

Diesel exhaust particulate exposures and risk control strategies in Australian UG Mining

Colin Chandler
CEO – Peak 3 Pty Ltd - Australia

Peak3

- Peak3 specializes in diesel emissions reduction technologies and services for the Australian mining sector.
- The company undertakes a range of collaborative R and D programs in this area with Australian research groups.

Clients



Confidential property of Peak3 Pty Ltd - www.peak3.com.au

3

Research partners



Confidential property of Peak3 Pty Ltd - www.peak3.com.au

4

The team

- Colin Chandler – CEO- Peak3
- Dr Chen, Dr Mousavioun, Neil Davey, Francis Cox, Peter Polak – Peak3
- Professor Ristovski – Queensland University of Technology.
- Associate Professor Brown – Queensland University of Technology.
- Dr Janis Jansz – Curtin University Western Australia
- Dr Patrick Glynn - CSIRO CESARE
- Peter Nicholls – EM EHS and T Barmenco Pty Ltd

confidential property of Peak3 Pty Ltd -
www.peak3.com.au

5

Summary Slide

- Diesel “emissions” achieved Group 1 IARC status.
- Diesel particulates are the majority of the problem.
- Nano Diesel Particulates present greater health risks than larger particulates.
- The current regulations call for mass to be measured and treated. This is most probably because mass is the “simplest” measure.
- Both mass and number of particulates should be measured and managed in underground mines.
- Ultimately a dosing time for exposure groups based on Lung Deposition Surface Area “dose” should be the standard for OEL.

confidential property of Peak3 Pty Ltd -
www.peak3.com.au

6

Summary Slide 2

- Resistance to change has resulted in slow acceptance of the need to do anything.
- Effective diesel emissions management has been wrongly seen as contrary to productive output and efficiency.
- Australian mining requires:
 - More consistent monitoring methodologies
 - Better planning
 - Better data management
 - Greater diversity of treatment solutions.
 - Greater understanding of the problem

confidential property of Peak3 Pty Ltd -
www.peak3.com.au

7

The objectives today

- To share information about current programs underway in Australian mining.
- To learn from North American experience
- This is an overview of the work done to date, not a detailed “deep dive” on each stream.

Note - This is not the limit of the programs underway, simply the ones the participants are involved in. It is a brief and general overview.

confidential property of Peak3 Pty Ltd - www.peak3.com.au

8

Project objectives

- Projects targeted reduction of both the emissions **and** the cost of management i.e. reduction of emissions and the cost of managing them. Action was more likely if there was a cost saving
- Projects aim to identify more innovative ways to monitor and manage emissions data and develop specific treatment for high idle/high transient diesels
- Projects were predominantly trialed in Hard Rock but undertaken for coal.

confidential property of Peak3 Pty Ltd -
www.peak3.com.au

9

Current Research and Development

Project Title	Project Sponsors	Research and Commercial Partners	Status
Optimising Gaseous and Particulate Emissions from Diesel Engines (inc remote and automated monitoring)	Australian Research Council Peak3	QUT ILAQH James Cook Uni of Applied Sciences North Western Switzerland Barminco	Commencing July 2012
Automated and Integrated Emissions Monitoring	Peak3	Neusoft QUT Barminco	Commenced June 2012
Particulate Management Platform inc monitoring	ACARP / CSIRO/Peak3	ACARP/ CSIRO/Peak3 Barminco	Phase 1 completed Jan2012 Phase 2 commencing Aug 2012
Dry Dust and DPM Reduction System	ACARP/ CSIRO/ Peak3	Newmont	Commenced 2011
Integrated Dust/ Gas/ DPM monitor	Peak3 / ACARP/ QUT/	Peak3/ QUT/ Matter Aerosol	Pending
Low Cost/Low Size personal monitor	Peak3/ CSIRO	Matter Aerosol	Pending
Crank Angle Sensor Project	Peak3, CIEAM,	Neusoft	Underway 2011
Wet Scrubber Steam Reduction	Peak3/James Cook Uni/ QUT	Peak3 /James Cook/QUT	Commenced

Changing times, growing awareness!

- Great improvements in vehicles, ventilation, engine and post engine treatment have been made.
- A better regime of managing kW in mine allegedly exists.
- But despite this, exceedance's remain.
- A better understanding of DPM also means we are more aware of what we should be treating.
- What we have been measuring and treating isn't always what we should have been measuring and treating.

The problems defined

- DPM **mass** is **not** the problem. It was simply the metric.
 - The DPM problem can be broken down as follows
 - Above 200nm - Safety problem- allergic and respiratory reactions, mucosa reaction.
 - Above 200nm - Environmental (black carbon impact)
 - Above 200nm - Opacity
 - Under 200nm – Health – Carcinogenic
- The health risk is predominantly nano and ultrafine particulates coated in Volatile Organic Compounds including Polycyclic Aromatic Hydrocarbons produced as a by product of diesel combustion. The problem is the “dose” of smaller particulates as measured by LDSA
- The safety risk and the environmental risk is larger DPM
- Measuring particulates accurately, and consistently at an affordable price in mining is challenging. An industry only just getting used to measuring DPM mass is now being asked to measure DPM number/size.
- Treating particulates for both mass and number is difficult in mining.
- Much is yet to be learned-have we got it right this time?

