



# Real-Time DPM Measurement as a Maintenance Tool : The Australian Experience



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Presentation:

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# Developing a DPM Management Strategy



**Research / Evaluation**

**Government Responses**

**Pre-Program DPM Emission Profiles**

**Test Equipment**

**Implementation**

**Program Effectiveness**

**Summary & Conclusions**

- An intensive testing and evaluation study undertaken by The Australian Coal Industry's Research Program (ACARP) and coordinated by the New South Wales Department of Primary Industry's Mines Technical Services Division
  - in conjunction with SIMTARS , NIOSH
  - supported by external consultants and industry
  - over the period 2000~2002
- **Aim:** *“...to find one or more methods for measuring diesel particulate matter (DPM) in the raw exhaust of diesel-powered mining equipment at underground coal mines”.*

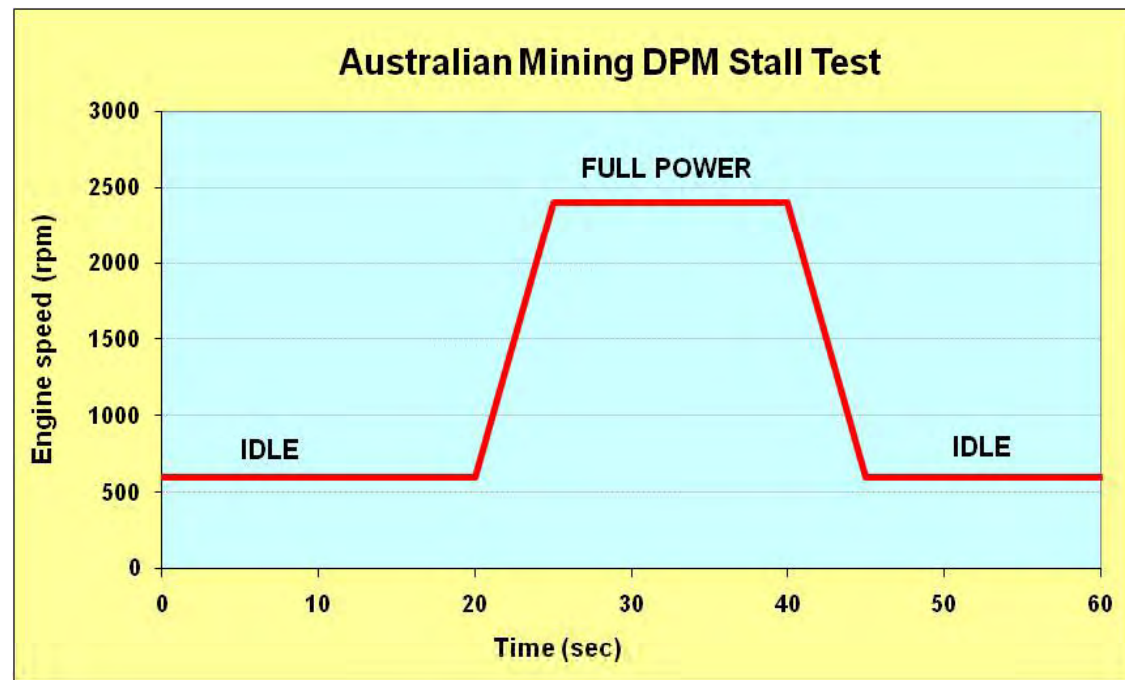
## Dynamometer Testing

- of candidate instrument performance and comparison
- Evaluation of suitability for DPM testing under closely controlled conditions
- 3 engines (Cat 3306, Kia 4100, Cat 3126)
- 4 instruments (three laser light-scattering, one pressure drop)
- tested over 8 steady state and two transient modes
- results correlated with traditional gravimetric filter method

