

A GLOBAL APPROACH TO MANAGING DIESEL EMISSIONS

S MCGINN¹, B DAVIES² & T WHITE³

¹ McGinn Integration Inc – Montreal, Canada

² AEHS Pty Ltd – Figtree, Australia

³ BHP Billiton Pty Ltd – Melbourne, Australia

INTRODUCTION

The invention of the diesel engine by Rudolph Diesel in the 1890's has over the past 115 years contributed significantly to the productivity of many nations. As a result of the widespread use of diesel powered equipment of all sizes, there is increased potential for adverse health outcomes due to the larger number of workers exposed to the complex mixture of toxic gaseous, adsorbed organics and particulate components found in the raw exhaust emissions.

BHP Billiton, a mining, metallurgy and petroleum company comprising more than 100 operations in approximately 20 countries with some 35,000 employees, regularly uses diesel equipment in its operations. In June 2004 a presentation was made to a meeting of the BHP Billiton Health, Safety, Environment and Community Forum, representative of senior management in this area, during which a number of potential issues arising from over-exposure to diesel emissions were discussed. As a result the HSEC Forum endorsed the pursuit of an initiative for all relevant operations within BHP Billiton. Over the last 12 months considerable effort has been expended to ensure sites are aware of the issues associated with diesel emissions and to provide assistance as to how they can be controlled. The following details how this process (designated as the "Diesel Emissions Initiative") was developed and then rolled out across the organisation.

WHAT IS THE DIESEL EMISSIONS INITIATIVE?

Within BHP Billiton the Diesel Emissions Initiative is deemed to be an appropriate strategy to control employee exposure to diesel emissions (gaseous and particulate) within its operations. The strategy, endorsed by the Company HSEC Forum, has the following key elements.

- Exposure levels for diesel emissions should be reduced to lowest practical levels.
- Diesel emission monitoring programmes should be implemented to ensure compliance with the relevant BHP Billiton Occupational Exposure Limits.
- Proven control strategies should be introduced to minimise diesel emissions.
- Maintenance procedures that focus on the reduction of emissions should be introduced.
- Low emission engines should be introduced at the first opportunity after they become available from equipment manufacturers.

WHY HAVE A DIESEL EMISSIONS INITIATIVE?

Given that there is substantial evidence to indicate that over-exposure to diesel exhaust emissions may give rise to both short-term and long-term adverse health effects, action must be taken to minimise employee exposure to such emissions. This approach is consistent with the BHP Billiton policy of Zero Harm.

While it is true to say that some health aspects of diesel emission remain scientifically unsettled, there is sufficient evidence to suggest that a prudent response is required and all diesel emissions should be reduced to as low as reasonably practicable (ALARP).

Given the long history of research on this topic by one Division within BHP Billiton (Illawarra Coal), it was considered appropriate to distribute that collective knowledge to other sites. Expertise was sourced from the Canadian underground mining sector (McGinn Integration Inc) to supplement the knowledge base within the Company.

SCOPE OF THE DIESEL EMISSIONS INITIATIVE

The nature of the operations that constitute BHP Billiton are such that many employees and contractors come into contact with diesel exhaust emissions during the course of a working day.

While it is reasonable to assume that the greatest exposure would occur with heavy mobile equipment in underground mines, experience has demonstrated that this may not necessarily be the case. Research in Australia and Canada has demonstrated that exposure to diesel emissions from light duty vehicles in underground mines may in some circumstances exceed that from heavy duty mobile equipment.

Employees working at surface mining operations are not exempt from exposure, however experience has shown that the majority of exposures occur in deep pits where temperature inversions are prevalent or in workshops where flow-through ventilation is limited (eg enclosed workshops where doors are closed during winter). In some situations emission levels can be excessive where multiple vehicles are “run-up” or idled in open workshops for testing purposes.

Another area where diesel emissions may be an issue is where diesel forklifts are working inside buildings or inside the holds of ships.

With this in mind, BHP Billiton decided that the focus of the Diesel Emissions Initiative should be their underground mining operations, however other operations such as surface mining, industrial plants and cargo holds of ships need to be aware of the above situations and if relevant to site operations take appropriate action.

