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Sent: Thursday, September 01, 2016 2:47 AM
To: zzMSHA-Standards - Comments to Fed Reg Group
Subject: Docket No. MSHA-2014-0031
Attachments: MSHA Submission_Final.pdf; Summary DEP report Final.pdf

Dear Sir / Madam

Please find attached or comments in response to the call for comments on diesel exhaust exposure in underground miners (Docket No. MSHA-2014-0031).

Kind regards

Rob

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Department of Labour
Mine Safety and Health Administration

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Dear Department of Labour, Mine Safety and Health Administration

Re: Docket No. MSHA-2014-0031

MSHA request for information in relation to Diesel Exhaust exposure in Underground Miners

This submission is presented in response to MSHA's request for comment dated June 8, 2016. We present case studies from an underground coal mine operated by the BHP Billiton Mitsubishi Alliance (BMA)[1] and a BHP Billiton owned and operated underground copper and uranium mine. The studies address the following questions in the call for information:

C. Exhaust After-Treatment and Engine Technologies

C.14. What exhaust after-treatment technologies are currently used on diesel-powered equipment?

C.15. What are the advantages, disadvantages, and relative costs of using DPM filters?

C.17. Are integrated engine and exhaust after-treatment systems used to control DPM and gaseous emissions in the mining industry?

C.18. What are the advantages, disadvantages, and relative costs of requiring that all light-duty diesel-powered equipment be equipped with high-efficiency DPM filters?

C.19. In the mining industry, are operators replacing the engines on existing equipment with Tier 4i (interim) or Tier 4 engines?

C.20. What types of diesel equipment purchased new for use in the mining industry is powered by Tier 4i or Tier 4 engines?

C.22. How long have Tier 4i or Tier 4 engines been in use in the mining industry and what additional cost is associated with maintaining equipment equipped with these engines?

C.23. What percentage of underground coal mines' total diesel equipment inventory is equipped with Tier 4i or Tier 4 engines?

E. MNM Miners' Personal Exposure Limit (PEL)

E.27. What existing controls were most effective in reducing exposures since 2006? Are these controls available and applicable to all MNM mines?

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[1] BHP Billiton owns 50 per cent of BMA.

E.28. Based on MSHA's data, MNM miners' average exposures are well below the existing standard of 160 $_{TC}$ µg/m^3. What are the technological challenges and relative costs of reducing the DPM exposure limit?

Regards,

Dr Robert McDonald
Vice President Health and Hygiene, Group HSE

About BHP Billiton

We are a leading global resources company. Our purpose is to create long-term shareholder value through the discovery, acquisition, development and marketing of natural resources. We have three Businesses – Minerals Australia; Minerals America, headquartered in Santiago; and Petroleum, headquartered in Houston. We are among the world's largest producers of major commodities, including iron ore, metallurgical coal, copper and uranium, and have substantial interests in conventional and unconventional oil and gas and energy coal.

Background

For over a decade, BHP Billiton has pursued a program to reduce exposures to diesel exhaust. This program has been based on the following objectives:

- Exposure levels for diesel emissions should be reduced to lowest practical levels.
- Diesel emission monitoring programs should be implemented to ensure compliance with the internal BHP Billiton Occupational Exposure Limit (OEL) for diesel exhaust.
- Proven control strategies should be applied to minimize diesel emissions.
- Maintenance procedures that focus on the reduction of emissions should be utilized.
- Low emission engines should be introduced promptly after they become available from equipment manufacturers.

In 2005, BHP Billiton's internal OEL for diesel exhaust was set at 0.1 mg/m^3 measured as elemental carbon (EC) according to NIOSH Method 5040.

In 2016, BHP Billiton introduced a requirement to manage exposures to as low as technically feasible with an interim requirement of 0.03 mg/m^3, following an independent expert review of the most recent science underpinning diesel exhaust exposure and lung cancer risk by the Institute of Occupational Medicine (Summary DEP Report – separate attachment 1)[2]. For some workers this will require the use of personal protective equipment while we identify and implement additional controls to reduce exposure levels.

Two Australian-based case studies are presented, one of work undertaken in an underground coal mine and the other in an underground hard rock mine. In the former case, there is the additional challenge that all equipment and engines must be intrinsically safe and comply with local regulatory requirements. This limits the ability to employ the latest technology engines and prevents the use of those diesel exhaust filters, which operate at high temperature.

