On-Board Ammonia Generation Using Delphi Diesel Fuel Reformer

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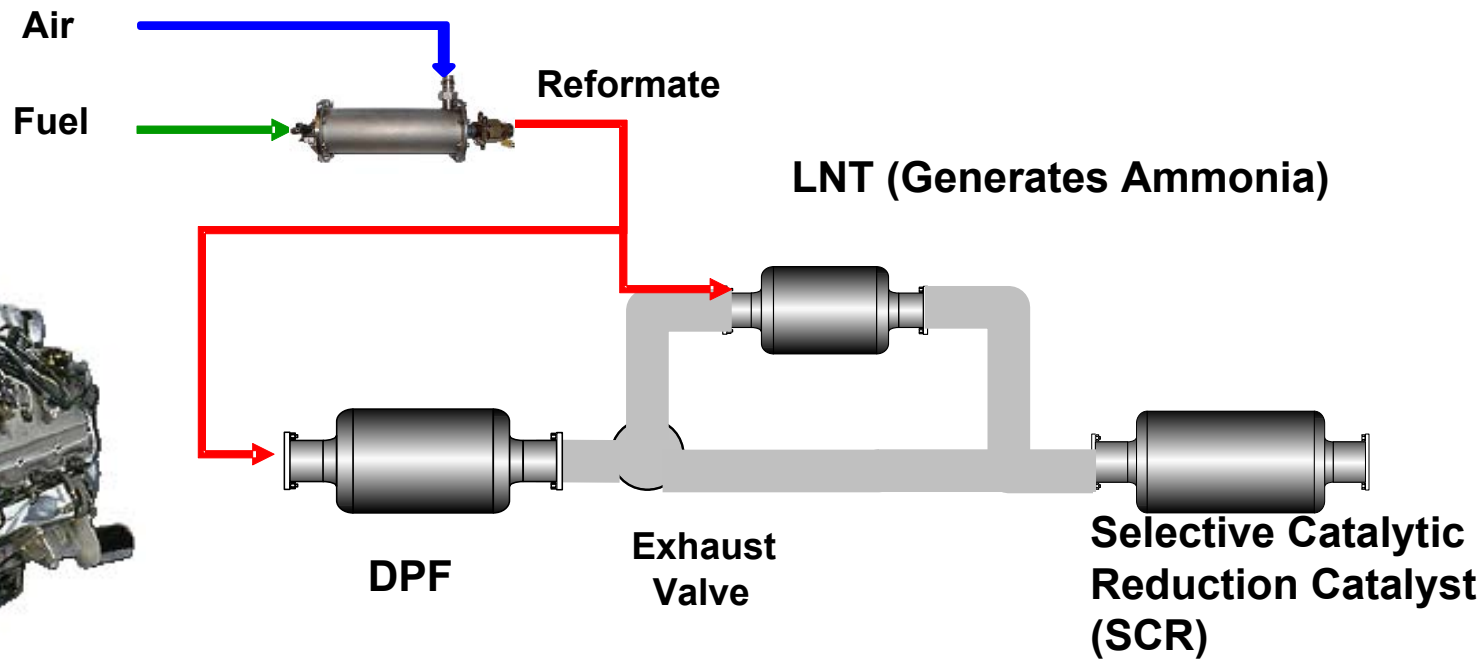
DEER, August 13-16, 2007

