Measurement of NO_2 Emissions from Heavy Duty Vehicles/Engines at Environment Canada

Emissions Research and Measurement Division
Environment Canada

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Environment Canada Environnement Canada

Outline

- Environment Canada - Emissions Test Facility
- NO_2 Sampling and Analysis Methods
- Engine NO_2 /NO_X Data
- Chassis NO_2 /NO_X 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

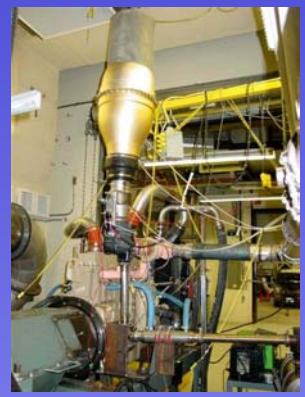
- Conformity Program for New Light Duty Vehicles and Certification of New Vehicles and Engines
- Quantifying the emission contribution of a range of mobile sources and stationary sources
- Support the development of technologies, fuels, and strategies to reduce the emissions from transportation
- Providing 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_2O 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

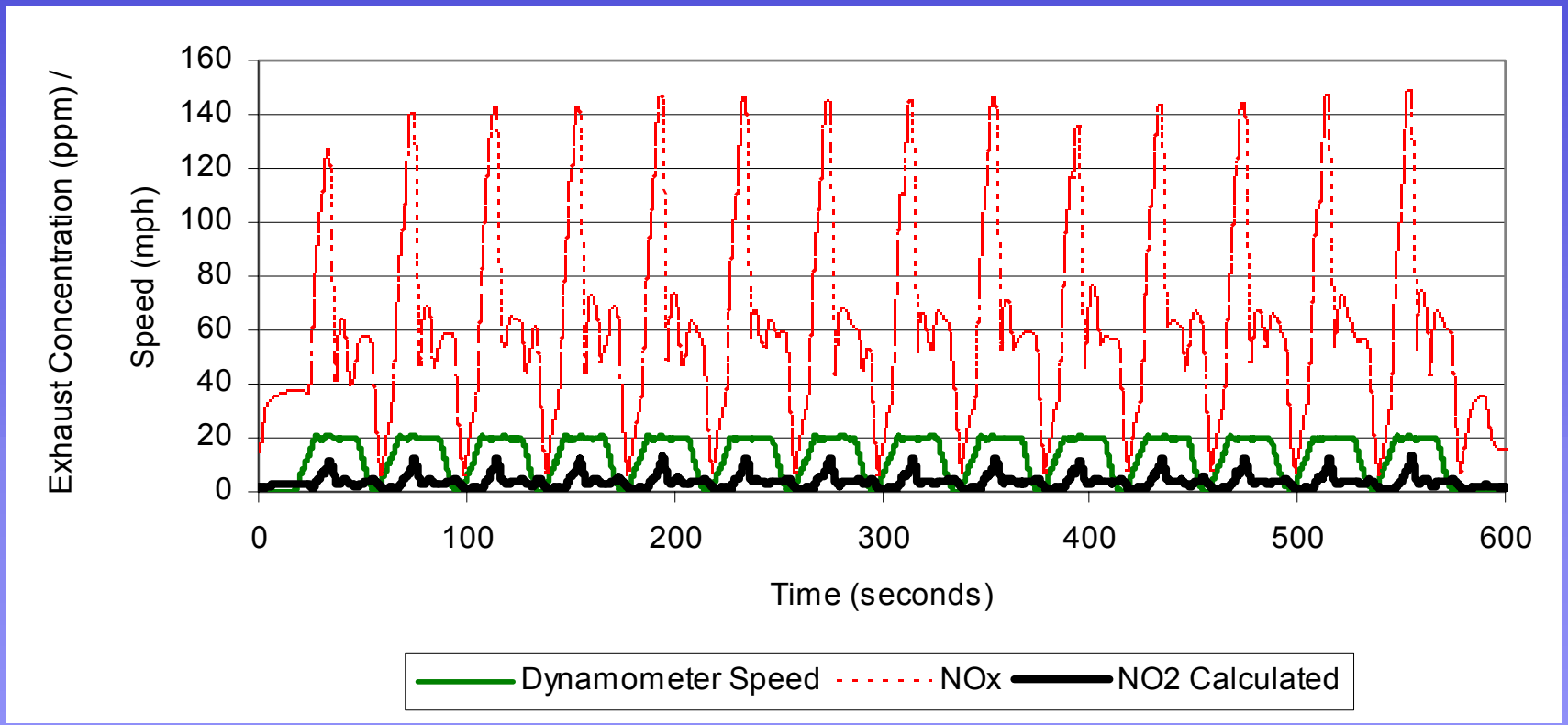
- Gaseous Emissions: NDIR, HCLD,HFID
- Particulate Matter: Gravimetric, particle size/count/distribution
- Carbonyl compounds: HPLC
- Volatile Organic Compounds: GC- FID
- Methane and light hydrocarbons, N_20: GC
- PAH, n-PAH: High Resolution MS
- OC/EC: Thermal Optical Transmittance
- NH_3, Particle Phase SO_4, SO_2: Ion Chromatography