The overall finding of these studies is that average exposure can be reduced to less than 0.03 mg/m^3 in the vast majority of SEGs (maximum of 0.05 mg/m^3) or to less than 0.05 mg/m^3 (for most SEGS, maximum of 0.08 mg/m^3) where the Lands 95% UCL (our method for comparing personal exposure to our OEL) is used as the measure of exposure assessment.

These levels can largely be achieved using existing technology so long as every effort is made to ensure engines burn the cleanest ultra-low sulphur fuel, are well maintained with a focus on emission reduction, and appropriate exhaust filtering technology is employed. Assessment of engine emission performance must be quantitative so that changes in individual engines can be tracked over time and engines with emissions outside acceptable control ranges can be identified and remedied. Additional exposure reductions will largely require the use of higher tier engines or electrification.

The performance of the two mines to control and reduce worker exposure to diesel exhaust is shown in Figures 1 and 2 below for mean exposure. Performance assessed at Lands 95% UCL is presented as Figures 3 and 4 in the case studies for each mine.

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[2] This is an interim requirement while our businesses are developing a five-year exposure reduction road map to further reduce exposures to a level consistent with our goal of "as low as technically feasible".

Figure 1: DPM exposure in an underground copper mine

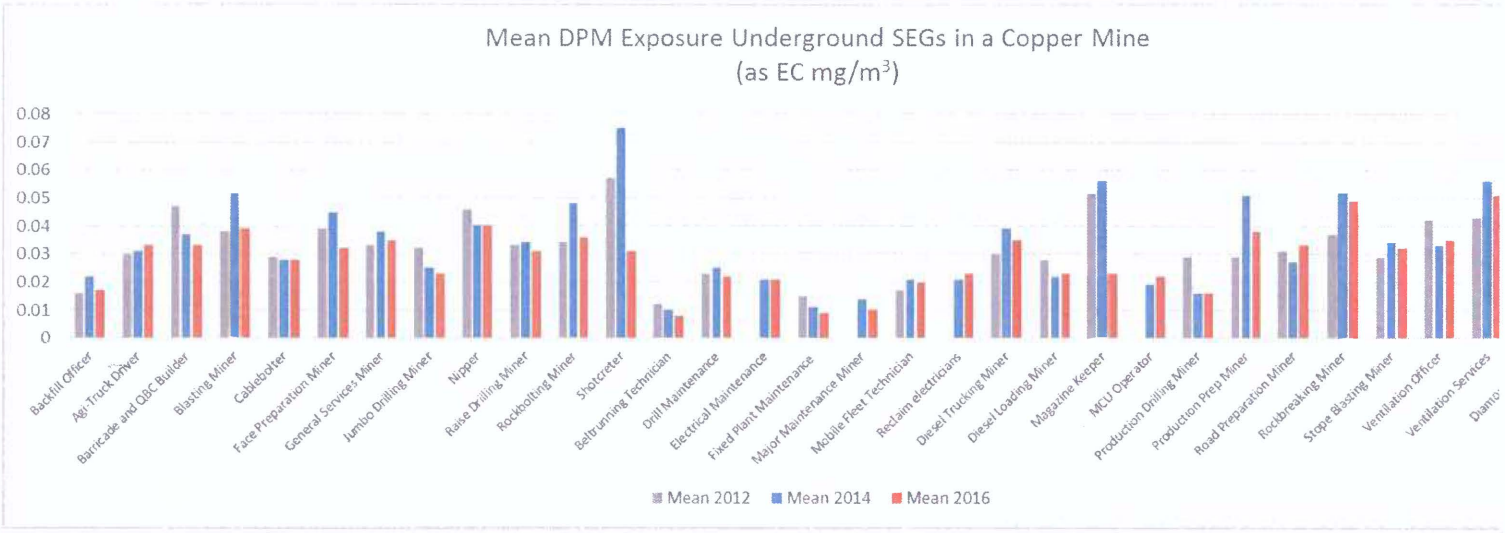
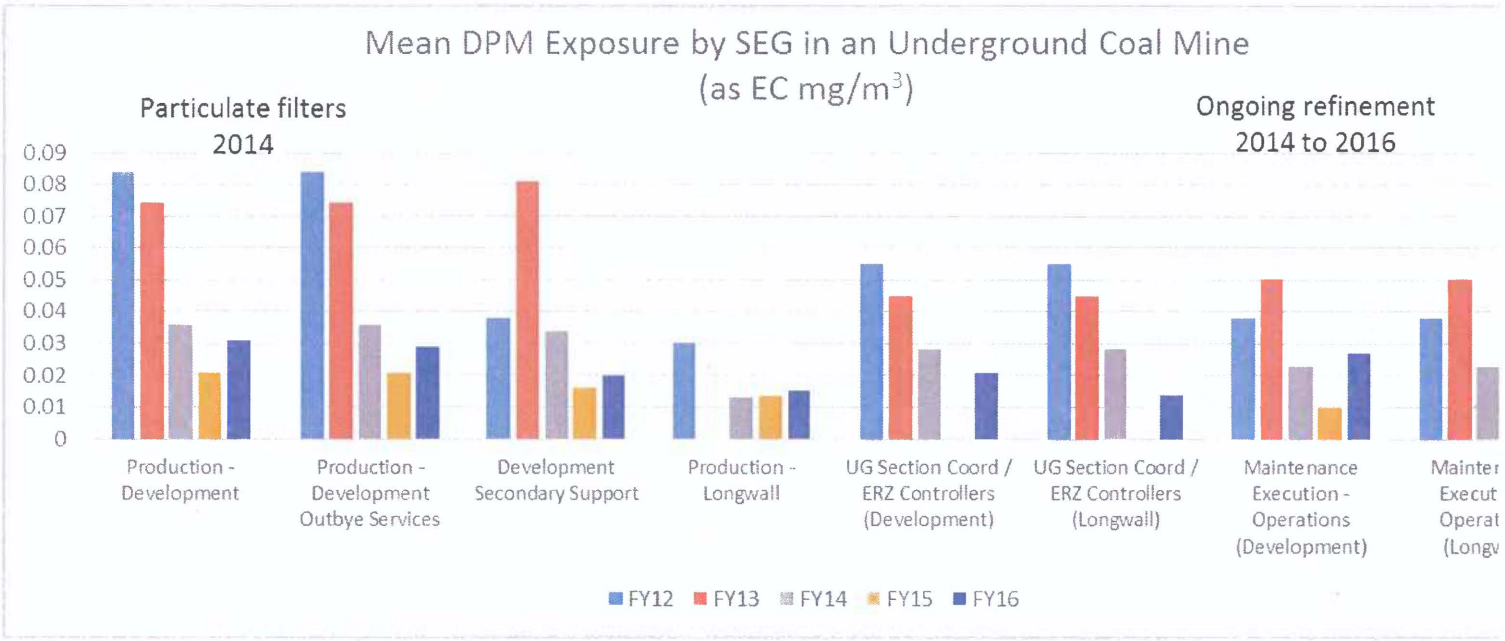