When discussing the range of control options possible it was decided at an early stage that there was a need for suitable guidance material. The aims of the guidance material developed by BHP Billiton were:

- To minimise employee and contractor exposure to diesel emissions within BHP Billiton operations.
- To indicate those technologies and procedures that have been shown to be practical and effective in minimising diesel exhaust emissions.
- To ensure that the lessons learnt over the past 10-15 years on the issue of diesel exhaust minimisation are communicated to all operations.
- To provide a basis for sites to develop and implement appropriate diesel emission management plans.

This material has been consolidated into a single document “Diesel Emissions Management” (2005). While this document leans very heavily on the experiences of the Canadian, Australian and USA mining sectors, the aim is for this document to be regularly updated with new learnings as sites implement management procedures. The comprehensive document covers:

- Health effects
- Why manage diesel emissions and benefits of doing so
- Regulatory requirements
- Monitoring methods – atmospheric and raw exhaust
- Engine selection, types, certification, new technology
- Fuels – quality and handling, additives, biofuels, synthetics
- Ventilation
- Engine maintenance
- Diesel particulate filters
- Disposable diesel particulate filters (low temperature and coal)
- Allied emissions controls – oxidation catalysts, scrubber tanks, fume diluters, operator cabs, shop extraction systems
- Production department and operator best practices
- Education and training
- Personal protective equipment
- Lists of engine and emission control suppliers for Australia, South Africa and North America

SITE MANAGEMENT PLANS

In order to comply with the recommendations of the Company HSEC Forum it was considered there was a need for sites to adopt a structured approach to the control of diesel emissions.

In this regard it was strongly recommended that each Site Manager ensure that a management plan be developed to ensure the control of both gaseous and particulate emissions.

It was envisaged that the plan should be sufficiently detailed to demonstrate how workplace emission levels would be controlled to levels below the BHP Billiton Occupational Exposure Limits of:

- Carbon monoxide - 30 ppm
- Nitric oxide - 25 ppm
- Nitrogen dioxide - 3 ppm
- Diesel particulate - 0.2 mg/m³ (as DP) or 0.1 mg/m³ (as EC and sampled as the submicron fraction and analysed as per NIOSH Method 5040 (1994))

Site management plans should be audited at a site level on a yearly basis and any corrective actions documented.

Given that local conditions may significantly affect site management plans, the following guidance was provided.

Initial Management Plan

At all sites where workplace exposures were above the BHP Billiton OEL, the following strategy was proposed. This included the introduction of:

- Low emission fuel (if available)
- An emissions based maintenance programme
- Workforce and driver education programme
- Ventilation strategies consistent with the control of diesel emissions
- A purchasing policy to buy low emission engines (where available)
- Controls on contractor or hire vehicles to minimise exhaust emissions

Secondary Management Plan

In cases where the initial management plan was not effective in reducing emissions to below the BHP Corporate OEL, sites needed to consider implementing one or more of the following:

- Low emission engines
- Diesel exhaust filters
- Disposable diesel exhaust filters
- Air conditioned and filtered operator cabins
- Alternative power systems (eg electric)

It was considered feasible for the initial management plan to be fully implemented within six (6) months from the date of receipt of Company guidance material. Secondary management plans

(if applicable) would be dependent on equipment availability and thus needed to be progressed without delay.

While no firm date was placed on any site for absolute compliance, the expectation was that the management of diesel emissions would be an ongoing part of site HSEC management plans.

IMPLEMENTATION PROCESS

Given the diversity of BHP Billiton, considerable effort has been expended to deliver the guidance material to sites in a form that would be both informative and helpful at a site level. To date the guideline document has been translated into Spanish to cover BHP Billiton global operations.

Using this principle, task groups were formed whereby technical specialists conversant with the control of diesel emissions linked with senior Corporate HSEC management and as a team, visited individual sites. This process was initially trialled in Australia at an underground coal and an underground metalliferous mine. From this process it became clear that site engineers gained most benefit from an exercise where the raw exhaust of a number of engines at each site were tested and the reasons for any abnormal results discussed.

