Hydrogen generation from plasmatron reformers and use for diesel exhaust aftertreatment*

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Diesel Engine Emissions Reduction(DEER) Meeting

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**Plasma Science and Fusion Center

***Sloan Automotive Laboratory

Plasmatron Reformer Technology

- Robust and versatile technology
  - Special low power plasma promotes partial oxidation conversion of gasoline, diesel, bio oils, and other fuels to hydrogen-rich gas
- Advantages:
  - Fast startup and rapid response to transient conditions
  - Relaxation or elimination of reformer catalyst requirements
  - Compact
  - Efficient
  - Robust capability for onboard multi-fuel reforming (can process difficult to reform fuels, e.g. diesel, bio-oils, ethanol)

Potential applications to internal combustion engines vehicles using diesel, gasoline and alternative fuels

- Enhanced diesel exhaust aftertreatment using plasmatron generated hydrogen rich gas (e.g. improved regeneration of NOx traps)
  - Reduced NOx
  - Reduced particulates
- Alternative and renewable energy derived fuels
  - Conversion of difficult to use fuels (e.g. bio oils) to hydrogen rich gas
  - Rapid response, efficient and robust conversion of ethanol
- HCCI engines using diesel and other fuels
- Hydrogen enhanced turbocharged gasoline SI engines
  - Improved combustion, including ultra-lean operation
  - Economically attractive means to substantially increase efficiency (e.g. 30% improvement)
  - Further reduction of already low emissions from spark ignition gasoline engine vehicles

Diesel plasmatron reformer

Average electrical power consumption ~250 W

Diesel reforming

- Reforming heavy fuels into hydrogen and light hydrocarbons,
  - low oxygen content
  - Low or no soot
  - Fast turn-on
- Reformate can be further processed by catalyst
  - Absence of free oxygen minimizes hot spots
  - High hydrogen yield

Diesel reforming without catalyst

Electric power	W	250
O/C		1.1
Diesel flow rate	g/s	0.8
Corresponding chemical power	kW	35

Concentration (vol %)	
H_2	8.2
O_2	1.4
N_2	68.7
CH_4	2.6
CO	14.3
CO_2	4.7
C_2H_4	2.4
C_2H_2	0.0

Energy efficiency to hydrogen, CO and light HC	70%
Soot (opacity meter)	0

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H_2-Assisted NOx Traps: Test Cell Results Vehicle Installations

Sam Crane
August 28, 2003

Project Objectives

- Determine Advantages of H_2 Assisted NO_x Trap Regeneration
- Establish Feasibility and Effectiveness of H_2 Assisted NO_x Traps in a Bus Installation
- Establish Feasibility and Effectiveness of H_2 Assisted NO_x Traps in a Light Duty Vehicle Installation

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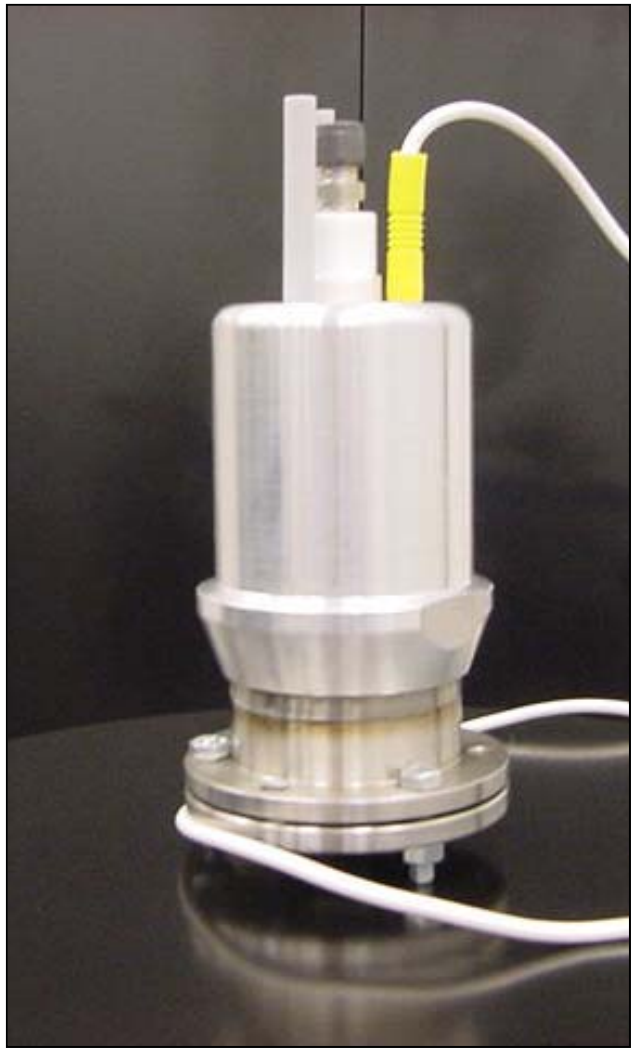
Gen H Fuel Reformer