Delphi On-Board Ammonia Generation (OAG) Based Exhaust Aftertreatment System



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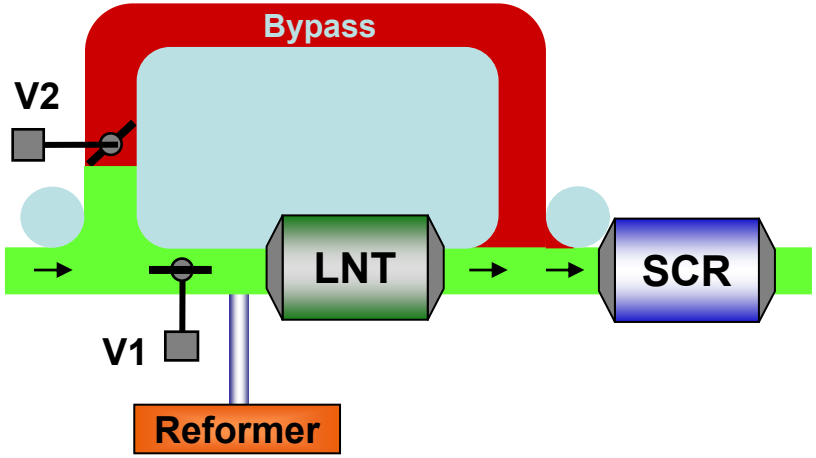
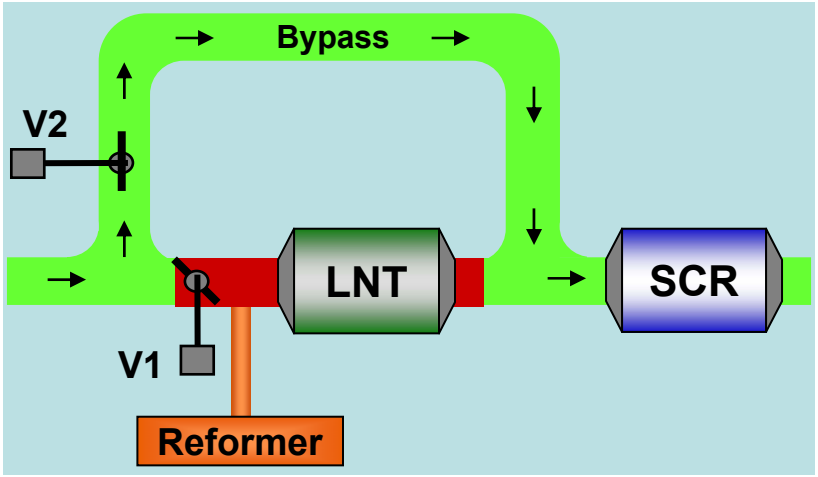
Delphi OAG Operating Principle



- **NOx storage**
- NO_x is stored on the LNT
- Breakthough NOx is converted by the SCR



- **Regeneration**
- Exhaust gas is bypassed around the LNT
- Reformat is injected into the LNT
- Stored NOx in the LNT is converted to NH_3
- NO_x in the exhaust is reduced by the SCR

- 2-way Valves
- When valve 1 is open, valve 2 is closed; when valve 2 is open, valve 1 is closed
- Reformat is injected with valve 1 closed

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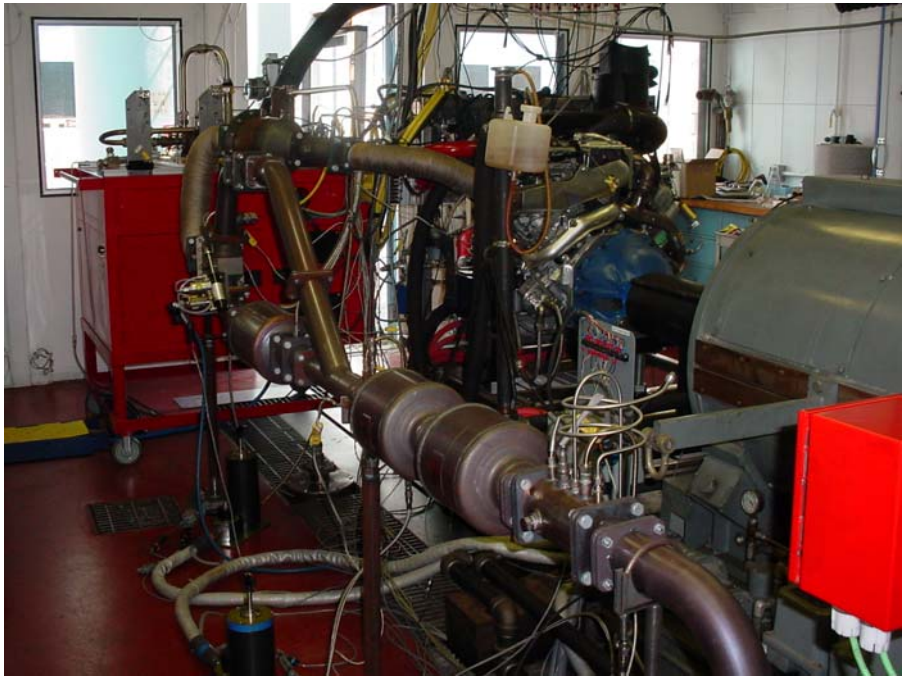
Delphi DFR Dynamometer Site