NO_2 Collection Methods

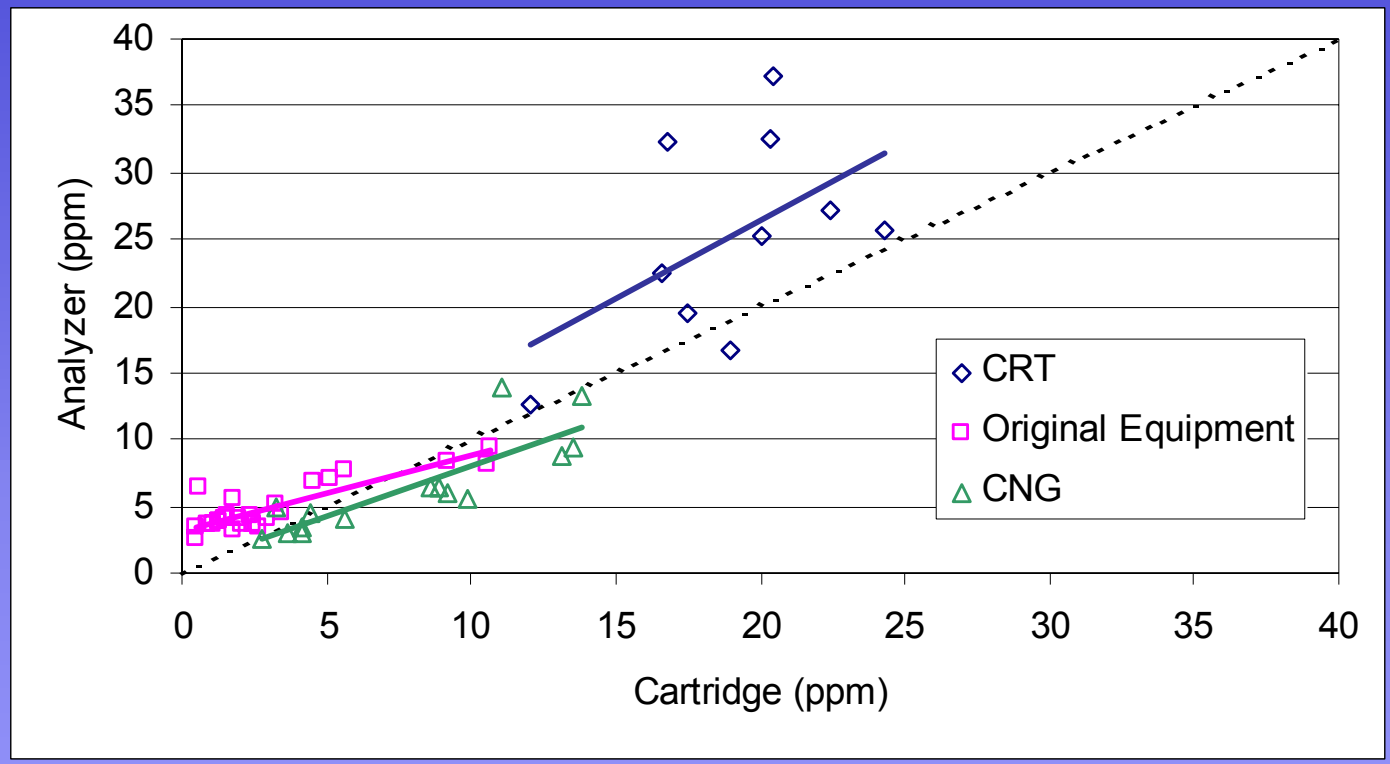
- Chemiluminescent Analyzer Method
  - NO & NO_X dilute exhaust concentrations determined
  - 2 heated analyzers -California Analytical Model 400-HCLD
  - Corrected for ambient concentrations and atmospheric conditions
  - Continuous collection at higher instrument range
- DNPH (2,4-dinitrophenylhydrazine) Cartridge Method*
  - Reaction of NO_2 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 Exhausts of HDD Trucks and Transit Buses by HPLC Following 2,4DNPH cartridge collection"