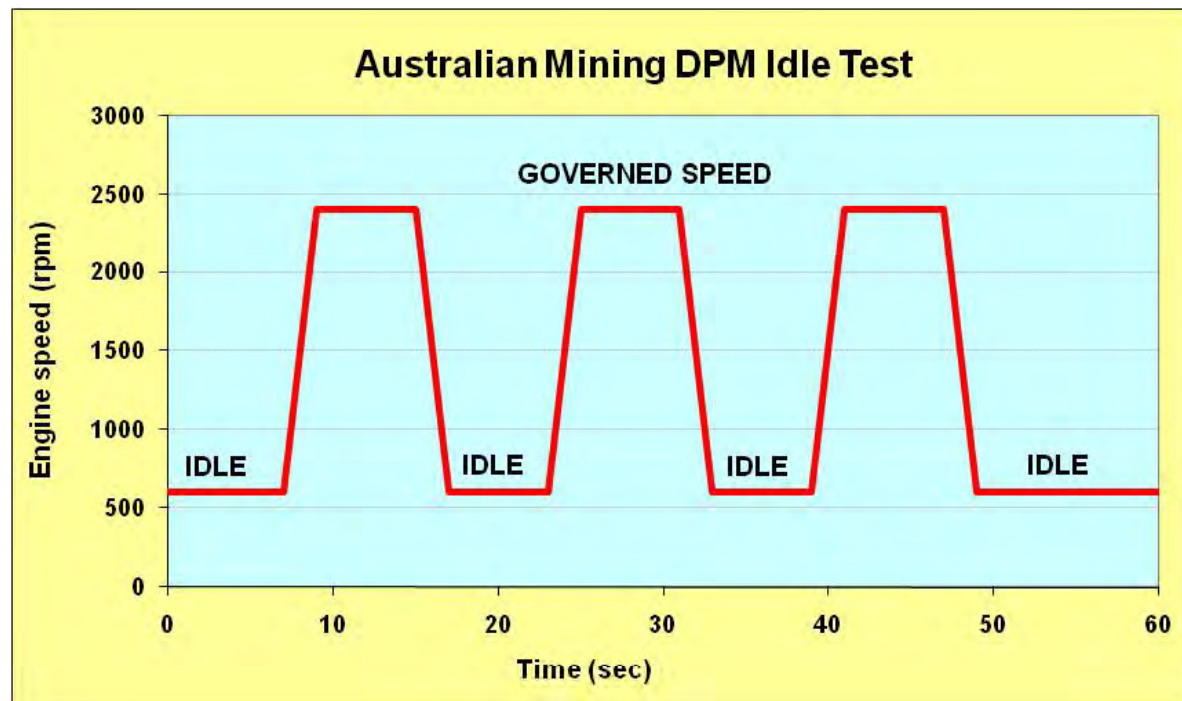
## Field Testing

- **five New South Wales mines selected as test sites**
- **where feasible, multiple instruments were operated in parallel**
- **mixture of steady-state and transient tests used**
- **tests included free acceleration, idle and acceleration/power modes with torque converter engaged**

- **Stall Test**
  - **60-second idle/full power/idle test with drive engaged, using the torque converter as a dynamometer.**



- **Free Acceleration Test**
  - for plant with no torque converter, three full-throttle accelerations (gear in neutral) to governed speed, spaced over 60 seconds



# Initial Government Response (Summary)



## Primary Guidelines

- ambient DPM exposure limit 0.1mg/m<sup>3</sup> elemental carbon (EC). EC to be calculated as equivalent to 0.5 x total suspended diesel particle mass
- all new engines to have “signature” test before entering service
- all existing engines to be maintained to “best” emissions level then have “signature” test
- periodic (max 4 week intervals) testing to monitor condition and trigger rectification if DPM exceeds limit (initially 30% > than signature, soon to be 20%)
- records to be maintained of all test results for individual vehicles/plant