- 3 Emission Sampling System: Engine, intermediate, Tailpipe
  - HC, CO, NOx, O_2, CO_2
  - Tail Pipe N_2O
- DC Dynamometer
  - Steady States (13 Mode)
  - Dynamic (FTP)

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Delphi OAG Standardized Testing

- Test Cell
  - ’06 6.6L Duramax Engine
  - 3 Sample Benches: EO, Int, TP
  - No heat exchanger
  - DC Dyn. capable of standardized schedules
- Hardware
  - 14L LNT catalyst
  - 15L SCR catalyst
  - 3.5” dia. exhaust
  - Delphi Diesel Fuel Reformer (DFR) providing reformate
- Test Schedules
  - Steady State
    - » ESC
    - » Not To Exceed (NTE)
    - » WHSC
  - Transient
    - » WHTC
    - » FTP-HDD

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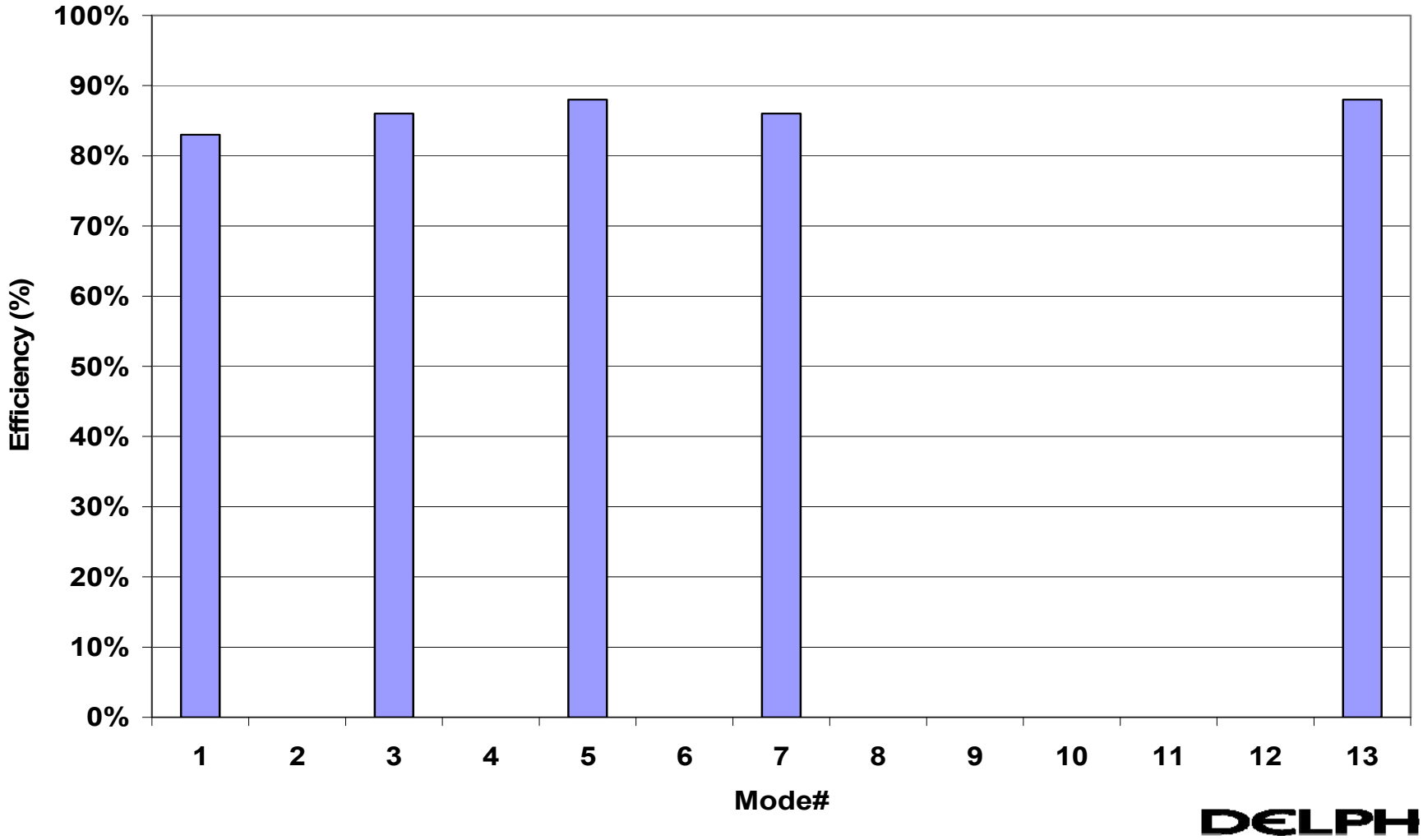
Results Reported at 2006 DEER Conference, ESC 13 Mode



