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## **DIESEL PARTICULATE - THE AUSTRALIAN EXPERIENCE**

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## **INTRODUCTION**

- First engine introduced underground in 1941
- Numbers low prior to mid 1960's
- Health effects of gaseous emissions recognised since introduction (statutory requirements introduced in 1941)
- Currently
  - 1,500 engines in coal mines
  - 2,000 - 2,500 engines in metaliferrous mines

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- Diesel particulate issue highlighted in 1988 by NIOSH Criteria Bulletin 50
- Coal industry commenced research in 1990
- Metaliferrous industry has funded some research but appears to have adopted a “wait and see” attitude

- Metaliferrous Industry
  - 1998 WA Study (US BOM Sampler)
  - 2001 Five Mine Study (Elemental Carbon)

<b>AEHS WEST AUSTRALIA STUDY RESULTS</b>	
<b>Mine Type</b>	<b>DP mg/m<sup>3</sup></b>
Alumina	0.15 - 0.23
Base Metal*	0.11 - 0.64
Nickel	0.10 - 0.66
Base Metal*	0.14 - 1.01
Gold	0.14 - 0.92

\* No distinction made in report

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<b>AEHS DP IN AUSTRALIAN MINES</b>			
<b>Mine</b>	<b>DP mg/m<sup>3</sup></b>	<b>EC mg/m<sup>3</sup></b>	<b>TC mg/m<sup>3</sup></b>
Cu extraction	0.11 - 1.30	0.042 - 0.372	0.112 - 0.572
Pb/Zn development	0.12 - 0.38	0.060 - 0.190	0.115 - 0.293
Pb/Zn extraction	0.07 - 0.56	0.021 - 0.265	0.060 - 0.456
Pb/Zn extraction	0.05 - 0.60	0.010 - 0.180	0.050 - 0.420
Pb/Zn extraction	0.16 - 0.57	0.017 - 0.418	0.130 - 0.532

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## AEHS WORKPLACE EXPOSURE LEVELS

- Coal Industry

1995 - Eight NSW mines (US BOM Sampler)

1999 - 15 NSW and Queensland mines (Elemental Carbon)

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## AEHS 1995 NSW STUDY

Mine	Coalfield	DP mg/m <sup>3</sup>
A	Northern	0.14 - 0.56
B	Western	0.15 - 0.31
C	Southern	0.03 - 0.17
D	Southern	0.06 - 0.47
E	Southern	0.04 - 1.65
F	Western	0.13 - 0.32
G	Northern	0.06 - 0.62
H	Southern	0.10 - 0.25

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<b>AEHS</b>		<b>1999 NSW/QLD STUDY</b>	
<b>State</b>	<b>Activity</b>	<b>EC mg/m<sup>3</sup></b>	<b>TC mg/m<sup>3</sup></b>
NSW	General duties	0.01 - 0.59	0.04 - 0.33
	Place change	0.01 - 0.05	0.06 - 0.10
	Longwall move	0.05 - 0.52	0.12 - 0.60
QLD	General duties	0.02 - 0.24	0.06 - 0.36
	Place change	0.05 - 0.34	0.11 - 0.58
	Longwall move	0.01 - 0.30	0.06 - 0.75

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<b>AEHS</b>		<b>WORKPLACE EXPOSURE LEVELS</b>
<ul style="list-style-type: none"> <li>• Approx 300 DP samples collected in Metaliferrous Industry</li> <li>• Approx 1,200 DP samples collected in Coal Industry</li> <li>• Currently no statutory exposure limits</li> <li>• In 1999 NSW Minerals Council published best practice DP standard of 0.2 mg/m<sup>3</sup></li> <li>• Significant proportion of results in both mining sectors above this guideline</li> </ul>		

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## DIESEL PARTICULATE MANAGEMENT

- Metaliferrous Sector
  - Ventilation (statutory requirements)
  - Fuel quality
  - Air conditioned cabins
  - PPE
  - Regenerative particulate (soot) filters
  - Limited research, reliance on overseas technology

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## DIESEL PARTICULATE MANAGEMENT (Cont'd)

- Coal Sector
  - Fuel quality
  - Scrubber tanks
  - Chemical decoking
  - Disposable exhaust filters
  - Ventilation (statutory requirements and tag boards)
  - Flow-through catalytic converters
  - Underground diesel test stations
  - Education
  - Extensive research