# Pre-Program DPM Emission Profiles

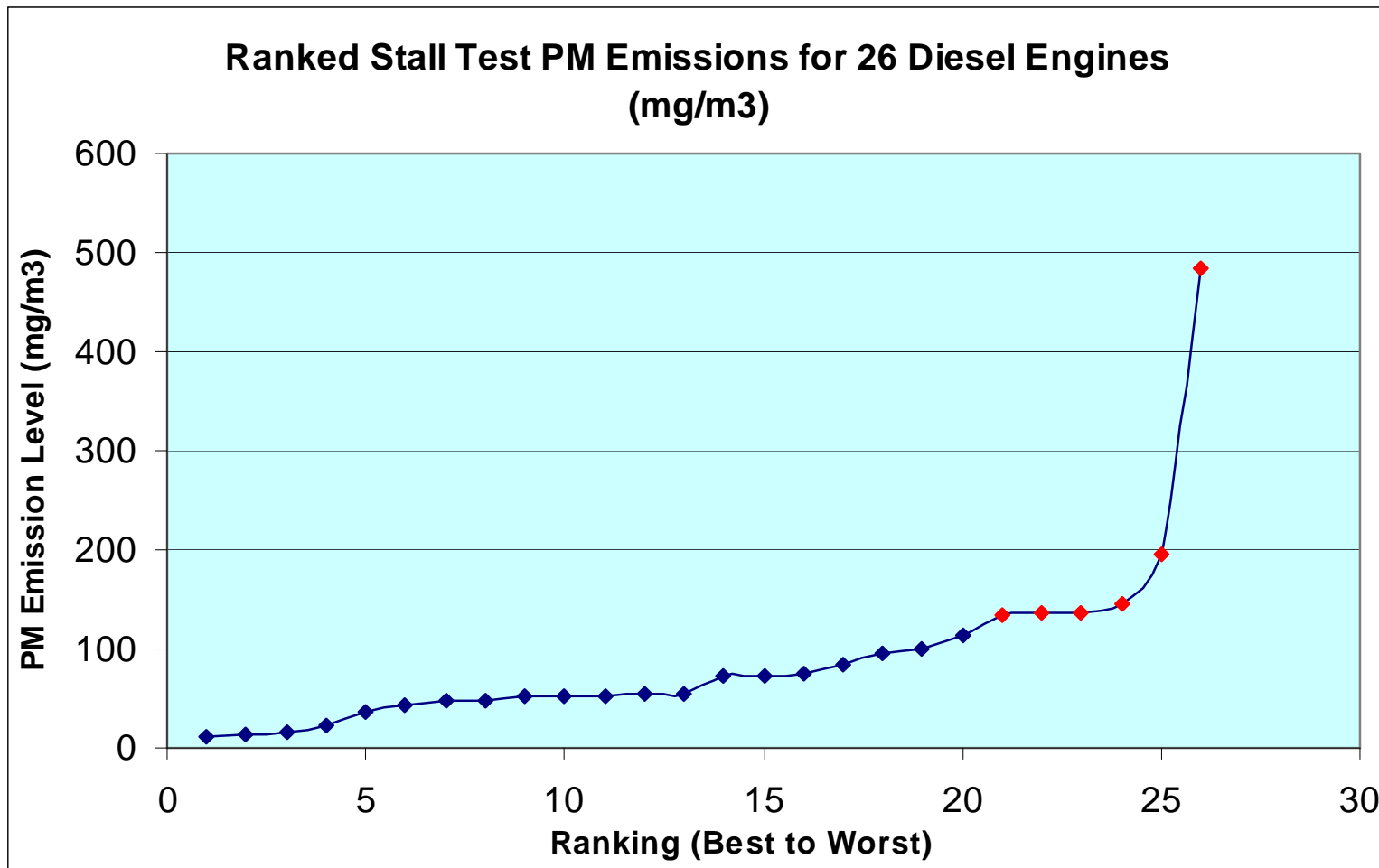


**Preliminary fleet testing was performed at several mines to characterize the emission profiles of vehicles.**

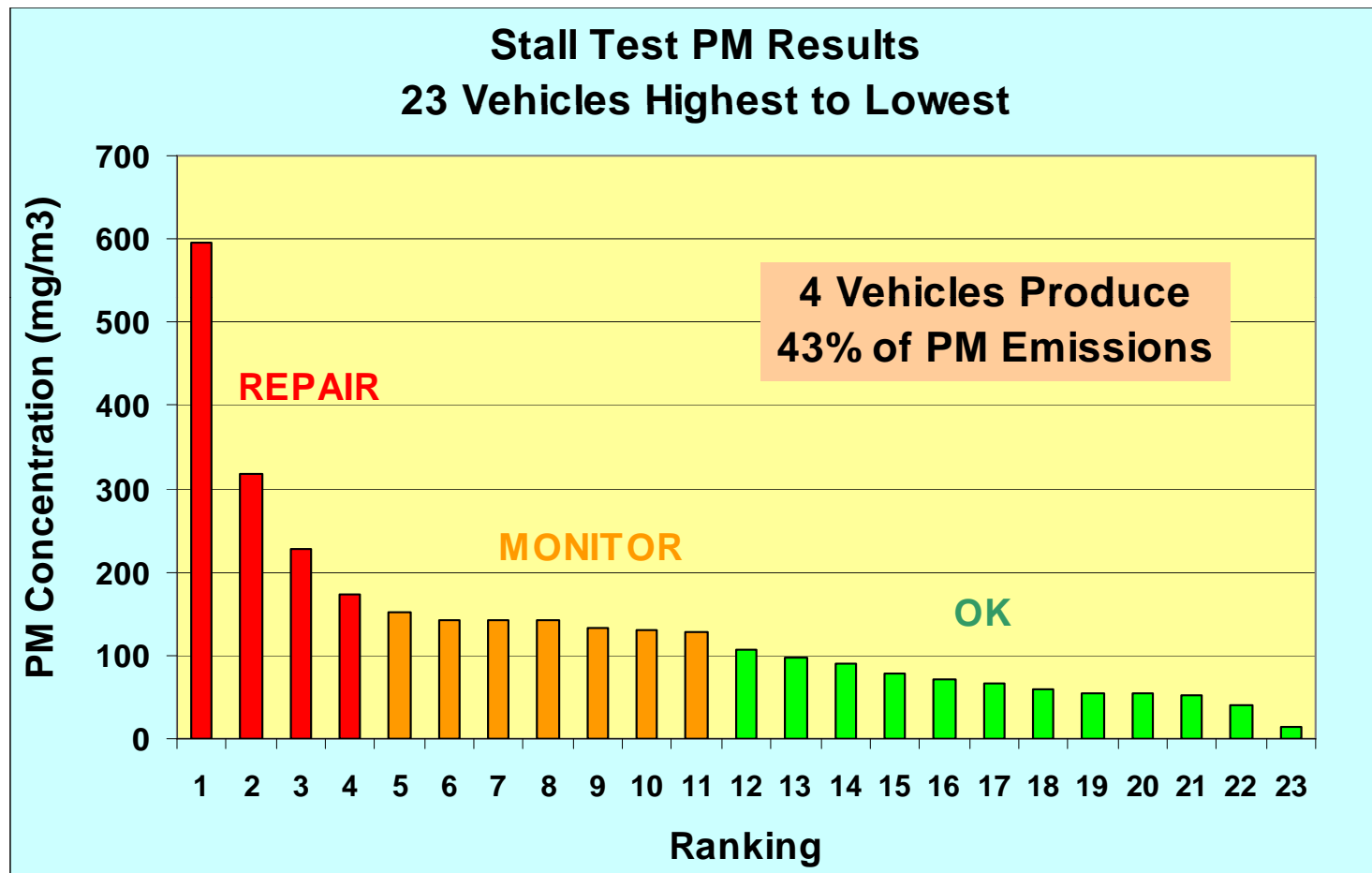
**Results of this testing showed considerable similarities**

- most engines had low - moderate emissions, with a few very high emitters peaking the curve**

# DPM Emission Distribution: Initial Survey (Example 1)



# DPM Emission Distribution: Initial Survey (Example 2)



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# Correlations, Test Cycle vs On-Task Operation

