Diesel Particulate Matter in Underground Mines – Controlling the Risk (an update)

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“Approximately 10% of all deaths in the industrialised world are due to lung cancer”

Professor Jimmy L Perkins
University of Texas - 2005

"Importantly, if the relative risk of lung cancer after diesel exposure is increased to 1.2, this means that the fraction of deaths caused by lung cancer would increase from **10% to 12%.** Within a large multi-national company this would amount to **few or perhaps as many as 10 deaths per year".**

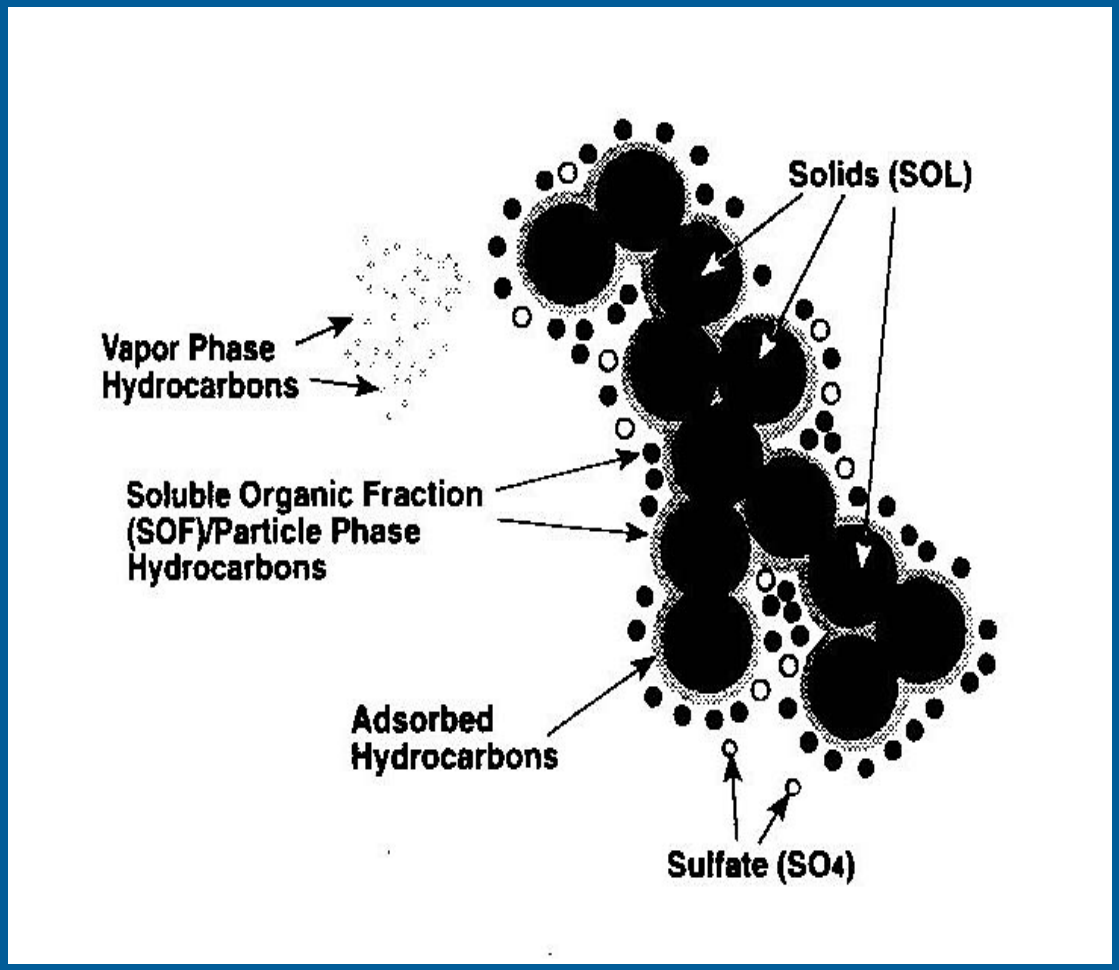
Professor Jimmy L Perkins
University of Texas - 2005

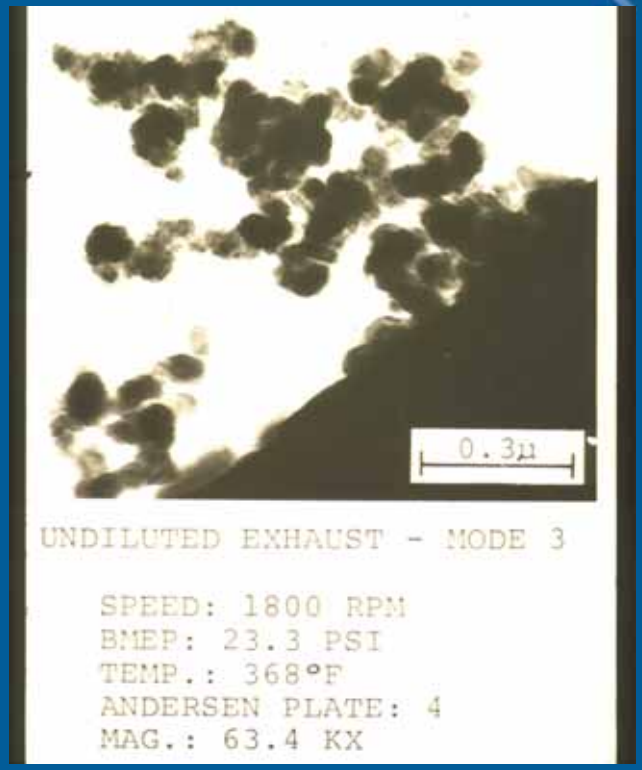
Diesel Particulate Matter in Underground Mines – Controlling the Risk.

- What is diesel emission?
  (Gases and diesel particulate matter - DPM).
- Health effects.
- How can it be measured – (what is the limit)?
- What is the current situation?
- Metalliferous.
- Coal.

What is diesel particulate matter - DPM?

