appliances return and leave.
The design should consider improvements to better manage PPE storage and ventilation. Approaches may include:
_ dedicated storage room and individual lockers for PPE that is separate from the

engine bay or closed off from the engine bay;
_ negative pressure air movement within the room and the air introduced is from outside the fire station; and
_ continuous air movement within the lockers and is exhausted directly to the outside of the fire station

Review the purpose of start of shift check.
The diesel emission study has also revealed another activity to consider. That is the start of shift check; since it is the source of the greatest exposures of exhaust emissions to fire fighters, it is reasonable to investigate the activity further. In terms of the risk control hierarchy, it is also the most obvious since it addresses eliminating the emissions and hence exposures.
It is recommended the start of shift check be reviewed since the potential benefits are significant. Reducing the start of shift check-starting the appliance to once a day will immediately reduce the fire fighter exposure by 50 %.

………

Summary

This report has been prepared for the State Secretary of the United Firefighters Union SA and the UFUSA State Council following concerns raised by members regarding adverse health effects associated with diesel exhaust emissions in the workplace and in particular the resultant Diesel Particulate Matter (DPM). As well as investigating the source and implications of the emissions, this report canvasses many of the issues related to DPM and hopefully provides context for developing strategies aimed at eliminating DPM and/or mitigating the deleterious health effects.

Firefighters worldwide are one of the most exposed to DPM. After many years of research and evaluation, in June of 2012, the World Health Organisation (WHO) International Agency for Research on Cancer (IARC) confirmed diesel engine exhaust as carcinogenic to humans (Group 1). This determination recognised that there was sufficient evidence to support a causal association between exposure to Diesel Particulate Matter and an increased risk of lung cancer.

Diesel Particulates arising from diesel exhaust emissions are of extreme concern in the general global environment. They are intrinsically more concerning in the confines of the SAMFS Firefighter work environment. To that extent, the following summary expresses these concerns and proffers some recommendations which may be useful in starting to address the negative health effects in a holistic way.

The key points arising from the investigation into diesel particulates in the SAMFS Firefighter work environment are:

In June of 2012, the World Health Organisation (WHO) International Agency for Research on Cancer (IARC) confirmed diesel engine exhaust as carcinogenic to humans (Group 1). During the last decade, further research has concluded that Polycyclic Aromatic Hydrocarbons (PAH)

are one of the more significant carcinogenic components of DPM. PAH is linked with lung cancer and bladder cancer amongst other adverse health effects.

In 2013 the SAMFS commissioned a report to study the air quality in several fire stations selected from a risk assessment previously carried out by the SAMFS. This report concluded that the levels of measured DPM were below the limit of detection and well below the 0.1 mg/m3 for DPM as elemental carbon. On analysis, the currency of the report should be called in to question given that the air monitoring was conducted in 2013 with the report subsequently published in 2014. Safework Australia advises that control measures should be reviewed every 5 years which renders the MFS report on Diesel Particulates carried out in 2013 now redundant.

In 2019, a survey was conducted prior to Enterprise Bargaining negotiations between the United Firefighters Union of South Australia (UFUSA) and the SA Metropolitan Fire Service. As part of that survey, union members were asked if they agreed or disagreed with the importance of the SAMFS carrying out risk assessments and undertaking testing of exposure rates for Diesel Particulates in Fire Stations. Union members overwhelmingly agreed on the importance of this initiative.

Safework Australia advises that there are currently no Exposure Standards agreed in Australia for Diesel exhaust. As at the time of writing, the ACTU and the AIOH are seeking a standard of the 0.05 mg/m3 but are yet to obtain agreement.

It was recorded in 2015 that 13.8% of Australian workers were substantially exposed to diesel engine exhaust and that the exposure rates are only second behind exposure rates to solar UV radiation.

There are both short-term (acute effects) and long-term health (chronic) effects arise from the exposure to diesel particulate matter. Short term exposure but in high concentrations may often cause irritation of eyes, nose, throat and lungs along with light headedness, coughing, phlegm and nausea. Long term (Chronic) effects of diesel particulate matter exposure can adversely impact upon existing respiratory issues such that asthma and allergies stand to be worsened along with an increased risk of heart, lung and bladder cancer due to the carcinogenic nature of diesel particulate components such as the polycyclic aromatic hydrocarbons (PAH).

Since 1974, researchers have also been concerned about the connection between parental diesel particulate matter exposure, particularly the PAH component and childhood brain tumours. Additionally, a recent Australian case study documented in 2013 revealed an association between maternal and paternal exposure to diesel particulates prior to childbirth and an increased risk of childhood brain tumours (Cancer Council, March 2017).