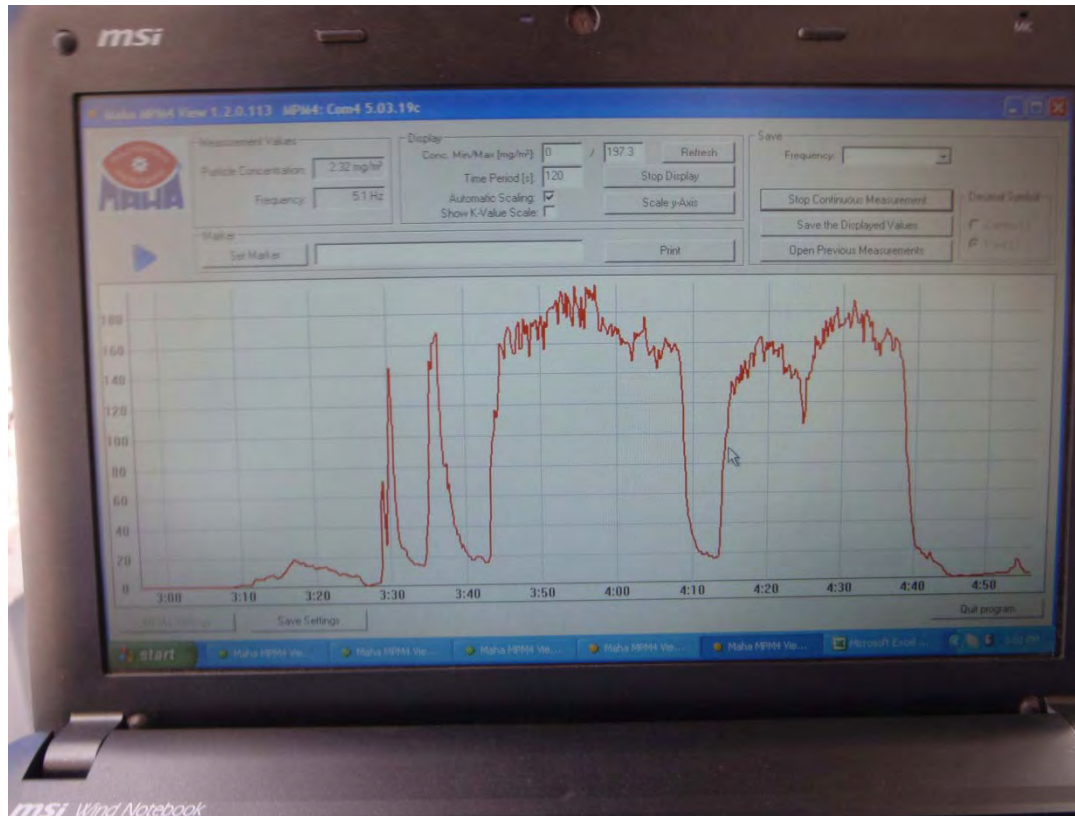


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# On-Vehicle Testing



# On-Board Real Time Recording

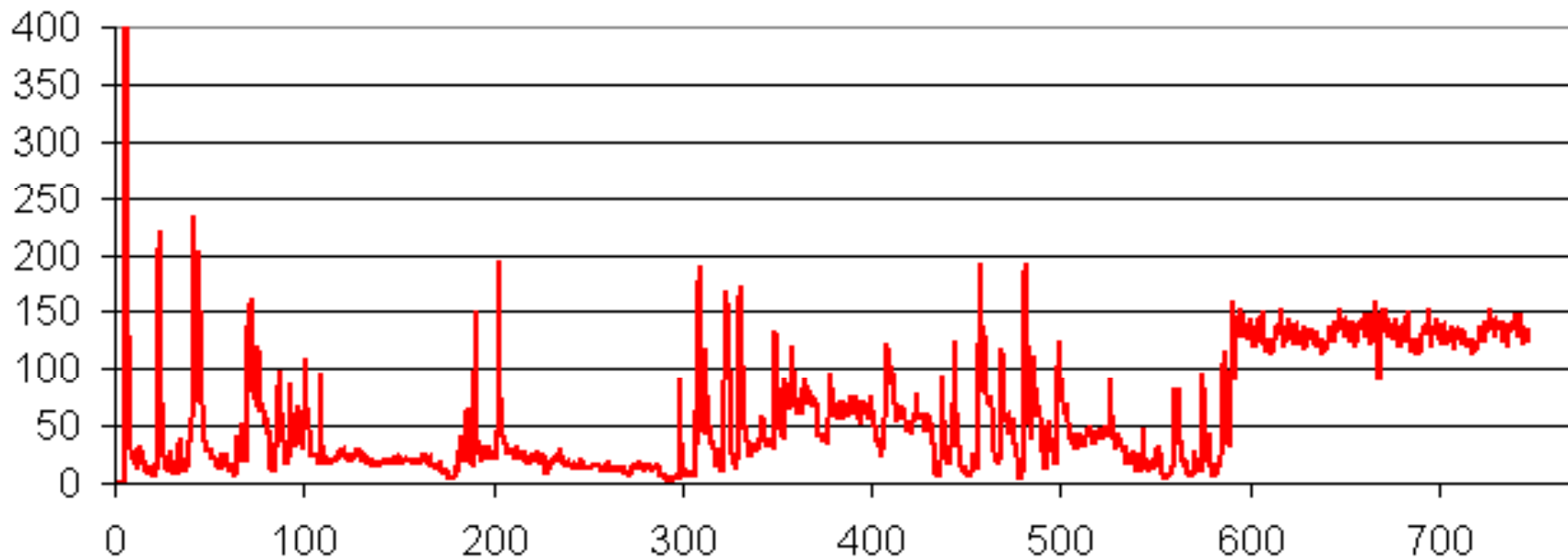


**Custom software (available with instrument) stores and charts continuous DPM Concentration vs Time for analysis and correlation studies**