NO_2/NO_X Concentrations from an Urban Transit Bus

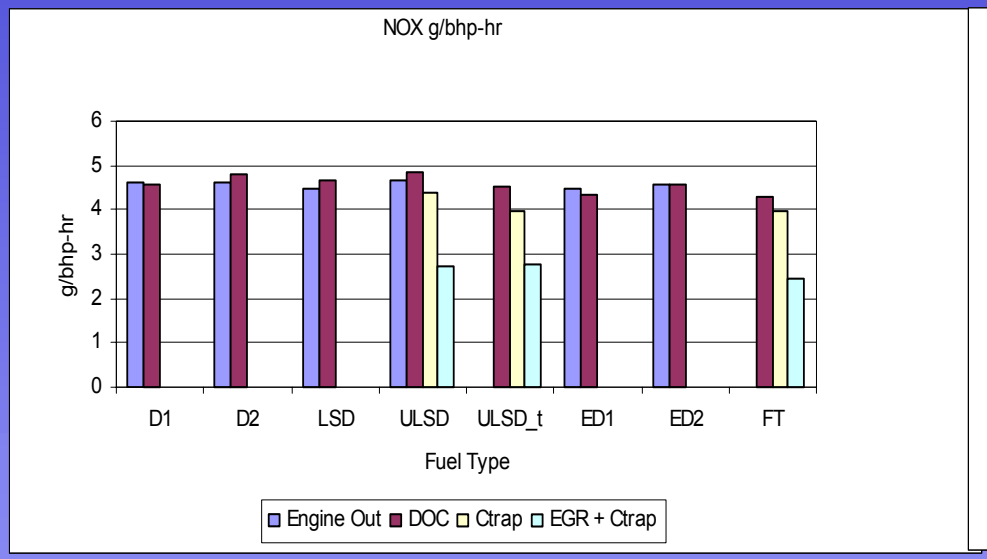


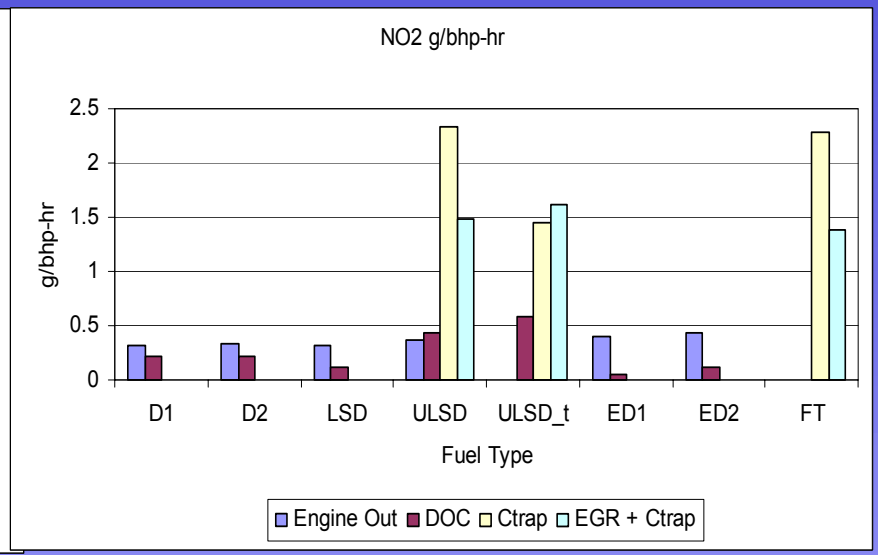
Comparison of Measured Dilute Exhaust NO_2 Concentrations



Reference: ES&T Tang, Graham et al.