- After-treatment Suitable
  - Reforms Diesel: 22% H_2
  - Low soot
- Enclosed housing
  - EMI reduced
  - Safety improvement
- New Power Supply
  - Under 250W consumption
  - Minimal heat rejected
  - Compact transformer
- High-temperature flange seals
  - Reduced leakage



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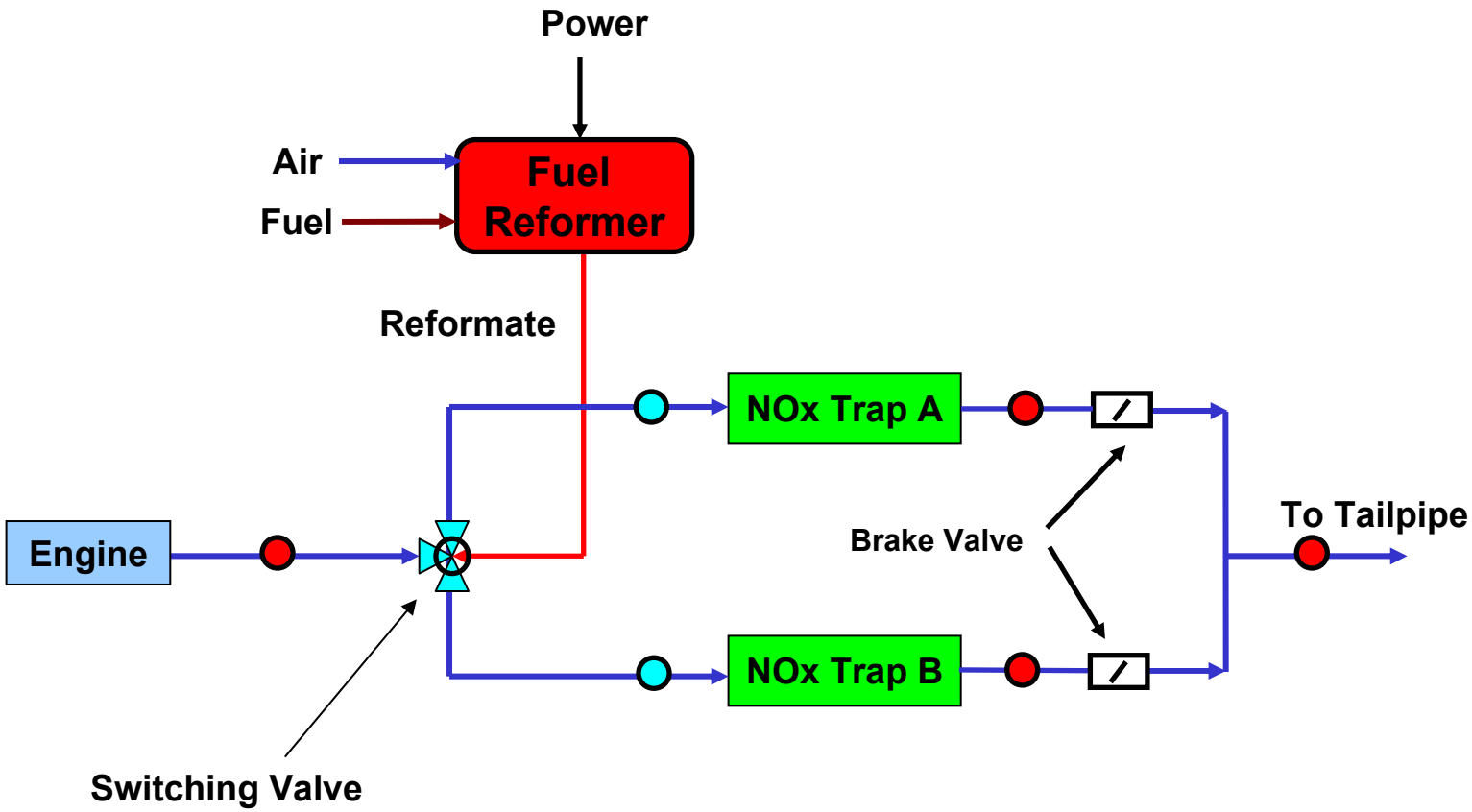
H2-Assisted NOx Trap: Test Set-up