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## FUEL QUALITY

- Low sulphur fuel shown to reduce DP by about 10%
- Odour and irritation reduced significantly
- For best results individual engines need to be tuned to individual fuels

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## SCRUBBER TANKS

- Shown to reduce DP by 10 - 15%
- Efficiency not significantly affected by cleanliness

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## ENGINE DECOKING

- Chemical decoking of head, cylinders and injectors
- Reduces DP levels for up to 12 months
- Greater effectiveness on older engines

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## DISPOSABLE EXHAUST FILTERS

- BOM (Donaldson) system
  - Reduction in DP levels of about 90%
  - Risk of fire incident if scrubber tank water is lost

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## AEHS DISPOSABLE EXHAUST FILTERS

- Tower Colliery (Microfresh Filters) system
  - Non flammable material
  - Reduction in DP levels of about 85%

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## FLOW-THROUGH CATALYTIC CONVERTERS

- Reductions of 25% DP achieved
- Appear effective for substantial period
- Majority most probably organic carbon
- Level of elemental carbon generated by engine probably unchanged

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## VENTILATION

- Thermal stratification in headings with large kW engines
- Current statutory requirement of 0.06 m<sup>3</sup>/s per kW may not be sufficient to control DP

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## VEHICLE TAG BOARDS

- Based on statutory airflow requirements
- Very effective in controlling atmospheric DP levels
- Does not affect production
- Compliance an issue

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## VEHICLE TAG BOARDS



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## DIESEL TEST STATIONS

- Measure gaseous emissions
- Lower DP levels achieved due to better control of NO/NO<sub>2</sub>

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## DIESEL TEST STATIONS



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## DIESEL TEST STATIONS



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## EDUCATION

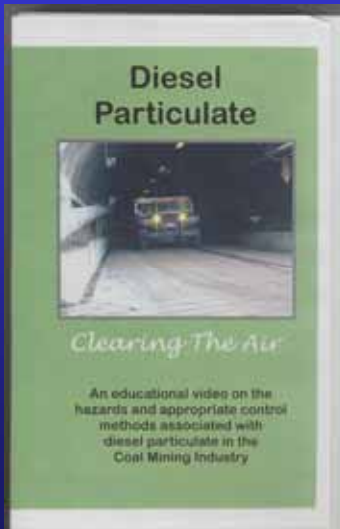
- Video distributed to every mine in NSW
- Booklet distributed to every employee in NSW (12,000)
- Minerals Council Guidelines
- Mine Engineers Seminar Presentations

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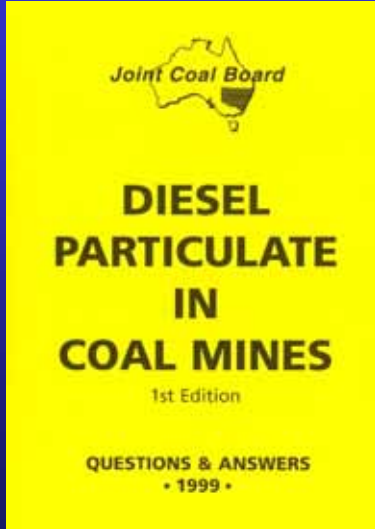
## EDUCATION



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**AEHS** EDUCATION



The image shows the cover of a book titled "DIESEL PARTICULATE IN COAL MINES". At the top, it says "Joint Coal Board" with a map of Australia. The title is in large, bold, black letters. Below the title, it says "1st Edition" and "QUESTIONS & ANSWERS • 1999 •". The cover is yellow with black text.