At approximately the same time the opportunity arose to present the concept of the Diesel Initiative to the broader BHP Billiton mining community through a presentation of a regional meeting of the Mine Operations Network. The MON is a forum established under the Company's Operational Excellence Programme at which senior mining personnel meet to discuss key issues and possible solutions. The Diesel Initiative received strong support from the underground mining community to the point that a two-day workshop was held at an underground operation in South Africa in November 2004. The workshop consisted of presentation on the health effects of diesel emissions, methods of monitoring, control strategies and most importantly developed initial site management plans for the two sites visited over the two-day workshop.

Using the learnings of this process subsequent site visits have been made to the majority of the underground mining sites within BHP Billiton. It is envisaged that the remaining two sites will be visited as soon as operational conditions allow.

Subsequent to the workshop in South Africa the MON hosted follow-up web meetings and posted the guidance material on their intranet website. As a result of discussions held during the web meetings, details of good and poor engine performance in terms of emissions were also posted on the MON website to allow sites to judge where their engines ranked.

OUTCOMES OF INITIATIVE TO DATE

A number of outcomes have evolved from the implementation of the Diesel Initiative across BHP Billiton, the key ones being:

- No universal single simple solution exists and each individual site needs to develop its own strategy for controlling diesel emissions. While the fundamentals of such strategies will be similar, issues such as the availability of low emission fuel and the supply of latest technology engines within developing countries provide substantial challenges.
- Knowledge of the issues of diesel emissions at a site level were at varying levels, with some sites being well versed in the topic and others at a lower level.
This outcome vindicated the production of the guidance material and ensures a consistent approach across the organisation.
- The level of commitment of original equipment manufacturers (OEMs) to managing the issue of diesel emissions was observed in many instances to be below that considered necessary. Some OEMs continue to supply old technology engines on the premise that approvals for new designs are either difficult or costly to obtain even though newer, cleaner alternatives currently exist. In some cases OEMs have embraced this problem and are working with sites to overcome the problem but these are unfortunately in the minority.
- Maintenance practices have been shown to have the potential for biggest gains in emission reduction and improved productivity. It is the potential for productivity returns that may ultimately drive culture change such that emission based maintenance practices become the standard not the exception.

For maintenance programmes to be effective there is a need for operations to have access to suitable raw exhaust monitoring equipment. Raw exhaust gas monitoring equipment has been available for many years and while effective only gives half the equation. The instrumentation used by Davies (2004) in the evaluation of raw exhaust particulate levels in a fleet of 66 engines (all BHP Billiton Illawarra Coal) is very accurate, however it is difficult to operate and not readily transportable.

Recent research by Volkwein et al (2005) and the Department of Primary Industries (2004), has demonstrated that it is possible to measure diesel particulate in the undiluted exhaust of diesel-powered mining equipment by means of simple hand-held devices with reasonable accuracy. This research has shown that both the SKC “Diesel Detective” and the Air Quality Technologies Pty Ltd particulate monitor provide mine operators with excellent screening and diagnostic tools by which to maintain engines. The relationship of both of these devices to elemental carbon levels as measured by NIOSH Method 5040 (1994) is provided in Figures 1 & 2.