# Correlation, Example 1



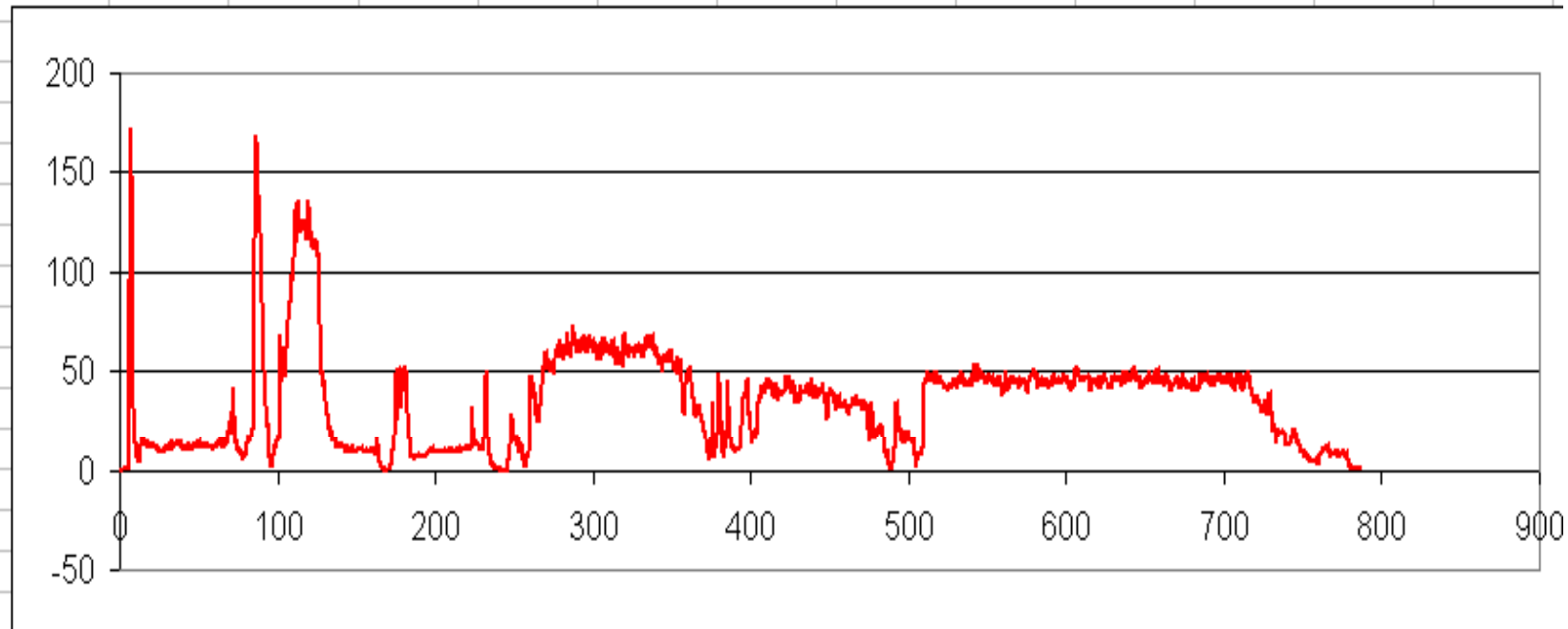
	Static Test	Min	Max	Average
		6.7	194	58.1
Average =	58.16394			
	Engine hours	6758		
	Last 1000 service	0		



# Correlation, Example 2



Static Test	Min	Max	Average
	20.5	66	36.5
Engine hours	7822		
Average = 34.34803	Last 1000 service		
	676		



