Southwest
Research
Institute

APBF-DEC
DEER Conference

Low Emissions Potential of EGR-SCR-DPF and Advanced Fuel Formulations-*A Progress Report*

Department of Emissions Research
Automotive Products and Emissions
Research Division

August 2002

Acknowledgments

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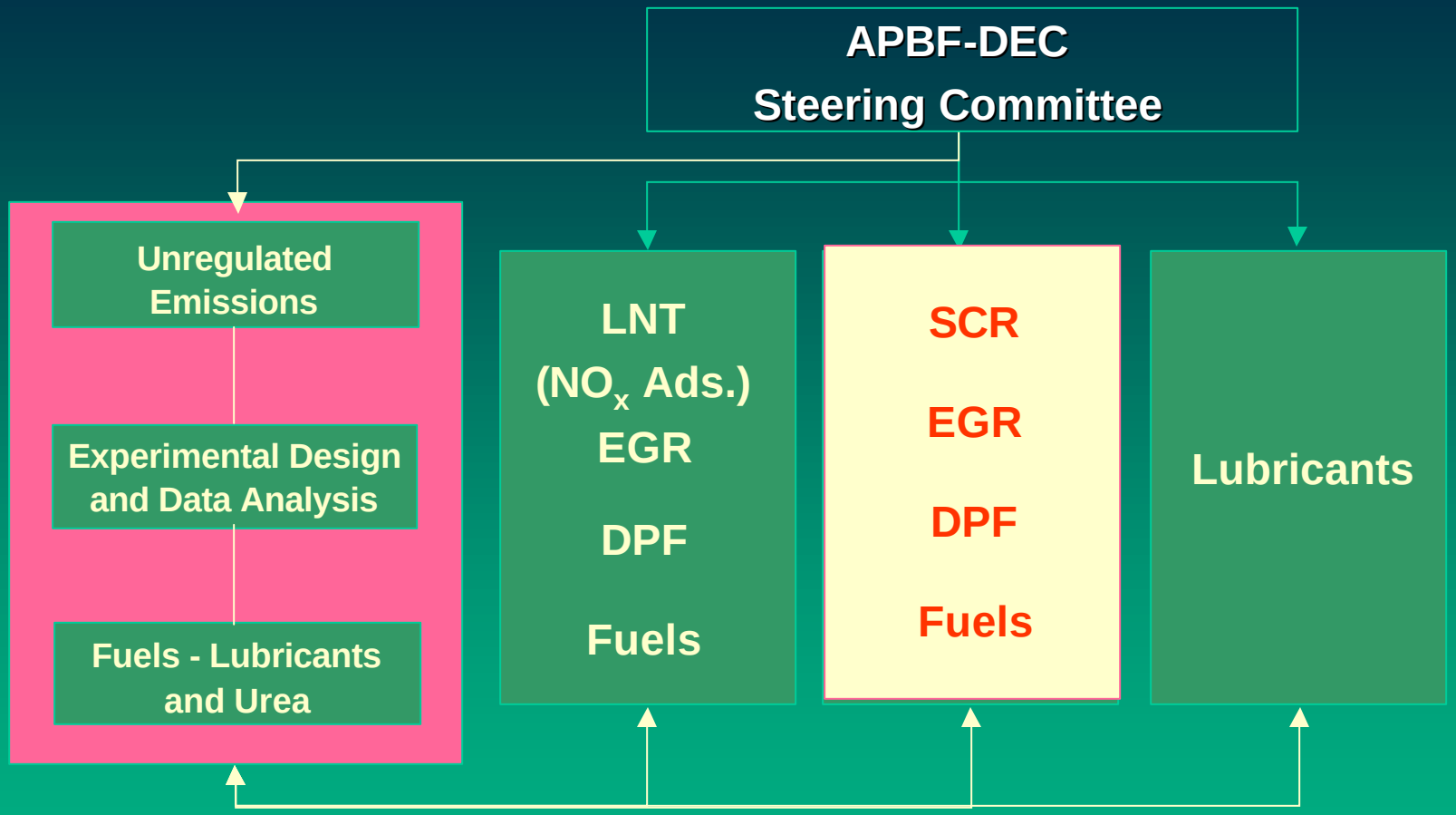
- U.S. EPA
- API-Fuels
- NPRA
- EMA
- MECA
- Battelle-Fluids
- CARB/SCAQMD
- Technical Team

Outline

- Introduction
- Objectives
- Technical Approach
- Test Setup
- System Components
- Results
- Summary & Conclusions

Introduction--APBF-DEC



Adapted From NREL/W. Clark Presentation 9/26/01

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Objectives

- To Demonstrate Low Emissions Performance of Advanced Diesels+LPL EGR*+Urea SCR+DPF (2 Different Systems)
- To Determine The Regulated And Unregulated Emissions W. &W/O Emission Controls
- To Examine The Emission Control System Durability
- To Sample Toxic Emissions For Analysis By Outside Lab
- To Evaluate Sensitivities of The Control System Performance To Fuel Variables

Emissions Goals: 2007 EPA HDE Standards

** Low Pressure Loop EGR*

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Technical Approach--Development (f 1)

Engine Baseline 4.0 NO_x

- Correlation
  - 2D Fuel 500 ppm
  - SwRI Caterpillar
- Characterization
  - 2D Fuel DECSE 3
  - Steady-State +Transient

Comparison Between Baseline & New System

2007 System Characterization (A)

- 4 Fuels
  - *DECSE3 + 8, 15 ppm & BP15
  - [10-100-200]-Hrs.
- Test Protocol
  - C+3Hs
  - 2 OICAs

EGR and Control 2.0 NO_x

- Design
  - Parts Procurement
  - Fabrication
- Development
  - Engine Installation
  - Test & Control

CB-DPF Adaptation (B)

Total System Integration

- Design
  - EGR Optimized
  - Urea Injection
- Development
  - Engine Installation
  - Test & Control