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Test Procedures

- Static Cycles
  - Conducted with “manual” control of divert valve and reformate flow.
  - ESC
  - Not To Exceed 1 & 2 (NTE1, NTE2)
  - WHSC
- Transient Cycles
  - Required automated valve and reformat controls.
  - WHTC
  - FTP-HDD
- When cold starting, reformate is combusted to heat LNT so as to start adsorption of NOx much earlier into the test.

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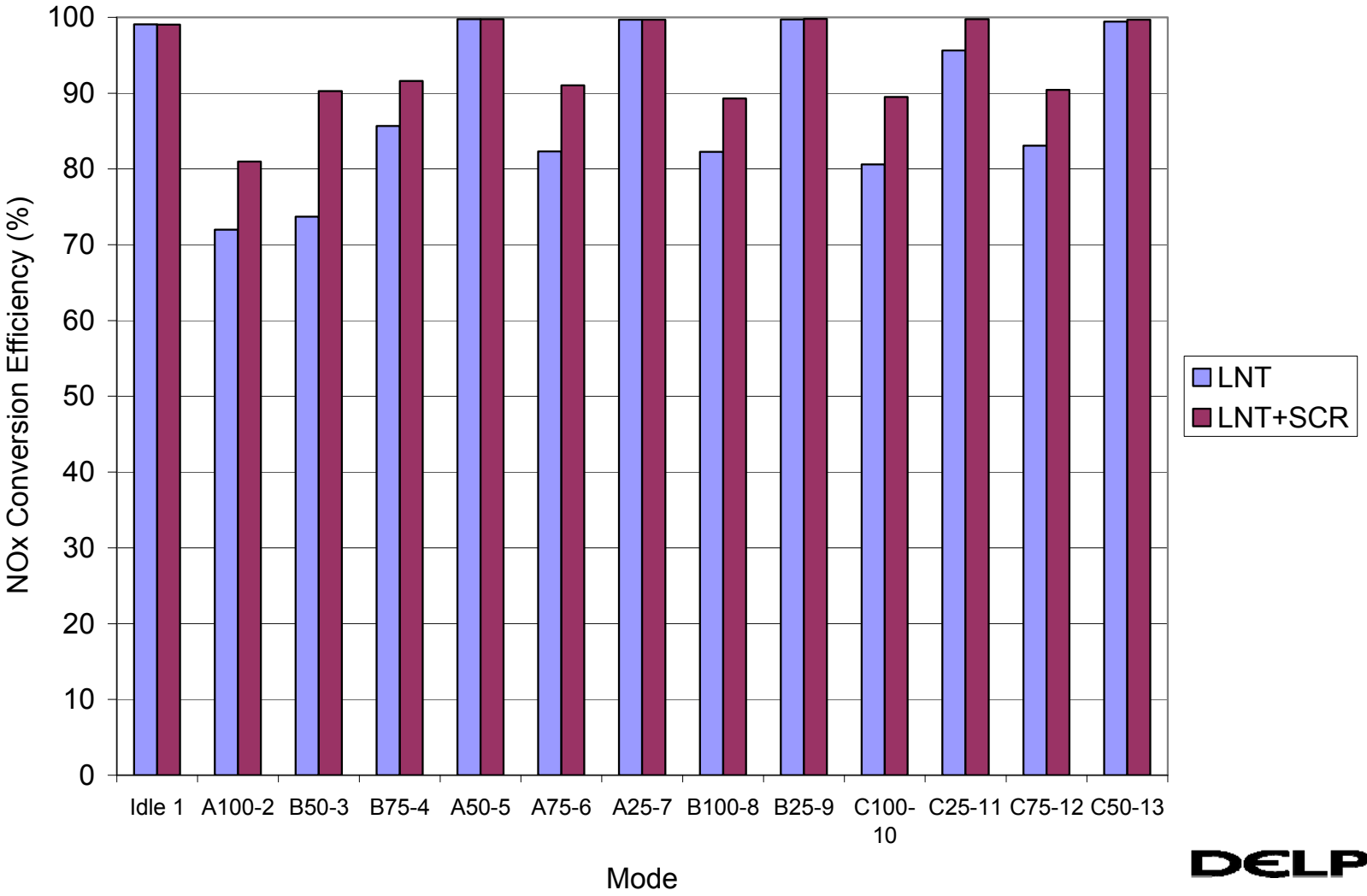
Static Test Results