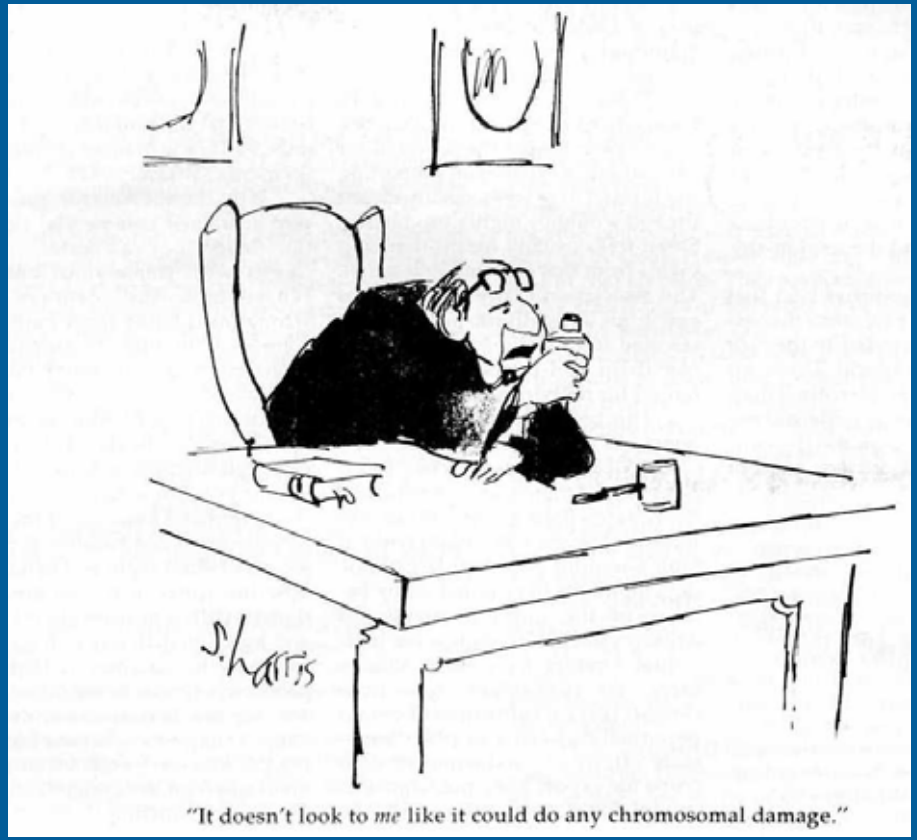

SCHOOL BUS
975


Solids (SOL)
Vapor Phase Hydrocarbons
Soluble Organic Fraction (SOF)/Particle Phase Hydrocarbons
Adsorbed Hydrocarbons
Sulfate (SO_4)


0.3µ
UNDILUTED EXHAUST - MODE 3
SPEED: 1800 RPM
BMEP: 23.3 PSI
TEMP.: 368°F
ANDERSEN PLATE: 4
MAG.: 63.4 KX

Health effects - DPM?

“It doesn’t look to me like it could do any chromosomal damage.”



"It doesn't look to *me* like it could do any chromosomal damage."

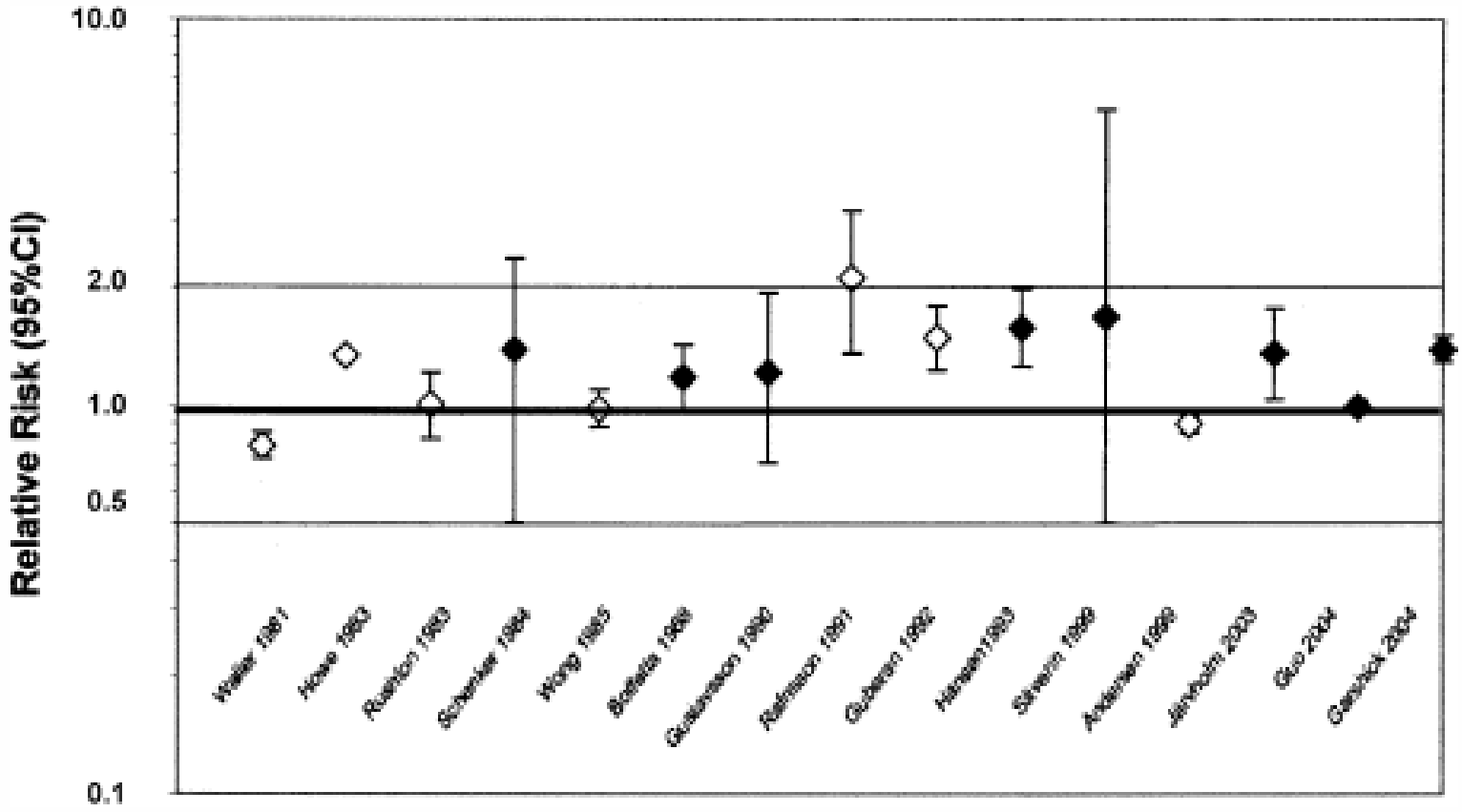


FIGURE 1. Cohort studies on occupational exposure to DE and lung cancer risk since 1981. Open marks indicate cohort studies with external reference group, filled marks represent cohort studies with internal reference group.

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Source: Diesel Exhaust and Coal Mine Dust Lung Cancer Risk in Occupational Settings
BARBARA HOFFMANN AND KARL-HEINZ JOCKEL

Queensland Government
Department of Mines and Energy

Other respiratory health effects

- Health effects from DPM on respiratory and immune systems - particularly in individuals with asthma.
- May induce non-specific inflammation and increase the response to allergens.

(HEI 2003)

How can it be measured?