*30 ppm for occasional verification

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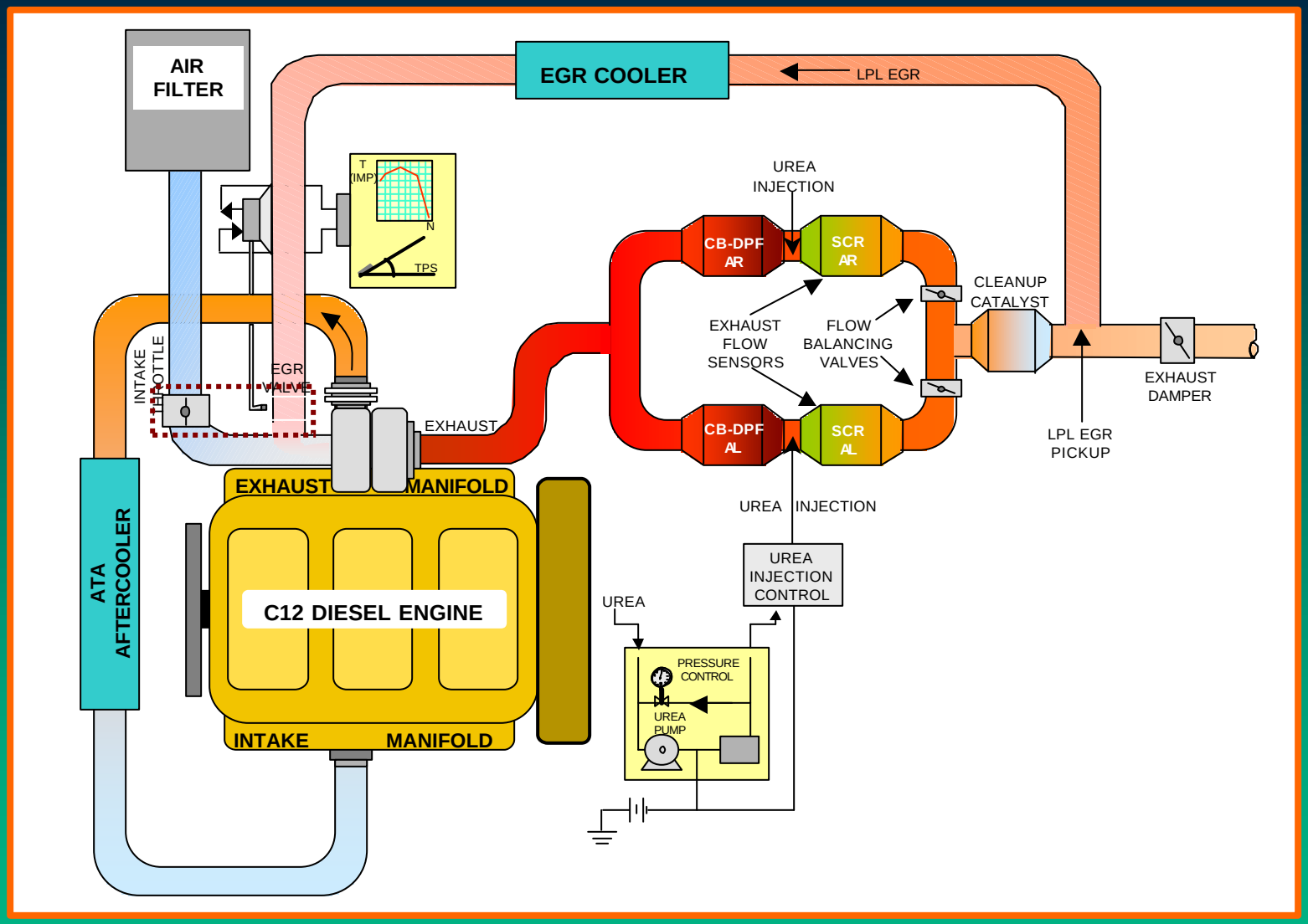
Test Setup


AIR FILTER
EGR COOLER
LPL EGR
T (IMP)
N
TPS
UREA INJECTION
CB-DPF AR
SCR AR
CLEANUP CATALYST
EXHAUST FLOW SENSORS
FLOW BALANCING VALVES
INTAKE THROTTLE
EGR VALVE
EXHAUST
EXHAUST DAMPER
CB-DPF AL
SCR AL
LPL EGR PICKUP
EXHAUST MANIFOLD
UREA INJECTION
ATA AFTERCOOLER
C12 DIESEL ENGINE
UREA INJECTION CONTROL
UREA
PRESSURE CONTROL
UREA PUMP
INTAKE MANIFOLD

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System Components--Engine

Engine Description (on consignment to the project)

- Caterpillar C12
- 12.0 L/450 hp
- In-Line/6 Cylinders
- Turbocharged/Intercooled
- Rated Speed: 1800 rpm
- Peak Torque: 1650 lb-ft
- Peak Torque Speed:1200 rpm
- Emission Calibration: MY 2000

System Components--Fuels

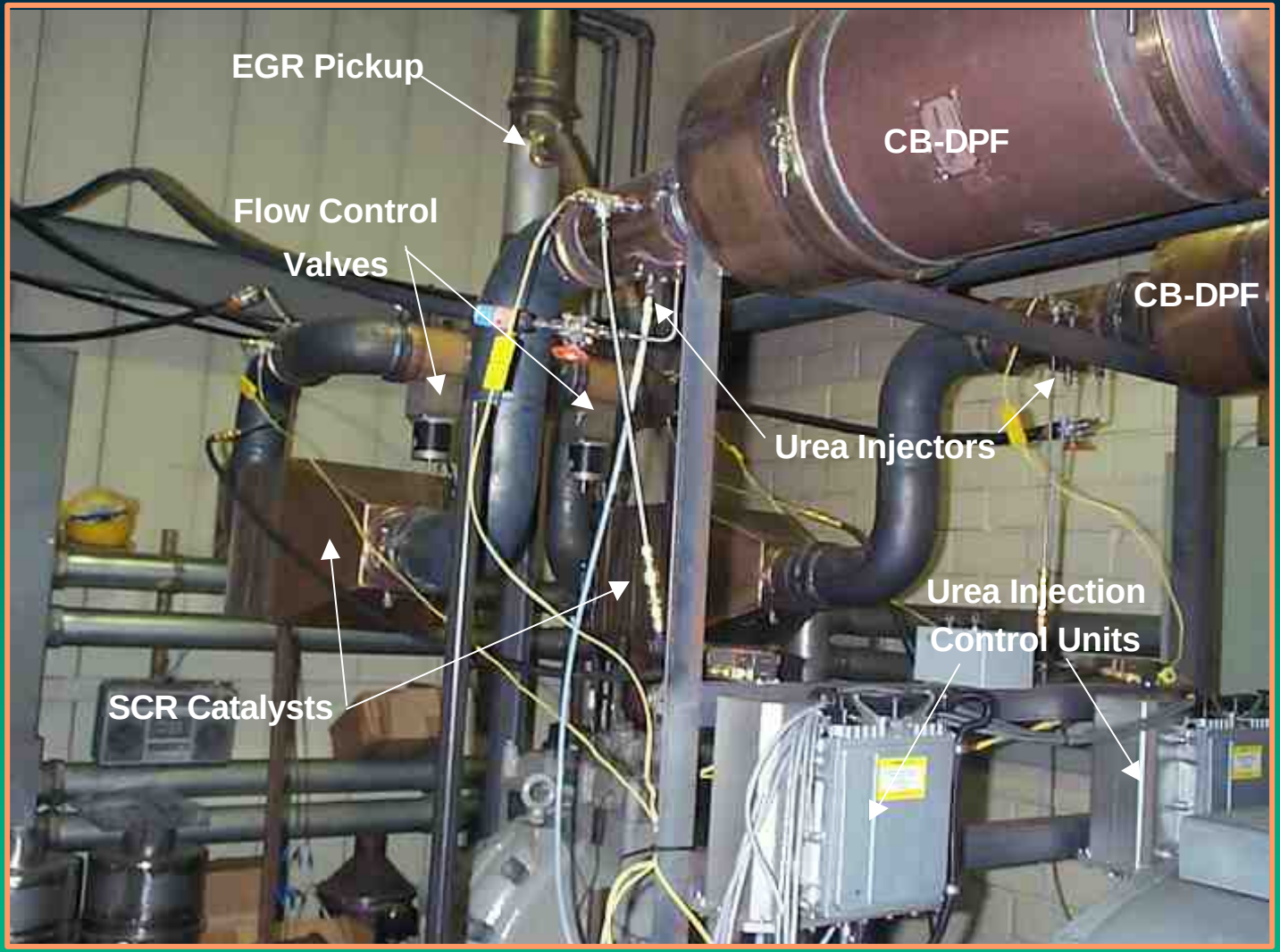
- **Fuel 1: Baseline --3 ppm S**
- **Fuel 2: Durability/Emission Eval. --8 ppm S**
- **Fuel 3: Research/Emission Eval.--15 ppm S**
- **Fuel 4: BP 15**
- **Fuel 5: 30 ppm (Excursions)**