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Test Cell Installation: H2-Assisted NOx Trap

Cummins 8.3L MY2000

NOx Traps 14L/leg

Switching Valve

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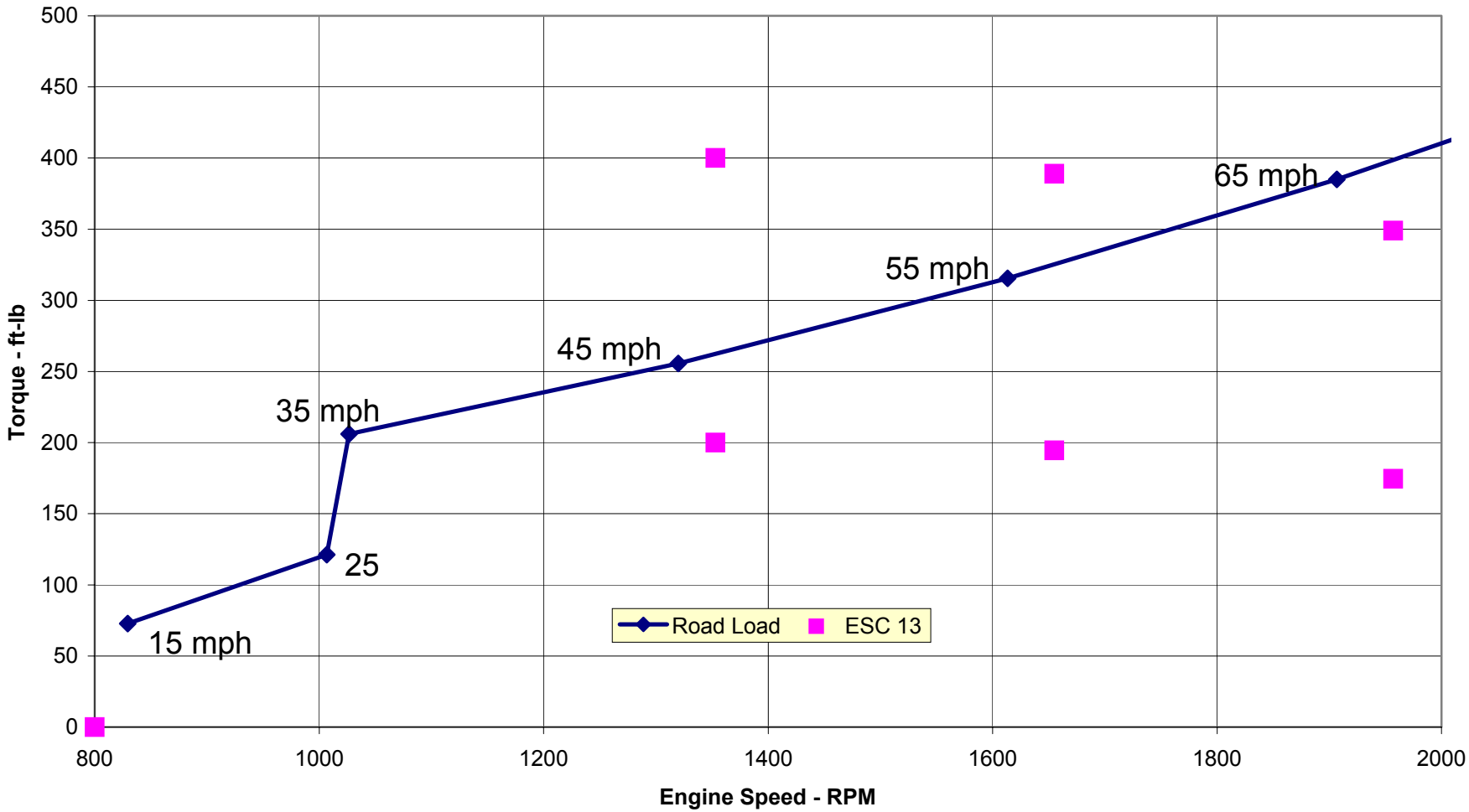
BUS Road Load vs ESC 13 Mode