ESC Mode Test Results



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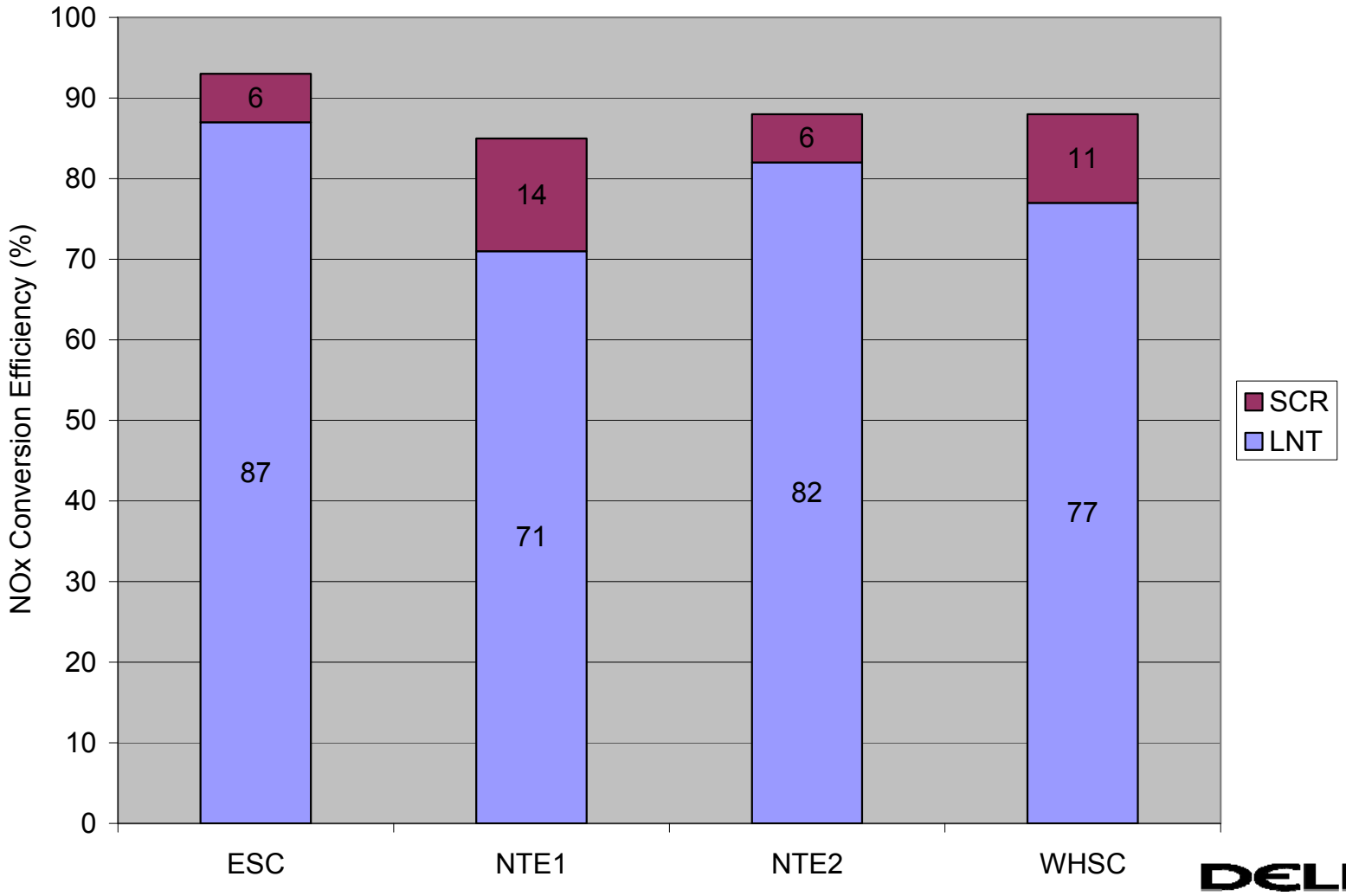
Composite ESC, NTE, and WHSC, Test Results