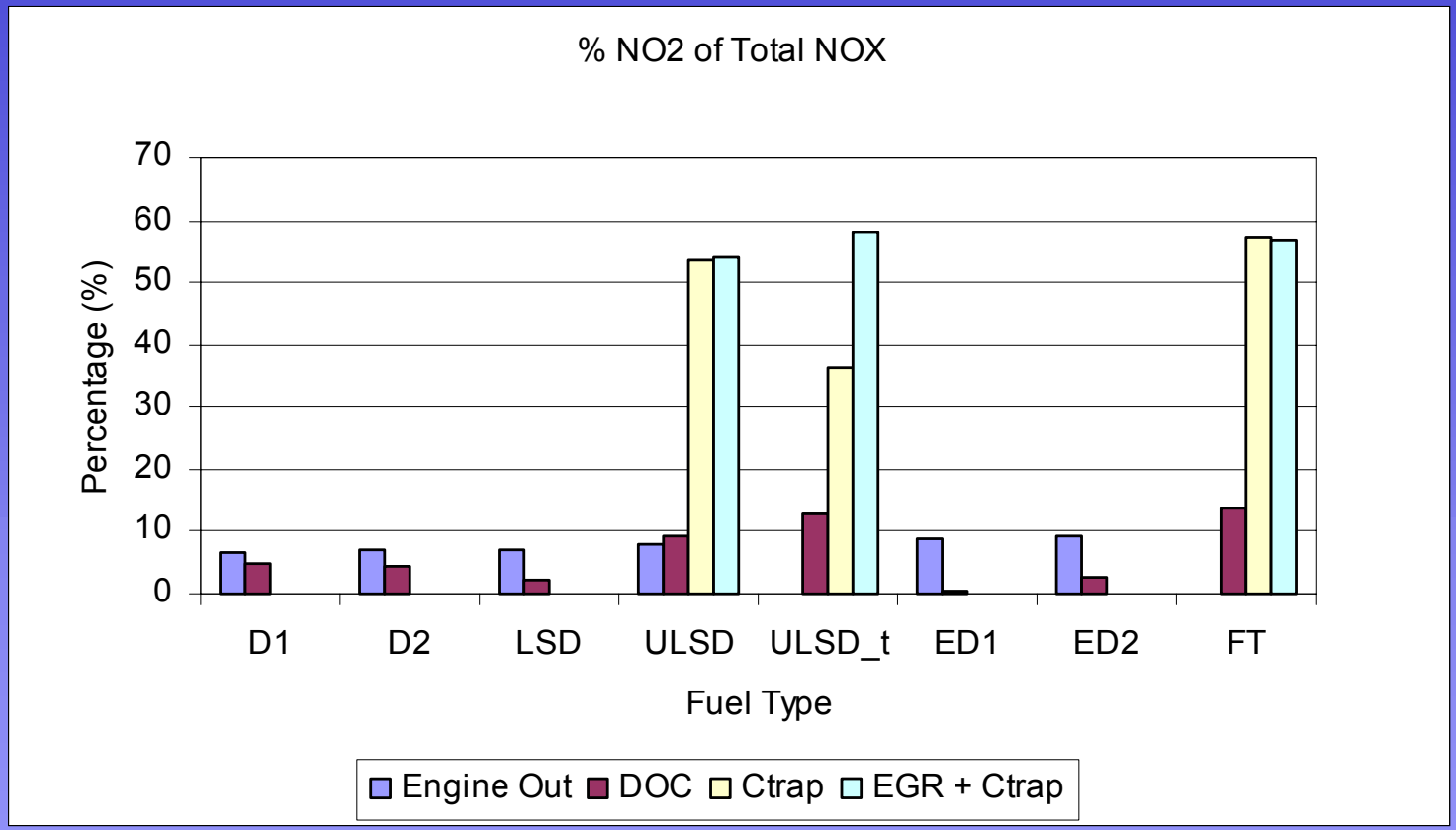
International DT466, MY 2000
7.6L, inline 6, 237bhp @ 1400 rpm