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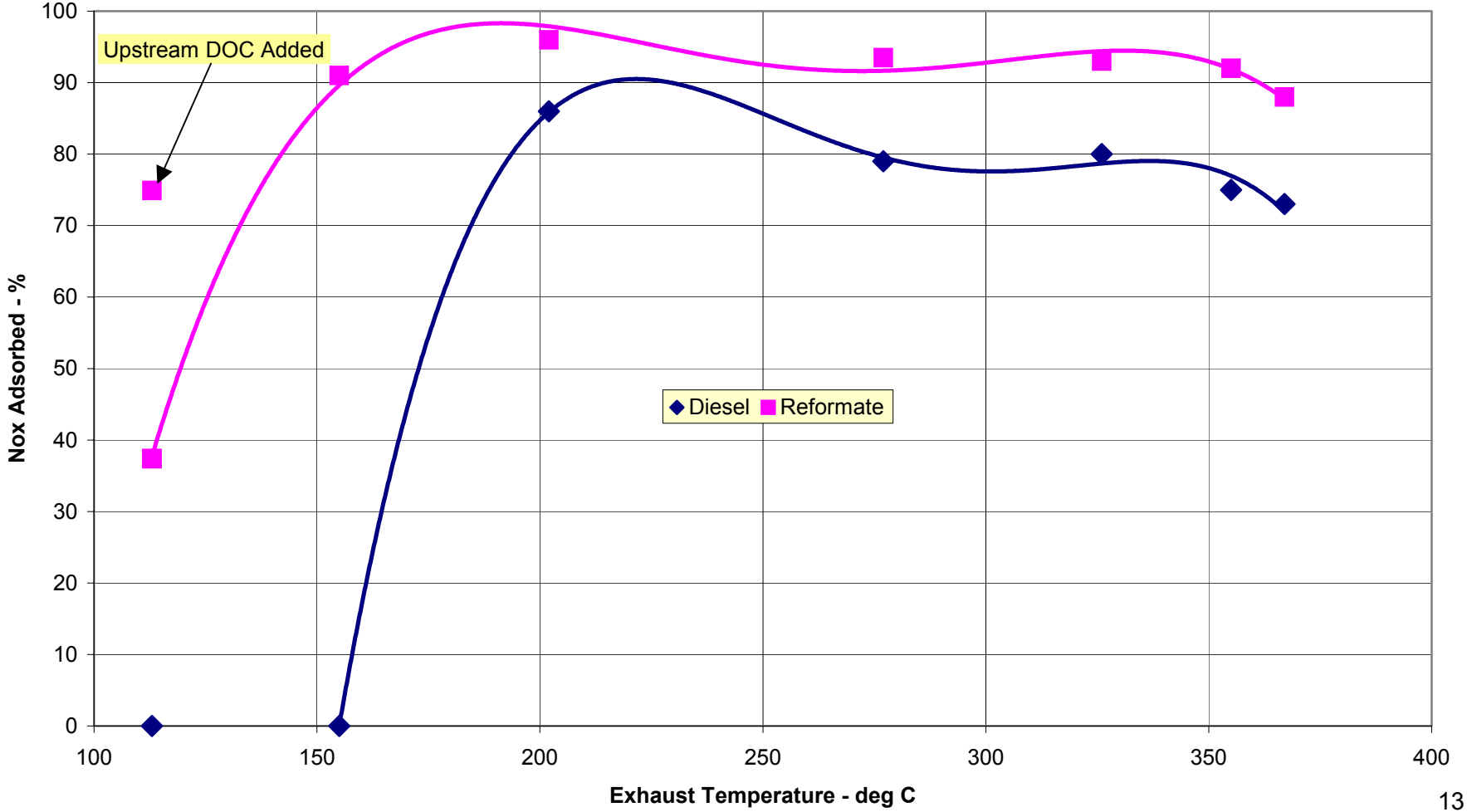
NOx Adsorption Comparison – Bus Road Load Same Fuel Penalty