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**AEHS** ONGOING RESEARCH

- Raw exhaust EC analyser (ACARP C7014)
- Application of Best Practice Principles (Elouera Colliery)
- DP levels versus maintenance (BHP Billiton - Illawarra Coal/Victoria University)

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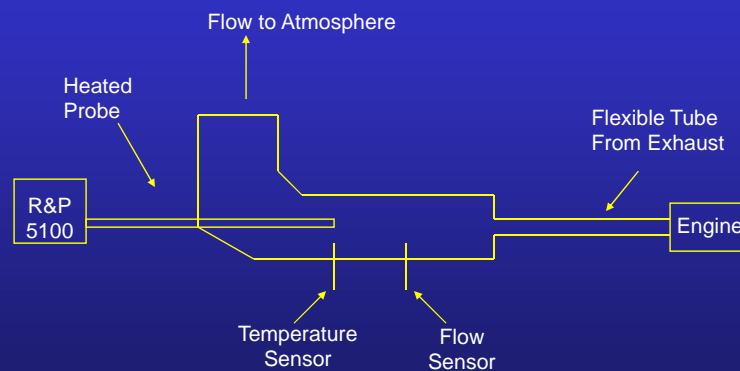
## AEHS ONGOING RESEARCH

- Test system for disposable filters (BHP Billiton/ Victoria University/Microfresh Filters)
- Emissions from “flame protected” vehicles
- Hand-held instrument for measuring raw exhaust DP

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## AEHS SAMPLING SYSTEM



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**RAW EXHAUST ANALYSER**



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**RAW EXHAUST ANALYSER**



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## AEHS RAW EXHAUST ANALYSER



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## AEHS RESULTS FROM IN-SERVICE VEHICLES

Engine Type	mg/m <sup>3</sup>	
	Elemental Carbon	Total Carbon
Caterpillar 3304	83 - 122	105 - 139
Caterpillar 3306	57 - 123	70 - 148
Kia	120 - 223	132 - >250
Perkins (6 cylinder)	85 - 88	103 - 104
MWM	92	115
Hino	41 - 42	62 - 98
Caterpillar 3306 (Turbo)	47	64

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AEHS		KIA ENGINES	
Vehicle No.	Engine Type	mg/m <sup>3</sup>	
		Elemental Carbon	Total Carbon
102	Kia	223	>250
108	Kia	120	132
115	Kia	207	230
116	Kia	144	162
132	Kia	205	225

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AEHS		DP IN AUSTRALIAN MINES	
Effect of Maintenance on Raw Exhaust DP			
		Total Carbon g/kWhr	
Pre Maintenance		0.84 - 1.4	
Post Maintenance		0.38 - 0.40	

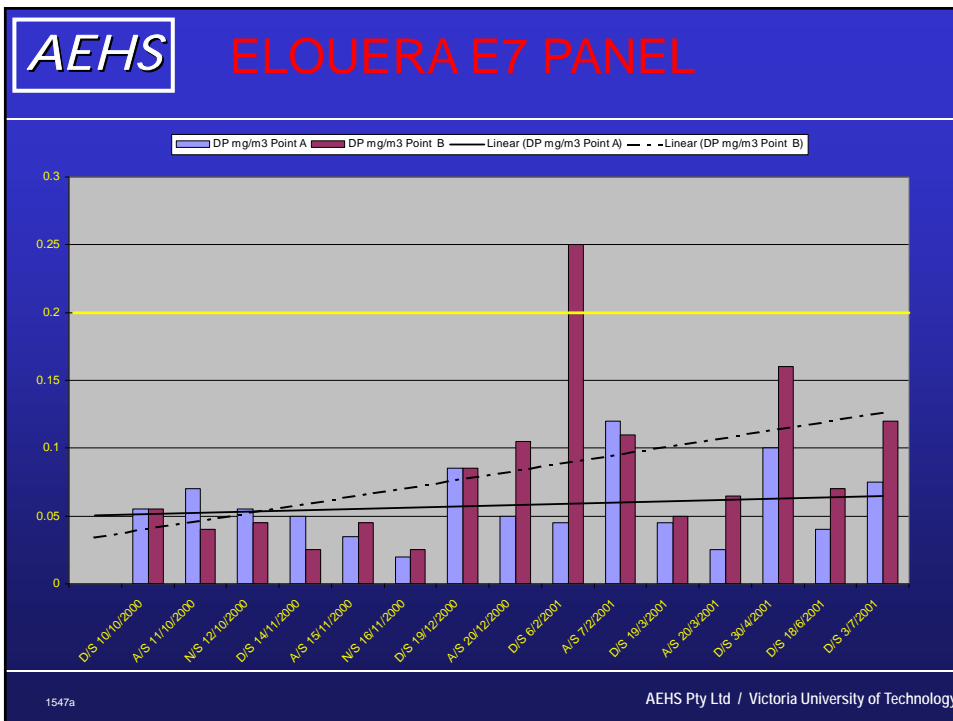
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APPLICATION OF BEST PRINCIPLES

