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

@ Mining Diesel Emissions Council Conference2010
October 5-9th, Toronto

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

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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

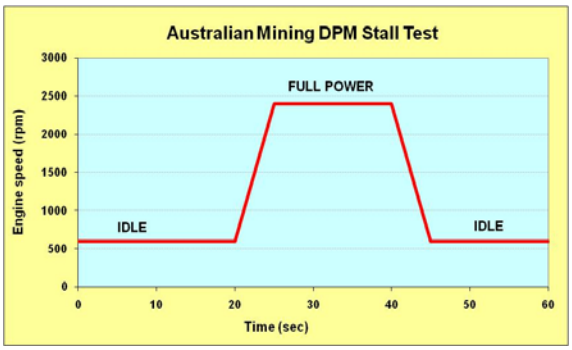
Test Program Structure

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

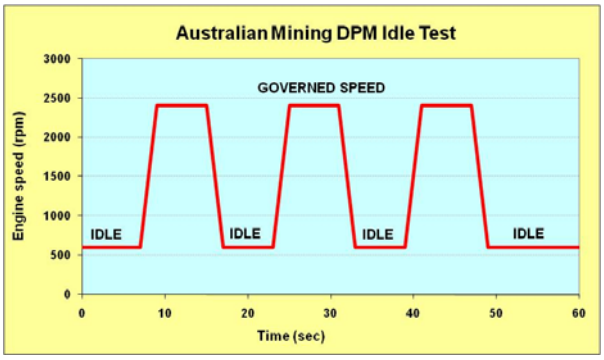
Key Project Outcomes

- **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**



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, intermediate limit 20%, now reduced to 15%)**
- **records to be maintained of all test results for individual vehicles/plant**

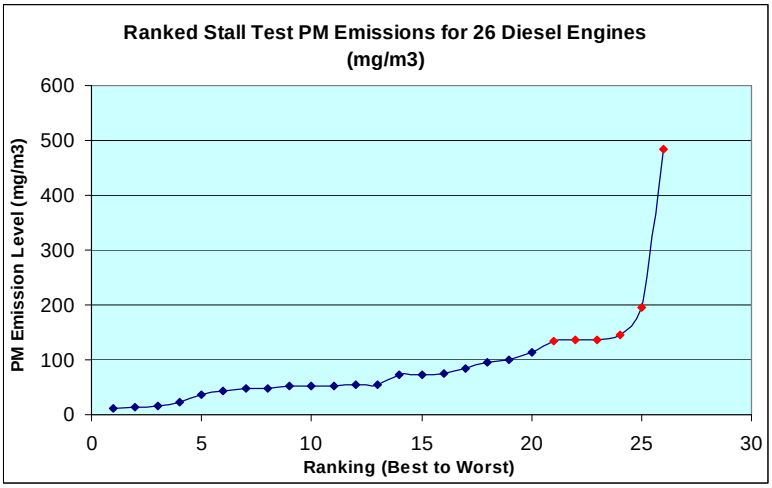
Pre-Program DPM Emission Profiles

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

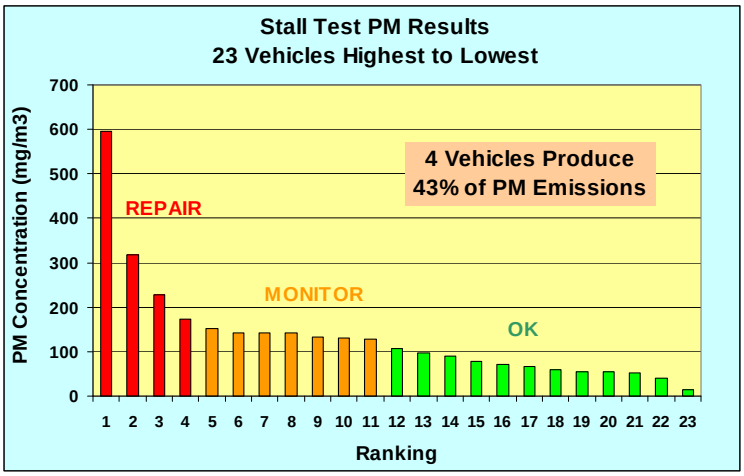
Results of this testing showed considerable similarities

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

DPM Emission Distribution: Initial Survey (Example 1)