Figure 2: DPM exposure in an underground coal mine



Diesel exhaust emissions at Broadmeadow coal mine.

Introduction

The Broadmeadow coal mine operates in the Bowen Basin in Central Queensland, Australia. It is an underground longwall mine with coal seams accessed by punch highwall method. Emission control implementation has been ongoing for many years with particular enhancements achieved since 2013. The efforts have centred on:

- The use of exhaust particulate filters.
- Emissions based maintenance by trained technicians.
- Routine measurement of vehicle emissions.
- Setting in-house emissions standards which are more stringent than legislated requirements.
- The use of high quality low sulphur fuel and ensuring the quality of fuel delivered to the vehicle and its engine.
- Using newer, higher Tier engines where possible and retiring older, dirtier engines from the fleet.
- Training vehicle operators and other workers to minimise vehicle emissions and exposure situations.
- The use of diesel-tag-boards to manage the total equipment numbers which can enter any part of the underground workings.
- Regular measurement of exposures and active investigation of all exposures exceeding the BHP Billiton OEL.

Exhaust particulate filters

Broadmeadow is an underground coal mine and all equipment entering the mine must be certified as intrinsically safe. Large vehicle exhausts are fitted with water traps. The use of high temperature auto-regenerating ceramic filters is not available in the coal mining environment. Filters must be low temperature and able to withstand the high humidity environment post the water trap.

