



Powering Business Worldwide

Fuel Reformer, LNT and SCR Aftertreatment System Meeting Emissions Useful Life Requirements

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Eaton Corporation

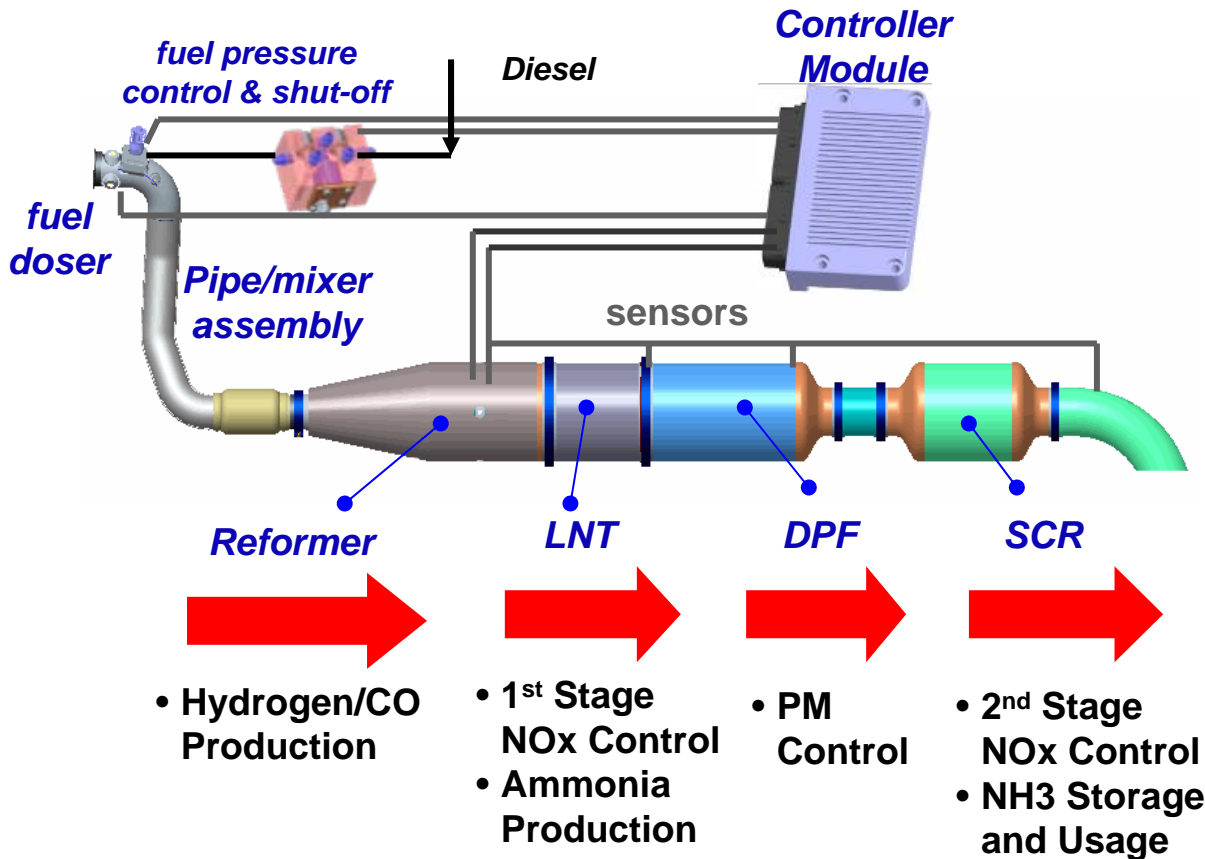
2009 DOE DEER Conference
Dearborn, MI
August 5, 2009

Topics

- **Introduction to Eaton Aftertreatment**
- Vehicle and Dyno Test Results
- Durability Test Results
- System Packaging
- Summary

