Overview

- Background
- Design of Diesel ChekMate®
- Calibration of ChekMate® vs NIOSH 5040
- In field comparisons
- Potential applications
- Limitations
Background

• 2000 – NIOSH demonstrate relationship between differential pressure vs workplace respirable dust levels
• 2004 – extension of this principle developed by NIOSH & SKC Inc to measure DPM under field conditions
• Device given operating name “Diesel Detective” and trialled in USA, Australia, Canada & South Africa

Background (cont)

• Australia study showed device had good potential as a survey type quality measurement instrument
• Device never commercialised due to sampling & filter issues
• Original patent lapsed in Australia on 7th July 2013
“Diesel Detective”

Diesel Detective Calibration (Australian Field Samples)

Source: NSW DPI 2004
LLS vs Backpressure

- Research in Australia by NSW DPI (2004) and Davies (2013) suggested the use of a single conversion factor from TSP to EC by LLS devices is not valid for all engine types.

- NSW DPI (2004) research indicated the use of $\Delta p$ not influenced by engine type. Recent EC/$\Delta p$ calibration using 8 different engine types supports this conclusion.

Design of Diesel ChekMate®

- Research by Davies (2013) showed:
  - Sampling from the tailpipe of a vehicle subject to probe insertion distance issues.
  - EC could be sampled on a quartz filter in the raw exhaust at temperatures up to at least 115°C.
  - Sampling post a water filled scrubber tank not practicable if using filters to collect DPM (EC).
  - Sampling from manifold gave a better overview of engine parameters.
Design of Diesel ChekMate®

• Developed ERP exhaust mixing & cooling system
• Enabled sampling direct from exhaust manifold and cooled exhaust to <50°C
• Overcame water on filter issues & gave better picture of key engine parameters
• Developed filter holder so a workplace dust sampling pump & a basic backpressure meter could be used

Design of Diesel ChekMate®

• Focus on simplicity & robust design for use in workshops by diesel mechanics
• Calibrated against NIOSH 5040 using 71 in field engine samples from both coal & metaliferrous mining industry
• Operating range 25 – 80 mg/m³ EC in raw exhaust
• Low range EC (<25mg/m³) & TC calibrations in progress
Design of Diesel ChekMate®

- Following feedback from operations ChekMate® has been fitted with flow control solenoid, linked timer & pendant for single person operation
- Patents pending in Australia, Canada & South Africa

ERP Mixing & Cooling System
Manifold vs Tailpipe Comparison
Australian Coal Industry

All TPM results measured with a MAHA MPM – 4M

ChekMate® Probe & Filter Holder

S4P1 - 7
Loading Filter into Probe

Sampling System & Probe
Connected to Raw Exhaust System
ChekMate® & ERP Mixing System During Sample Collection

ChekMate® Calibration Curve
71 Samples from In Service Engines

Diesel ChekMate® Calibration (August 2014)

Flowrate 1.5L/min
HIGH RANGE

EC mg/l

mmwc
Linear Regression with 95% Confidence Bands

\[ R^2 = 0.854 \]
\[ R^2 \text{ adjusted} = 0.852 \]

Pearson Correlation with 95% Confidence Bands

\[ r = 0.924 \]
### Residuals

![Residuals Graph]

### In Field Comparisons

<table>
<thead>
<tr>
<th>Workshop Location</th>
<th>Engine</th>
<th>ChekMate® EC mg/m3 (+/- 20% unc)</th>
<th>Sunset Lab. EC mg/m3 (+/- 15% unc)</th>
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Potential Applications

• In mine workshops as a tool (linked with an ECOM EN2-F gas analyser & DEEM6S software interface) for mine mechanics operating an emissions based maintenance program

• To test the in-service efficiency of DPFs

• Estimation of raw exhaust EC levels for ventilation calculations

Limitations

• Engine exhausts with very high organics (grossly over fuelled) can give high results due to blockage of filter causing increased back pressure. Identified by ECOM Gas analysis

• Uncertainty of results +/- 20% which is adequate for a screening device (NIOSH 5040 analysis +/-12% on ChekMate® samples and +/- 15% including volume)
Summary

• A new simple low cost tool for site mechanics to screen dirty engines for maintenance
• When linked with an ECOM EN-2F gas analyser & DEEM6S software interface gives a powerful low cost diagnostic system that can be used at sites by site personnel

References

• Davies B (2013), Calibration of portable raw exhaust diesel particulate analysers. Coal Services Health & Safety Trust Research Project
• NSW DPI (2004), Methods for measuring diesel particulate matter from underground mining equipment, Report 04/0884, November 2004