Filters were initially installed in 2013 on larger underground equipment and this was then extended to all equipment. This resulted in an approximately 50% reduction in worker exposure. The initial filters were of a washable type; however, there were concerns with the quality and that the life of the filter was just a single shift. A review identified a fibreglass based filter, Brand FST, which is better able to withstand the humid atmosphere and extends the life of filter from 8 to around 50 hours. Filter replacement on smaller vehicles which operate for 6 to 8 hours per day is built into the weekly maintenance service. In the first hour 'green' filters operate at about 90% efficiency which then rises to close to 100% for the balance of the service life.

An exhaust back pressure system is installed in larger vehicles to monitor filter loading. Change out occurs at 10 kPa back pressure across the filter. Filter hours are logged for each vehicle individually and filters are always changed by trained technicians. When filters are changed, attention is paid to installation to ensure an effective seal and prevent exhaust by-pass. Exhaust system backpressure without filters is logged and reduced to less than 2 kPa to ensure maximum filter life, i.e. exhaust backpressure is due to filter clogging and not to other exhaust build-up.

The fibreglass filters are about 3 times costlier but have a service life which is 6 times longer. The savings extend beyond the cost of filters to the reduced cost of technician time attending to filter changes and increased machine availability. The cost of filter disposal is also impacted and has been further reduced but crushing filters to approximately one fifth of their original volume.

Emissions based maintenance

The bulk of the diesel fleet are front-end loaders, with the majority powered by Caterpillar 3126 engines, and a smaller number by Caterpillar 3306 engine or the newer Caterpillar C9 engines. Additionally, there are a number of PJB and Drift runner personnel transport vehicles which use Perkins 1104 and 1006 engines respectively.

The Queensland coal mines agreed limit for exhaust emissions for all engines is 40 mg/m^3 of diesel particulate matter (DPM). The limit is not regulated. The Broadmeadow mine identified that lower limits were achievable based on the performance of engines in the fleet and in-house limits in the range 20 to 26 mg/m^3, depending on the engine type, have been established. These limits apply to concentrations at the manifold and do not take account of exhaust treatment. Gas and particulate testing is undertaken each 28 days with a Bosch BEA 850 analyser.

No vehicle, either company or contractor owned, is permitted to return to the underground environment if its emissions performance exceeds the in-house limit for that vehicle. Each vehicle and engine type has been assessed to identify the key maintenance requirements to minimise emissions. As the mine generally uses older style engines, particular attention is paid to the fuel delivery system including the fuel pump and injectors. It has also been found that emissions levels from some engines are affected by the oil condition and oil changes can bring the engine within limits.

Fitters are trained by original equipment manufacturers (OEMs) to undertake the required maintenance and, where emissions exceed specified limits, to diagnose and rectify the faults responsible.

Fuel Quality
The Broadmeadow mine uses Ultra Low Sulphur Diesel (ULSD) which contains no more than 7 parts per million of sulphur. Regular FLAC (Fuel, Lubricant, Air, Coolant) audits are conducted to ensure the quality of the fuel and the fuel handling systems. Fuel delivered to the Broadmeadow operation is filtered between the delivery truck and bulk storage and filtered again when taken from that tank to vehicle top up tanks. Maintenance programs ensure the filter systems are clean and functioning correctly.

Using newer cleaner engine technology.
Where possible, vehicles with older engine technology are retired. Just one Tier 1 engine loader remains in service; the majority are Tier 2 while the newer loaders have electronically controlled Tier 3 engines. Tier 4 engines presently do not meet the intrinsically safe regulatory requirements.

Operator training
There are three aspects to training:

- equipment maintainers are trained to undertake maintenance which is specifically aimed at reducing emissions. They are competent to operate the gas and particulate measurement equipment and are responsible for changing all exhaust filters
- equipment operators are provided with training to minimise emissions which includes quite simple requirements such as not leaving equipment idling
- all mining personnel are provided with DPM awareness training, which help them avoid potential higher exposure situations.

Tag boards
The Broadmeadow mine manages the number of diesel-powered plant into ventilation splits by diesel-tag-boards. The regular review of tag board allocation and their placement is required to ensure compliance as the mine develops; this ensures optimum placement and setting of diesel-tag boards to improve DPM dilution efficiency. Further controls are applied through integrated planning detailing vehicle allocations in the panels, and job setup with consideration of vehicle exhaust to reduce exposure.

