

# The Longview Diesel Emission Control System: Emissions Performance of a Combined DPF and NOx Reduction Catalyst System

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## Outline

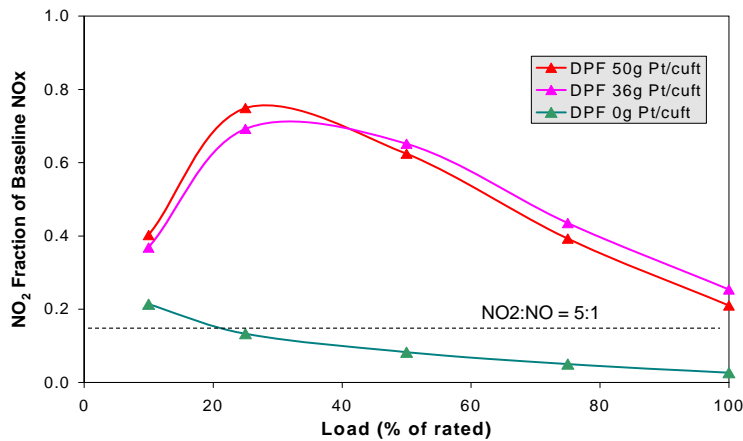
- **Background**
- Longview system
- Testing
- Summary



## Background

- PM control (elemental carbon) is required/desired on Diesel engines in underground mines.
- Wall flow filters offer desired levels of PM/EC control, but....
- ....use of precious metals as part of regeneration strategy has an adverse impact on NO<sub>2</sub> formation.
- Reductions in PM/EC control are offset by increases in NO<sub>2</sub>, thus offsetting the benefit of the filter.
- The Holy Grail: A system that offers the benefits of a passive regeneration system without the disbenefit of high NO<sub>2</sub> formation.

## Catalyzed DPFs can adversely affect NO<sub>2</sub>:NO ratio



## Outline

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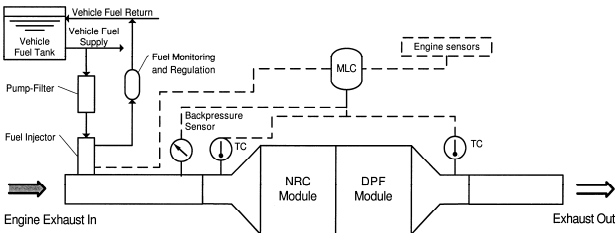
## The Longview® System

- Developed for the above ground markets concerned with PM and Ozone
- Combines HC-SCR with catalyzed DPF to reduce NO<sub>x</sub>, PM, CO, and HC.
- HC-SCR means active hydrocarbon dosing upstream of a NO<sub>x</sub> Reduction Catalyst (aka Lean NO<sub>x</sub> Catalyst)
- Patented HC dosing and electronic control components

# The Longview® System

- CARB verified for on-road mobile applications in 2003
  - 5 to 15 L diesel engines.
  - Requires exhaust temperatures of 260 dec C for 25% time.
  - 5 year/150,000 mile warranty
  - Annual warranty reports required
- 2800 retrofit applications in California including transit bus, refuse truck, and line-haul vehicles.
  - 7.5 million hours / 142 million kilometers
  - Temperature and backpressure history is constantly logged
  - Warranty claims <1% (no filter or catalyst failures)
- Non-road verification work in progress with many field trials underway.

# The Longview System



## System Design Features



Modular design



Advanced diagnostics and controls



Rugged components: SiC and Stainless Steel

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## Test Objectives

1. Demonstrate emission performance of Longview system.
2. Investigate impact of elevated backpressure on emissions.
3. Investigate impact of fuel sulfur level on emissions.