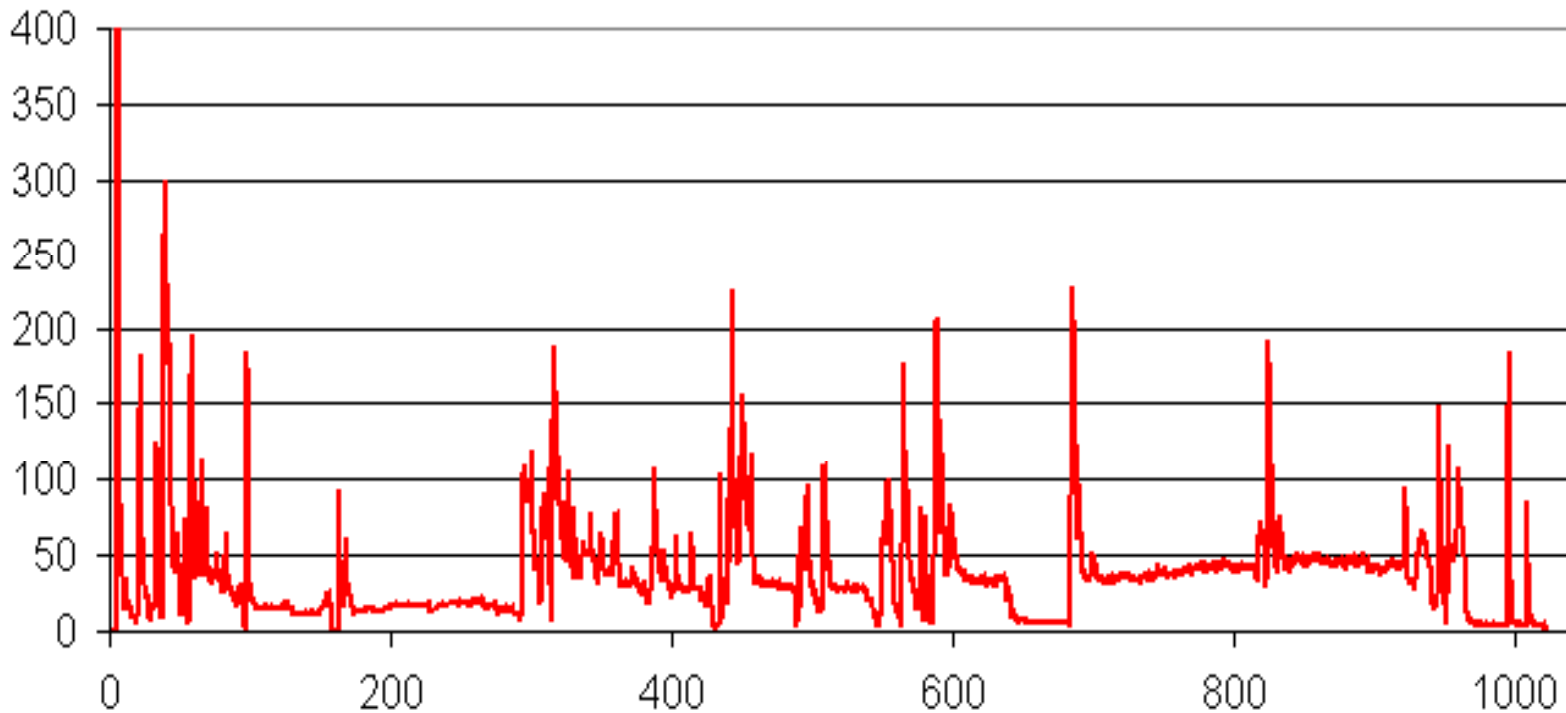


# Correlation, Example 3



Static Test	Min	Max	Average
	6.6	416	48.8

Average = 38.0728



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# Implementation



- **Third generation laser light scattering (LLSP) is now the measuring method of choice in Australia**
- **Incorporates several years of experience and industry feedback**
- **Simple one-button operation**
- **Auto-zero before every test**
- **NiMH Battery, >2hrs testing**
- **Remote control for single person testing**
- **On-screen and flashing LED operator prompts**
- **Automatic test result generation**
- **Simple field calibration and service**



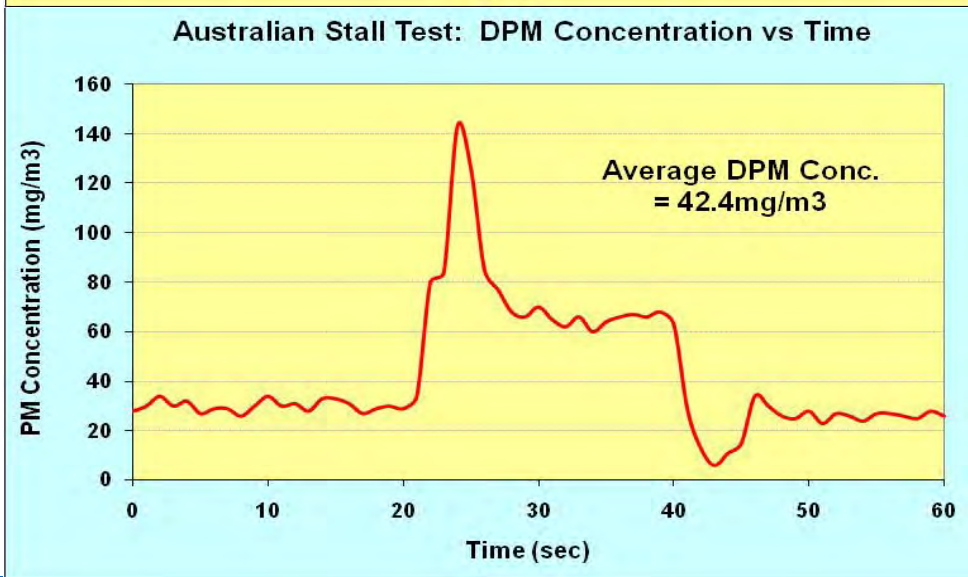
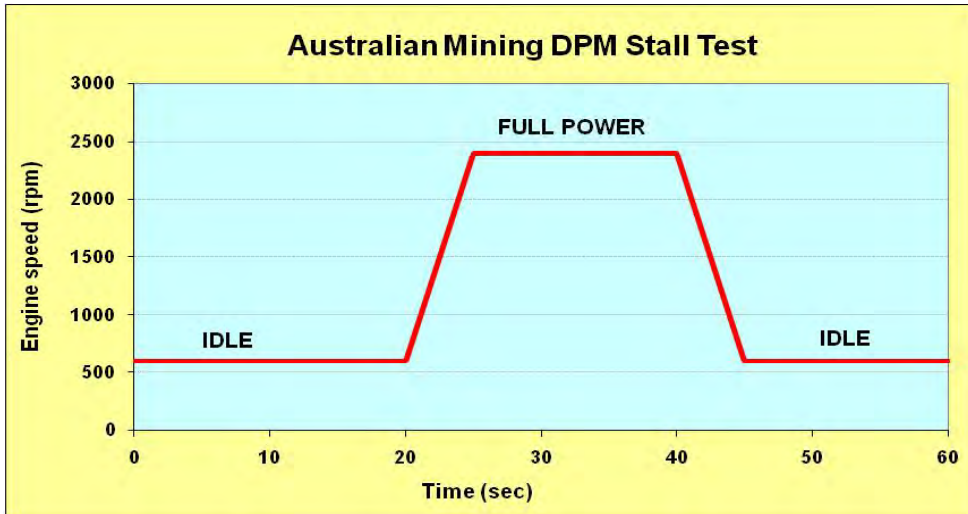
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## MPM-4M (4<sup>th</sup> Generation)