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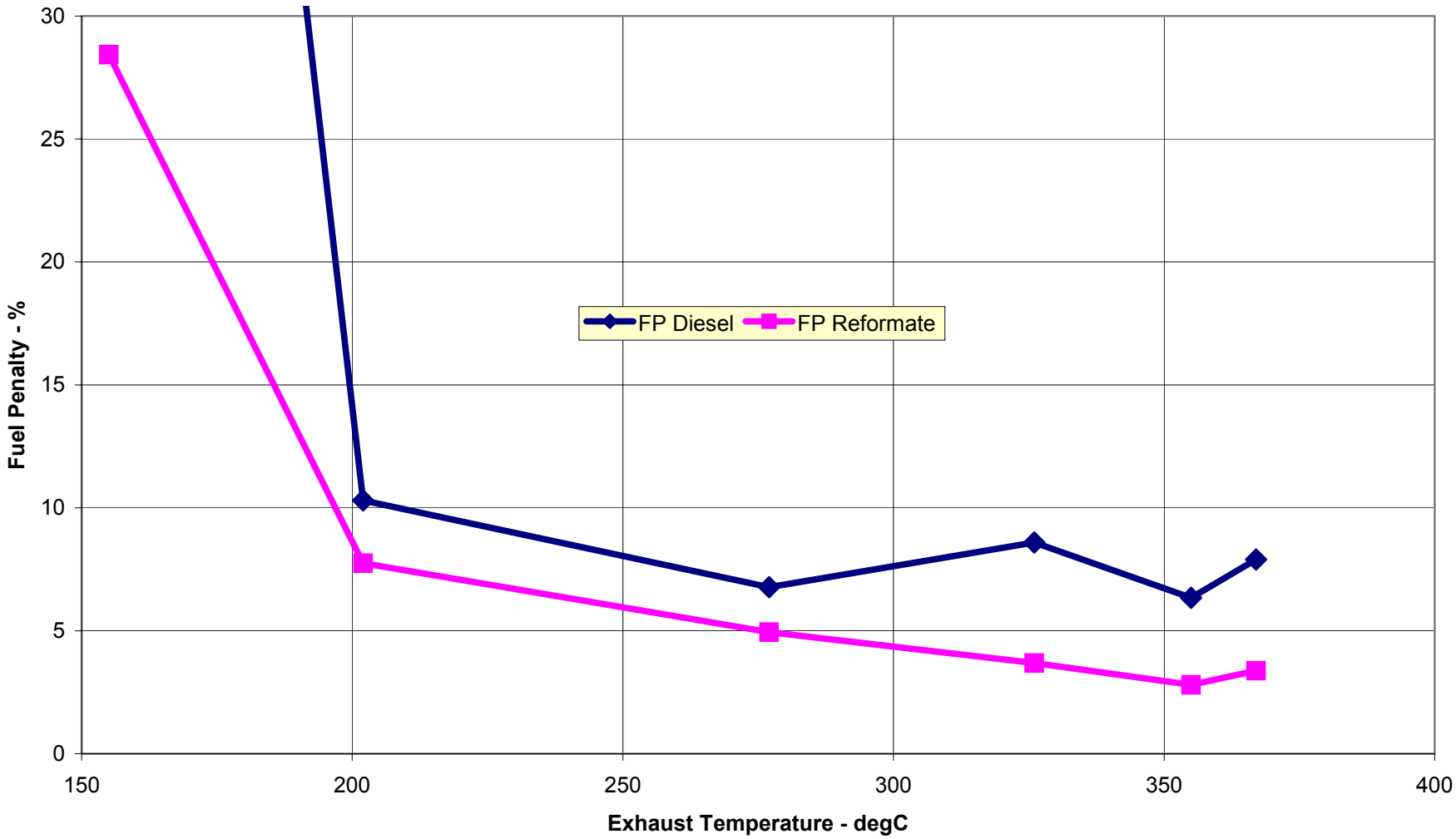
Fuel Penalty - Bus Road Load Same NOx Adsorption