## Test Setup

Cummins Test Laboratory in Rocky Mount, North Carolina

- Raw emissions sampling of:
  - NO and NO<sub>x</sub> (NO<sub>2</sub> inferred by subtraction)
  - CO
  - CO<sub>2</sub>
- Filter composed silicon carbide,
  - CARB verified and VERT approved at >85% efficiency.
  - Performance of SiC wall flow filters are very well understood

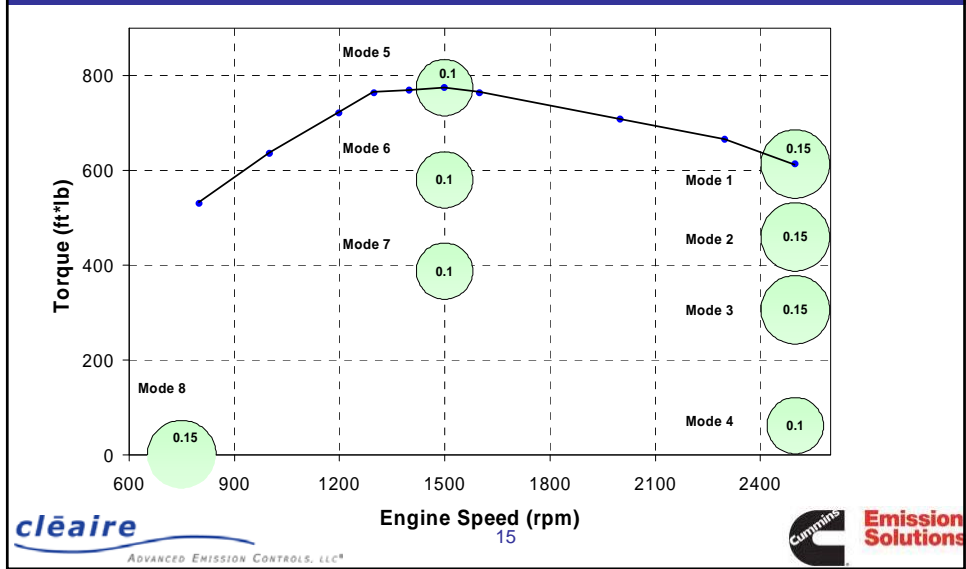
## Test Plan

- ISO 8178 D1 8-Mode Test Cycle
- Baseline Emissions
  - Standard (3”Hg) and high backpressure (11” Hg)
  - Fuels: ULSD (<15 ppm S) and #2 diesel (308 ppm S)
- Longview
  - With and without HC injection
  - Standard (6” Hg) and high backpressure (11” Hg)
  - Fuels: ULSD (<15 ppm S) and #2 diesel (308 ppm S)

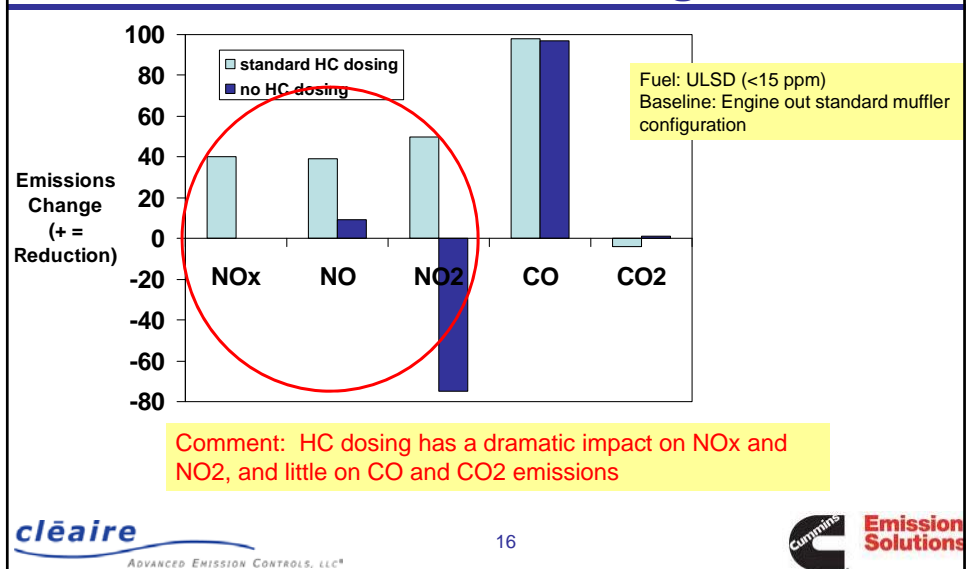
## Test Engine

- MY 2005 Cummins QSB Tier III engine
- 6.7 L Displacement
- 285 hp at 2500 rpm
- Common rail fuel injection system