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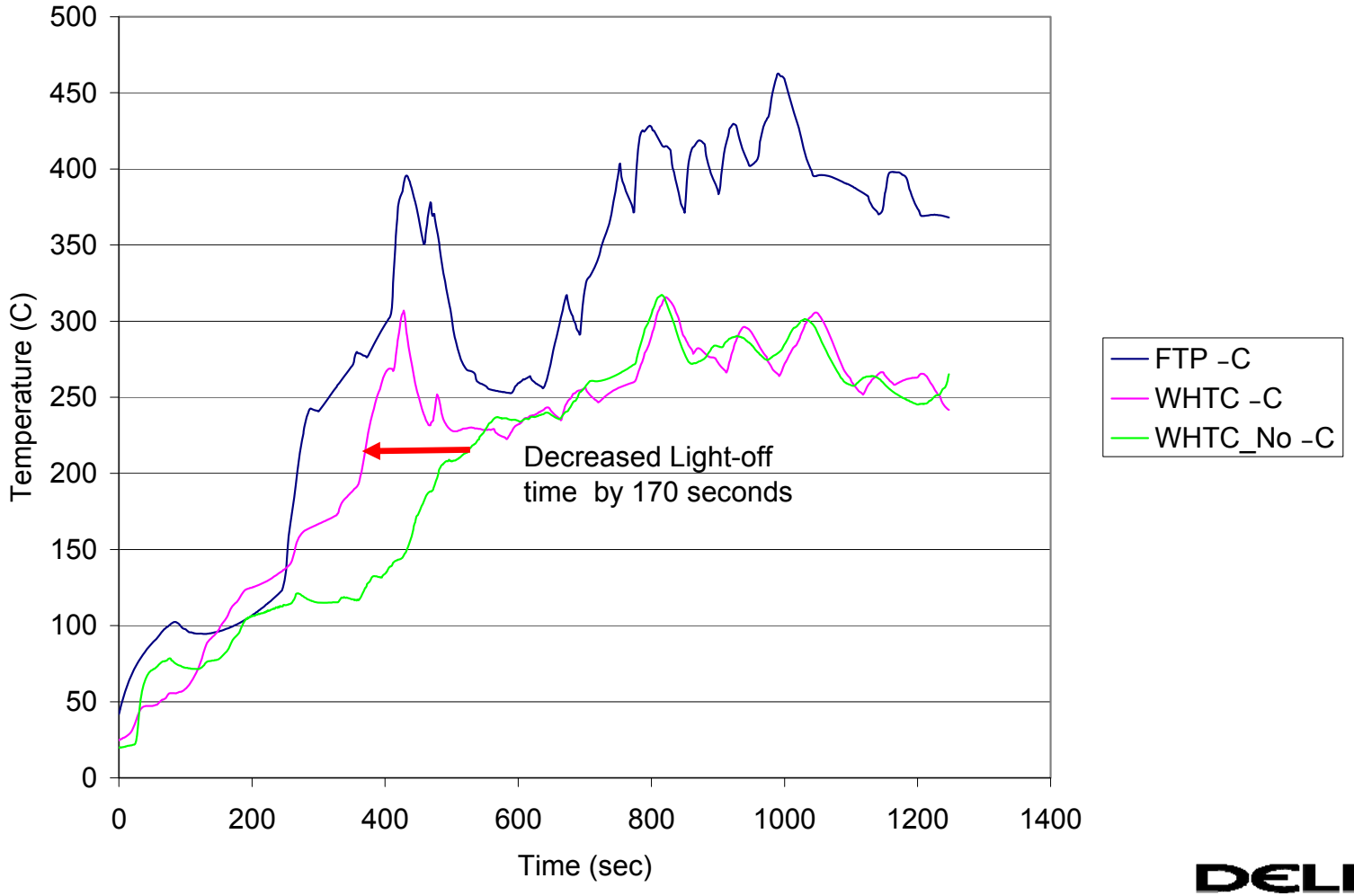
Transient Test Results