Introduction

Eaton Aftertreatment System



LNT – Lean NOx Trap

SCR – Selective Catalyst Reduction

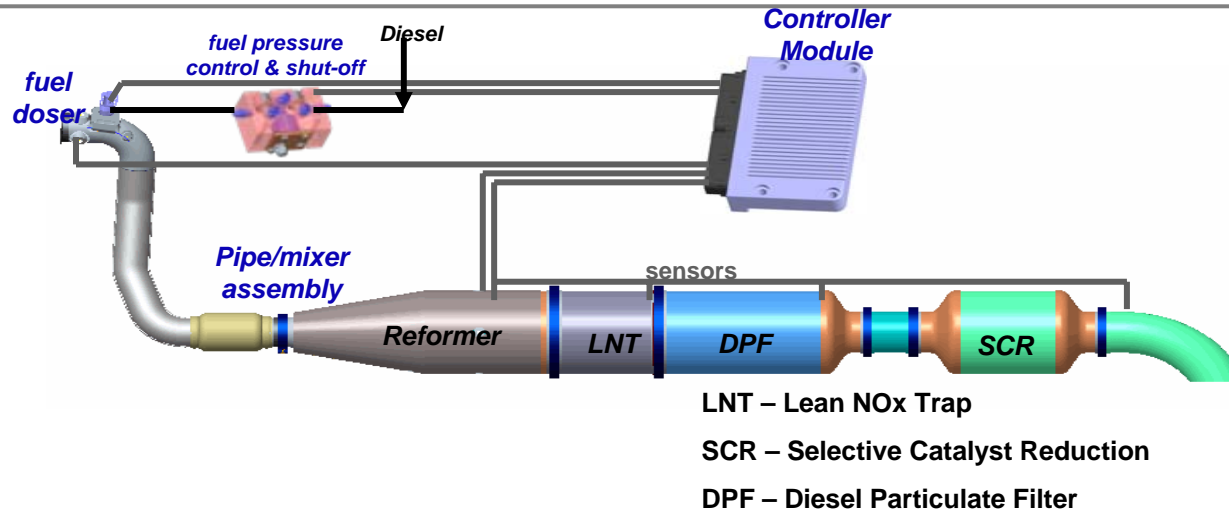
DPF – Diesel Particulate Filter

How it Works:

- Engine NOx is reduced by the Lean NOx Trap (LNT) and Selective Catalytic Reduction (SCR) catalysts.
- The LNT stores NOx and undergoes controlled periodic regeneration, releasing the NOx as nitrogen and ammonia.
- The SCR collects the released ammonia and uses it to continuously treat the remaining NOx.
- A Diesel Particulate Filter (DPF) traps Particulate Matter (PM) and undergoes periodic regeneration.

Introduction

Value Proposition



Customer Values & Product Differentiation

- Compliance with strict diesel emission standards
- **Single fluid system** (one dosing system needed)
- **Independent** of urea solution & infrastructure
 - Eliminates urea sensors and compliance-related penalties
- Reliable aftertreatment system
- Flexible, customized and **smaller packaging**
- Scalable with engine power (size)

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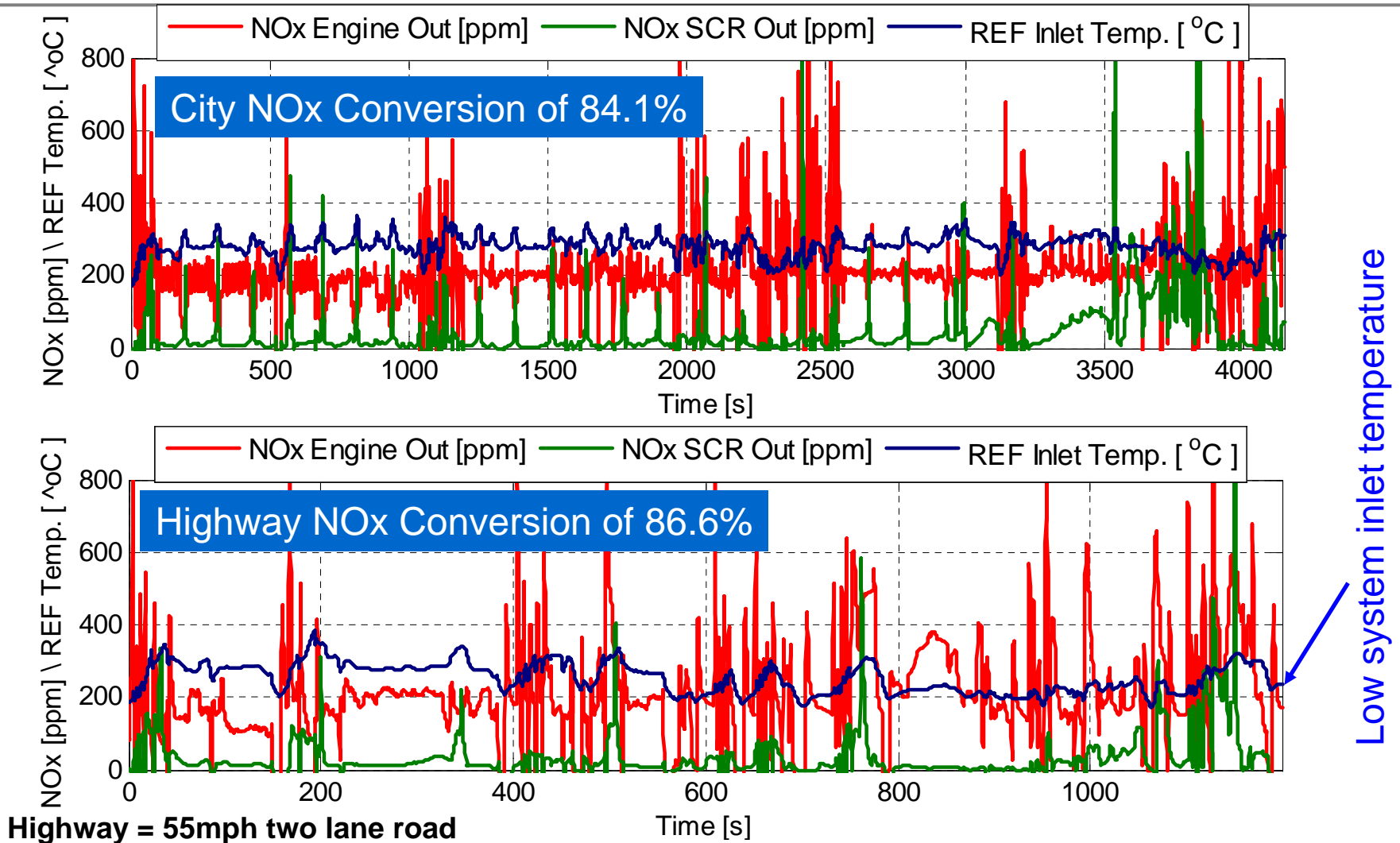
Vehicle Testing

