# Real-Time DPM Measurement as a Maintenance Tool

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## Presentation:

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PM Tech

# Developing a DPM Management Strategy

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## Research / Evaluation

## Government Responses

## Pre-Program DPM Emission Profiles

## Test Equipment

## Implementation

## Program Effectiveness

## Summary & Conclusions

# Research

- **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".***

# Test Program Structure

## 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

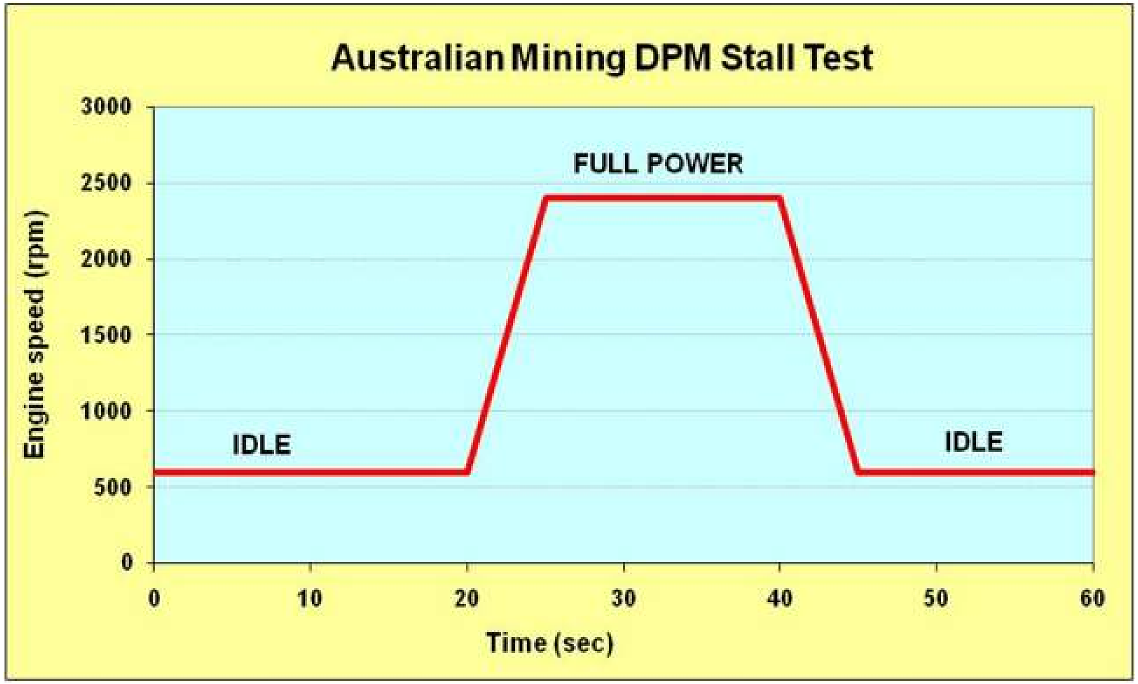
# Test Program Structure

## 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

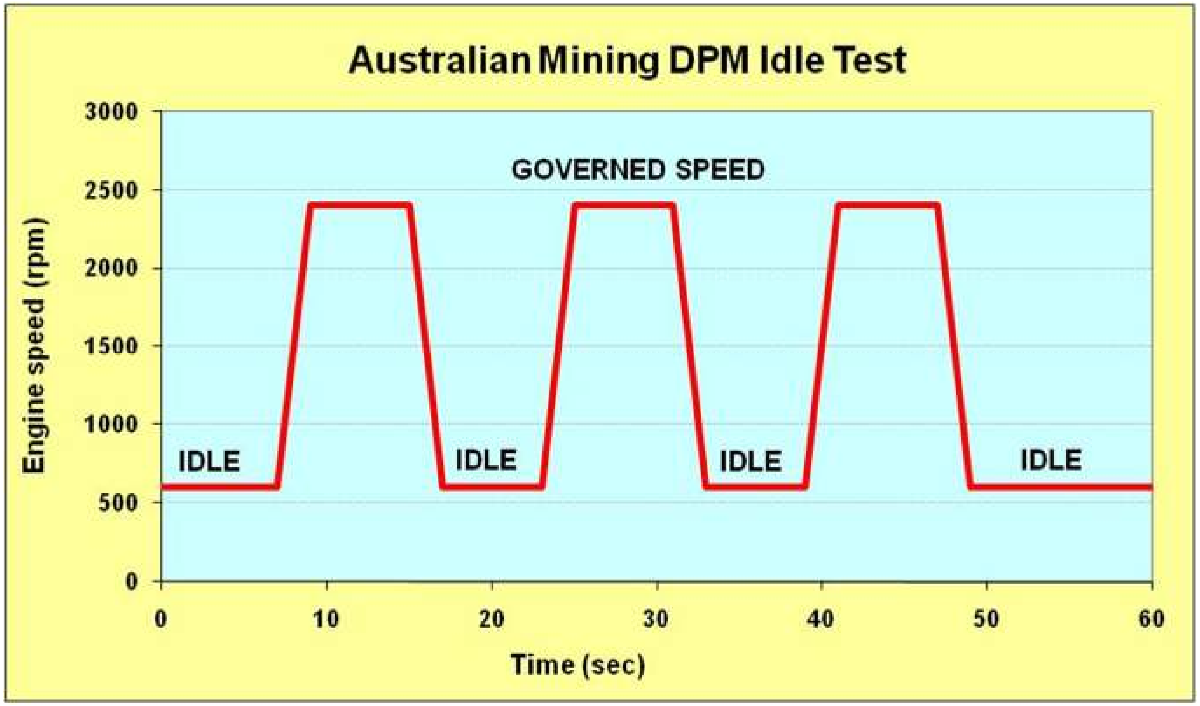
# Key Project Outcomes

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



# Key Project Outcomes

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



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# Initial Government Response (Summary)

## Primary Guidelines

- ambient DPM exposure limit 0.1mg/m3 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