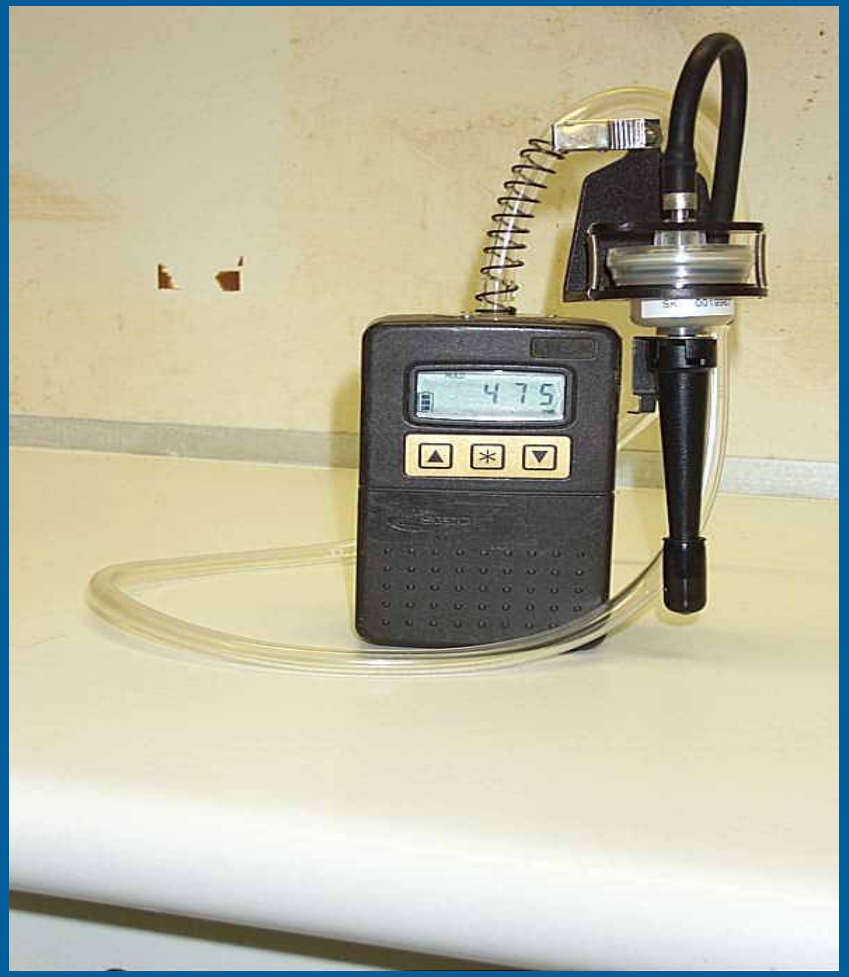
Measurement – raw exhaust gases.

Dräger
MSI 150 EURO-E
Diesel Exhaust Tester

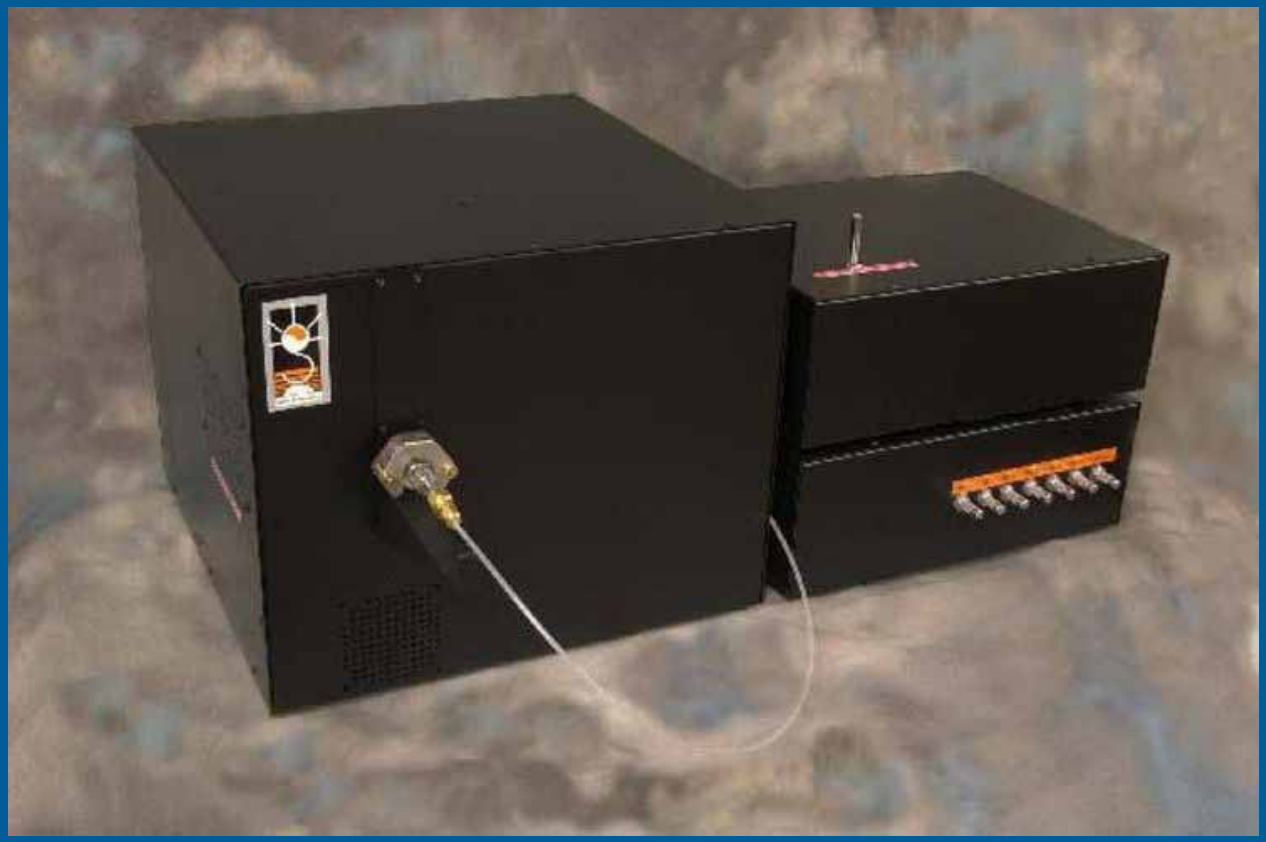
Measurement – raw exhaust diesel particulate matter (DPM).

Measurement – raw exhaust diesel particulate matter.

Personal exposure monitoring for elemental carbon. NIOSH 5040



Measurement – diesel particulate matter (EC).



What is the recommended guideline value?

(Limit for personal exposure).

Recommended Guideline Value (TWA).

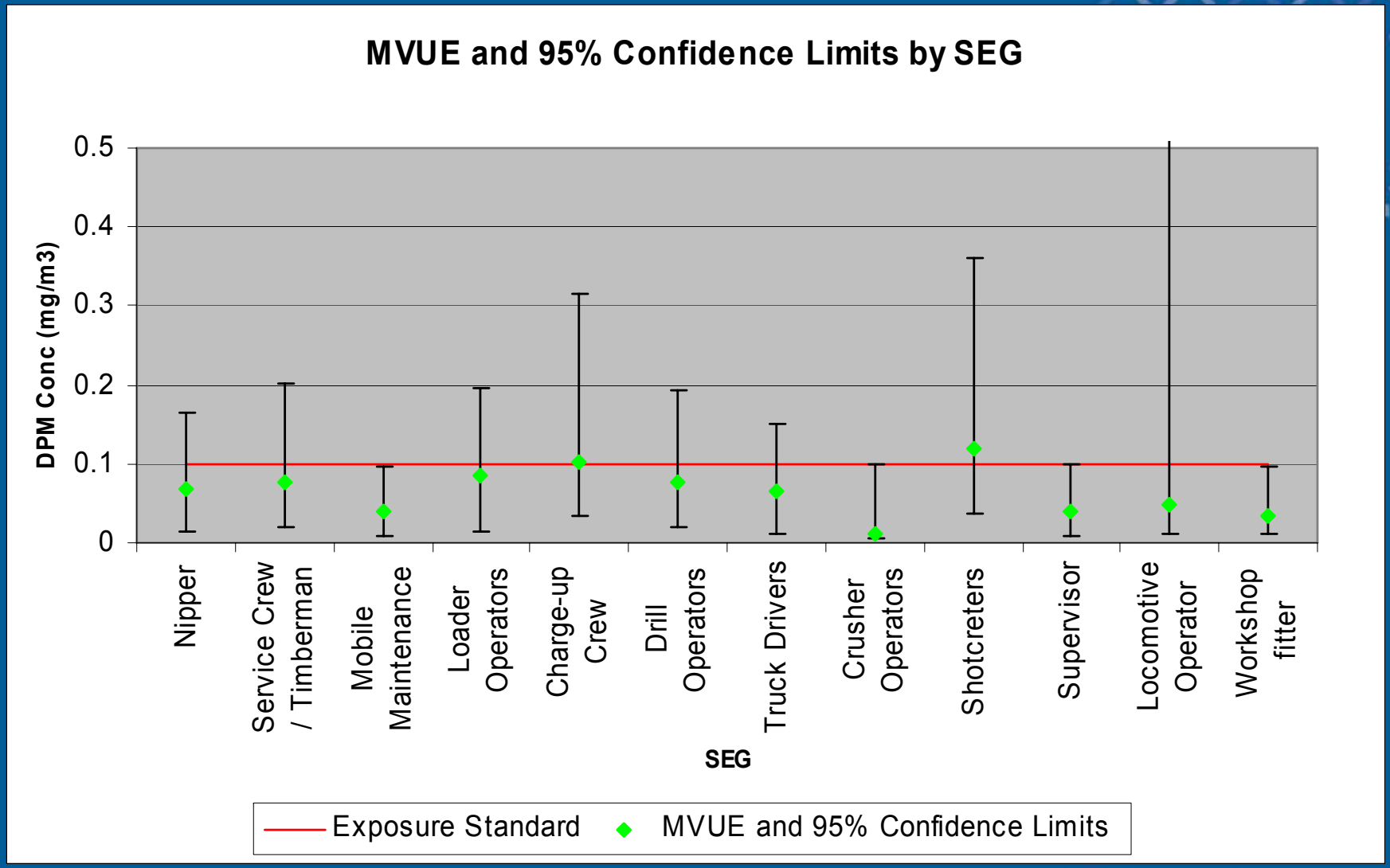
(Limit)