Fuel Estimates

- ***Phase 1: Development 25,000 To 30,000 Gallons***
- ***Phase 2: 6.5 Gallons/OICA--2 OICAs/Hr.--13 Gallons/Hr. or 78,000 Gallons Per 6,000 Hours***

Engine Installation -- EGR System

Exhaust Treatment Arrangement--CB-DPF and SCR



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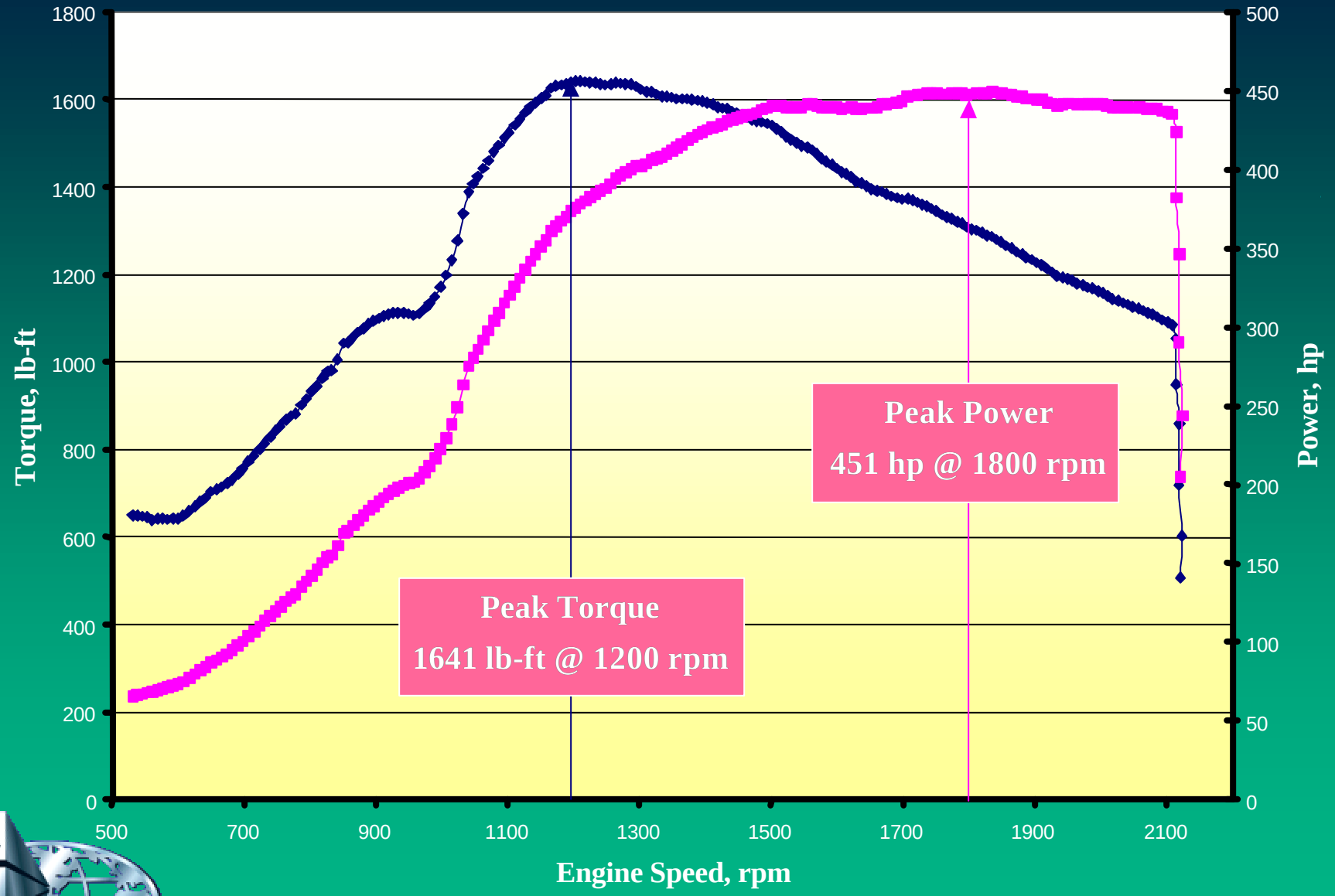
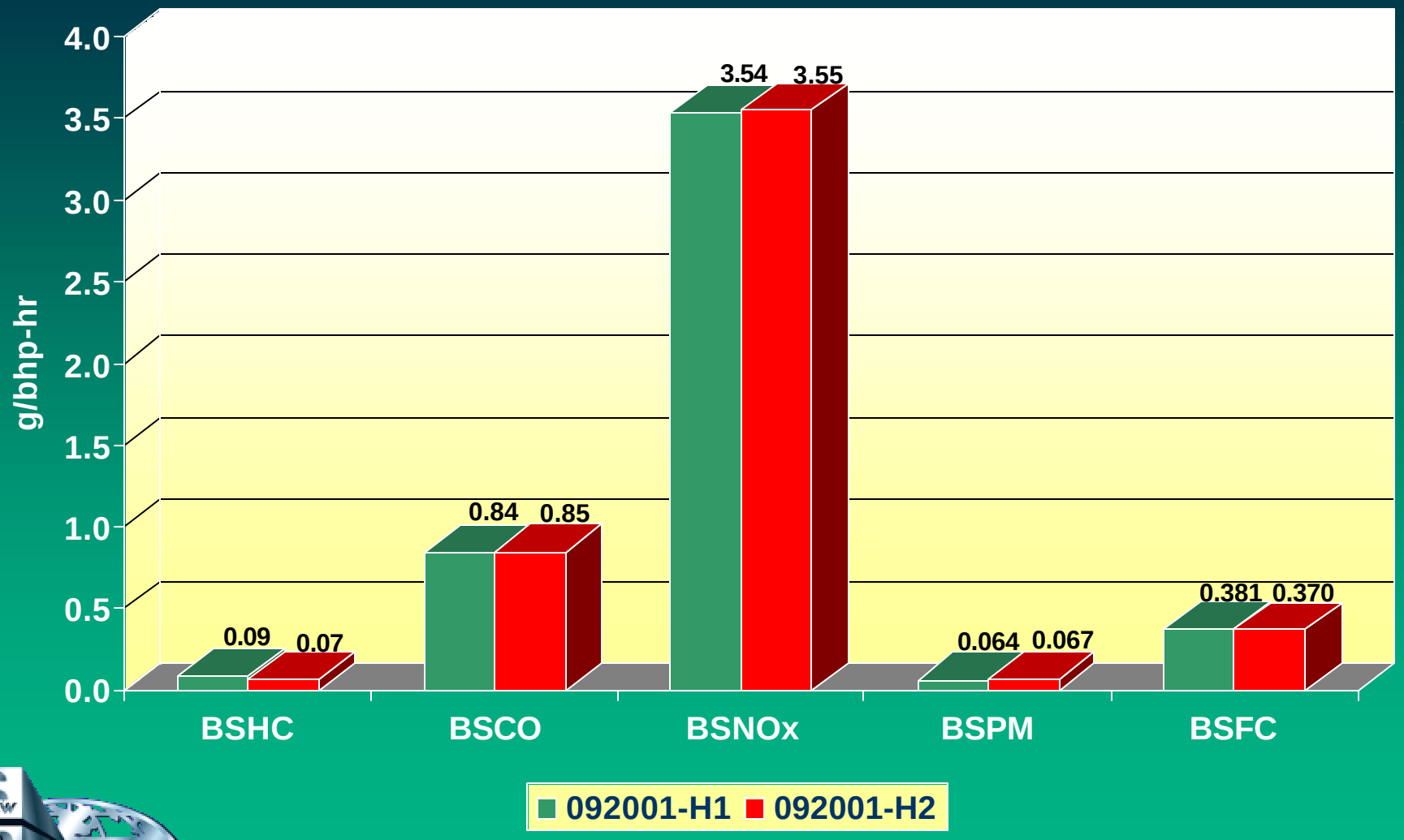
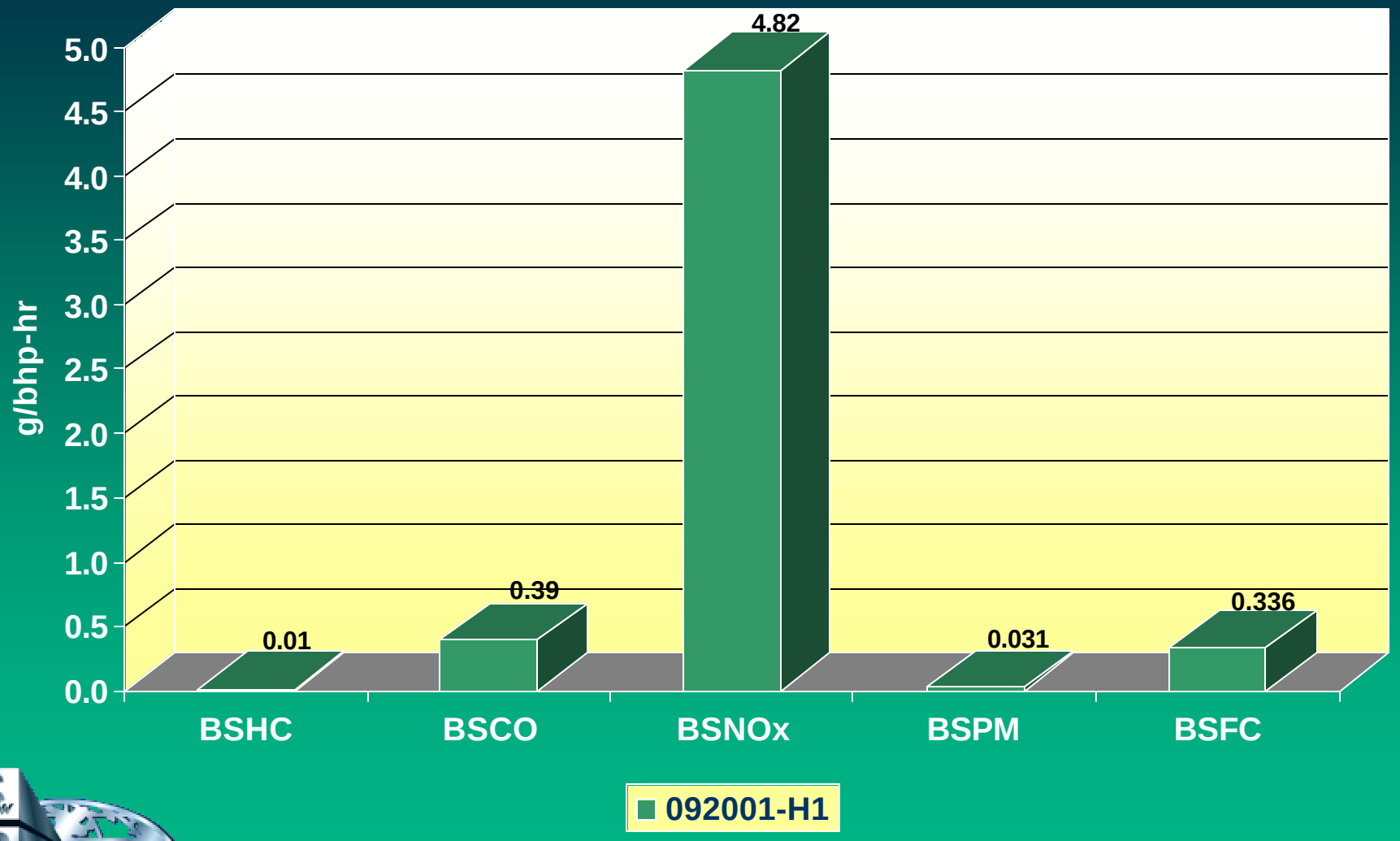
Engine Performance