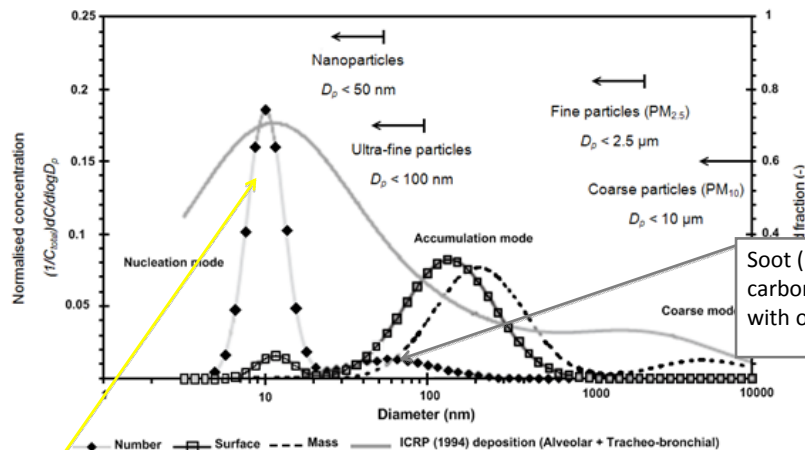
The problem continued

- DPM occur down to low nano metre range- below that they can be liquid and gas but remain part of the DPM formation process
- Treatment solutions and protective equipment are not currently designed to treat/protect from such small particles in an UG environment.
- DPM are hard to measure/monitor
- At an environmental level – Black Carbon Particles have 500,000 GWP global warming impact and an economic impact of \$400per kg.

confidential property of Peak3 Pty Ltd -
www.peak3.com.au

13

DPM Particle Size Distribution



Mainly liquid droplets
made of organic materials

DPM Chemical composition

It is an extremely complex mixture of various chemicals:

Soot – black carbon

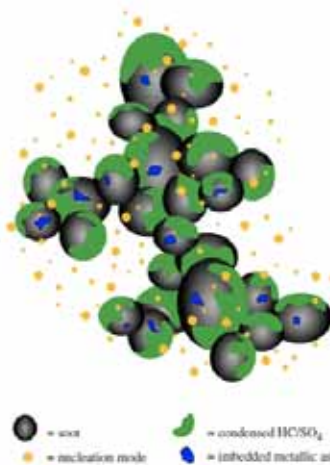
Metallic Ash (i.e ZnO from lube oil)

Soluble (volatile) organic fraction condensed on the soot.

Soluble organic fraction + sulfates in ultra fine particles.

Solid

Liquid



confidential property of Peak3 Pty Ltd -
www.peak3.com.au

15

Other Particulates

- DPM are an active particulate and can combine opportunistically with other fine particles.
- Particulates can continue to “evolve” and develop post engine.
- This is influenced by the atmospheric condition.
- Simply put the more polluted the air the more the engine pollutes.
- However those same particles can be used to co treat DPM

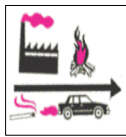
confidential property of Peak3 Pty Ltd -
www.peak3.com.au

16

PM & health effects

- Epidemiological studies - strong associations between levels of ambient particulate matter (PM) and increased respiratory and cardiovascular disease morbidity and mortality.
- mechanism(s) by which particles induce adverse health effects are still not entirely understood- this does not mean they don't occur- it means they are not understood.

Proposed mechanism: Oxidative stress hypothesis (Ristovski - 2012)



PM → free radicals; ROS → oxidative stress → inflammation



cell injury / death

Why Diesel?

- Incomplete combustion
- Mix of Lubricants and unburned fuel
- Production of smaller and smaller particles
- Atmospheric creation
- "In scrubber" creation
- New engines
- Average size distribution for a modern diesel is under 70nm.
- MAJORITY of mass (90%) comes from 10% of number of DPM
- VOCs tend to adsorb from 20nm up

The breakdown

- Awareness
 - Problem
 - Monitoring
 - Treatment
- Monitoring
 - Cost
 - Frequency
 - Data granularity
 - Data Management
- Planning
- Treatment
 - High Transient
 - High Idle

A brief review

THE FINDINGS

In mine findings

- Exposure groups clearly delineated i.e. occupation determined exposures.
- Correlations between gaseous and DPM levels.
- Concentration zones not simply caused by activity i.e. working headings. Recirculation cells, eddy points play an important role.
- Ventilation not able to treat all DPM effectively (cost, efficiency et al)
- Monitoring and treatment of the complete environment is not possible. Identification of key concentration zones enables more specific management.
- Most monitoring locations were incorrect.
- Monitoring was inconsistent and predominantly TWA.
- Little real time data use.
- Little use of emissions data.
- No use of data for forecasting kW application.
- Infrequent inclusion of light vehicle data or treatment of vehicles
- Issues post wet scrubber in Coal Vehicles

Findings


- Limited use of integrated tag board/dispatch.
- kW-emissions data from OEM's often at variance to vehicle- Signatures wrong
- kW loading requirements not managed well
- Maintenance a significant contributor – Average non compliance with Emissions Effective maintenance 30% across 8 sites.
- Limited training or information around Diesel Emissions. Much of what did exist was wrong.
- Diesel Emissions Planning was often out of date and not frequently used.
- Excessive reliance on treatment post engine alone.
- Little consideration given to whole ecosystem management.
- Limited understanding of legal or corporate risks.
- Limited understanding of responsibilities.
- Undying belief in "magic" solutions prevails
- High Transient issues impacting treatment solutions
- High Idle times impacting treatment solutions
- Wet Scrubber outputs impacting treatment solutions
- High Dust load impacting treatment solutions

Local considerations


- Very remote locations.
- Climatic challenges (high wet bulb etc)- monitoring.
- Geology challenges.
- Limited data infrastructure.
- FIFO culture- change management and training challenges.
- Lack of belief that there is a problem.
- Different regulatory environments in each state.

confidential property of Peak3 Pty Ltd -
www.peak3.com.au

23



Maintenance Findings – (Easy Wins).



Simple things make a big difference:

- Air filters.
- Injectors.
- Crank case ventilation.
- Fuel.
- Lubricants.
- Tyres.
- Hydraulics.
- Poor scrubber maintenance.