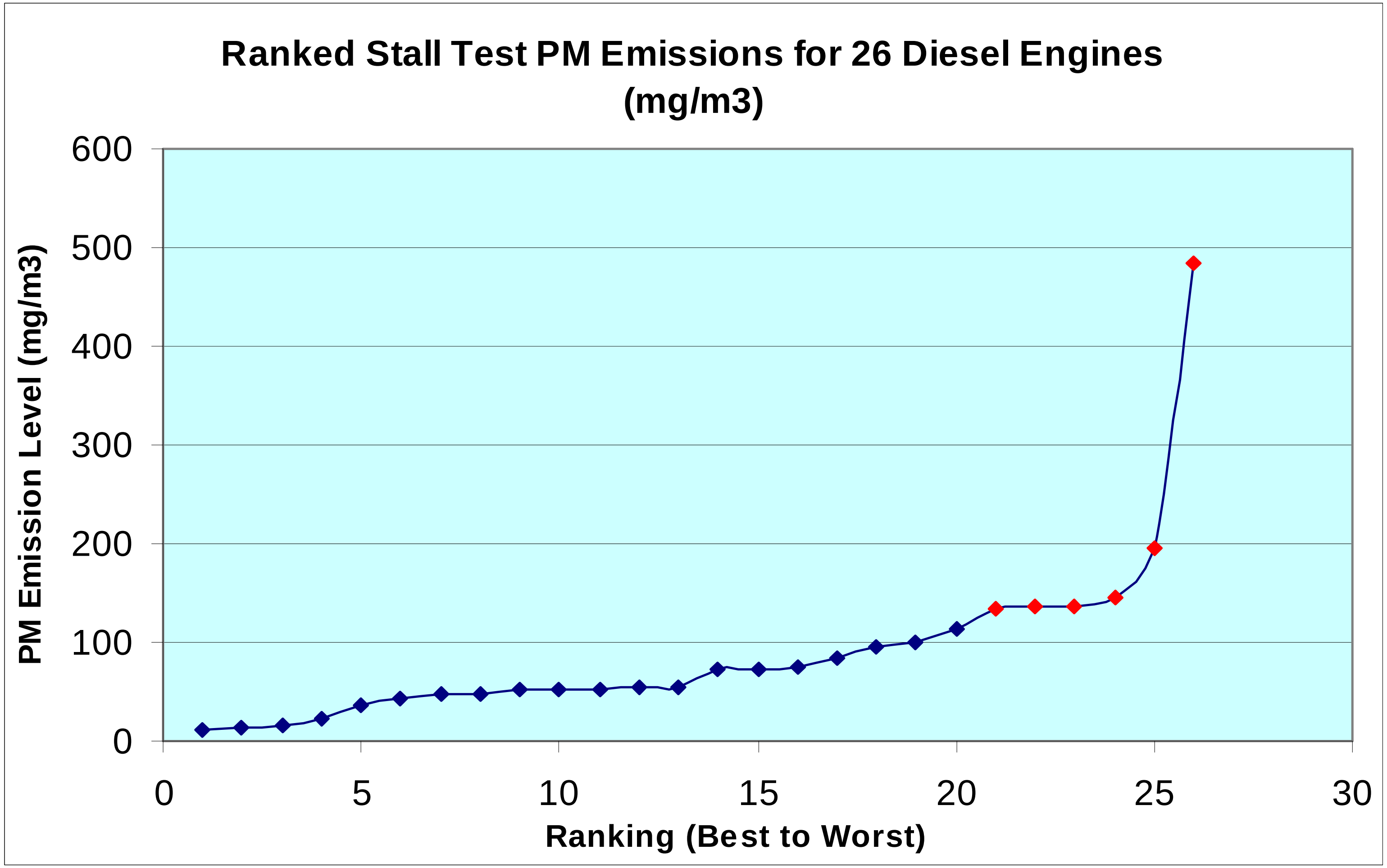
# Pre-Program DPM Emission Profiles

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

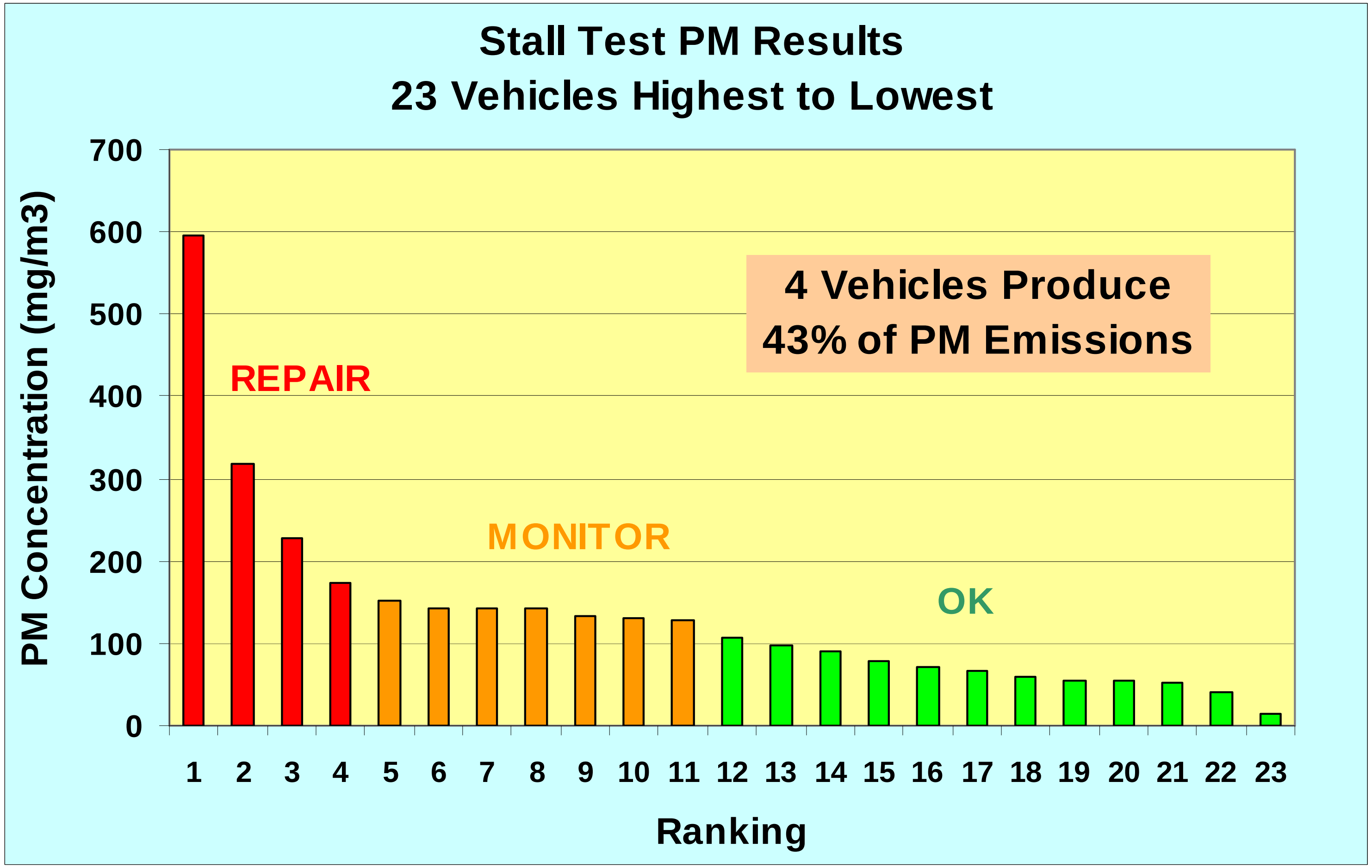
**Results of this testing showed considerable similarities**

- **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)