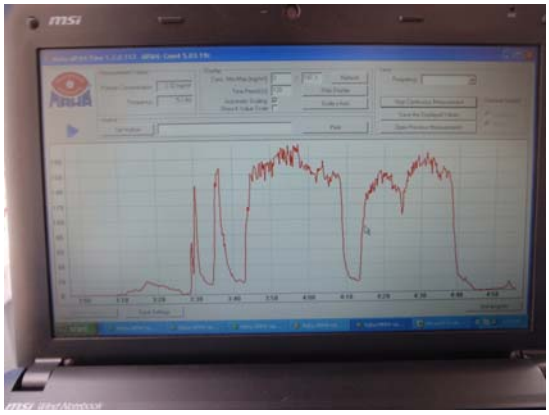
DPM Emission Distribution: Initial Survey (Example 2)



Correlations, Test Cycle vs On-Task Operation

On-Vehicle Testing

On-Board Real Time Recording



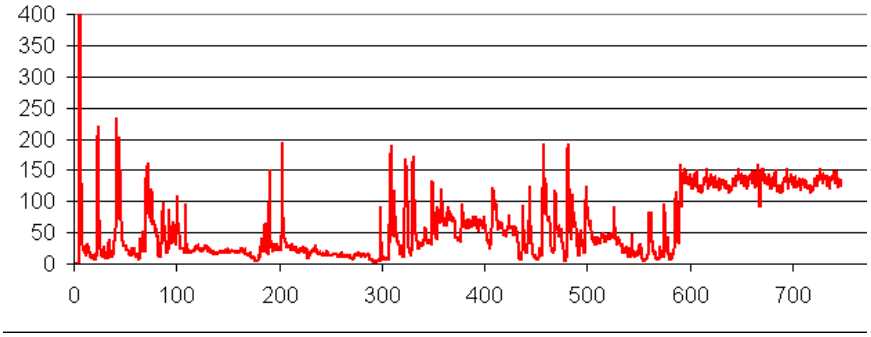
Custom software (available with instrument) stores and charts continuous DPM Concentration vs Time for analysis and correlation studies

Correlation, Example 1

Static Test	Min	Max	Average
	6.7	194	58.1

Average = 58.16394

Engine hours	6758
Last 1000 service	0

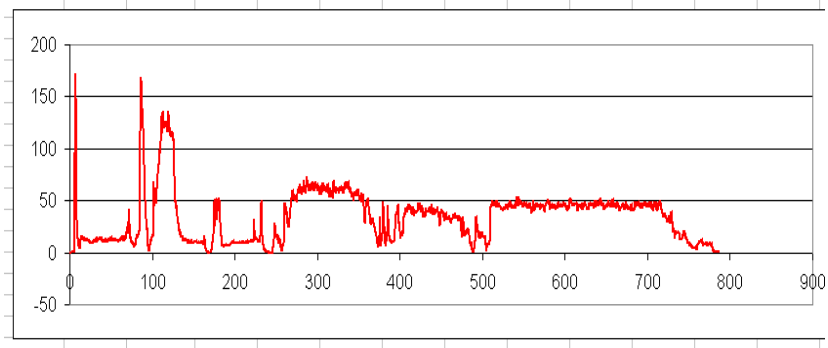


Correlation, Example 2

Static Test	Min	Max	Average
	20.5	66	36.5

Average = 34.34803

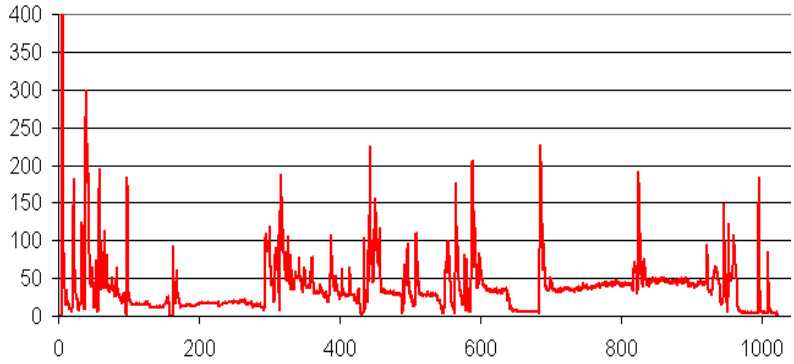
Engine hours	7822
Last 1000 service	676



Correlation, Example 3

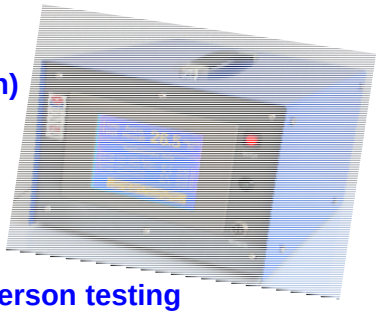
Static Test	Min	Max	Average
	6.6	416	48.8