- E7 Panel Elouera Colliery
- Regular monitoring for gaseous and DP emission during driving of longwall gate roads (10 months)
- Only one result above NSW Minerals Council Guideline
  - Ventilation stopping leak
- No complaints from workforce versus significant industrial action during drivage of E6 gate roads (parallel to E7)

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## MAINTENANCE

- Measuring raw exhaust DP levels in BHP Billiton - Illawarra Coal fleet (104 units)
- Evaluation of results in terms of maintenance procedures

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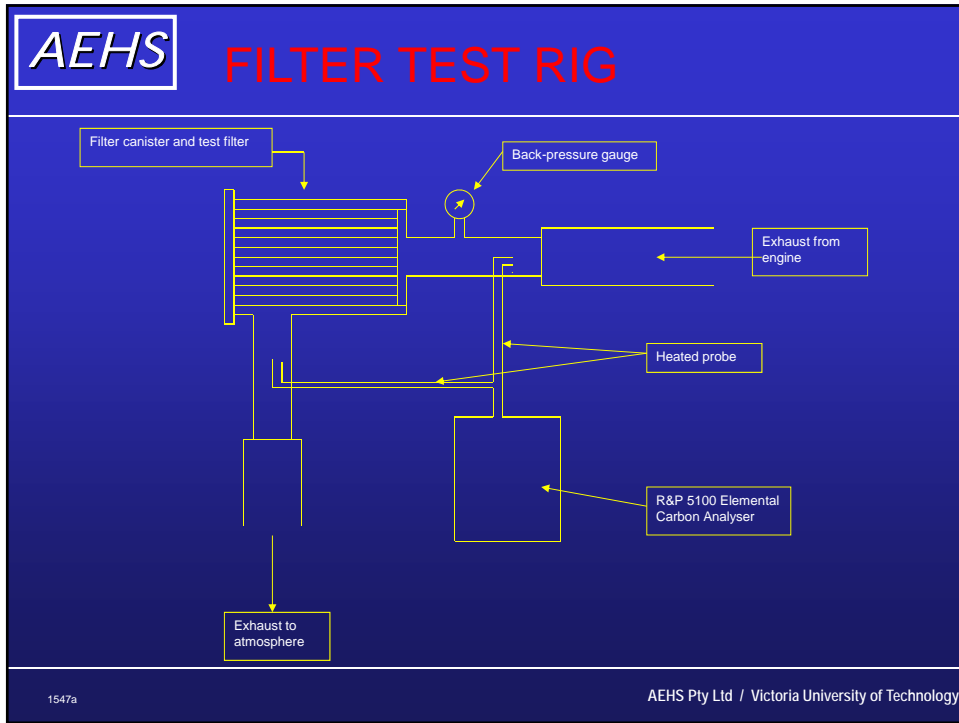
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## FILTER TEST RIG

- Aim is to use R&P 5100 to accurately test efficiency of disposable filters
- Aim to reduce backpressure without compromising filtration efficiency

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# FILTER TEST RIG



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# FILTER TEST RIG



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**AEHS****FILTER TEST RIG**

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**AEHS****RESULTS**

<b>Filter Manufacturer</b>	<b>Pleat Nos.</b>	<b>% Efficiency (95% confidence limits)</b>	
Microfresh DA100	200	83.2	(81.4 - 85.0)
	190	84.8	(83.2 - 86.5)
	180	85.7	(84.7 - 86.8)
	170	86.6	(84.7 - 88.4)
Donaldson P142100	270	64.3	(60.6 - 68.6)

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## RAW EXHAUST ANALYSIS

- Health & Safety Trust Project to evaluate surrogate hand-held technologies to measure raw exhaust DP
- Project Manager - NSW Department of Mineral Resources

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## FLAME PROTECTED VEHICLES

- Industry moving away from fully flameproof vehicles
- Fear this will increase vehicle numbers and hence DP levels in mine atmosphere
- Past research indicates lower emissions likely due to better engine design

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## SUMMARY

- Considerable progress over last 10 years in managing issue
- Focus of activity has been in Coal sector
- Metaliferrous sector becoming more active
- Considerable research in progress