0.1 mg/m^3

(analysed as elemental carbon - NIOSH 5040).

Progress Metalliferous

Baseline study carried out by G Irving (Simtars) 2005



Questionnaire responses received from underground metalliferous mines (2005).

Main gaps from questionnaire responses.

Parameter:	Sulphur in fuel	Ventilation	Maintenance	
Mine Id	Nominal sulphur (ppm)	Secondary ventilation design rate (m3/s/kW)	Exhaust back pressure monitored.	Procedure to diagnose after exhaust treatment.
8	45	0.05	No	Yes
7	45	0.05	No	Yes
6	45	0.05	No	Yes
5	500	0.06	No	No
4	500	0.06	No	Yes
12	<500	0.05	Yes	Yes
10	500	0.04	No	Yes
1	100	0.04	No	No
9	320	0.04	No	No
11	Not reported	0.05	Yes	Yes
3	200	0.04	Yes	No

Ventilation

Some mines are still designing minimum ventilation rates to meet the superseded Mines Regulation Act 1964 which required 0.04 m3/s/kW.

Industry good practice generally requires a minimum of 0.06 m3/s/kW.

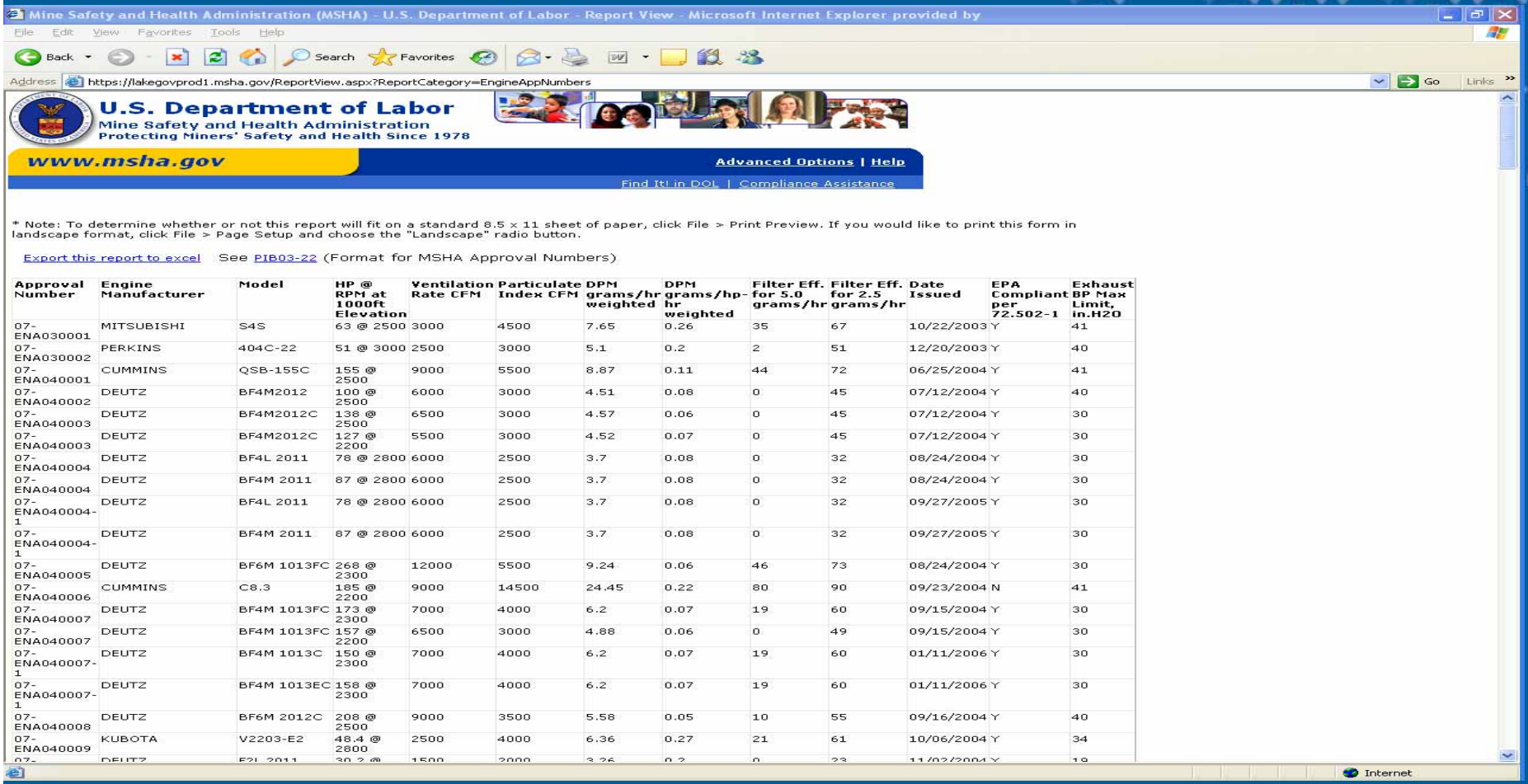
The mine ventilation design should *ensure the ventilating air in a place where a person may be present at the mine is of a sufficient volume, velocity and quality to achieve a healthy atmosphere* (*Mining and Quarrying Safety and Health Regulation 2001*).

Fuel Quality Standards Act 2000 as of 1 January 2006 the specification (limit) has been reduced to 50 ppm.

Timetable for low sulphur fuel introduction.