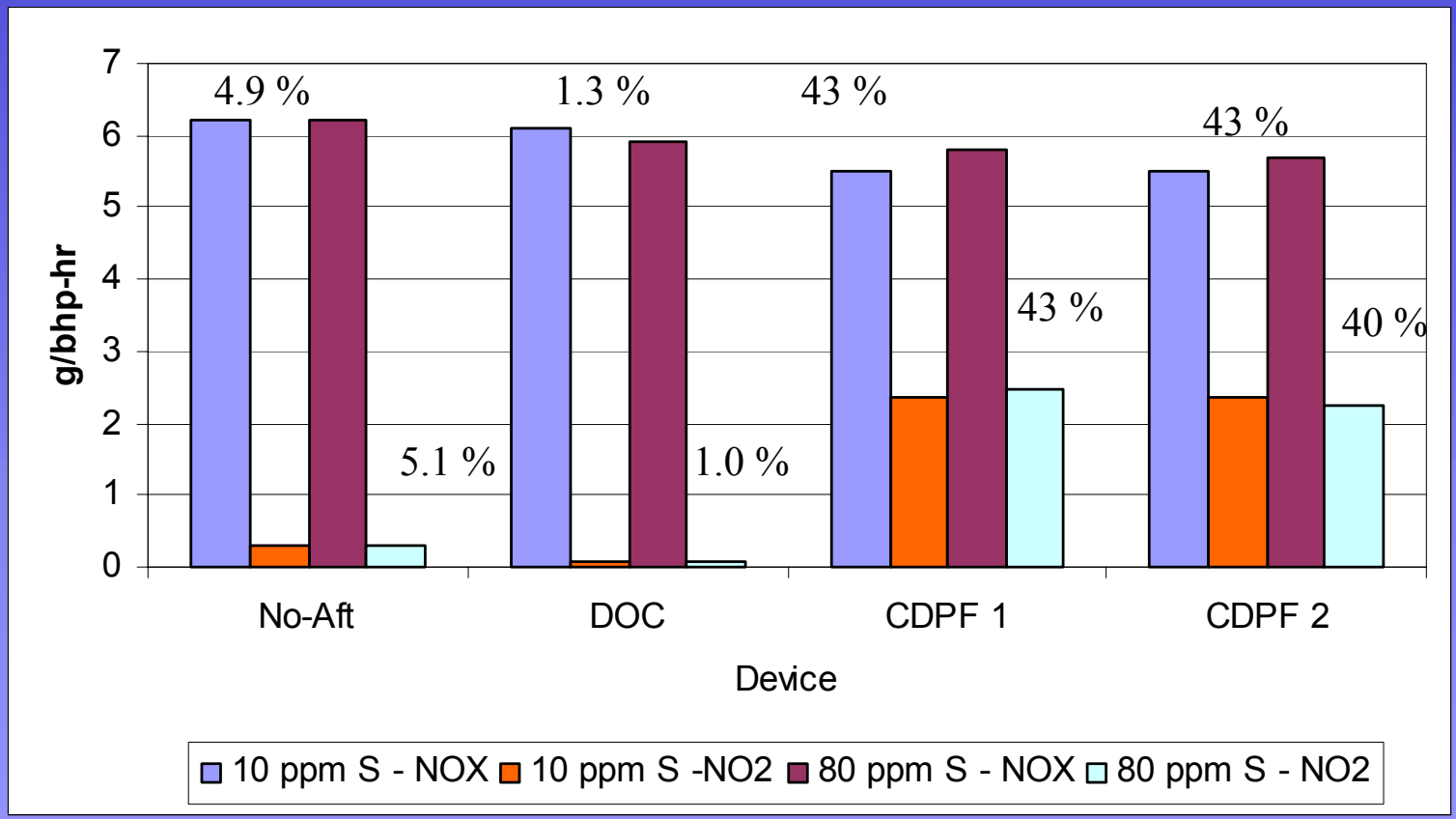
Reference: SAE 2004-01-1085

International DT466 % NO_2/NO_X



Reference: SAE 2004-01-1085

DDC Series 50, MY 1996, 8.5L, inline 4, 275 bhp @ 2110 rpm



CAT C11, MY 2004, 11.1L, inline 6, 305 bhp @ 2100 rpm