Catalyst Temperatures WHTC & FTP with Refomate Combustion LNT Heating



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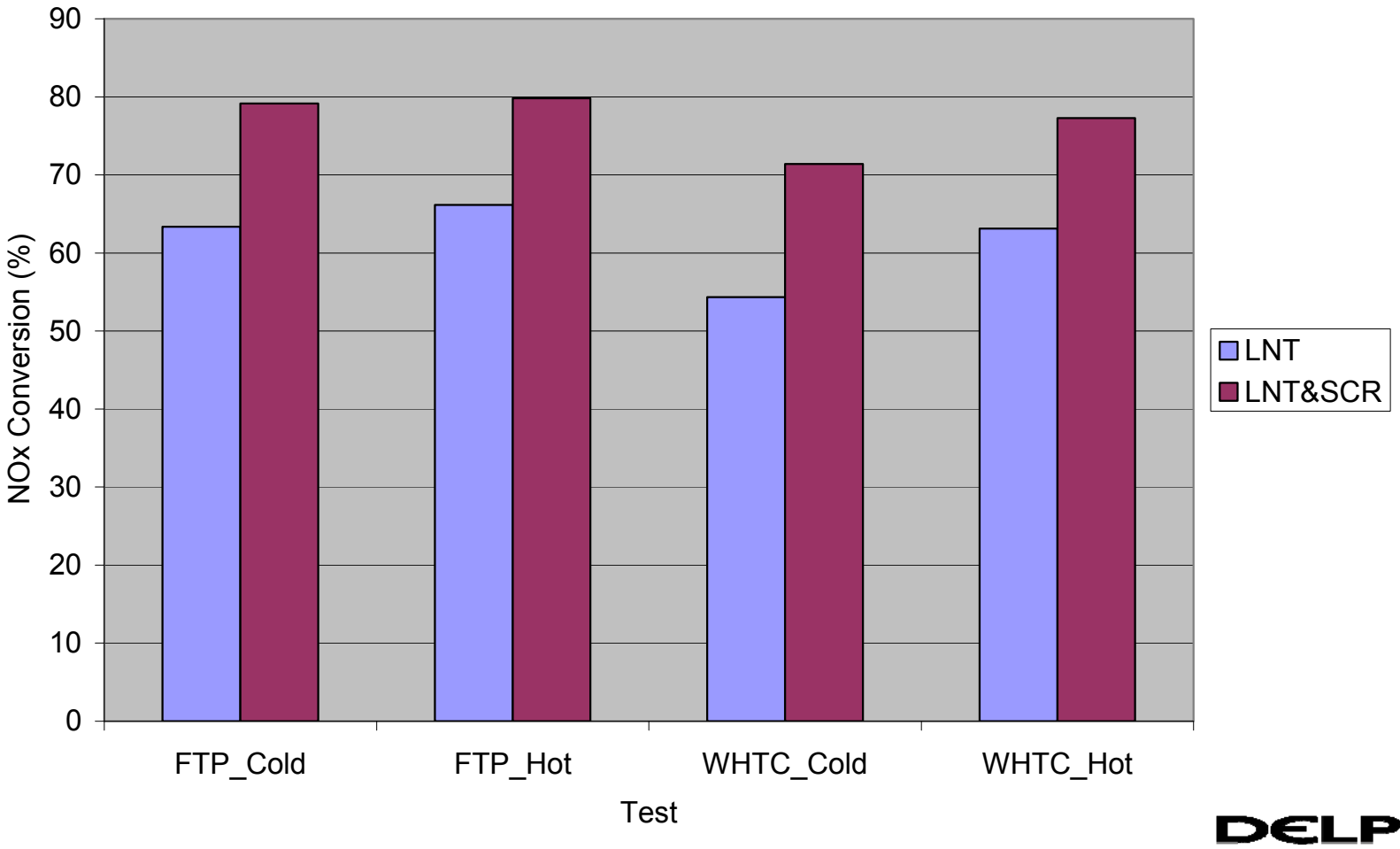
Transient Test Results



Summary

- The OAG system showed high NOx conversion over both static and transient test conditions
  - Testing at Static Cycles ranged 88-92% NOx conversion
  - Testing at Transient Cycles ranged 72-80% NOx conversion
- Reformate can be combusted to decrease the time required for catalysts to reach operating temperatures

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Conclusions

- The Delphi OAG system showed high NOx conversion over a wide range of temperatures and flows
- The Delphi OAG system does not require any additional reductant such as urea.
- The Delphi reformer can be used to enhance exhaust temperature management
- Aftertreatment is decoupled from engine management, offering a high degree of operating flexibility.
- Since the Delphi OAG system does not require engine control modification, system it is applicable to retro-fit applications as well as OEM
- The Delphi OAG system can also be used to regenerate a Diesel Particulate Filter (DPF) in a controlled manner so as to enable low cost cordierite use.

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Delphi On-Board Ammonia Generation System

- Thank you for your attention

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