The stated source of DPM emissions in the SAMFS work environment is very clearly the SAMFS Appliances. There can be no doubt that Appliances are the most significant contributor to DPM in the workplace and consequently PAH emission in the Firefighter and engineering work environment. A significant factor in the DPM emission relates to the Appliance age. The latest available information reveals that in excess of 50% of the total SAMFS Appliance fleet (Metro and Regional) are aged between 10 and 20 years old with a small number in excess of 20 years. In order to reduce the emission of DPM in any meaningful way at the source, the fleet requires renewal with a view to compliance with Euro VI emission standards. The fitting of supplementary exhaust filters on earlier age vehicles may also be worthy of investigation.

A holistic strategy is required to mitigate the exposure of SAMFS firefighters to DPM in the work environment which encompasses the total work environment with considerations such as the installation of Point of Capture (POC) local Exhaust Ventilation (LEV) systems along with cross flow ventilation of the engine room, positive pressure areas and with PPC and living quarters separated hermetically from contamination areas.

Consideration should be given to developing a transition plan for SAMFS stations to switch from the current extraction ventilation systems to exhaust emission source capture systems and all new station designs should have LEV systems as standard moving forward.

This report has not detailed the entirety of the issues specifically concerned with DPM contamination of Firefighter Personal Protective Clothing (PPC) except to the extent of highlighting the need for storage separation of PPC from station engine rooms. The authors are aware at the time of writing that the SAMFS are investigating a total cleaning response to Firefighter PPC contamination.

A number of recommendations are made at the conclusion of this report which may be of assistance to Firefighters and the SAMFS in addressing the complexity of the DPM issue and its adverse health related effects. Above all else, this report premises its approach on the "Precautionary Principle" which according to an SA Public Health publication is that;

"*If there is a perceived material risk to public health, lack of full scientific certainty should not be used as a reason for postponing measures to prevent, control or abate that risk*." (SA Health, Public Health Act, Principles, 2013).

And the Work Health & Safety Act 2012

"eliminating exposure to diesel exhaust, so far as is reasonably practicable"

Furthermore, there are many significant concerns which have arisen from the investigation into DPM exposure and as such, there are a number of areas which require closer attention in order to ensure firefighter and worker health and safety. These include but are not limited to such things as the source of the emissions (the Appliances), the ageing fleet of Firefighting appliances, the differing Fire station constructs which have differing arrangements of Local Exhaust Ventilation (LEV) systems (presumably some more efficacious than others). There are also discrete matters such as historical cultural work practices such as the "bunkering" of PPC in the engine room. This report has spotlighted these matters in the context of building greater awareness of Firefighter Health, Safety and Welfare.

12. Recommendations.

The recommendations contained IN THIS SECTION also do not stand in isolation from the recommendations contained elsewhere in this report and in particular in the additional report extracts from the Victorian MFB and the Queensland Fire and Rescue Service.

Recommendation 1.

The UFUSA and the SAMFS seek an agreed consultative process to implement systematic and regular health and air quality monitoring of all workplace environments where DPM is of concern including all stations, engineering workshops and training facilities. The system of monitoring should be informed by reference to and in collaboration with an agreed Occupational Hygienist from the Australian Institute of Occupational Hygienists (AIOH). The testing should be directed to see if DPM is present and not benchmarked against any outdated "guidelines".

Recommendation 2.

With reference to and in collaboration with an agreed Occupational Hygienist from the Australian Institute of Occupational Hygienists (AIOH) or an appropriately qualified ventilation specialist; **That the UFU seek agreement with the SAMFS regarding the installation of automatically operating, appropriately designed and appropriately sized Point of Capture Local Exhaust Ventilation (LEV) systems in all Stations, Engineering workshop and Training environments.** Any such initiatives should be done in a holistic manner which encompasses the total work environment with considerations such as cross flow ventilation of the engine room, positive pressure areas along with PPC and living quarters separation from contamination areas. Consideration should be given to negotiating a transition plan for SAMFS work environments to switch from the current extraction ventilation to exhaust emission source capture systems. This will seek to further reduce and control exposures to DPM so far as reasonably practicable, as recommended by the world’s leading workplace health, safety agencies and Safe Work Australia, with aim of targeting a world’s best practice of zero emissions within fire station engine bays.

Recommendation 3.

The routine replacement of SAMFS Appliances per year be pursued as a matter of priority by the parties with the global goal of the replacement process ensuring that 100% of the SAMFS Appliance fleet is Euro 6 compliant by 2025 at the latest.

Recommendation 4:

PPC must be removed from being stored in engine bays as a matter of urgency and stored in fit for purpose, positively pressured PPC storage rooms.

Recommendation 5: A training and awareness package needs to be developed to educate staff about the dangers of exposure to diesel exhaust and best practice for reducing exposure.

Recommendation 6: A procedural document be developed around engine bay procedures and use to reduce exposure to diesel exhaust.