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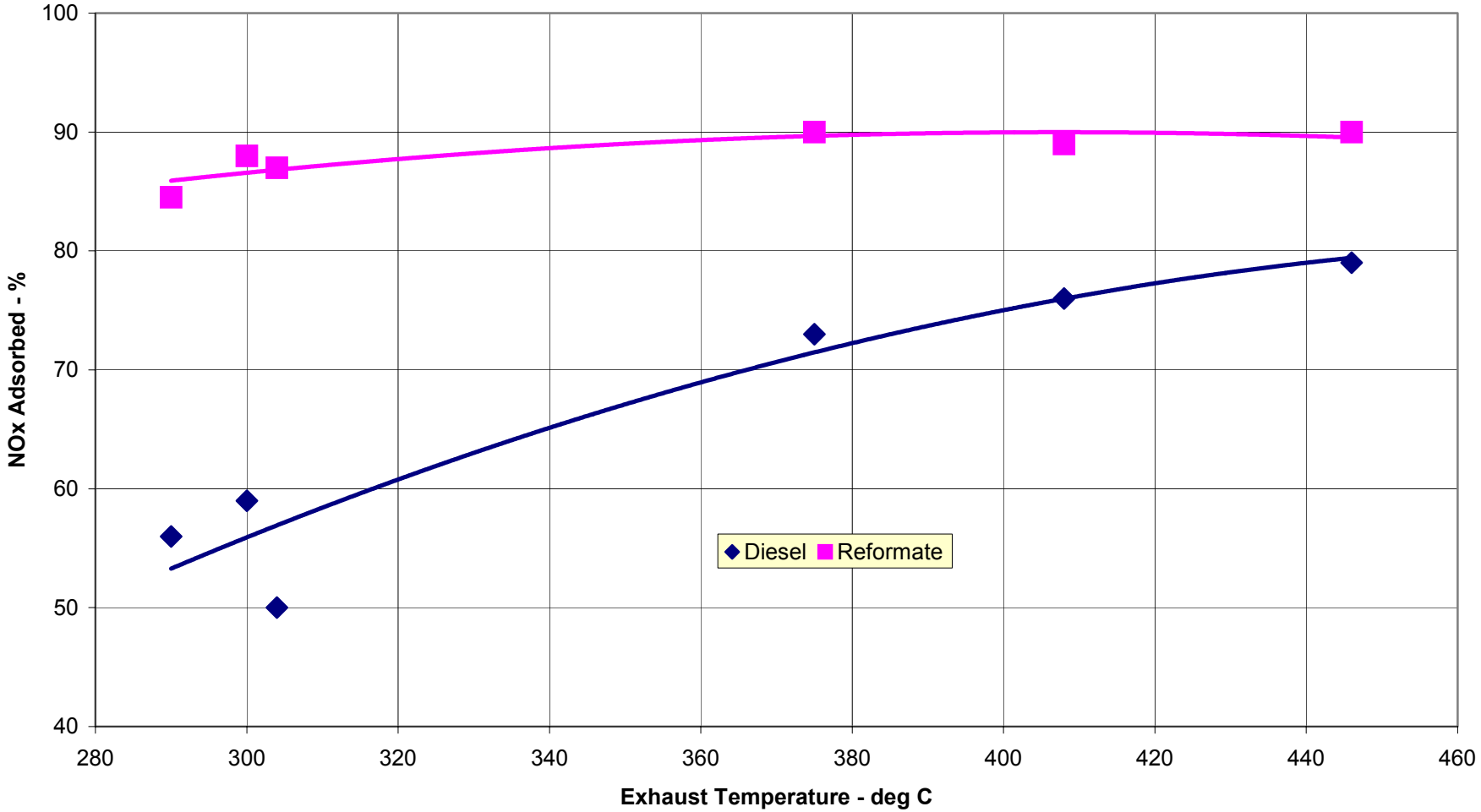
NOx Adsorption - ESC Modes Same Fuel Penalty



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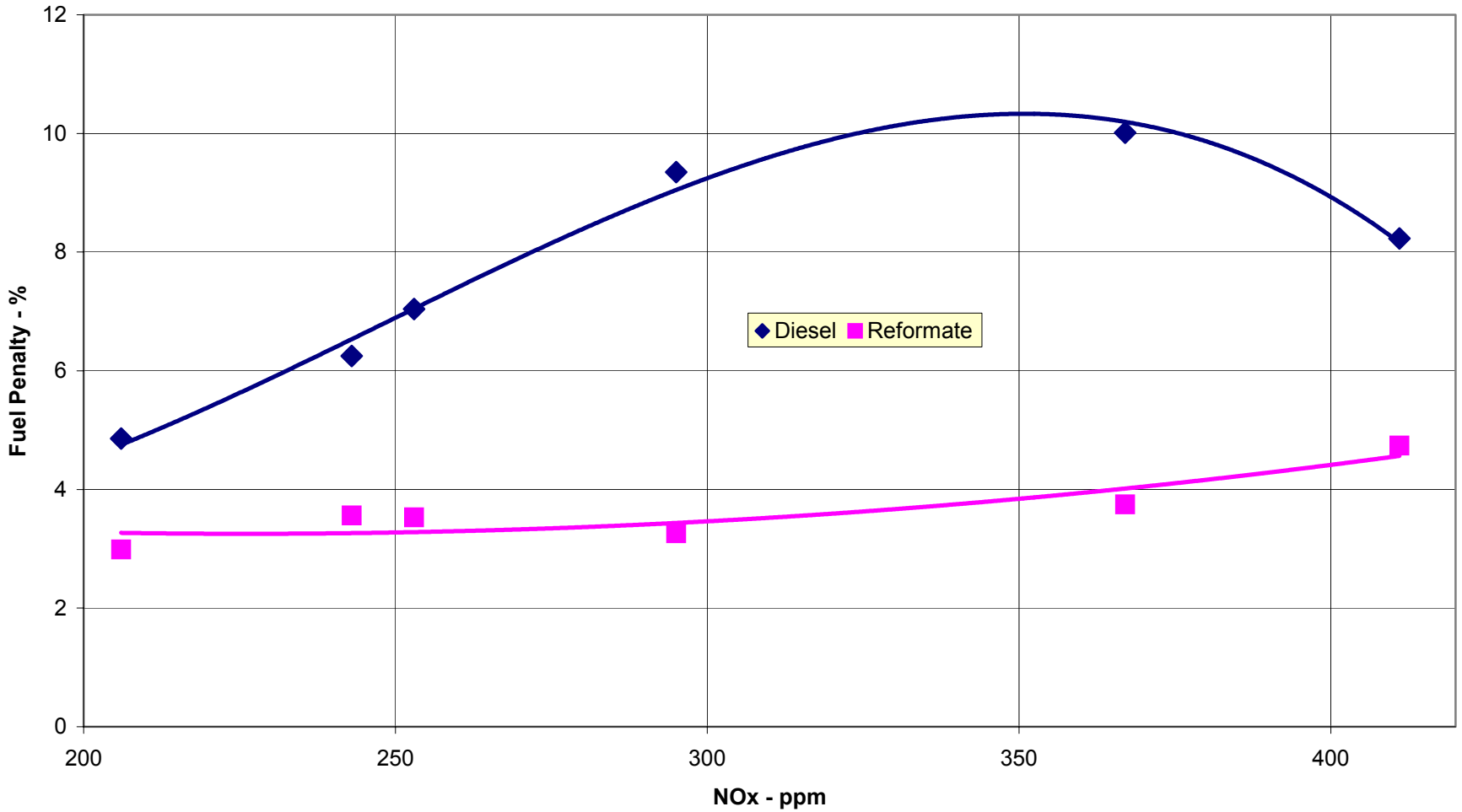
Fuel Penalty - ESC Modes
Same NOx Adsorption