- Accumulated ~ 26,000 miles operation
- Variety of Ambient Conditions
 - Temperature from -40 to 51 C
 - Altitude to 11,158 feet



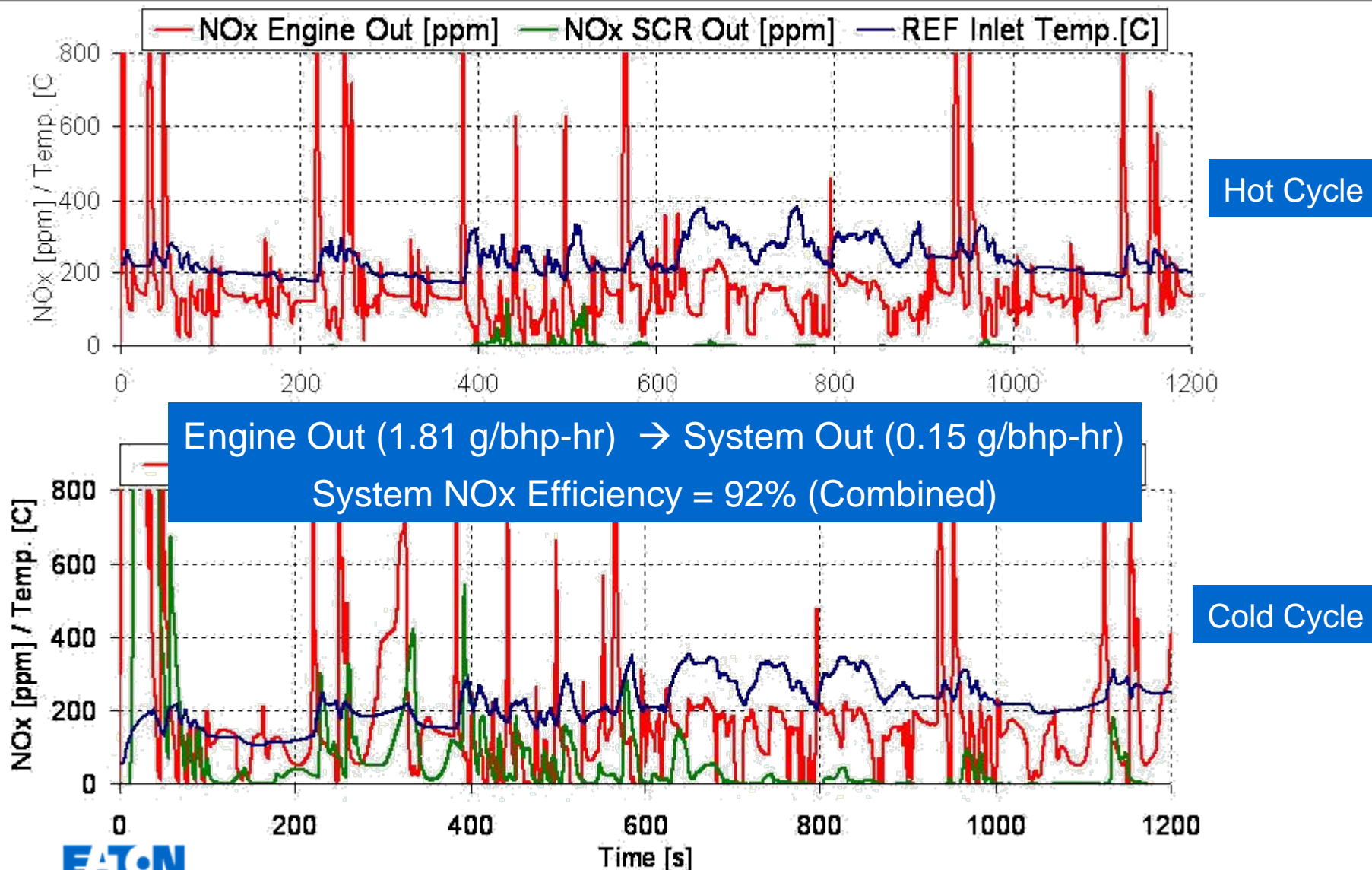
- Achieving 80%+ NOx reduction under majority of driving conditions
- Automatic aftertreatment operation (transparent to driver)
 - No drivability issues