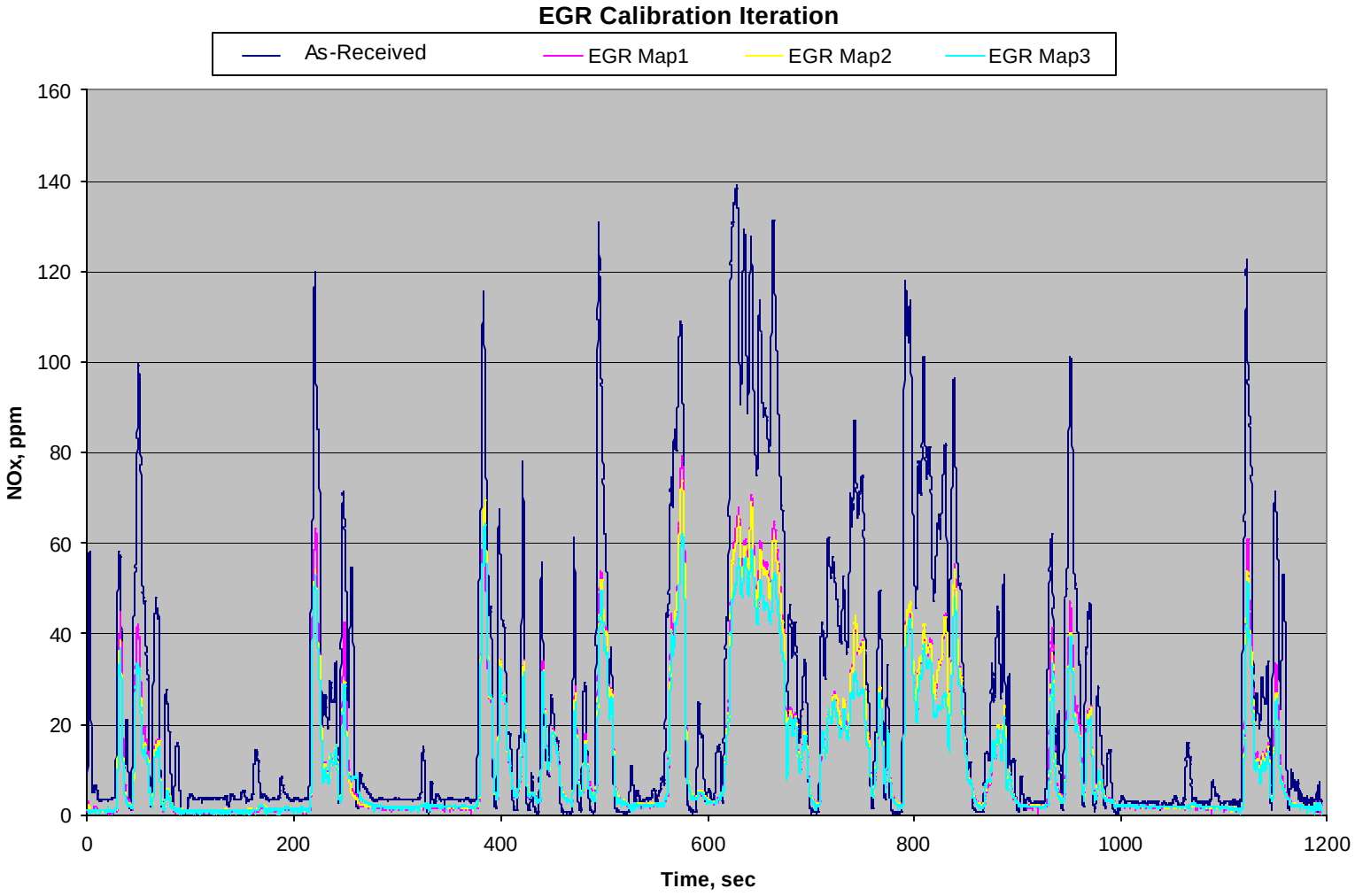
Transient Emissions--350ppm Cert. 2D Fuel