# Correlations,
# Test Cycle vs On-Task Operation

# On-Vehicle Testing

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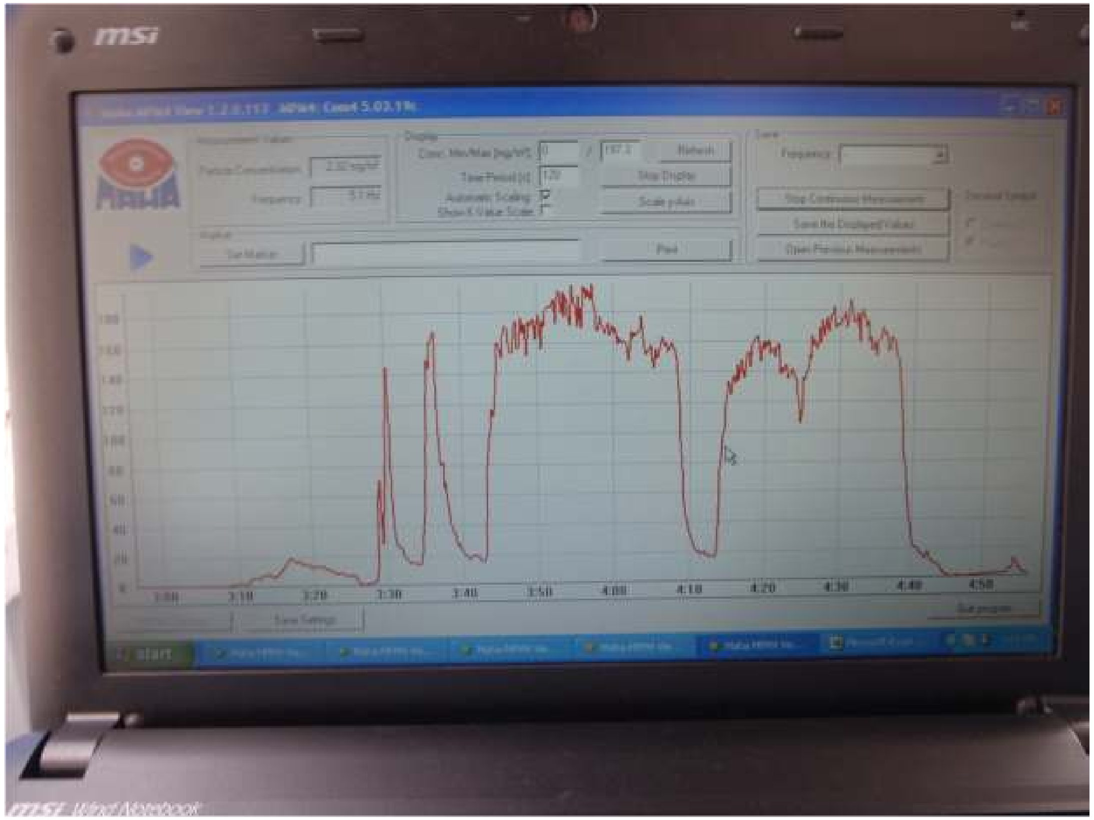
# On-Board Real Time Recording




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

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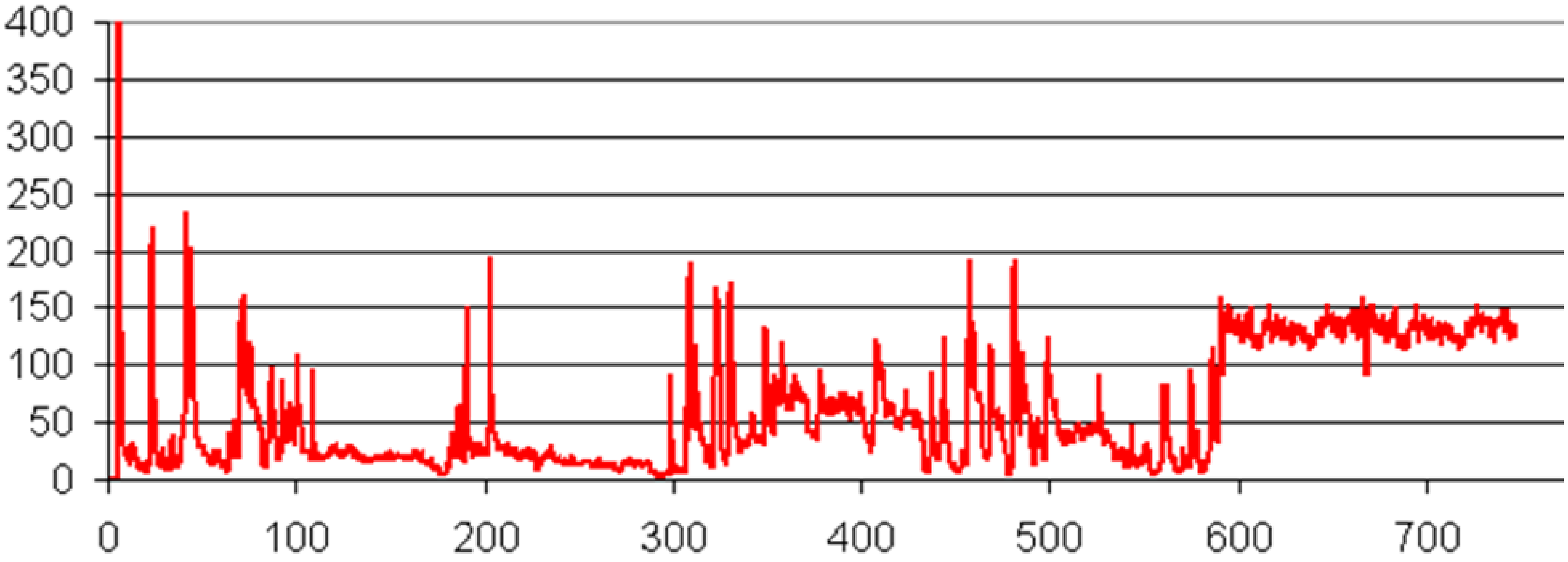
# Correlation, Example 1

