Measurement of NO$_2$ Emissions from Heavy Duty Vehicles/Engines at Environment Canada

Emissions Research and Measurement Division
Environment Canada

Presented at IDRAC
October 5, 2004
Outline

• Environment Canada - Emissions Test Facility
• NO₂ Sampling and Analysis Methods
• Engine NO₂/NOₓ Data
• Chassis NO₂/NOₓ Data
• Summary/Next Steps
Environment Canada Organization

- Five Regions: Pacific & Yukon, Prairie & Northern, Ontario, Quebec, Atlantic
- Canadian Environmental Assessment Agency
- Meteorological Services of Canada
- Human Resources & Service Innovation
- Policy & Communications
- Environmental Conservation Service
- Environmental Protection Service
Environment Canada Organization cont’d

• Environmental Protection Service:
  – Air Pollution Prevention
  – Pollution Prevention
  – Risk Management
  – Strategic Priorities
    Environmental Technology Advancement

• Environmental Technology Centre
• Emissions Research and Measurement Division - ERMD
ERMD Programs

• Conformity Program for New Light Duty Vehicles and Certification of New Vehicles and Engines
• Quantifying the emission contribution of a range of mobile sources and stationary sources
• Support the development of technologies, fuels, and strategies to reduce the emissions from transportation
• Providing technical assistance and expertise to government divisions, industry, and other countries
ERMD Test Facility

- 4 Light Duty Chassis Dynamometer Labs
- 2 Heavy Duty Chassis Dynamometer Labs
- 3 Heavy Duty Engine Dynamometer Labs
- Utility Engine Laboratory
- Light Duty Evaporative Emissions Enclosure
- Environmental Chambers (-5°C to -25°C)
- Organic Chemistry Laboratory
- Portable Emissions Sampling System
Technology Development & Evaluations

- Fuels
  - ULSD, BioD, E-D, H\textsubscript{2}O
  - Emulsions, CNG, Alcohols, gasoline reformulations
- Emission Controls
  - Diesel Particulate Filters
  - Diesel Oxidation Cat’s
  - EGR, SCR
- Diesel-Electric Hybrids & Fuel Cell Buses
Sampling & Analysis Capabilities

- Gaseous Emissions: NDIR, HCLD, HFID
- Particulate Matter: Gravimetric, particle size/count/distribution
- Carbonyl compounds: HPLC
- Volatile Organic Compounds: GC- FID
- Methane and light hydrocarbons, N₂0: GC
- PAH, n-PAH: High Resolution MS
- OC/EC: Thermal Optical Transmittance
- NH₃, Particle Phase SO₄, SO₂: Ion Chromatography
NO₂ Collection Methods

• Chemiluminescent Analyzer Method
  – NO & NOₓ dilute exhaust concentrations determined
  – 2 heated analyzers -California Analytical Model 400-HCLD
  – Corrected for ambient concentrations and atmospheric conditions
  – Continuous collection at higher instrument range

• DNPH (2,4-dinitrophenylhydrazine) Cartridge Method*
  – Reaction of NO₂ and DNPH to form 2,4 dinitrophenylazide (DNPA)
  – DNPH and DNPA monitored at different wavelengths
  – Hewlett Packard 1090M Series II & Photo diode array

Reference: ES&T: Tang, Graham et al. “Simultaneous Determination of Carbonyls and NO₂ in Exhausits of HDD Trucks and Transit Buses by HPLC Following 2,4DNPH cartridge collection”
NO$_2$/NO$_x$ Concentrations from an Urban Transit Bus

![Graph showing NO$_2$/NO$_x$ concentrations over time.](image)

- **X-axis**: Time (seconds)
- **Y-axis 1**: Exhaust Concentration (ppm)
- **Y-axis 2**: Speed (mph)

Legend:
- Green line: Dynamometer Speed
- Dotted line: NOx
- Solid black line: NO2 Calculated
Comparison of Measured Dilute Exhaust NO$_2$ Concentrations

Reference: ES&T Tang, Graham et al.
International DT466, MY 2000
7.6L, inline 6, 237bhp @ 1400 rpm

Reference: SAE 2004-01-1085
International DT466 % NO$_2$/NO$_X$

Reference: SAE 2004-01-1085
DDC Series 50, MY 1996, 8.5L, inline 4, 275 bhp @ 2110 rpm

- No-Aft DOC CDPF 1 CDPF 2
- 10 ppm S - NOX
- 10 ppm S - NO2
- 80 ppm S - NOX
- 80 ppm S - NO2

Bar chart showing emissions data.
CAT C11, MY 2004, 11.1L, inline 6, 305 bhp @ 2100 rpm

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<tr>
<th></th>
<th>$\text{NO}_x$ g/bhp-hr</th>
<th>$\text{NO}_2$ g/bhp-hr</th>
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## Urban Transit Bus NO₂/NOₓ Emissions over the CBD Cycle (g/mile)

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<th>Model</th>
<th>Engine</th>
<th>Configuration</th>
<th>Fuel Sulphur (ppm)</th>
<th>NOX</th>
<th>NO2</th>
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Reference: SAE 2002-01-0430
Hybrid Bus with Selected Emission Control Devices

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<th>Fuel Type and Device</th>
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<th>NO2 (g/mile)</th>
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Evolution of Urban Transit Bus NOX

NOX Trend

Engine Model Year

NOX (g/mile)
Summary/Next Steps

- Accurate and precise measurement of NO$_X$ species is increasingly important as NO$_X$ emissions standards become more stringent.
- Increases in the % NO$_2$ of NO$_X$ have been noted with specific emission control devices although the total NO$_X$ remains unchanged.
- EC will continue to compare DNPH Cartridge NO$_2$ Method with the Chemiluminescent NO$_2$ Method.
- NO$_2$ will be measured for the majority of heavy duty vehicles and engines tested at EC.
- N$_2$O is routinely measured to understand contribution from transportation sources.
- NH$_3$ measured with in-line raw exhaust analyzer with modified path length.
- EC will continue with future research on 2004 CAT C11 and Cummins ISM engines: complete characterization of emissions, fuels, emission control devices, NO$_2$/NO$_X$ comparisons.
Additional Information

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