Broadmeadow mine UG machines are fitted with over speed protection to prevent over revving however, they do not have a protection device for limiting idling. This is presently dependent on operator behaviour, which creates an opportunity for improvement through culture and compliance. The machines are tested every 28 days to ensure the maximum allowable revs are within OEM specifications.

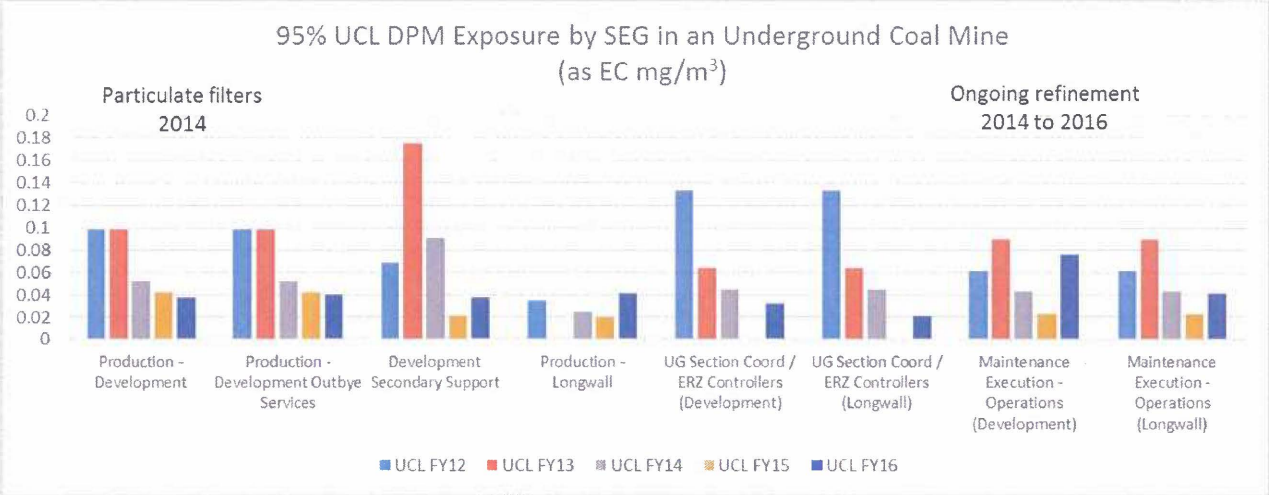
All operators at Broadmeadow mine are trained and authorised to operate the machines within the OEM specifications.

Exposure Monitoring
A program of personal exposure monitoring is in place with measurement conducted using NIOSH method 5040, based on elemental carbon. The monitoring program is now conducted monthly to assist in the improvement program. All cases where exposure is found to exceed the current maximum requirement of 0.03 mg/m^3 are investigated to identify and address potential sources of exposure and exposure situations.

The implementation of the emission reduction program has reduced exposure to the point where no SEG has a mean exposure exceeding 0.03 mg/m^3 expressed as EC. Using the Lands 95% UCL of the mean exposure just one SEGs has exposure exceeding 0.05 mg/m^3. See Figure 3 below. Where

SEG exposure exceed 0.03 mg/m^3, using Lands 95% UCL, respiratory protective equipment will be required.

Figure 3: DPM Exposure in an Underground Coal Mine based on the Lands 95% UCL



Olympic Dam Copper and Uranium Mine

Introduction

Olympic Dam mine is a large underground multi-metallic mine producing copper (principal commodity) uranium, gold and silver. Located in central South Australia, the mine operates by the sublevel open stoping method using modern mining equipment. Being a hard rock mine, Olympic Dam is freed of the constraints of a coal mine where mining equipment is required to be intrinsically safe.

Olympic Dam has implemented a number of higher order controls and is developing a range of other controls to further reduce exposure to diesel exhaust including:

- Using high quality, low sulphur diesel fuel
- Engaging with suppliers to improve engine design and exhaust treatment devices
- Replacing older diesel equipment with new technologies where possible
- Replacing open cabin machinery and vehicles with enclosed cabin equipment fitted with air filtration units
- Installation of diesel exhaust filtration devices to heavy underground machinery e.g. jumbos and trucks
- Increased ventilation in mine areas where diesel equipment is in use
- Focused attention on high exposure SEGs.

Fuel and Oil Quality

The Olympic Dam mine uses only high quality ultra-low sulphur fuel, which is suitable for use with after treatment devices and filtered prior to delivery to onsite tanks. Oil is low SAPS (sulphated ash, phosphorous and sulphur) oil which is specifically designed to be used in modern turbo engines, particularly those fitted with diesel particulate filters.