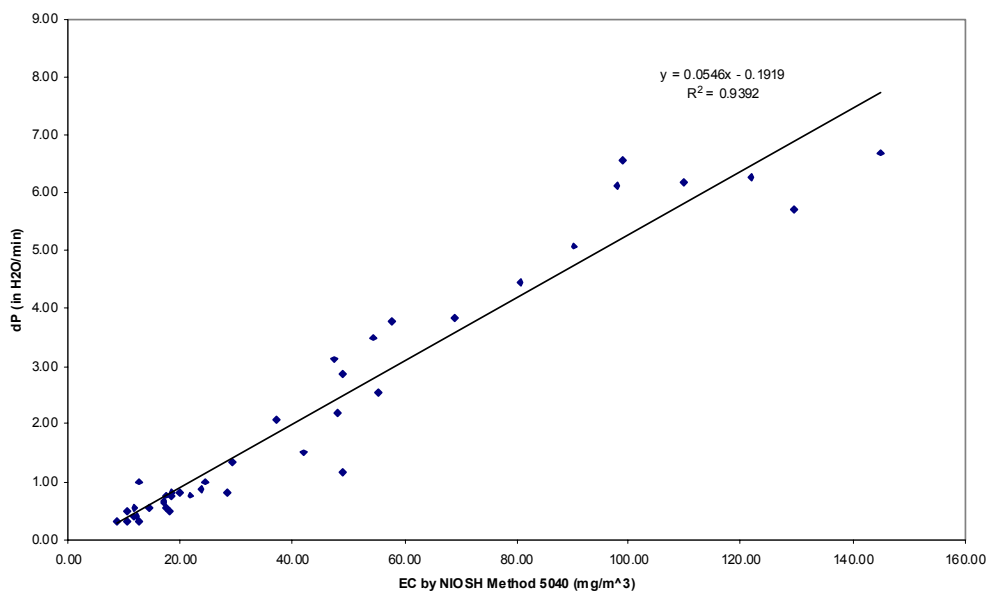


Figure 1
Comparison of SKC Diesel Detective to Elemental Carbon

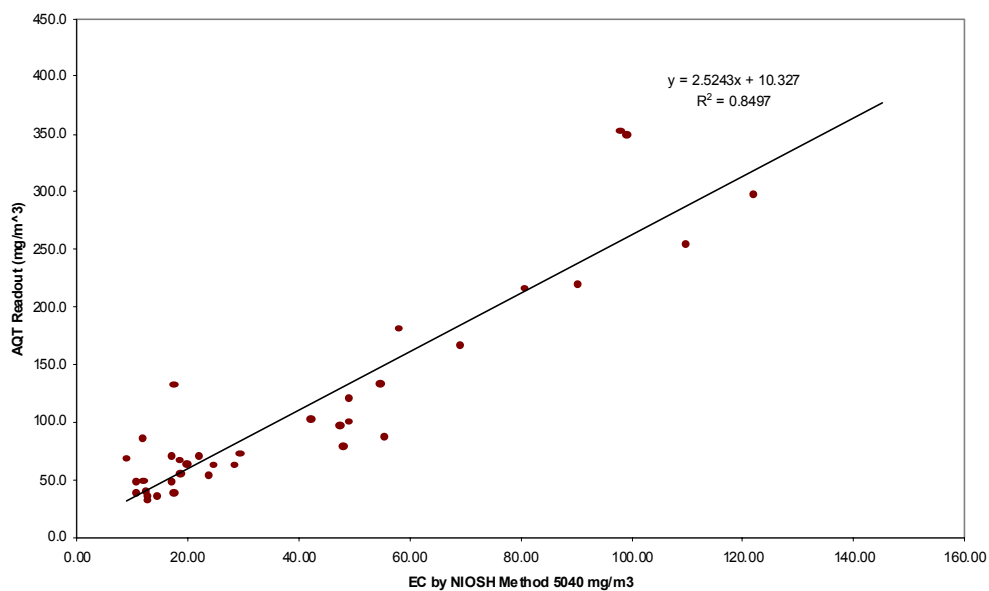


Figure 2
Comparison of AQT Pty Ltd Device to Elemental Carbon

Both these devices have been trialled at BHP Billiton operations in Australia and South Africa with encouraging results. Once commercial versions of these devices become available it is envisaged that they will form the basis of site maintenance emission management plans within BHP Billiton.

CONCLUSIONS

As part of its Company Policy of Zero Harm, BHP Billiton has developed specific guidance material for its operations aimed at assisting sites to minimise employee exposure to diesel emissions. During the implementation phase of this initiative it has become evident that maintenance offers the major cost effective response for controlling raw exhaust emission outputs. To this end assistance has been provided to a number of research establishments to develop simple cost effective raw exhaust monitoring instrumentation.

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