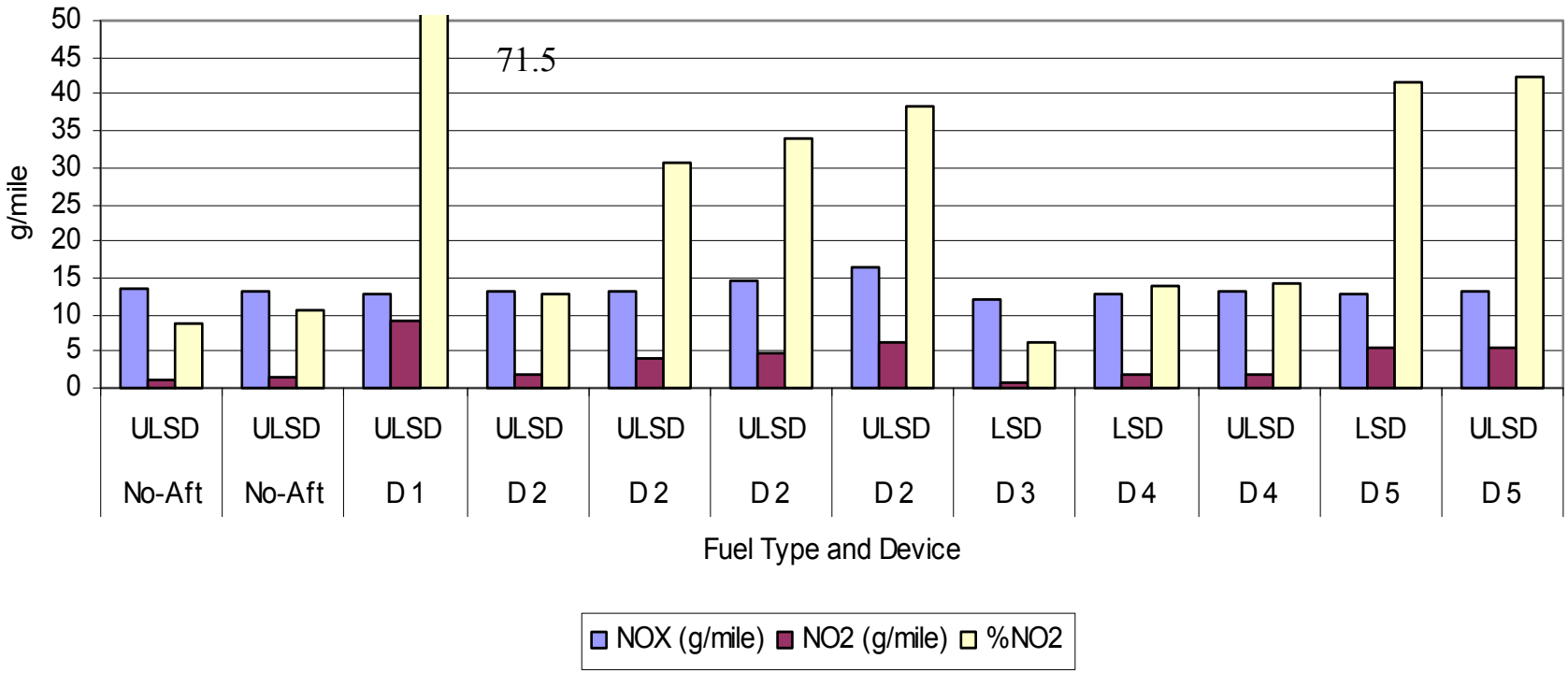
	NO_X g/bhp-hr	NO_2 g/bhp-hr	% NO_2
CS	2.323	0.107	4.61
HS 1	2.077	0.007	0.34
HS 2	2.127	0.010	0.47
HS 3	2.100	0.009	0.43
HS 4	2.094	0.003	0.14

Urban Transit Bus NO_2/NO_X Emissions over the CBD Cycle (g/mile)