New Technology Engines

The Olympic Dam mine approaches this aspect in several ways. The focus is on having the latest technology in engines. Older engines have been replaced on a planned replacement schedule so that the majority of engines used in heavy equipment are Tier 3 and will be Tier 4 by 2020. Table 1 below shows the progress in transitioning to new engine technologies.

Where possible, Caterpillar engines were upgraded with the Ventilation Reduction package incorporating selective engine hardware and software to minimize DPM in the engine exhaust. The package is consistent with exhaust filters and requires the use of ULSD fuel. This effectively provides more modern engine management systems to older engines.

Contractors' vehicles are required to have an EPA rated Tier 4 engine, or if a Tier 4 solution is not available an EPA Tier 3 engine retrofitted with Continuously Regenerative Trap (CRT) style diesel particulate filter (DPF). Particulate exhaust emissions of these vehicle must be < 0.5 mg/m^3 post filtration when measured by real time analyser or similar light scattering measurement device

Table 1: Proposed timetable for replacement of fleet to Tier 4 engines

	FY15	FY16	FY17	FY18	FY19	FY20
Trucks	Tier 3	Tier 3+	Tier 3+	Tier 3+	Tier 3+	Tier 4
Loaders	Tier 3	Tier 3+	Tier 3+	Tier 3+	Tier 4	Tier 4
IT's	Tier 3	Tier 3/4	Tier 3/4	Tier 3/4	Tier 4	Tier 4
Light Vehicles	No "Tier 4" solution in scope					
Charge Up Truck	Tier 3	Tier 3	Tier 3/4	Tier 3/4	Tier 3/4	Tier 4

Exhaust Treatment

Diesel Particulate Filters

In 2013, Olympic Dam began a program to retrofit all heavy machinery with Diesel Particulate Filters (DPFs) on a priority risk basis. DPF's have now been fitted to all currently in service BHP Billiton trucks and loaders and trials are progressing to fit DPFs to ancillary fleet machines which do not have suitable OEM solutions. The following points summarise Olympic Dam's current progress and plans in relation to retrofitting its fleet with DPF technologies:

- The Loader fleet has been fitted with OEM DPFs in conjunction with a recent OEM ventilation reduction engine upgrade which has reduced total emissions of the loader fleet by an average of 77% from baseline emission testing results from 2013.
- BHP Billiton's AD55 truck fleet has been retrofitted with OEM DPFs resulting in an average reduction of 66% from baseline emission testing results from 2013. New AD60 CAT trucks are fitted with DPF as standard and have lower emissions than AD55 machines.
- Ancillary fleet, including rock breakers and tool-carriers, have had DPFs trialled from three different suppliers. Results have varied and effectiveness of the technology over replacement with more efficient engines is being considered. The best solution will be implemented across the remaining ancillary fleet.
- There are a significant number of light vehicles operating underground. Trials of partial flow DPF technology has been trialled on light vehicles achieving an approximately 75% reduction. Low emission V8 1VD engines are being purchased as replacements for 1HZ engines. 1VD engine emissions are lower emissions than 1HZ engines fitted with DPFs.

The following table shows the emissions reduction achieved for one truck by firstly upgrading the engine management system and then fitting an exhaust filter.

Table 2: Progressive emissions reductions achieved in one truck

Test Date	Test Type	Veh. No.	Veh. Model	Veh. Type	DPM Improvement	Average (mg/m3)
14/01/2014	Free Acc.	LD050	R2900G	Loader	None	25.7
27/02/2014	Free Acc.	LD050	R2900G	Loader	VR Spec	10.3
8/04/2014	Free Acc.	LD050	R2900G	Loader	VR Spec + DPM Filter	4.6

Diesel Exhaust Fluid Addition

This fluid is a urea solution and is added to the raw exhaust. The aim of the product is to allow an over stoichiometric fuel mixture to be used. While this results in a cleaner burn, nitrogen oxides formation is increased. The urea solution converts the nitrogen oxides to nitrogen and water.