Year	Sulphur Content (ppm)
Pre 2003	1300 – 5000
2003 – 2005	300 – 500
2006	50
2009 - 2010	10

Manufacturers' guidelines for the backpressure limit



Mine Safety and Health Administration (MSHA) - U.S. Department of Labor - Report View - Microsoft Internet Explorer provided by

https://lakegovprod1.msha.gov/ReportView.aspx?ReportCategory=EngineAppNumbers

U.S. Department of Labor
Mine Safety and Health Administration
Protecting Miners' Safety and Health Since 1978

www.msha.gov

Advanced Options | Help

Find It! in DOL | Compliance Assistance

* Note: To determine whether or not this report will fit on a standard 8.5 x 11 sheet of paper, click File > Print Preview. If you would like to print this form in landscape format, click File > Page Setup and choose the "Landscape" radio button.

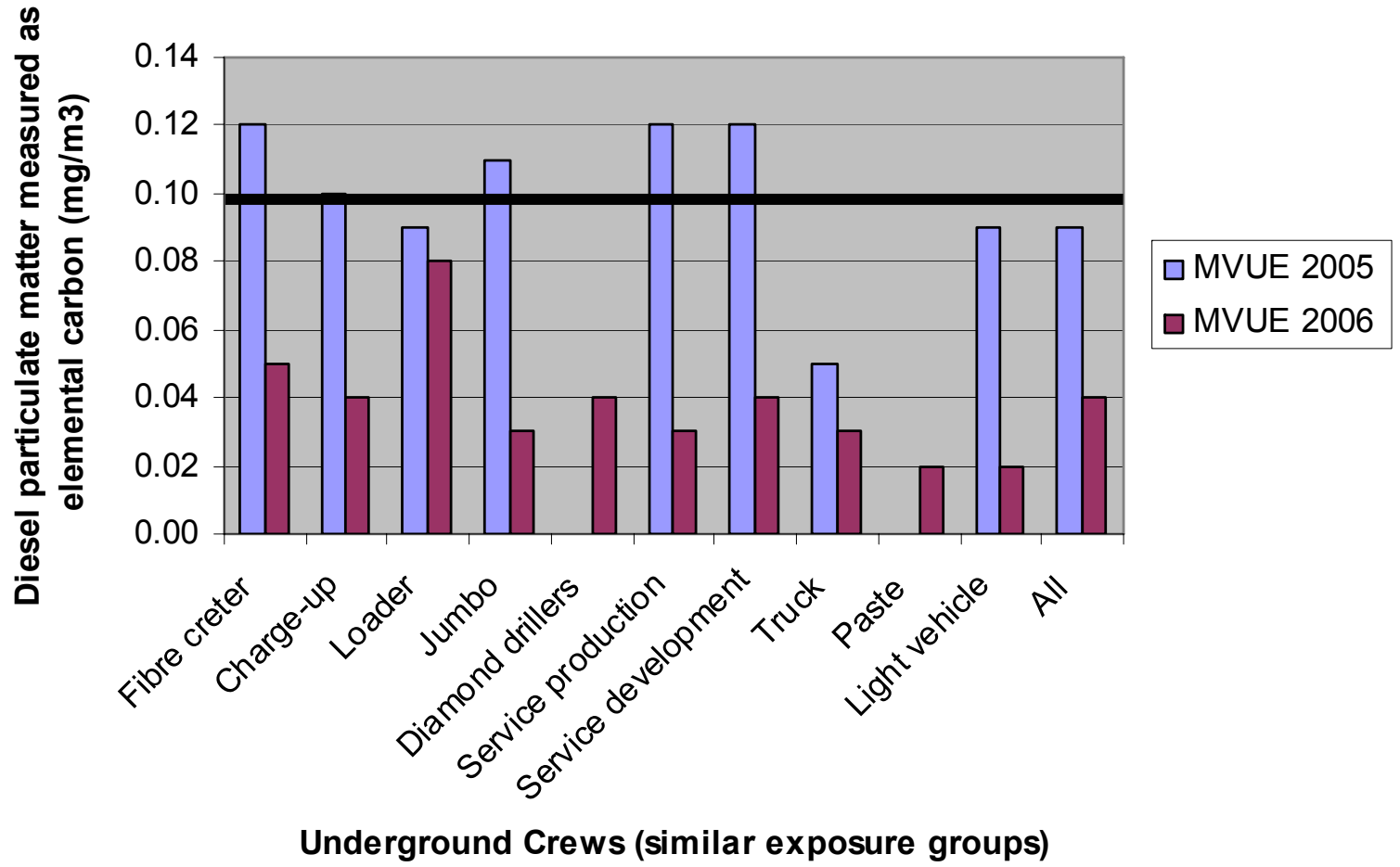
Export this report to excel See PIB03-22 (Format for MSHA Approval Numbers)

Approval Number	Engine Manufacturer	Model	HP @ RPM at 1000ft Elevation	Ventilation Rate CFM	Particulate Index CFM	DPM grams/hr weighted	DPM grams/hp-hr weighted	Filter Eff. for 5.0 grams/hr	Filter Eff. for 2.5 grams/hr	Date Issued	EPA Compliant per 72.502-1	Exhaust BP Max Limit, in.H2O
07-ENA030001	MITSUBISHI	S4S	63 @ 2500	3000	4500	7.65	0.26	35	67	10/22/2003	Y	41
07-ENA030002	PERKINS	404C-22	51 @ 3000	2500	3000	5.1	0.2	2	51	12/20/2003	Y	40
07-ENA040001	CUMMINS	QSB-155C	155 @ 2500	9000	5500	8.87	0.11	44	72	06/25/2004	Y	41
07-ENA040002	DEUTZ	BF4M2012	100 @ 2500	6000	3000	4.51	0.08	0	45	07/12/2004	Y	40
07-ENA040003	DEUTZ	BF4M2012C	138 @ 2500	6500	3000	4.57	0.06	0	45	07/12/2004	Y	30
07-ENA040003	DEUTZ	BF4M2012C	127 @ 2200	5500	3000	4.52	0.07	0	45	07/12/2004	Y	30
07-ENA040004	DEUTZ	BF4L 2011	78 @ 2800	6000	2500	3.7	0.08	0	32	08/24/2004	Y	30
07-ENA040004	DEUTZ	BF4M 2011	87 @ 2800	6000	2500	3.7	0.08	0	32	08/24/2004	Y	30
07-ENA040004-1	DEUTZ	BF4L 2011	78 @ 2800	6000	2500	3.7	0.08	0	32	09/27/2005	Y	30
07-ENA040004-1	DEUTZ	BF4M 2011	87 @ 2800	6000	2500	3.7	0.08	0	32	09/27/2005	Y	30
07-ENA040005	DEUTZ	BF6M 1013FC	268 @ 2300	12000	5500	9.24	0.06	46	73	08/24/2004	Y	30
07-ENA040006	CUMMINS	C8.3	185 @ 2200	9000	14500	24.45	0.22	80	90	09/23/2004	N	41
07-ENA040007	DEUTZ	BF4M 1013FC	173 @ 2300	7000	4000	6.2	0.07	19	60	09/15/2004	Y	30
07-ENA040007	DEUTZ	BF4M 1013FC	157 @ 2200	6500	3000	4.88	0.06	0	49	09/15/2004	Y	30
07-ENA040007-1	DEUTZ	BF4M 1013C	150 @ 2300	7000	4000	6.2	0.07	19	60	01/11/2006	Y	30
07-ENA040007-1	DEUTZ	BF4M 1013EC	158 @ 2300	7000	4000	6.2	0.07	19	60	01/11/2006	Y	30
07-ENA040008	DEUTZ	BF6M 2012C	208 @ 2500	9000	3500	5.58	0.05	10	55	09/16/2004	Y	40
07-ENA040009	KUBOTA	V2203-E2	48.4 @ 2800	2500	4000	6.36	0.27	21	61	10/06/2004	Y	34
07-	DEUTZ	F2L 2011	30.2 @	1500	2000	3.26	0.2	0	23	11/02/2004	Y	19