Vehicle Testing – Cold Weather (-20 F)



FTP Test Results – Combined Cycle

Initial Results (Removed ~1.7 g/bhp-hr NOx)



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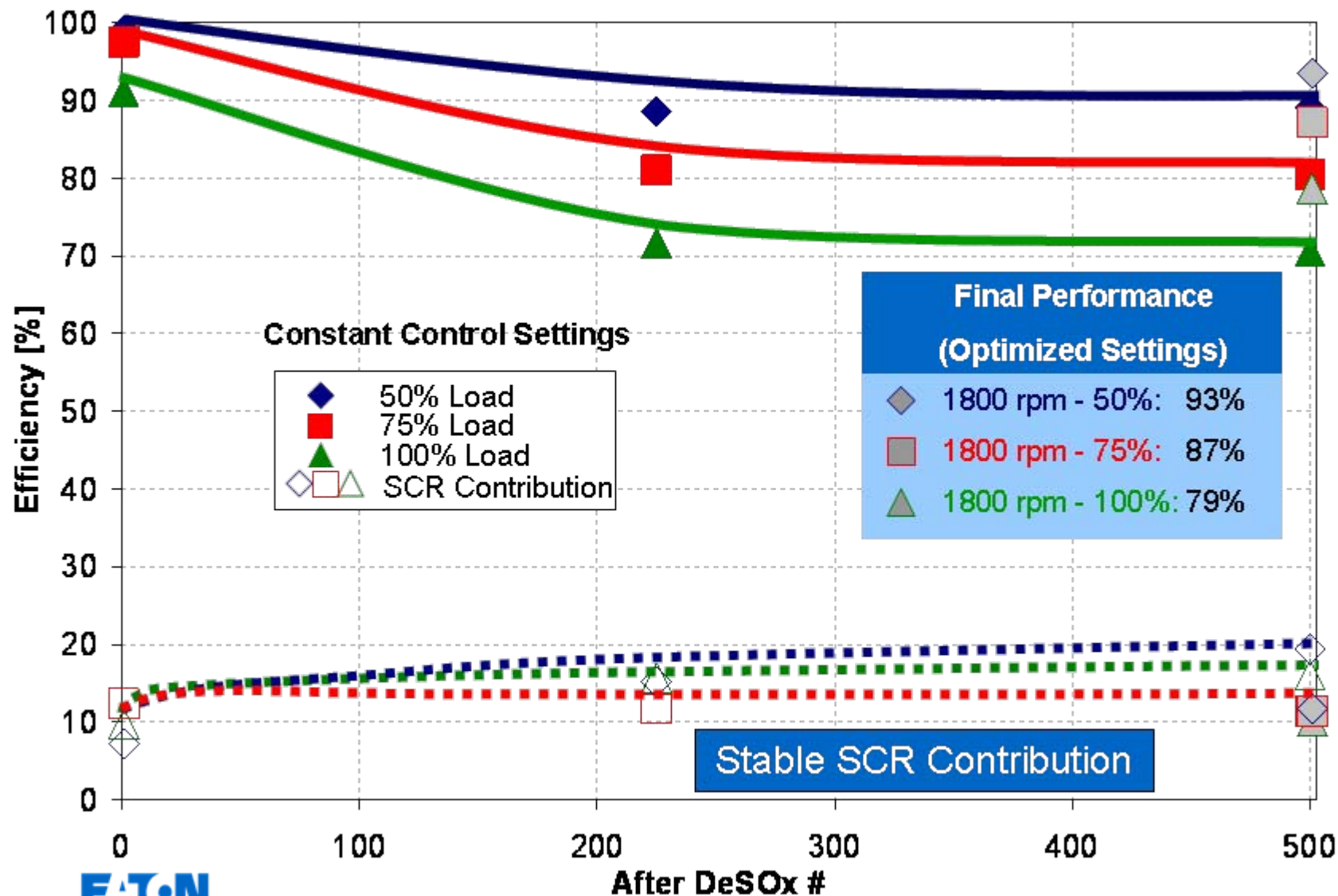
Aftertreatment Durability Aging