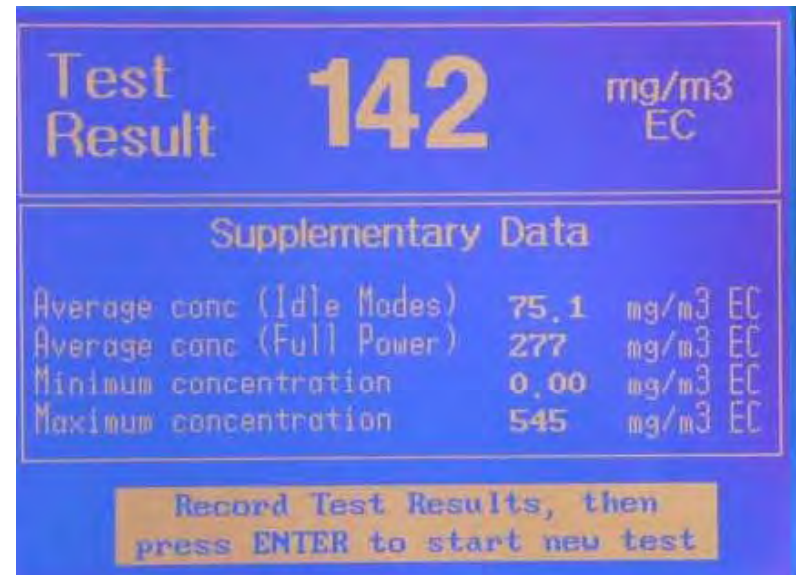


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# Stall Test DPM Results (Typical)



## Test Result Screen (Example)



**Second-by-second test data can also be exported directly to PC via RS232/USB**

# Testing Program

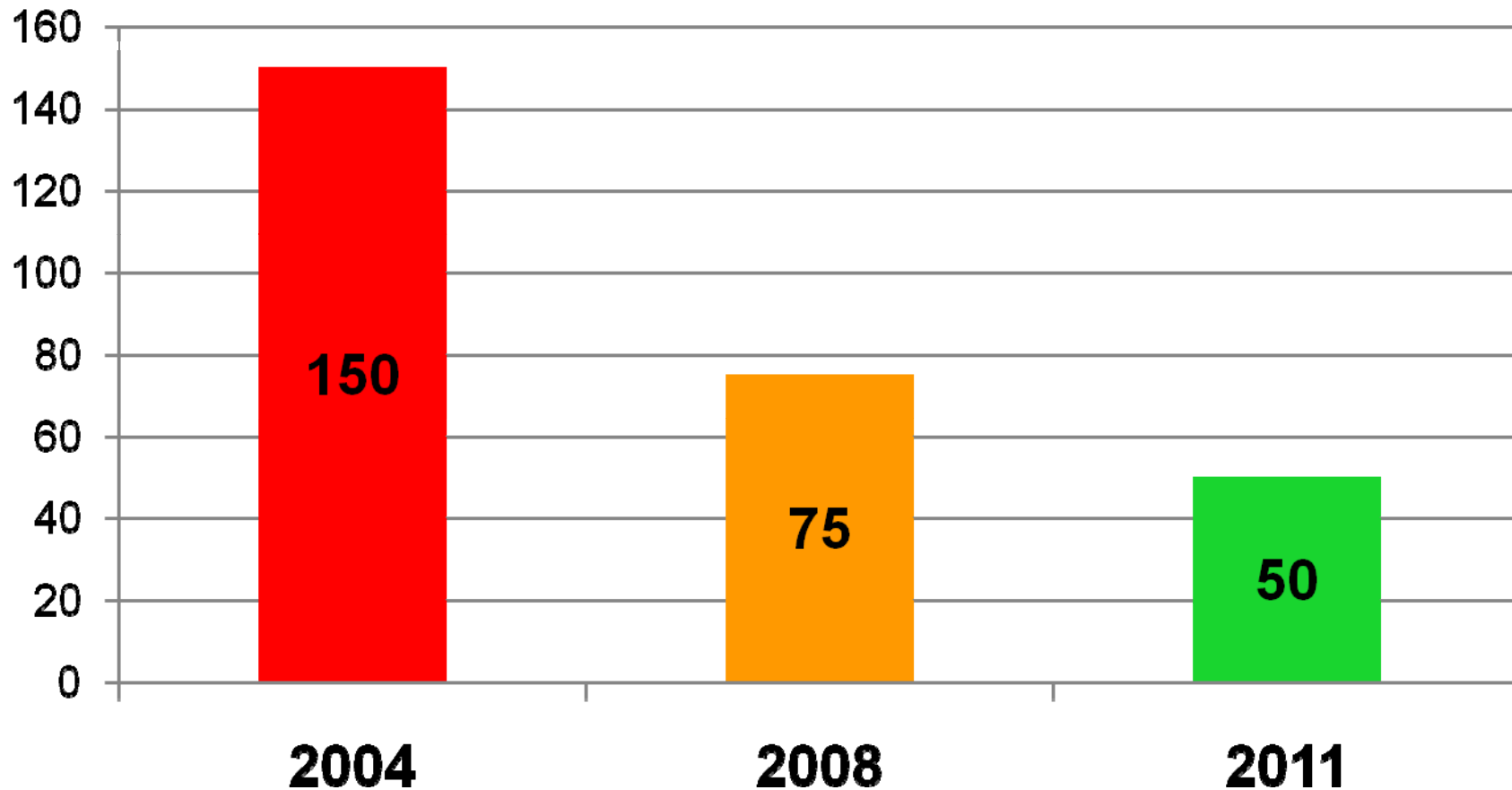


- **Every vehicle and item of plant operating underground is tested (minimum) monthly. Most mines test every 2 weeks or weekly.**
- **DPM result >20% above “signature” level for that vehicle mandates maintenance/repair before returning underground.**
- **Absolute DPM limits are also applied (next slide)**
- **A standardized diagnostic tree is generally used to identify and rectify high emissions, based on cost/frequency analysis (eg, start with air filter and work down from there)**