Internet

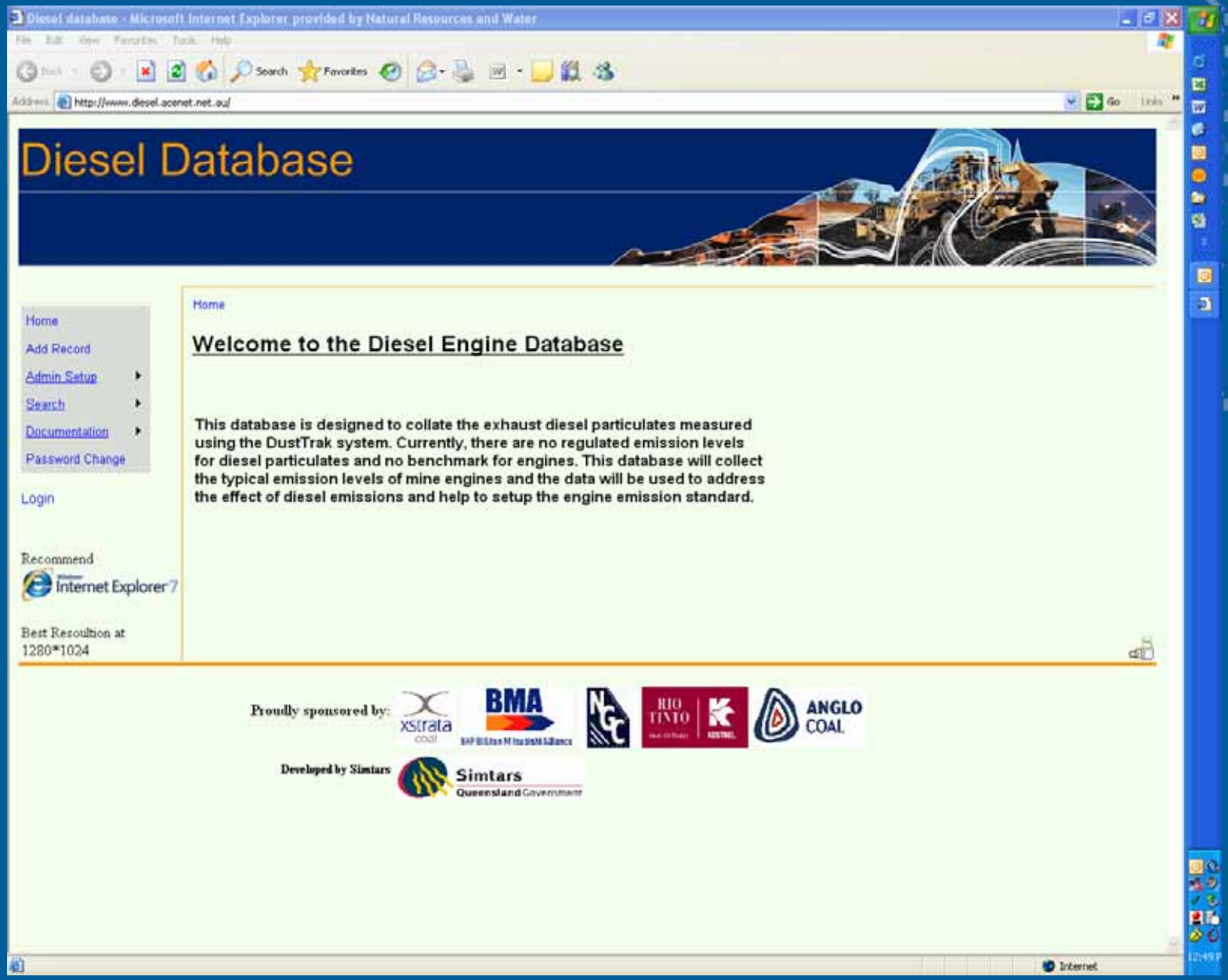
- Is meeting the recommended guideline value (limit) of 0.1 mg/m^3 EC achievable?

Reduction of potential exposures to elemental carbon from diesel emission in one metalliferous mine.



Progress in Coal

- Industry steering committee established in February 2004. Representation from Mines Inspectorate, CFMEU and industry.
- DPM raw exhaust testing as part of PM program.
- Coal mines are currently participating in DPM audits administered by the Inspectorate.
- Database (Simtars) provided to industry to track diesel engines.


Diesel database - Microsoft Internet Explorer provided by Natural Resources and Water
http://www.diesel.acenet.net.au/
Diesel Database
Home
Add Record
Admin Setup
Search
Documentation
Password Change
Login
Recommend
Internet Explorer 7
Best Resolution at 1280*1024
Home
Welcome to the Diesel Engine Database
This database is designed to collate the exhaust diesel particulates measured using the DustTrak system. Currently, there are no regulated emission levels for diesel particulates and no benchmark for engines. This database will collect the typical emission levels of mine engines and the data will be used to address the effect of diesel emissions and help to setup the engine emission standard.
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xstrata coal
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Simtars
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Internet

BHP Billiton Mitsubishi Alliance
GREGORY CRINUM MINE

BMA – Gregory Crinum

BHP Billiton Mitsubishi Alliance
GREGORY CRINUM MINE

Using Diesel Exhaust Testing as a Diagnostic Tool

- High emissions also indicate unhealthy engines.
- Baseline exhaust monitoring has been used to predict optimum service times and to refine existing maintenance regimes
- Highly proactive (don't wait for the problem to present itself)
- Benefits extended to Worker Health and Engine Life.

BHP Billiton Mitsubishi Alliance
GREGORY CRINUM MINE

Maintenance Guide

- When engine raw exhaust exceeds DP of 60 mg/m^3 → indicates a problem.
- A step by step maintenance flow chart has been developed to assist fitters.
- Begins with relatively simple checks (filter condition and cleaning scrubbers)
- Progresses to more involved procedures (ie. reset valve clearances and replacing injectors).
- Raw exhaust is measured at each stage.