Steady-State Emissions--350ppm Cert. 2D Fuel

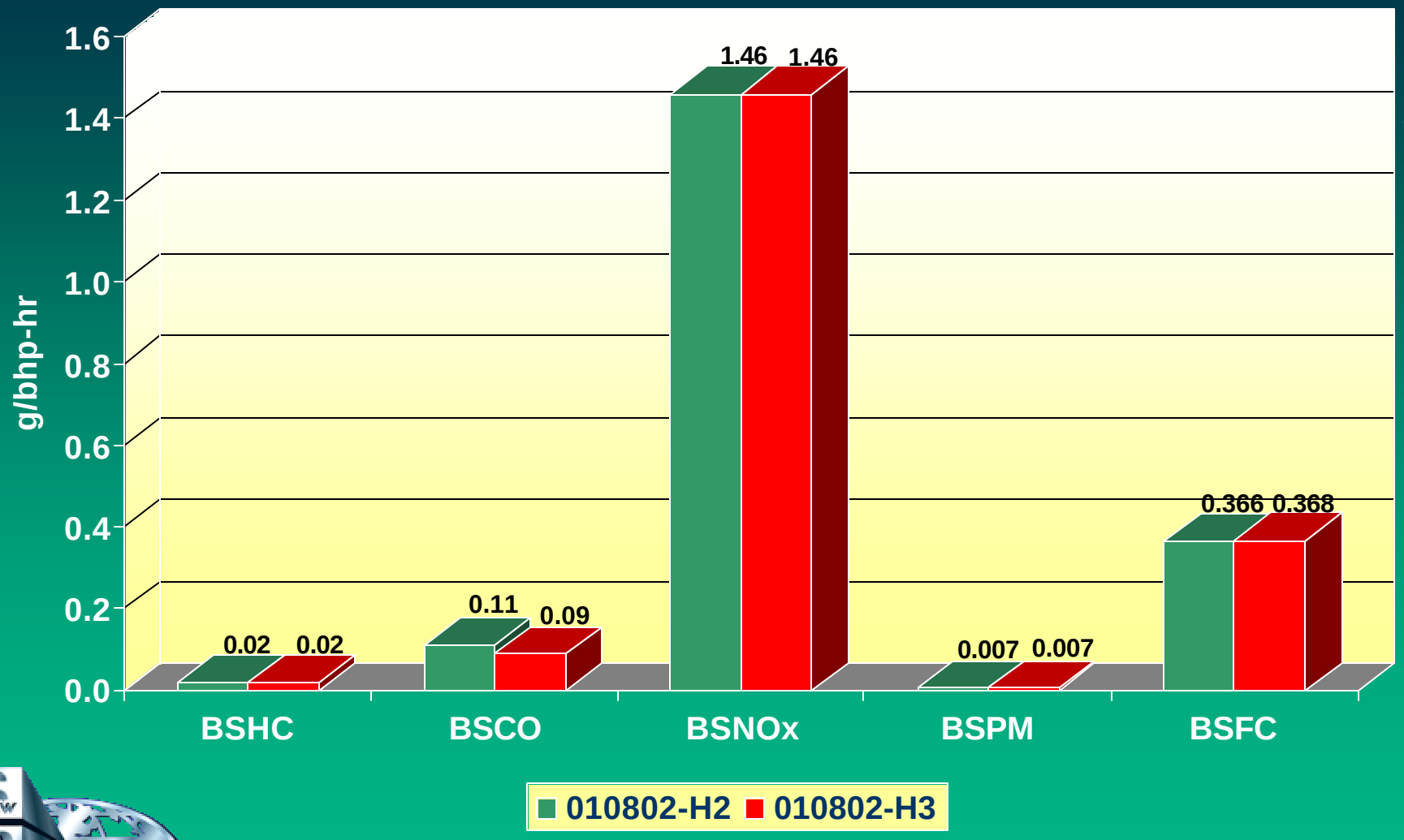


EGR* Calibration



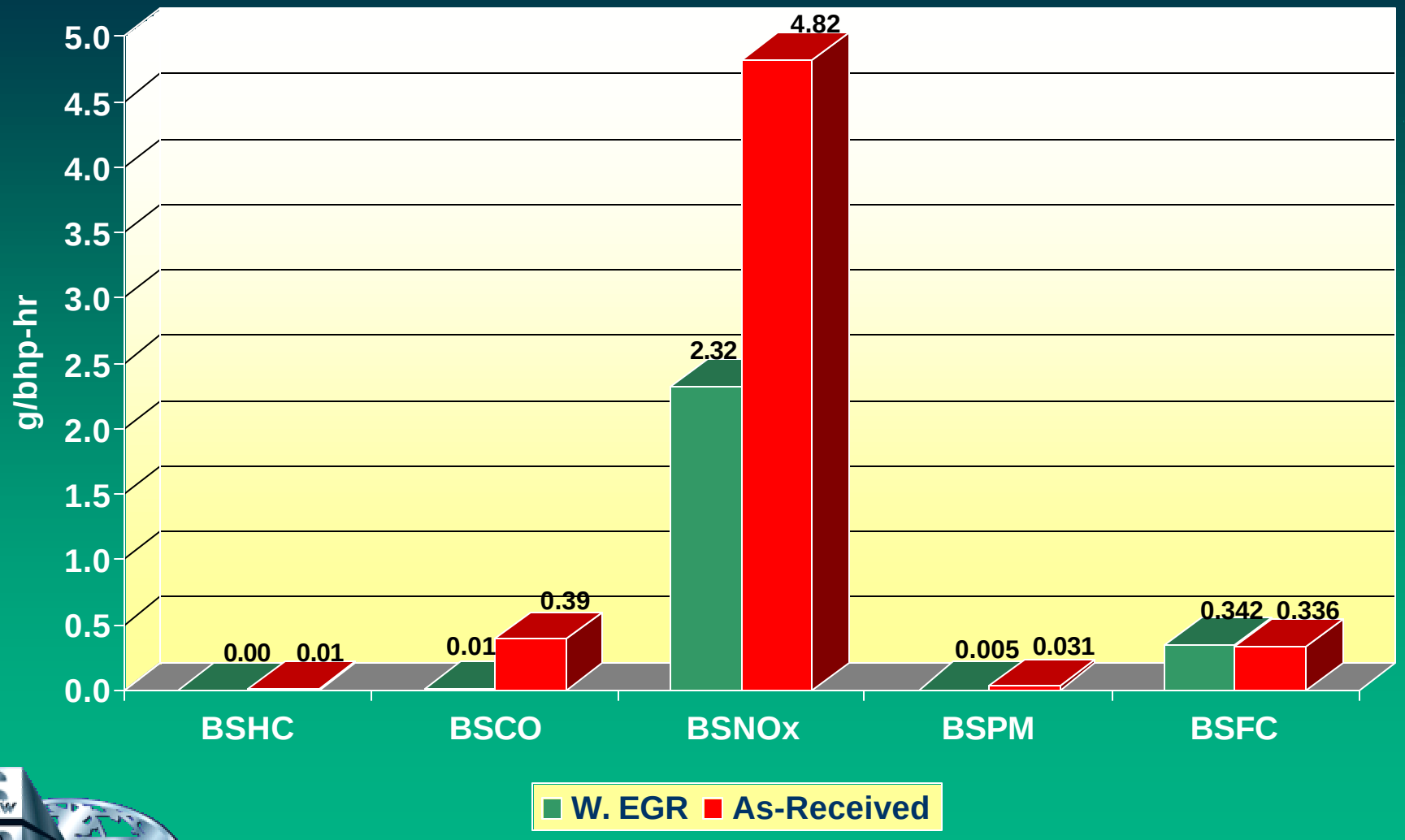
EGR : Low Pressure Loop EGR With CB-DPF*