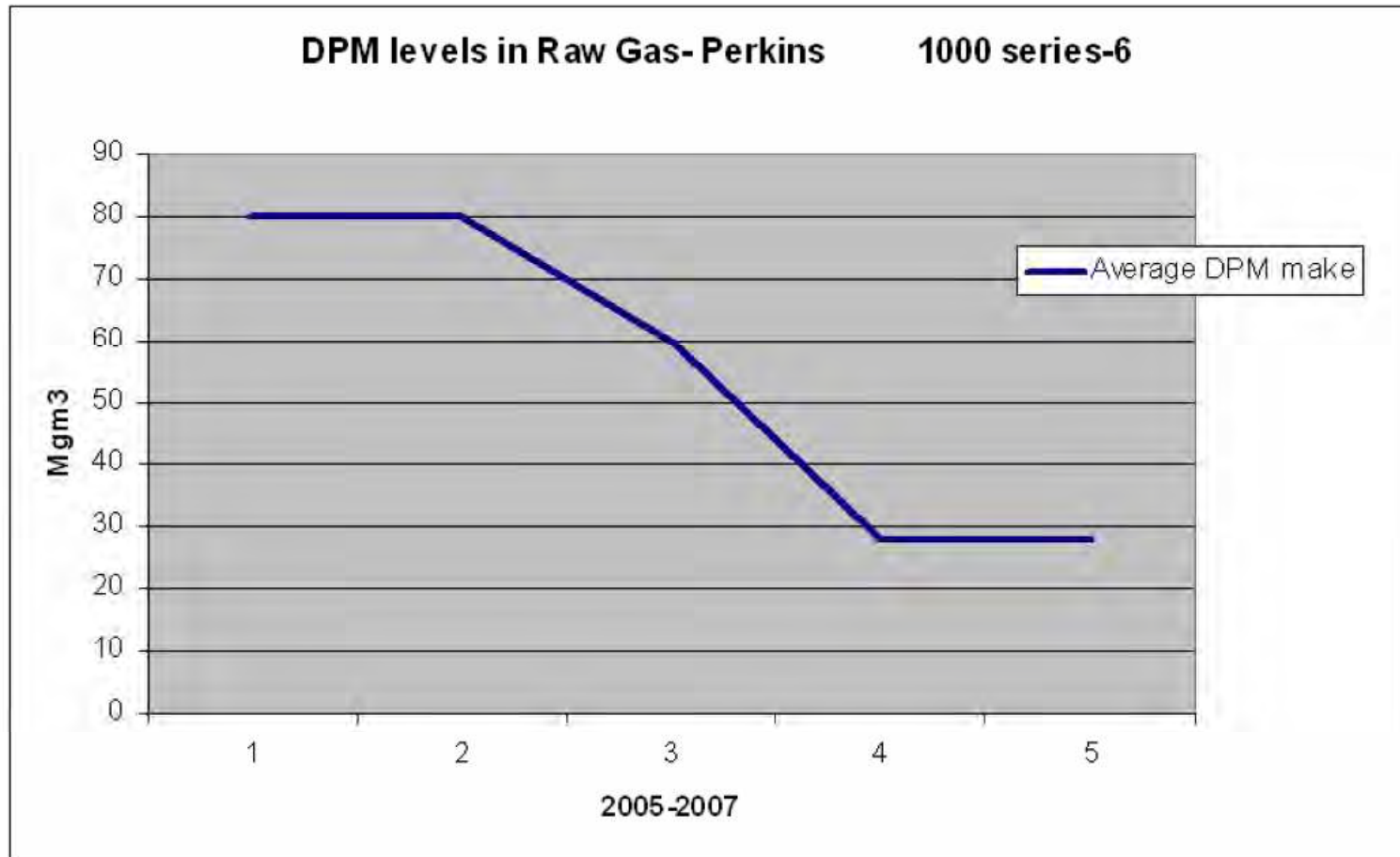
# DPM Limit Progression (Stall Test)



**Limit DPM Concentration (mg/m<sup>3</sup>) by Year**



# Program Effectiveness (Example)



**Average DPM Reduction = 60%**



## Benefits (Health & Economic)



- **Program minimizes DPM exposure risk to underground personnel**
- **Measured Maintenance also optimizes fuel consumption and has potential to improve engine reliability.**
- **By maintaining “On-Condition”, wastage costs due to unnecessary maintenance are avoided.**
- **Assigning specific cubic flow requirements to individual vehicles allows optimization of equipment deployment and ventilation flows, without exceeding DPM exposure levels**

## Summary



- **DPM measurement is now broadly accepted as a necessary and integral part of mine equipment and ventilation management.**
- **Test cycles and test equipment have proved to be practical and effective**
- **Continuing dialogue and cooperation between and within industry and government has been essential for effective program implementation**

# Measured Maintenance

**“IF YOU CAN'T MEASURE IT  
YOU CAN'T FIX IT”**