- Application
 - Aged on an Off-Highway Engine at an OEM test facility to end-of-emissions life conditions
- Sulfur Loading Assumptions
 - Total Sulfur in exhaust: 12 ppm on a fuel basis
 - 7 ppm from diesel fuel
 - 5 ppm from oil
 - Triggered DeSO_x Event: 0.5 g/L Sulfur on LNT
 - LNT Sizing: 1.5 times engine displacement

End-of-Life Emissions Requirements

- Off-Highway Analysis
 - 500 DeSOx events required – 8000 hour useful emissions life
 - One DeSOx event every 16 hours
- On-Highway Analysis – Medium Duty Vehicles
 - 225 DeSOx events required – 185,000 miles useful emissions life
 - One DeSOx event every 822 miles
- On-Highway Analysis – Heavy Duty Vehicles
 - 500 DeSOx events required – 435,000 miles useful emissions life
 - One DeSOx event every 870 miles

Durability NOx System Efficiency



Durability Performance Summary

**EAS performance results following 500 DeSOx Cycles
Meets Off-Road Final Tier 4 and HD On-road Emission Standards**

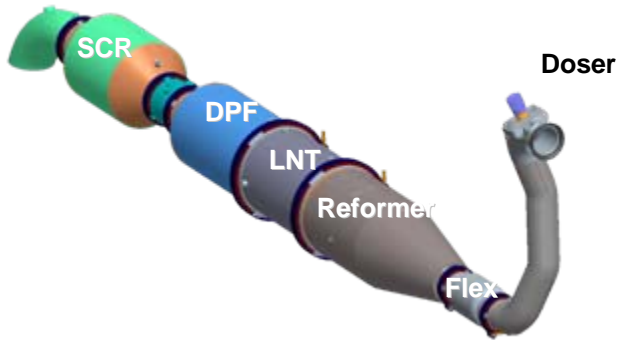
	System NOx Conversion	Tailpipe NOx (g/kW-hr)	Tailpipe HC (g/kW-hr)
1800 rpm - 50% load	93%	0.10	0.10
1800 rpm - 75% load	87%	0.20	0.19
1800 rpm - 100% load	79%	0.36	0.20

- Demonstrated NOx Margin (<0.4 g/kW-hr)
 - ¼ of NOx standard @ 50% load
 - ½ of NOx standard @ 75% load
 - Slightly below NOx standard @ 100% load (safely within NTE zone)