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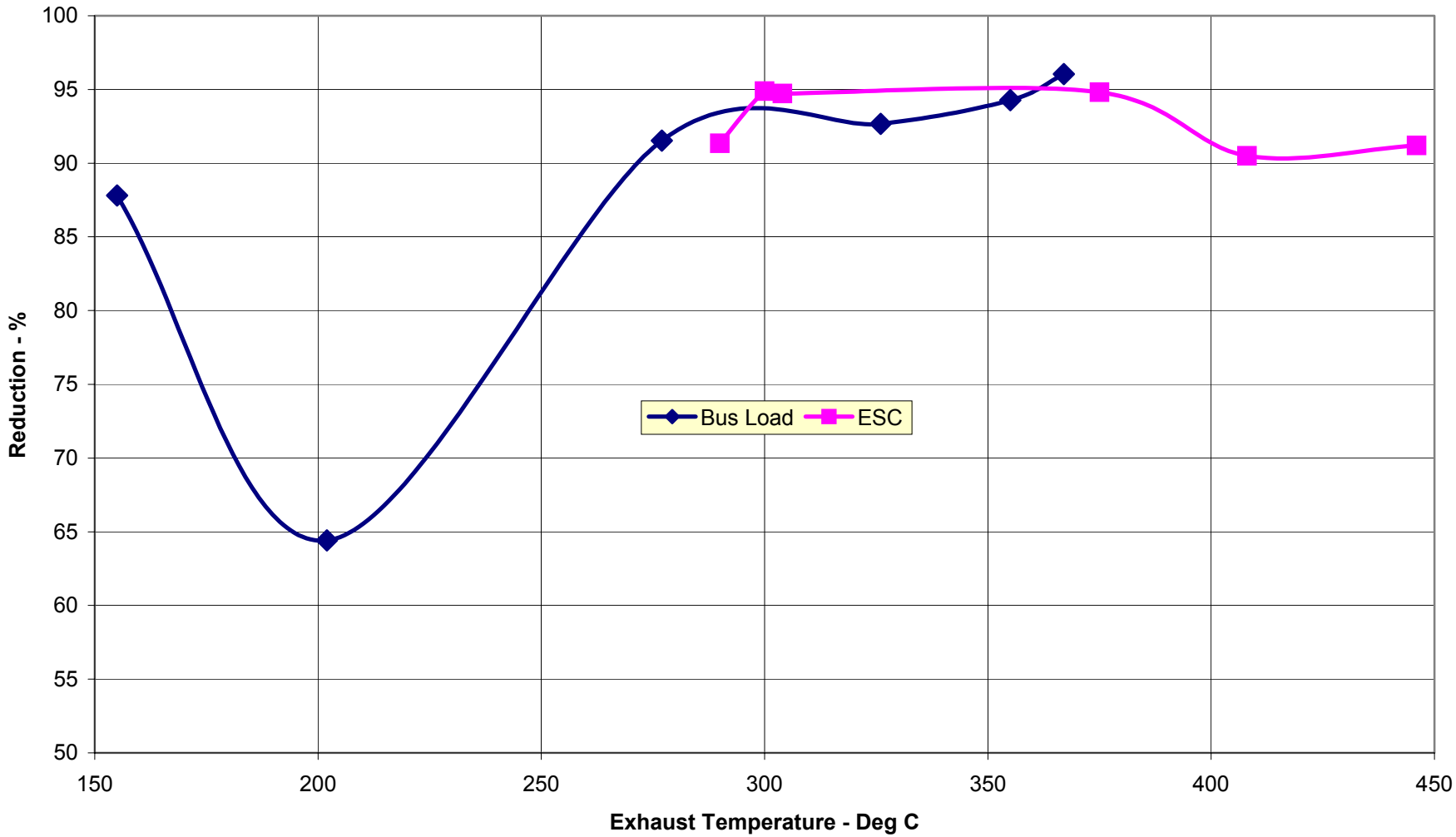
Reduced Hydrocarbon Slip



