Objectives of the AECC heavy-duty Euro VI test programme

• Demonstrate the performance of an integrated emissions control system on a modern, low NOx engine to be less than 0.4g/kWh from the ETC Cycle
• Compare current full-flow European gravimetric and heavy-duty Particle Measurement Programme (PMP) methods for particulate mass (PM).
• Assess heavy-duty PMP particle number methodology.
• Provide data on European, World-harmonised and other major test procedures.

High Efficiency Wall-Flow DPF Employed

PMP Particle Number Results for ETC & WHC Show >99% Filtration Efficiency

Filtration efficiency for elemental carbon >99% for all emissions cycles

- PMP measured as follows
  - 10 minute soak.
  - Dilution Air Led to High Apparent Emissions –
    - Background contamination problem encountered on both full-flow and partial flow.

Particle Numbers Measured from Transient Operation Are Almost Independent of Cycle - DPF Flat-topped emissions

ETC and WHTC PM emissions for engine-out and tailpipe show >99% reduction

Schematic of Test Engine, Emissions Control Systems, Measurement and Emissions Sampling Locations

Particulate Matter Number System Employed. Heating, Dilution and Size Classification to Define the Particle Measured

- PM measurements from MLDT show very low levels of mass
  - Maximum tailpipe collection on filter is only 10µg GWP
  - Other cyclone results typically 100 times similar.
  - Typical engine-out emissions from LD3 (HDA) are below 2 mg/kWh
  - ETC results were higher but limited to due to 15±3 µm volatility that can evaporate from the filter.

Authors
Jon Anderson, John Kasab, Andrew Nicol, Chris Such Ricardo UK
John May, Dirk Bouteil AEC (www.aecc.eub)

Detailed Preconditioning Procedures Employed to Ensure Constant ESS State for Each Day's Testing

- For reproducibility, the daily test engine started with a single step test (WHTC, FTP or ETC) and finalised with a standard preconditioning engine.
- The end of day preconditioning consisted of
  - Warm-up (15 min).
  - Follow the procedure as described in the standard preconditioning methods.

MTD particulate matter method provides an example where MTD may be used to define PM from different PMP methods.

Particle Number Range of Engine Out PM and Tailpipe PM from Partial Flow

- Engine-out particle number data was in the range of 2.5 to 5 x 10^10/kWh.
- All transient cycles data showed tailpipe particle number emissions below 10^10/kWh.
- Particle numbers were essentially cycle-independent.
- Background-corrected PM from PMP method gave results below 5mg/kWh.

Overview

- The PMP particle number method proved very repeatable even at near-ambient particle levels.
- Engine-out particle number data was in the range of 2.5 to 5 x 10^10/kWh.
- All transient cycles data showed tailpipe particle number emissions below 10^10/kWh.
- Particle numbers were essentially cycle-independent.
- Background-corrected PM from PMP method gave results below 5mg/kWh.
- PM measurements from MLDT show very low mass levels
  - Maximum tailpipe collection on filter is only 10µg
  - Other cyclone results typically 100 times similar.
- Typical engine-out emissions from LD3 (HDA) are below 2 mg/kWh

Background contamination problem encountered on both full flow methods but
- Masses indistinguishable from background levels from all tests.
- Subtraction of background reduces all masses to zero.
- Filtration efficiencies for PM, Particle number and Elemental Carbon were all in excess of 99%.