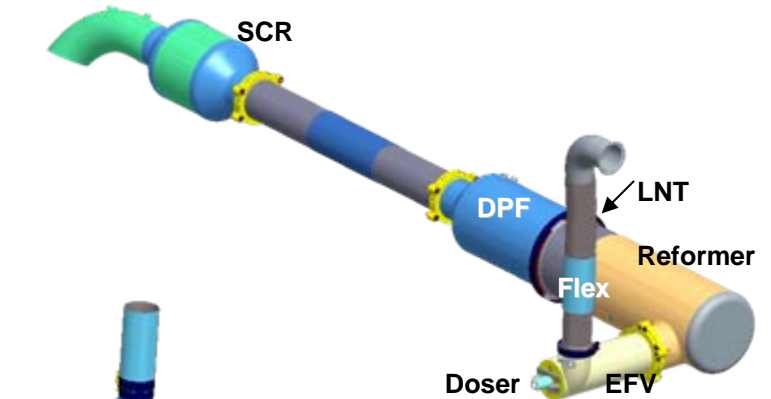
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- Durability Test Results
- **System Packaging**
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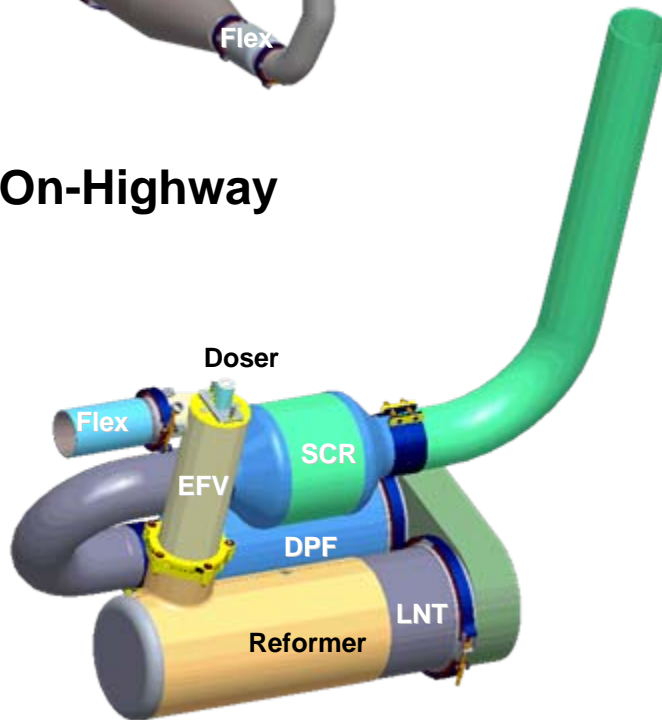
System Packaging Flexible Options to Meet OEM Applications



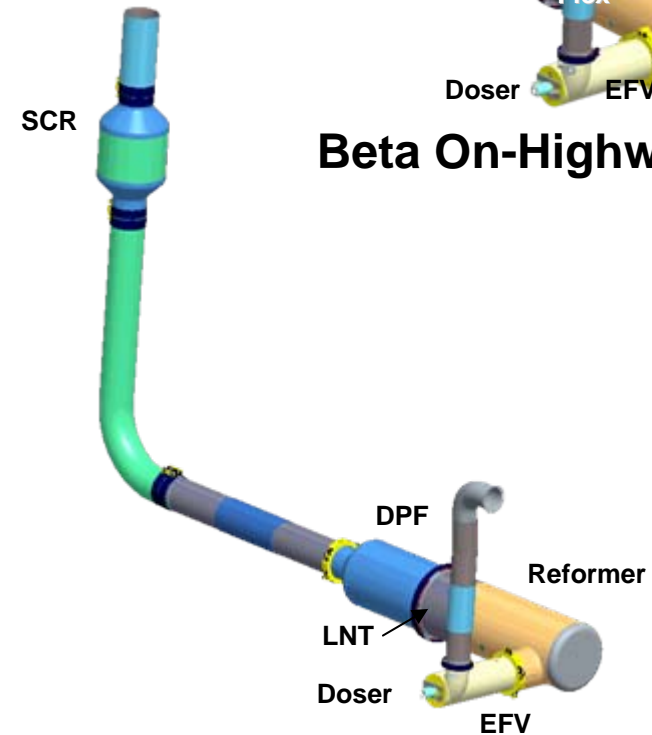
Alpha On-Highway



Beta On-Highway



Compact Option



Beta On-Highway

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Summary

- Vehicle Testing
 - Demonstrated 80%+ NOx reduction (cold temperature & high altitude)
- Dyno Testing
 - Demonstrated Viability for FTP testing
- Durability Testing
 - Met stringent durability requirements (Off-Highway & HD On-Highway)
- System Packaging
 - Flexible packaging options to meet OEM needs
- Targeted launch dates
 - 2012 targeted for On-Highway
 - 2013 targeted for Off-Highway
 - Joint Development with global engine OEM's

Acknowledgements

- Eaton Aftertreatment Team
 - Southfield, MI
 - Galesburg, MI
 - Santa Clara, CA
 - Pune, India
- OEM Partners & Suppliers



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