Average = 58.16394

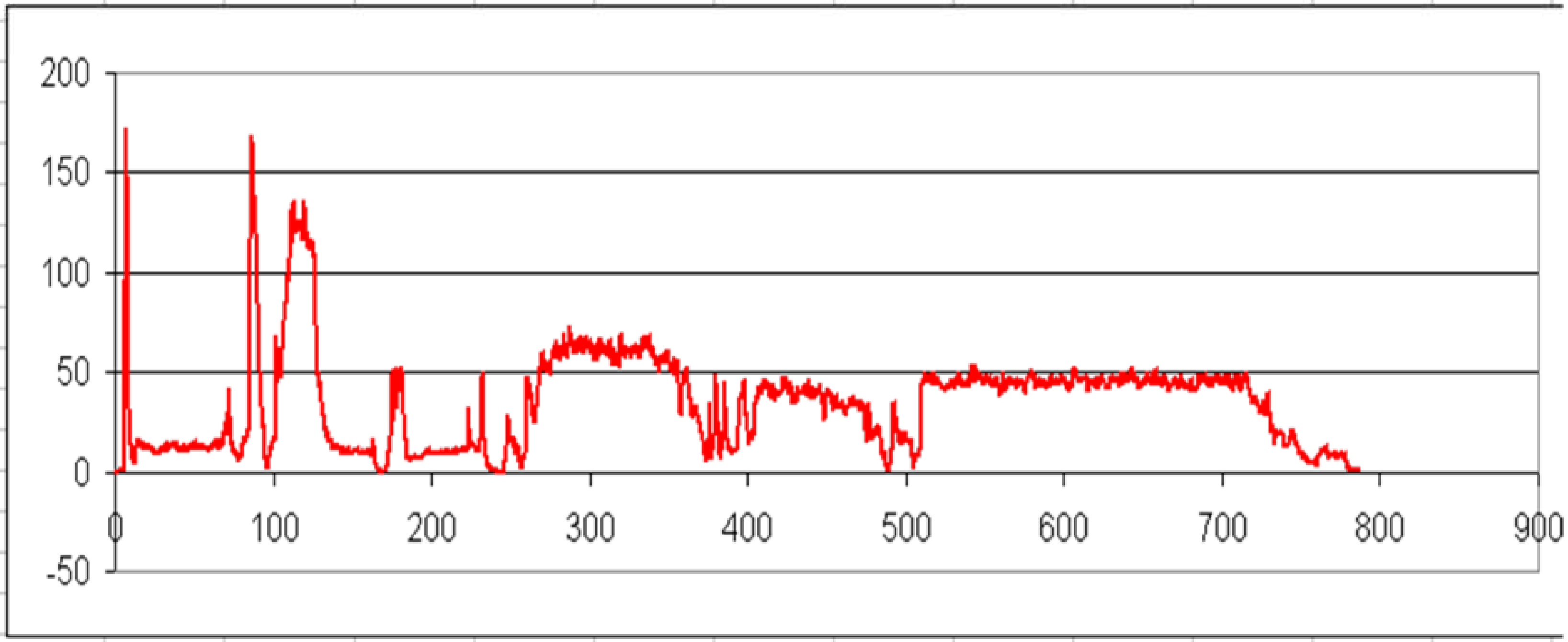
| Static Test | Min | Max | Average |
| --- | --- | --- | --- |
| | 6.7 | 194 | 58.1 |