Transient Emissions--EGR* and DECSE 3ppm Fuel



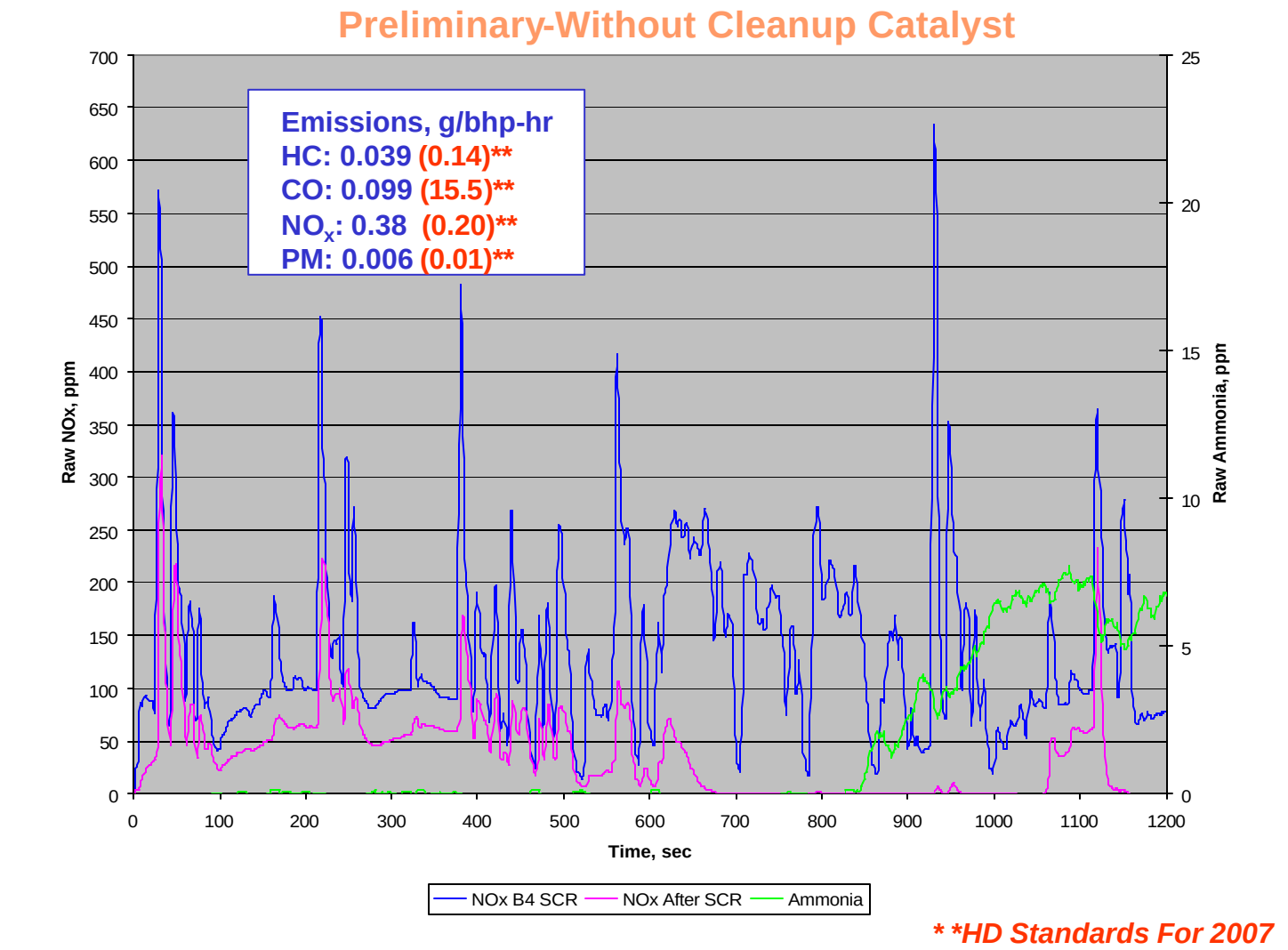
EGR : Low Pressure Loop EGR With CB-DPF*

Steady-State Emissions Comparison--As-Received W. Cert. Fuel 350ppm S and W.EGR*--DECSE 3ppm Fuel



