Integrated Vehicle and Powertrain Technology for EPA 2010 and Beyond

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2007 Diesel Engine-Efficiency and Emissions Research (DEER) Conference
Detroit, August 14, 2007
Contents

- EPA 2010 Requirements
- Powertrain Technology
- Vehicle Integration
- Diesel Exhaust Fluid (DEF) – SCR Certification Requirements
EPA 2010 Requirements

- **Regulatory**
  - 83% Reduction in NOx Compared to EPA ’07
    - From 1.20 to 0.20 g/hp-hr
  - On-board Diagnostics (OBD) Requirements
  - Not-to-exceed (NTE) Enforced Through In-use Emissions Test Run by Manufacturer

- **Customer**
  - Key Metrics Comparable or Better Relative to EPA ’07
    - Fuel Economy
    - Performance
    - Heat Rejection
    - Durability / Reliability
    - Cost
SCR Remains the Lead NOx Aftertreatment Technology for 2010 Heavy-Duty

- Mature Technology
  - Durability and Reliability for End-Customer
- Opportunity to Maintain / Improve Fuel Economy
- Low Lifecycle Cost
- Minimal Impact on Vehicle Cooling System
- Requires Secondary Fluid - DEF
  - DEF Infrastructure Required
  - Compliance / Anti-Tampering Measures Required
- Progress is being made on both the Infrastructure and the Compliance Issues in Collaboration with other Stakeholders Including other Engine and Vehicle OEMs
  - SCR Certification Guidance Document Issued by EPA on March 27, 2007
DEF-SCR Offers Potential to Improve Fuel Economy
Magnitude Depends on Combustion System Characteristics
Selective Implementation of Low Emissions Combustion over Transient Hot FTP Cycle

20% Reduction in engine-out FTP NOx, relative to prototype EPA ’07 reference baseline, while maintaining engine-out PM

-20%
Selective Implementation of Low Emissions Combustion over Transient Hot FTP Cycle

18% Reduction in engine-out FTP PM, relative to baseline, while maintaining engine-out NOx levels
Multiple-Mode, Low-Emissions Combustion Implemented over Transient FTP

![Graph showing engine-out PM vs. engine-out NOx with baseline and improved NOx/PM trade-off trends.](image-url)
Technical Demonstration of EPA 2010 Emissions

Weighted FTP

Tailpipe-out NOx (g/hp-hr)

Test Cycles

ESC
Model-based Control Systems Remain a Key Enabling Technology to Optimize the Integrated Performance of Multiple, Flexible Sub-systems
Low Emissions Combustion, DPF and DEF-SCR Integrated on a Vehicle Test-bed

Example System Integration Installation for Long Sleeper Cabs

2010 Technology Vehicle at the DEER 2006 Vehicle Display

11/08/2006
A SAMPLE OF HD FREIGHTLINER & STERLING PRODUCT LINES & VOCATIONS
DEF-SCR Certification

- EPA’s SCR Certification Guidance Issued on March 27th, 2007
- Detroit Diesel (through its parent company Freightliner LLC), Volvo and Mack have teamed up to address non-competitive issues related to DEF-SCR certification

- Key topics being addressed by the consortium include collaboration with the EPA, development of DEF infrastructure, facilitating DEF distribution to fuel retailers and truck stop chains and creating and enforcing DEF quality standards

- The consortium is open to any manufacturer with a declared intention to use SCR

- Invitations to join the consortium have been extended to all members of the Engine Manufacturers' and Truck Manufacturers' Associations
Specific Topics being Addressed

- DEF standards
  - Nozzle
  - Fluid quality
- DEF infrastructure
- DEF tank sizing
- Low DEF driver warning and inducement
- DEF thawing and refreeze protection
- Tamper resistance
- Education and outreach
EPA 2010 DEF Consumption ~1-2% of Fuel Consumption

EPA 2010 Driving Range 8-16k Miles between DEF Refills for 30 Gallon Tank
EPA 2010 Driving Range 2.5-5k Miles between DEF Refills for 10 Gallon Tank
DEF Infrastructure through Truck Stops and Dealerships

- DDC, Freightliner, Mack & Volvo Dealers (as of 12/2003)
- Travel Centers of America (as of 6/2007)
- Petro Truck Stops (as of 6/2007)
- Mercedes-Benz Dealers (as of 6/2007)
Proximity of DEF at Volvo, Mack, Freightliner, DDC dealers based upon HD Diesel VMT

Cumulative Percentage of National HD Diesel VMT within X miles of dealers

Number of Dealer Locations

- Within 100 Mi
- Within 50 Mi
- Within 25 Mi
Summary

- SCR Remains the Lead NOx Aftertreatment Technology for 2010 Heavy-Duty
- Model-based Controls are a Key Enabling Technology to Optimize the Integrated Performance of Multiple, Flexible Sub-systems
- Progress is being made on both the Infrastructure and the Compliance Issues Related to DEF, in Collaboration with Multi-Stakeholder Group Including Other Engine and Vehicle OEMs
- Detroit Diesel (through its Parent Company Freightliner LLC), Volvo and Mack have Teamed up to Address Non-Competitive Issues Related to DEF-SCR Certification
- The Consortium is Open to any Manufacturer with a Declared Intention to use SCR
- Invitations to Join the Consortium have been Extended to all Members of the Engine Manufacturers' and Truck Manufacturers' Associations