| | |
| --- | --- |
| Engine hours | 6758 |
| Last 1000 service | 0 |



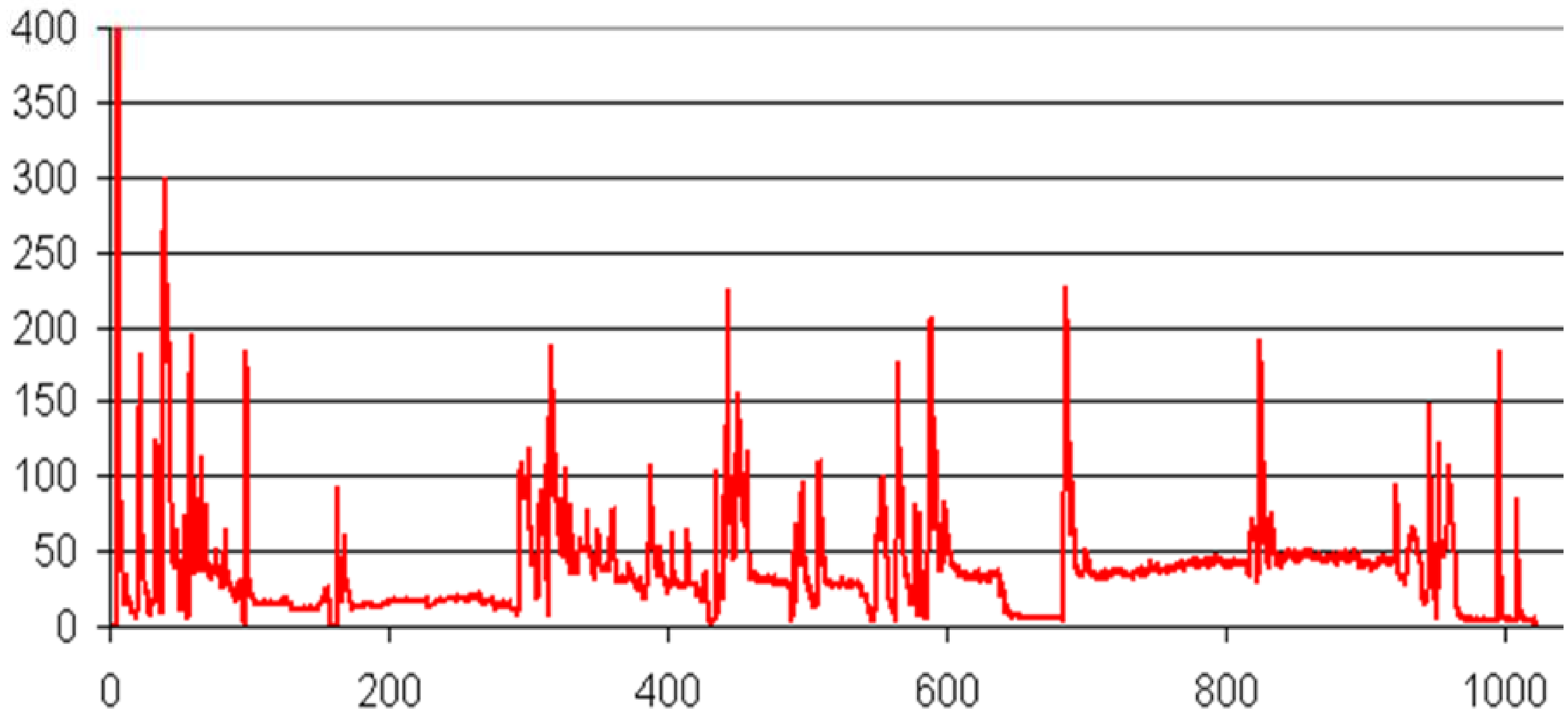
# Correlation, Example 2

| | | | | | |
|---|---|---|---|---|---|
| | | 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