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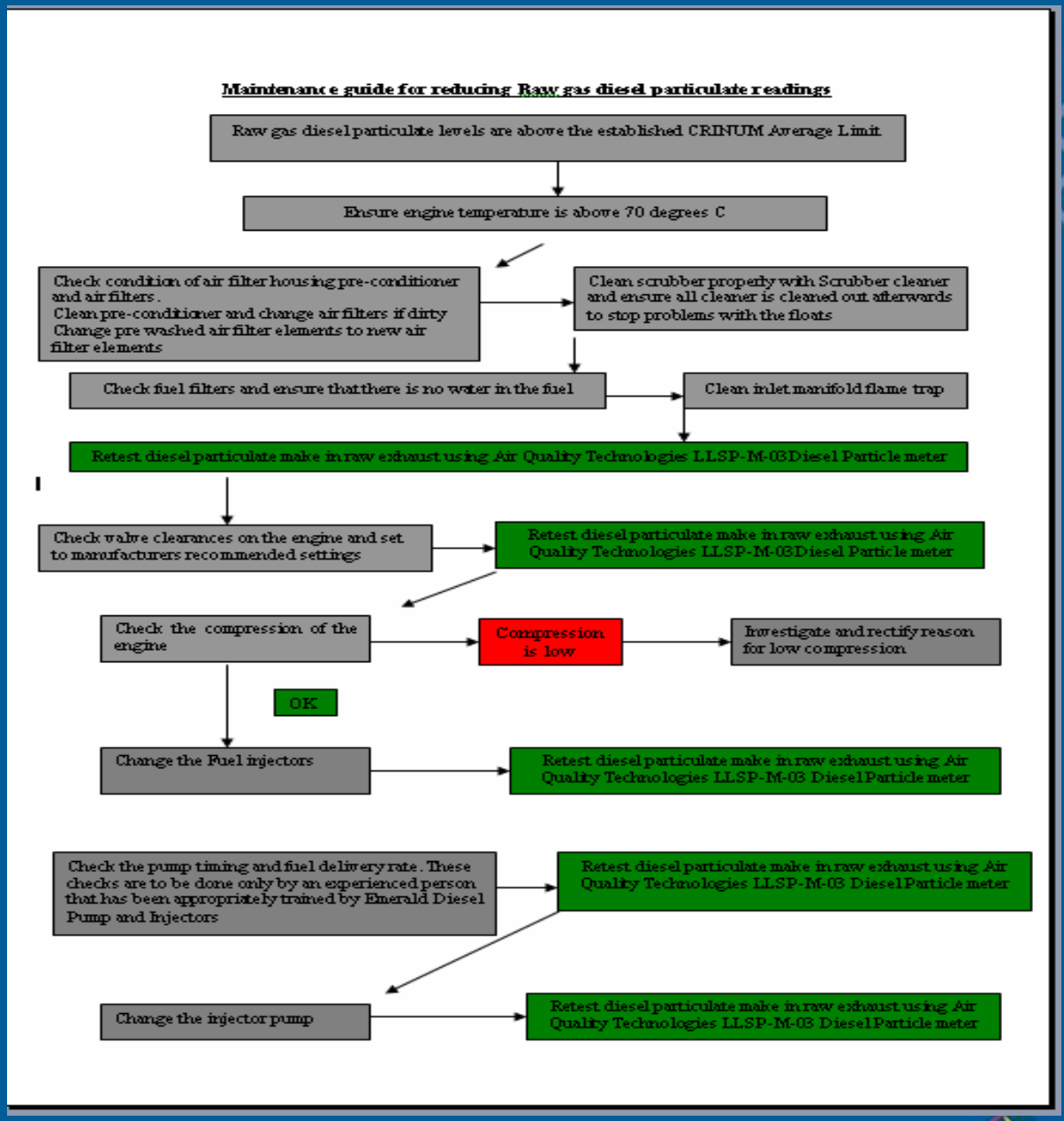

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Dyno Testing conducted by Kestrel and Emerald Diesel Pumps and Injector Service

- SMV Driftrunner with a 6L 1000 series Perkins engine.
- DPM measurements taken pre scrubber.
- Reduction in average DPM from 15 – 0.35 mg/$m^{3.}$
- Major Gains were achieved by resetting valve clearances and replacing injectors.
- Further gain by changing pump (DB2 to DB4)
- Now all valve clearances are reset and injectors replaced at every 1000hrs

Establishing Limits

- Extensive baseline monitoring conducted (6 – 8 months)
- Limits were established for Max and Average DPM in mg/m3
- If either limit is exceeded the equipment is removed from service
- Limits are constantly being reviewed to as low as reasonably achievable (alara)

Kestrel Coals Upper tail pipe limits (measured post scrubber as DPM in mg/m^3)

Equipment	Engine	Max DP limit	Max Av DP Limit
Eimco 913	Cat 3304	80	40
Eimco 975	Cat 3304	80	40
Eimco trencher	Cat 3304	80	40
Grader	Cat 3304	80	40
Eimco EJC130	Cat 3306	120	60
Eimco ED10	Cat 3126DITA	100	55
Eimco 913-6	Cat 3306	120	60
Eimco chock carrier	Cat 3306	120	60
SMV Driftrunner	Perkins 1000/6	120	50
SMV Ranger	Perkins 1000/4	80	40
Bobcat	Perkins 1000/4	80	40
Juganaut	Hino	40	25

How to control the risk?

Low Sulfur (≤ 15 ppm) Fuel

US EPA, say when fully implemented (in US):

Prevention of (/year):

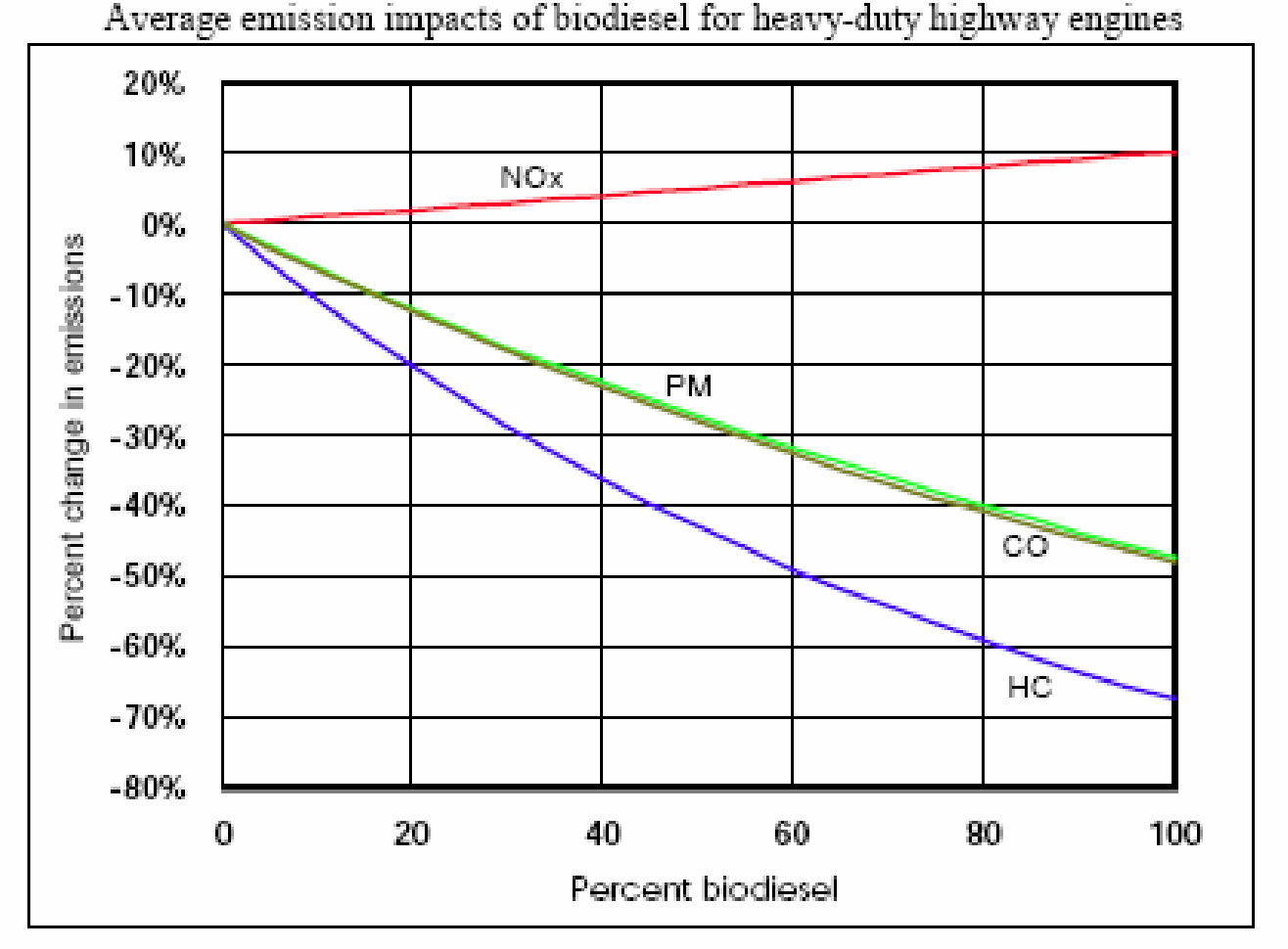
- 8,300 premature deaths
- 5,500 cases of chronic bronchitis
- 17,600 cases of acute bronchitis in children
- 360,000 asthma attacks/ 386,000 cases of respiratory symptoms in asthmatic children