Average = 38.0728



Implementation

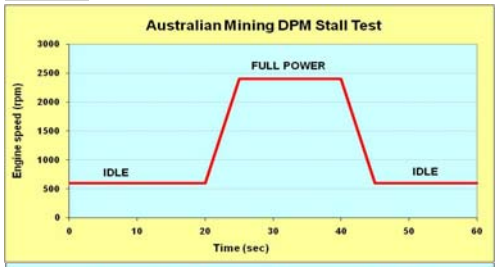
Test Equipment

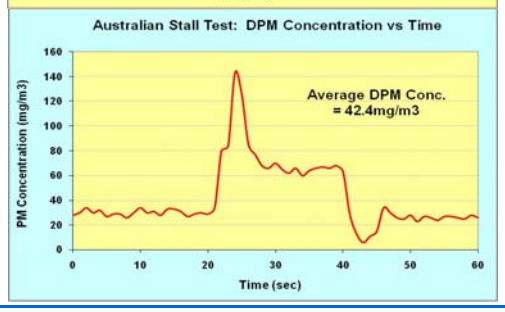


- Fourth generation laser light scattering (LLSP) is now the measuring method of choice in Australia
- One minute test (stall or free accn)
- Simple one-button operation
- Auto-zero before every test
- Reliable, repeatable test results
- Automatic test result generation
- Wired remote control for single person testing
- NiMH Battery, >2hrs testing
- Portable, rugged, completely self-contained
- Simple field calibration and service

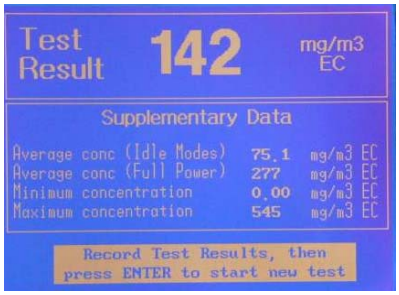
MPM-4M (4th Generation)

Stall Test DPM Results (Typical)





Test Result Screen (Example)

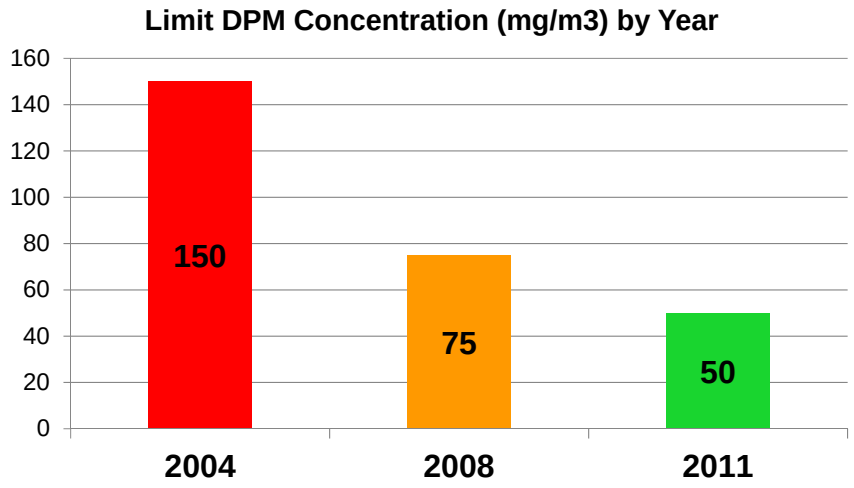


Second-by-second test data can also be exported directly to PC via RS232/USB

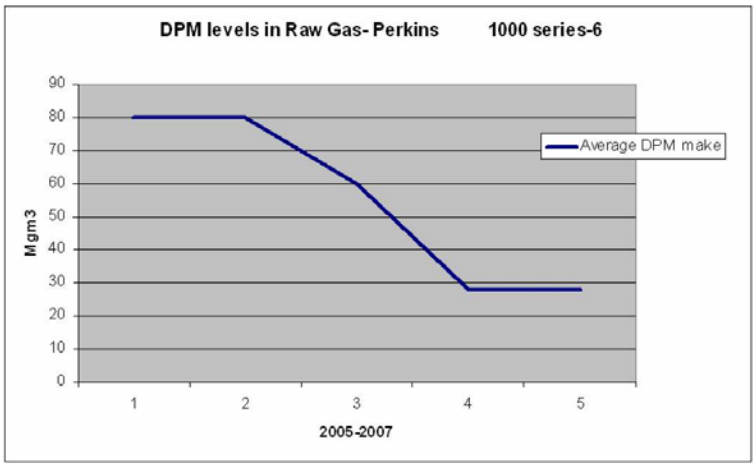
Testing Program

- **Every vehicle and item of plant operating underground is tested (minimum) monthly. Most mines test every 2 weeks or weekly.**
- **DPM result >20% (now 15%) above "signature" level for that vehicle requires 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”