# Test Equipment

- 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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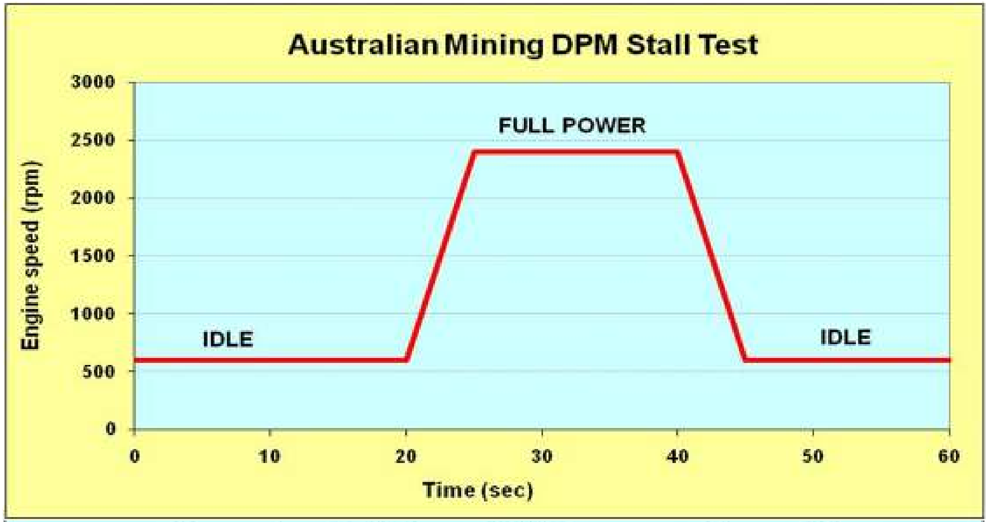
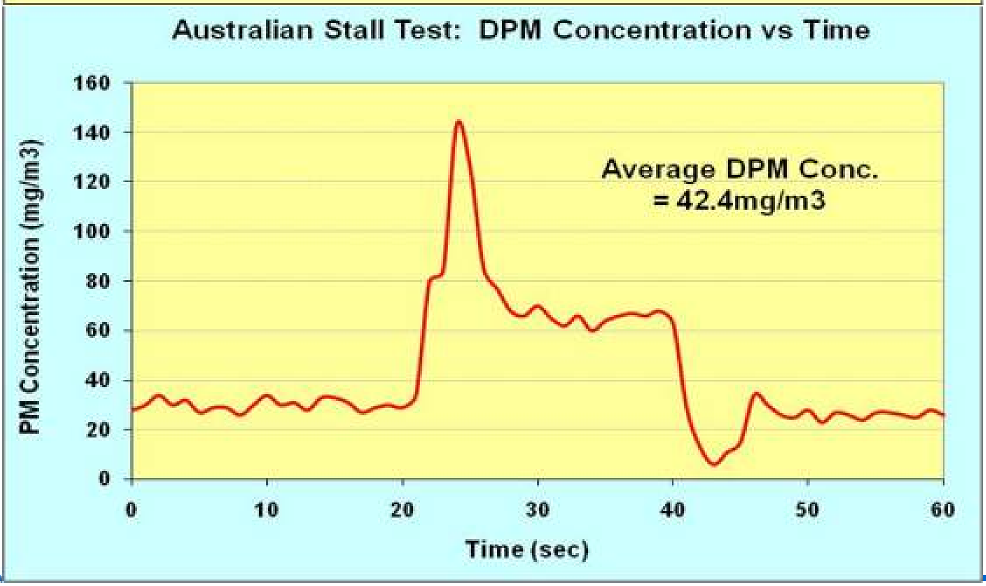
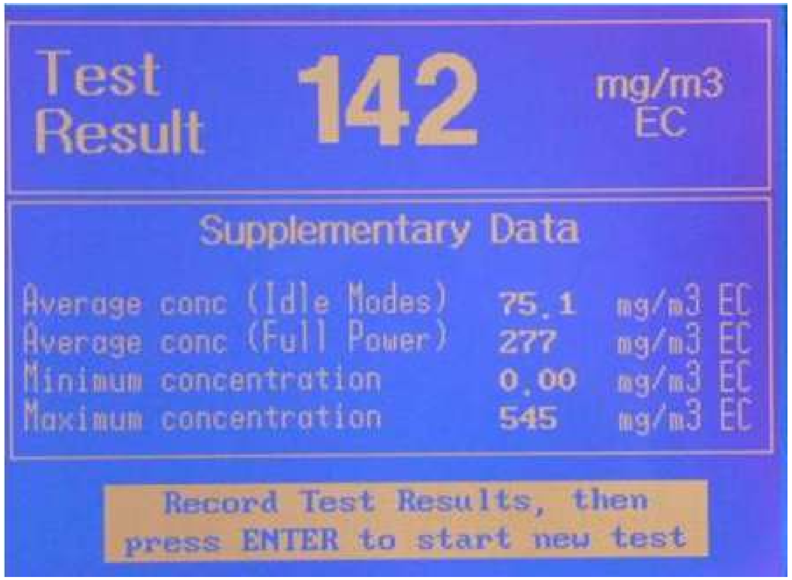
# MPM-4M (4th Generation)