For asthmatics:

- 1.5 million less lost work days
- 7,100 fewer hospital visits
- 2,400 fewer emergency room visits

Source:
Susan T. Bagley
Department of Biological Sciences Michigan Technological University
Houghton, Michigan USA

Biodiesel



Source:
United States Environmental Protection Agency 2002; A comprehensive Analysis of Diesel Impacts on Exhaust Emissions – Draft Technical Report, October 2002.

RIO TINTO COAL AUSTRALIA | KESTREL

BMA
BHP Billiton Mitsubishi Alliance
GREGORY CRINUM MINE

Bio diesel Trials

- Gregory Crinum and Kestrel conducting preliminary trials on the potential of bio diesel.
- A driftrunner and a PJB will be switched to biodiesel.
- Parameters such as DP and exhaust gas will be measured.
- Engine performance, engine power and fuel consumption will be monitored.
- This may lead to more extensive onsite trials.

Maintenance

Diesel Emissions Evaluation Program (DEEP) website:

http://www.deep.org/

- The relationship between diesel engine maintenance and exhaust emissions.
- Maintenance guidelines and best practices for diesel engines in underground mining.
- Diesel engine maintenance audit plan.
- Diesel emissions mechanics maintenance manual.
- Diesel emissions instructors guide.

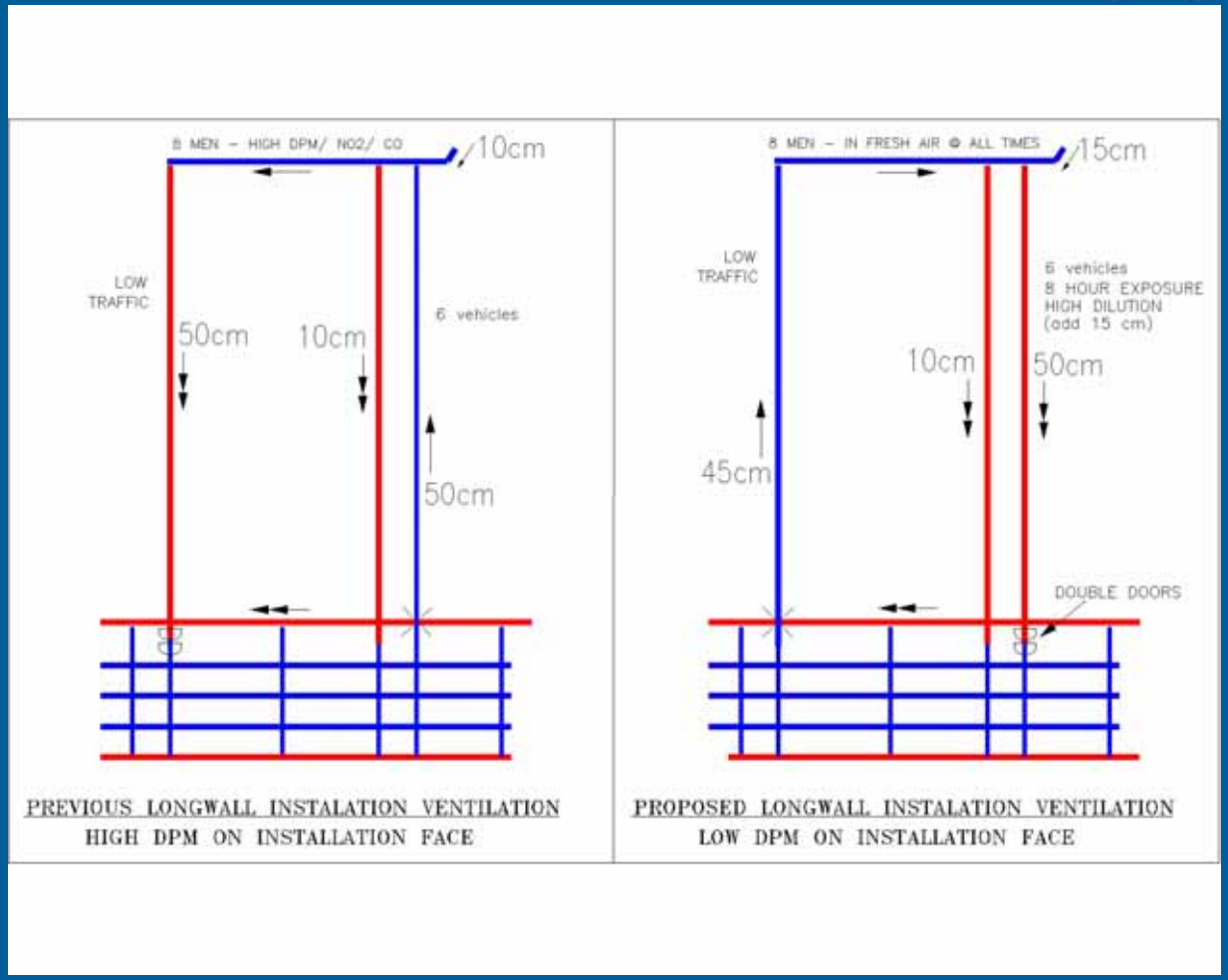
- NSW MDG 29 (DPI) (July 2007), *Guideline for the Management of Diesel Pollutants in Underground Environments*.

Education

- Checking ventilation.
- Pre-start checks.
- Drive to conditions.
- Regular road maintenance.
- Do not labour the engine excessively.
- Don’t convoy.
- Fuel handling.
- Cooling system.
- Lubrication.


FRONT
TWO ARE
GROUTED
19-12-04
DO NOT
27 APR 2005

Ventilation during Longwall Moves



Ventilation and sex

- “Everyone” is for it.
- “Everyone” feels that they understand it.
- “Everyone” thinks that it is natural.
- “Everyone” practices it.
- “Everyone” thinks that any problems are caused by the other party.

There is no single solution!

The DPM reduction program must use an integrated approach.

Respiratory protective equipment program.

Until you can bring DPM within industry limit.