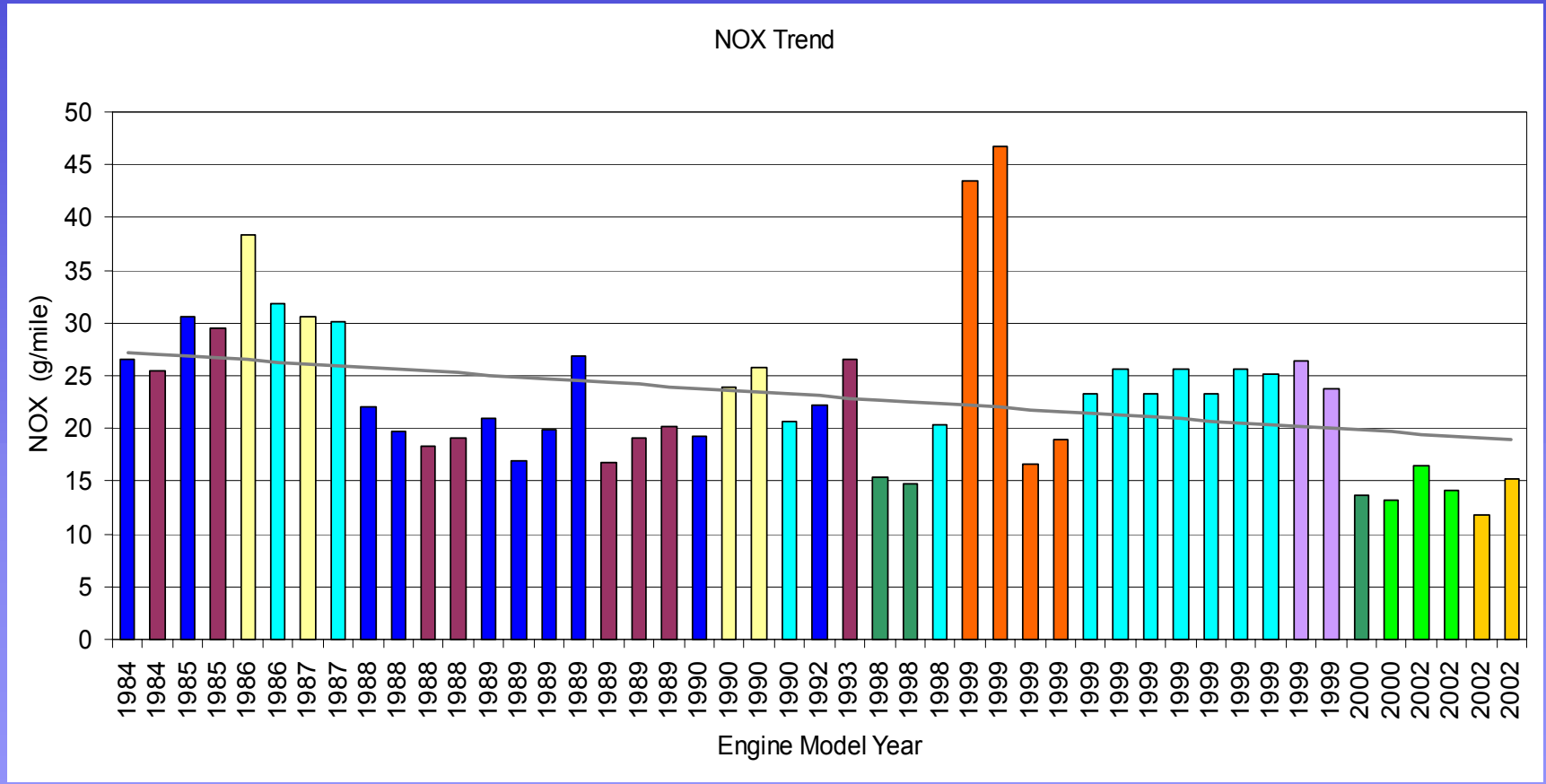
Model	Engine	Configura-tion	Fuel Sulphur (ppm)	NOX	NO2	%NO2
Orion V	DDC Series 50	OEM	247	25.6	1.6	**6**
Orion V	DDC Series 50	OEM	27	25.6	1.8	**7**
Orion V	DDC Series 50	OEM	27	25.1	1.9	**8**
New Flyer CLF	DDC Series 50 G	OEM	CNG	46.7	3.6	**8**
Orion V	DDC Series 50	OEM	247	23.3	1.8	**8**
Orion V	DDC 6v92	OEM	27	25.6	2.0	**8**
Orion V	DDC 6v92	OEM	247	26.6	2.1	**8**
New Flyer CLF	DDC Series 50 G	OEM	CNG	19	2	**11**
Orion V	DDC 6v92	OEM	247	20.5	2.8	**14**
Orion V	DDC 6v92	OEM	27	21.1	2.9	**14**
Orion V	DDC 6v92	OEM	27	21.6	3.3	**15**
New Flyer CLF	DDC Series 50 G	OEM	CNG	16.6	3.3	**20**
Orion V	DDC Series 50	CDPF	27	23.8	12.6	**53**
Orion V	DDC Series 50	CDPF	27	26.4	14.5	**55**

Reference: SAE 2002-01-0430

Hybrid Bus with Selected Emission Control Devices



Evolution of Urban Transit Bus NO_X



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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_2O 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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