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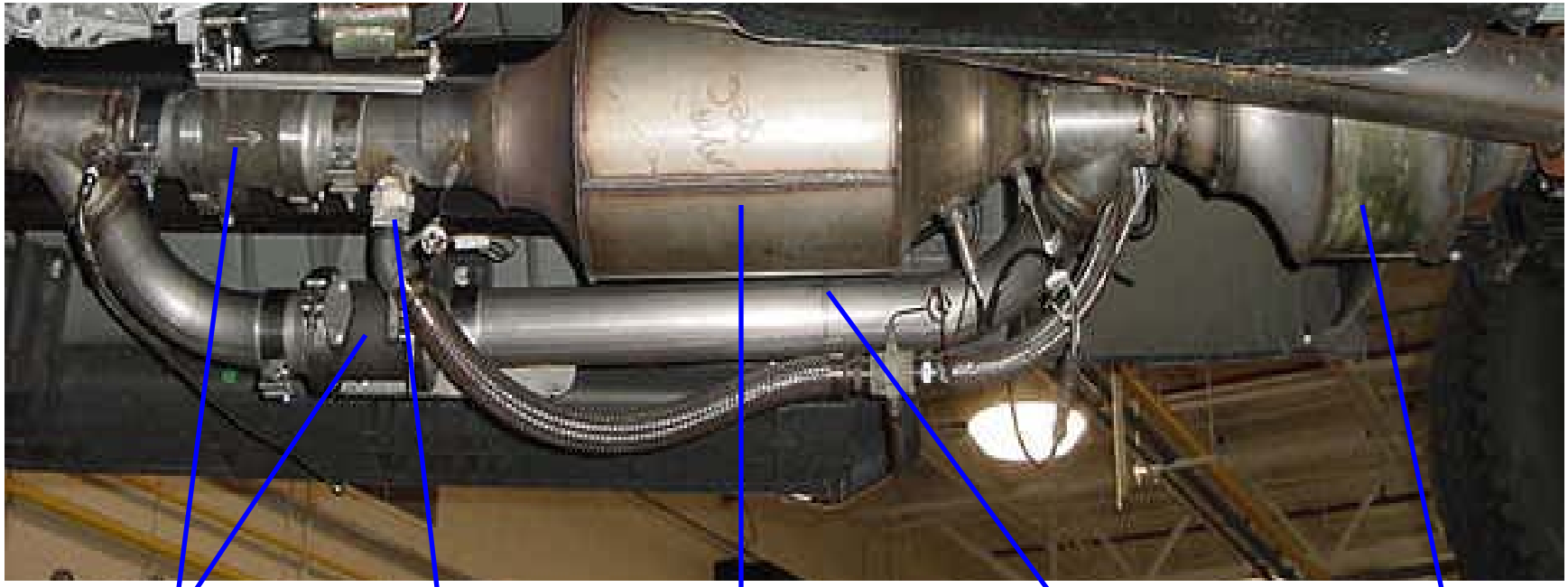
F250 H2-Assisted NOx Trap Installation



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Bus H2-Assisted NOx Trap Installation

Access Door

Fuel Reformer Box

NOx Trap:
21L/leg

Summary of Results: H2-Assisted NOx Trap

- Regeneration Fuel Penalty Reduction of roughly 50% at moderate exhaust temperatures
- Idle regenerations achieved
- Hydrocarbon slip dramatically reduced
- Dual Leg System installed and operating on a Transit Bus : 80 – 90% NOx Reduction
- Single Leg Bypass System installed and operating on an F250 Truck: 70% NOx Reduction

Future Efforts: H2-Assisted NOx Trap

- Investigate Potential Advantages in Desulfation of NOx Traps: Lower Temperature and Reduced Duration
- Test other NOx Trap Formulations: Improve both High and Low Temperature Performance
- Develop Gen H Fuel Reformer into a mature product