EGR* : Low Pressure Loop EGR With CB-DPF

Transient Emissions--EGR*/SCR/DPF/DECSE 3ppm Fuel

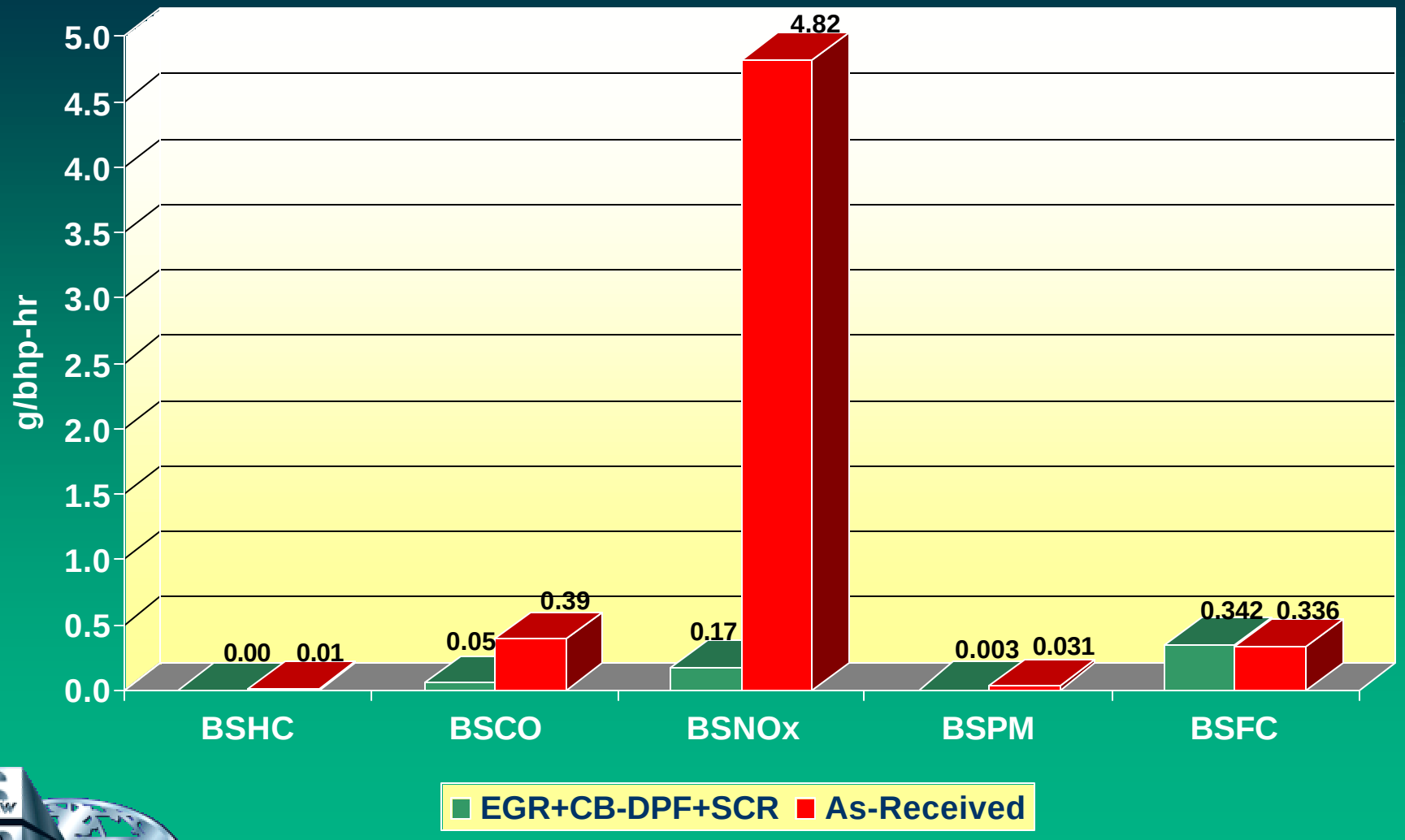


* *HD Standards For 2007

EGR* : Low Pressure Loop EGR With CB-DPF

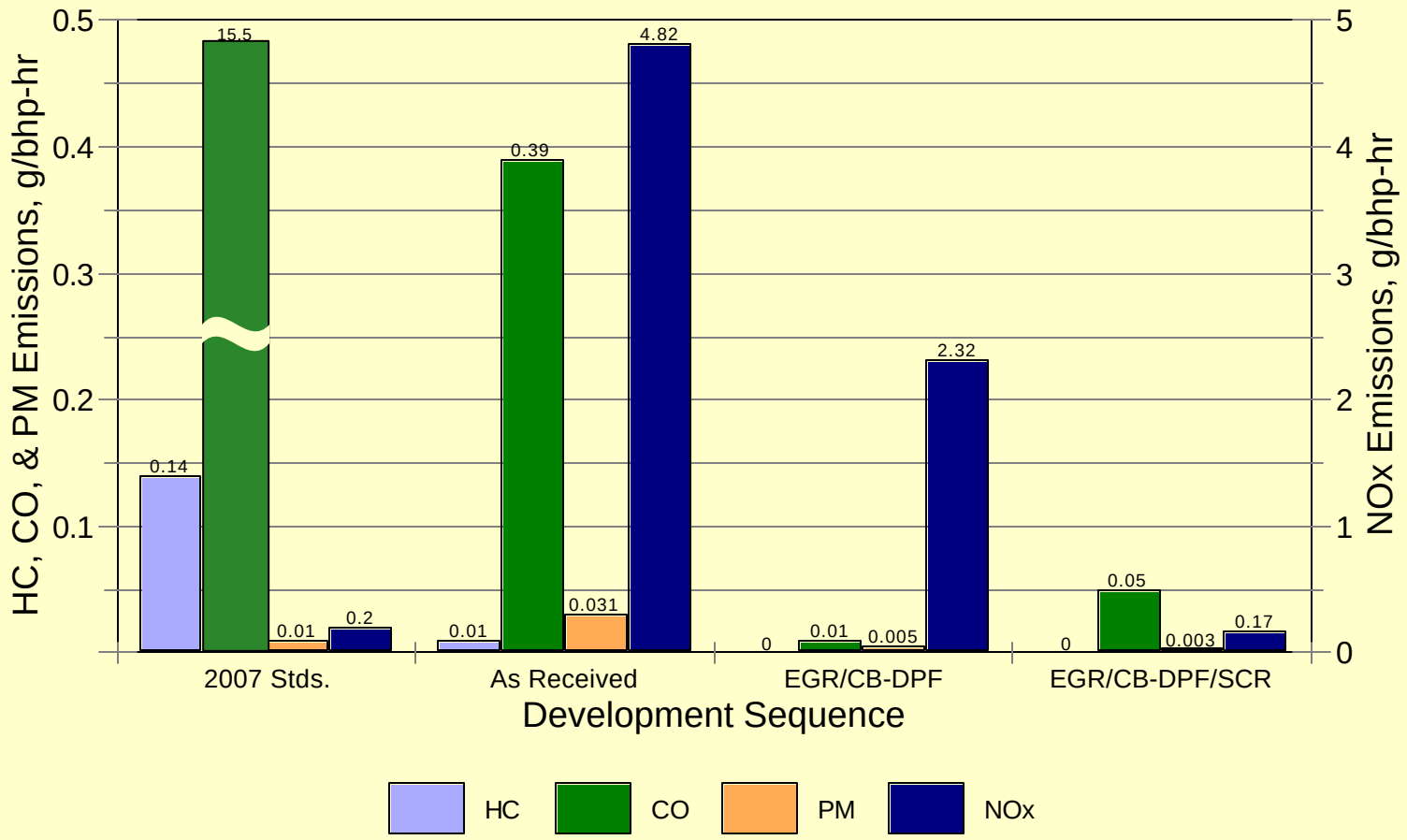
Steady-State Emissions Emissions Comparison--
As Received vs. EGR*/CB-DPF/SCR--DECSE 3ppm Fuel

Preliminary-Without Cleanup Catalyst



EGR : Low Pressure Loop EGR With CB-DPF*

Steady-State Emissions--DEVELOPMENT & PROGRESS



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Summary and Conclusions

- The C-12 Caterpillar test engine had an EPA Transient NOx/PM emissions of 3.5/0.07 g/bhp-hr.
- The LPL EGR system was installed and calibrated to yield:
  - over 50% NOx reduction and,
  - about 90%PM reduction
- System A SCR was installed and urea injection was optimized for the OICA cycle.
- System A (including LPL EGR) yielded NOx/PM of 0.17/0.003 g/bhp-hr in the OICA test.
- System A calibration for the EPA transient test cycle is in progress and nearing completion.
- System B calibration will follow the completion of System A calibration.
- Preparation for the durability phase of the program is complete.
- Both durability engines have been broken in.

Some Conclusions Were Based on Preliminary Results

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