# Stall Test DPM Results (Typical)




## Test Result Screen (Example)

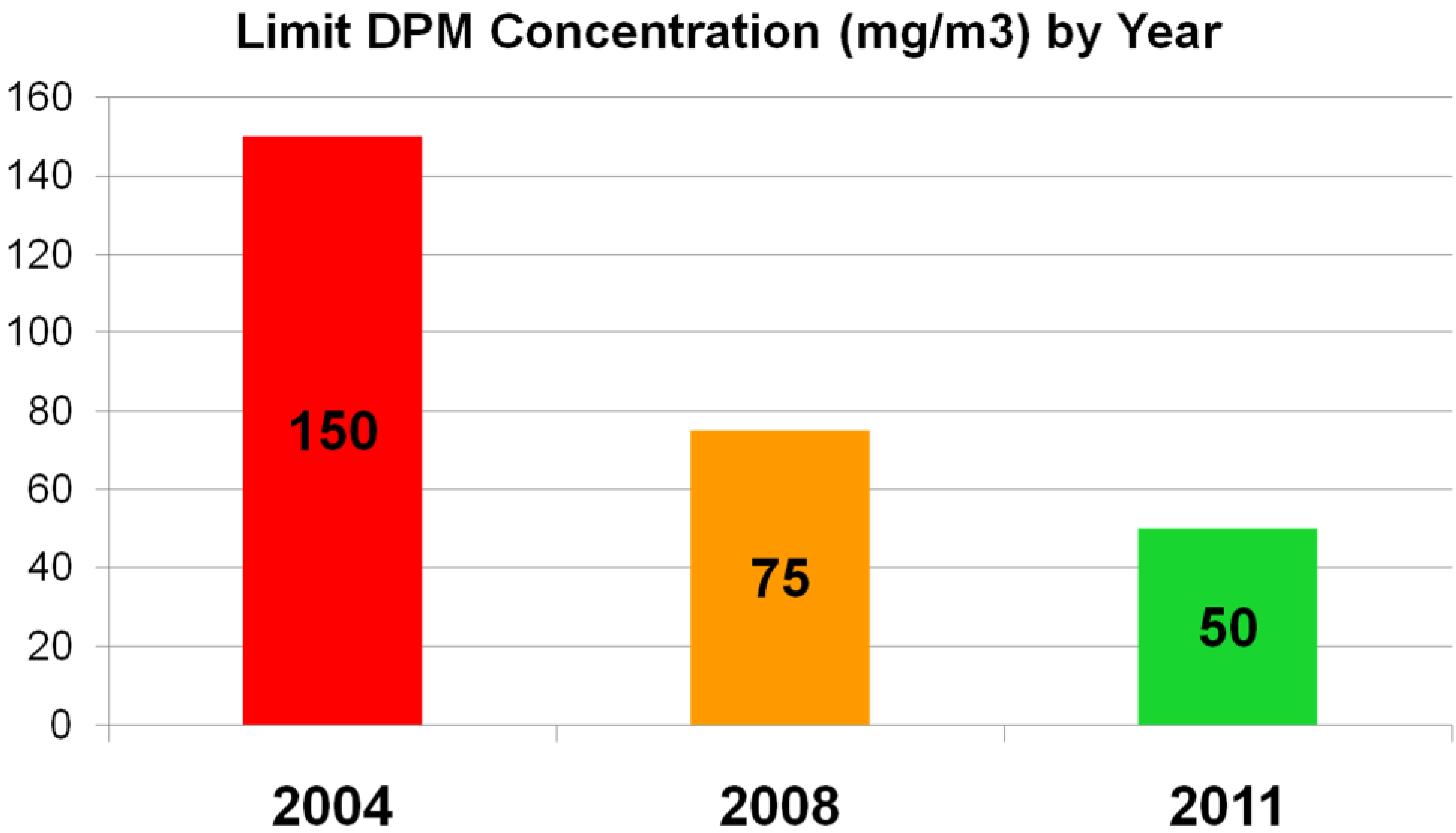



**Second-by-second test data can also be exported directly to PC via RS232/USB**

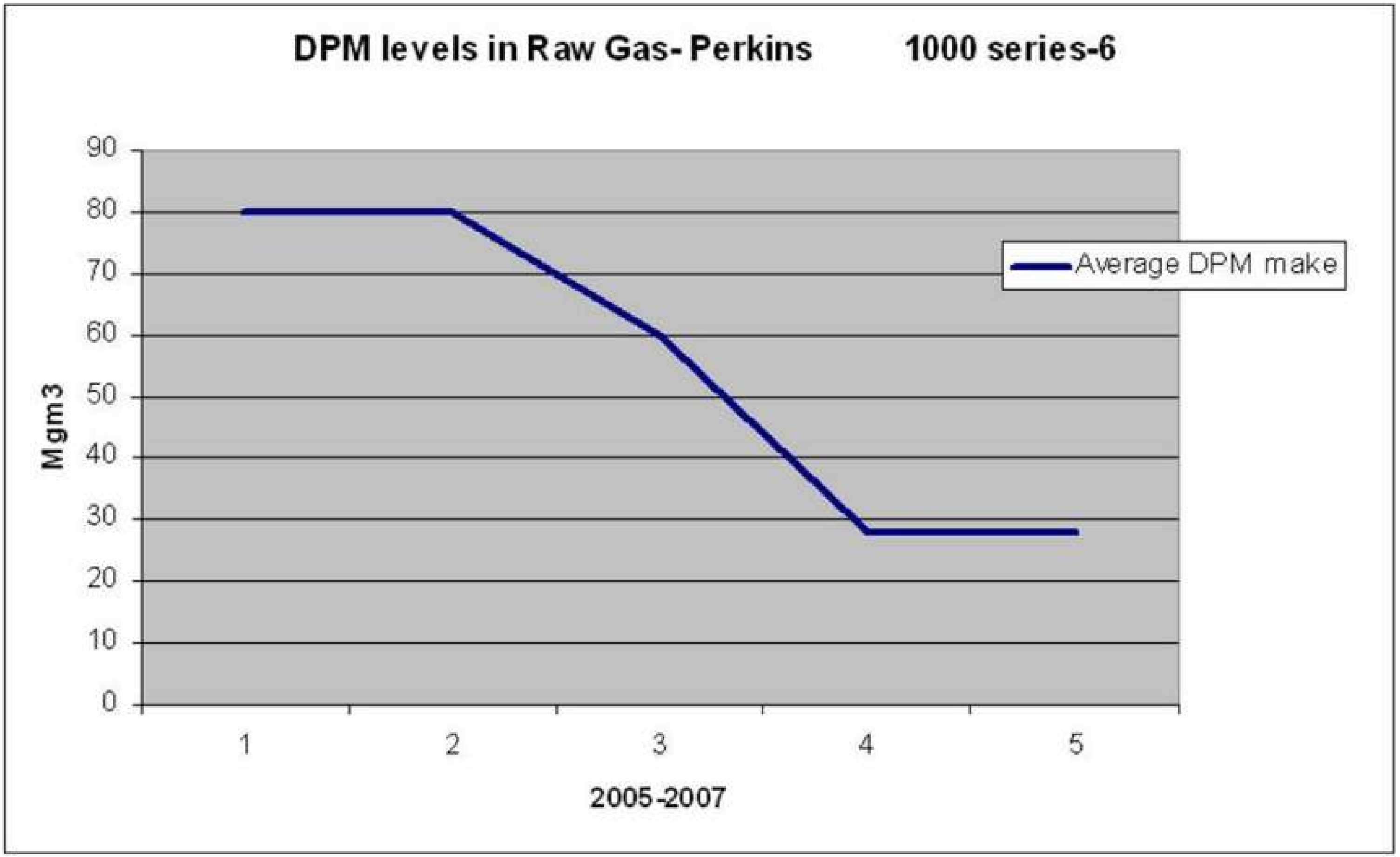
# Testing Program

- **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)



# 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**

## Last Word

# Measured Maintenance

**"IF YOU CAN'T MEASURE IT**
**YOU CAN'T FIX IT"**