Emissions Based Maintenance

All vehicle maintenance is carried out as per OEM recommendations and maintenance plans are specific to each vehicle type. All primary servicing is performed in surface workshops and smaller maintenance repairs and inspections are carried out in underground workshops. Maintenance items specific to controlling DPM exposure include:

- Servicing of lubrication system and injectors
- Inspection and servicing of cabin integrity including windows, doors, seals and pressurising systems
- Replacement of air conditioner return and cabin pressure filters
- Servicing of air filters, oil filters and fuel lines
- DPM emissions testing using a MAHA MP-4 emissions tester.

Major mechanical services, which involve the above items and emissions tests for particulate matter, are performed at least monthly on all BHP Billiton fleet.

Emissions Testing Program

As mentioned above, emissions testing is performed on BHP Billiton fleet vehicles at 1 M mechanical services using a MAHA MP-4 DPM analyser. Baseline data has been collected and used to develop specific standards for each vehicle type that identify engine issues leading to increased emissions. These limits are reviewed periodically as older vehicles are replaced. Emissions testing data has also been used to test the effectiveness of exhaust filtration devices applied to vehicles. These requirements apply to company owned and contractor vehicles. Additionally, no vehicle is permitted to enter the underground workings without testing to ensure they meet site emission standards and that an exhaust filter is fitted.

Higher Exposed SEGs

Figure 2 above shows that in 2014 the SEGs with the highest mean exposure were the Shotcreters and the Magazine Keeper and that by 2016 the exposure of the workers in both SEGs was reduced by 60%. Continuously Regenerating Trap (CTR) DPFs have been fitted on shotcrete rigs which were the highest emitting vehicles in the underground mine achieving a 99% reduction in emissions from baseline testing. In the case of the Magazine Keeper, vehicles were rerouted away from the magazine which resulted in a significant exposure reduction in that area of the mine. For other SEGs, any exposure measurement recorded in excess of 0.03 mg/m^3 is investigated to identify and address the reasons.

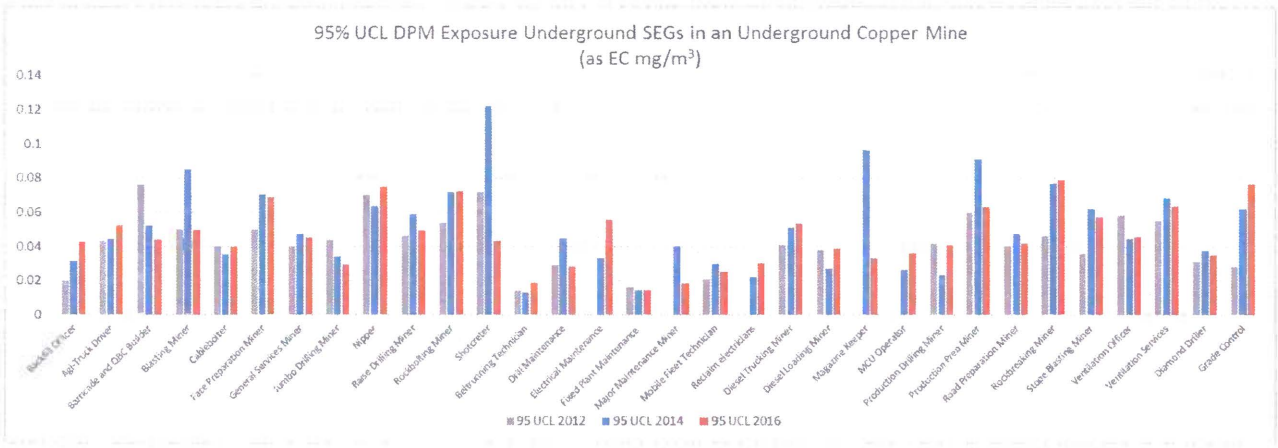
Exposure Monitoring

A program of personal exposure monitoring is in place and measurement is conducted using NIOSH method 5040, based on elemental carbon.

The implementation of the emission reduction program has reduced exposure to the point where the mean exposure of all SEGs is less than 0.05 mg/m^3 expressed as EC and just two SEGs exceed 0.04 mg/m^3.

Using the Lands 95% UCL of the mean exposure, all SEGs have exposure less than 0.08 mg/m^3 and 65% have exposure less than 0.05 mg/m^3. See Figure 4 below.

Figure 4: DPM exposure in an underground copper mine based on the Lands 95% UCL



Where SEG exposure exceed 0.03 mg/m^3, using Lands 95% UCL, respiratory protective equipment is required.