## Test Cycle: ISO 8178 C1 8-Mode

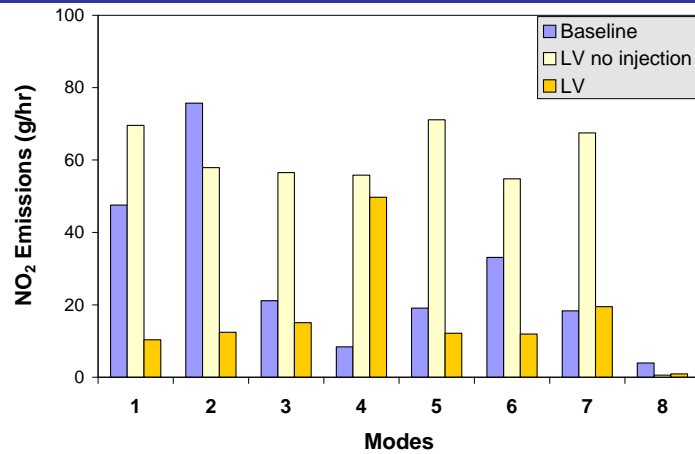


## Cycle averaged emissions with and without HC dosing



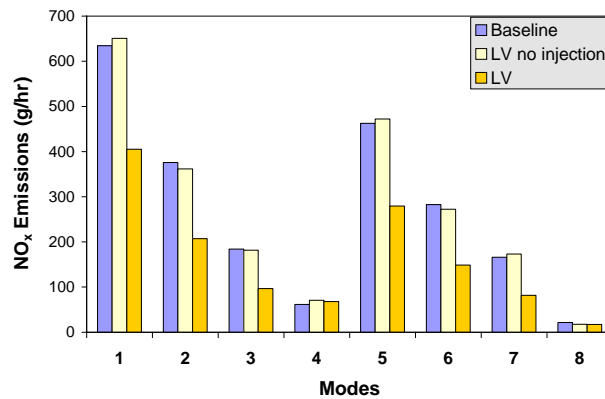


## Impact of HC dosing on NO<sub>2</sub> by mode

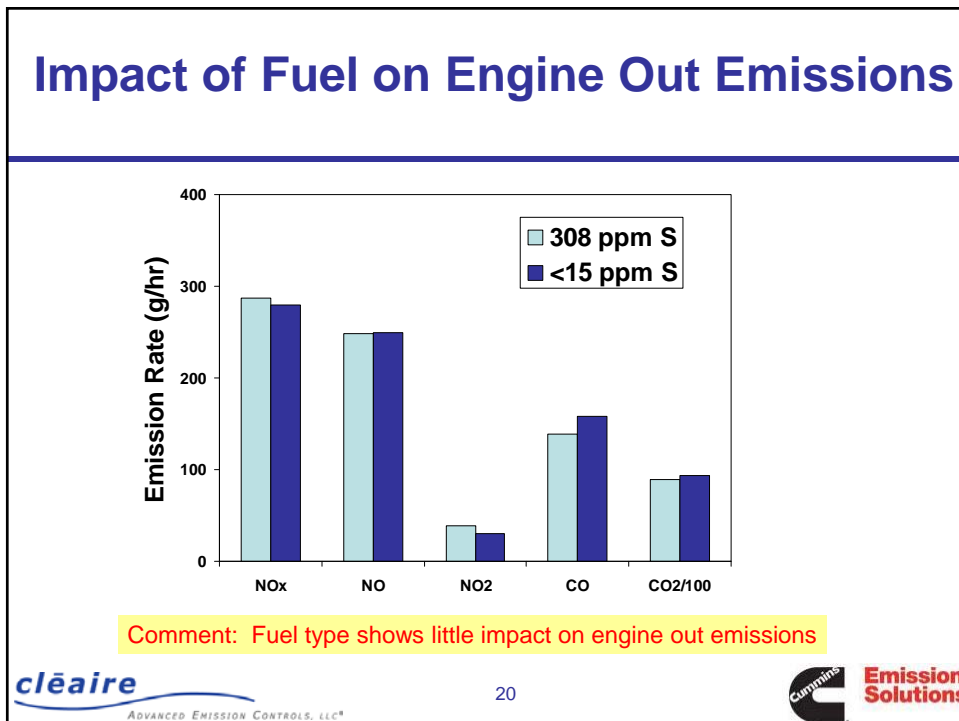
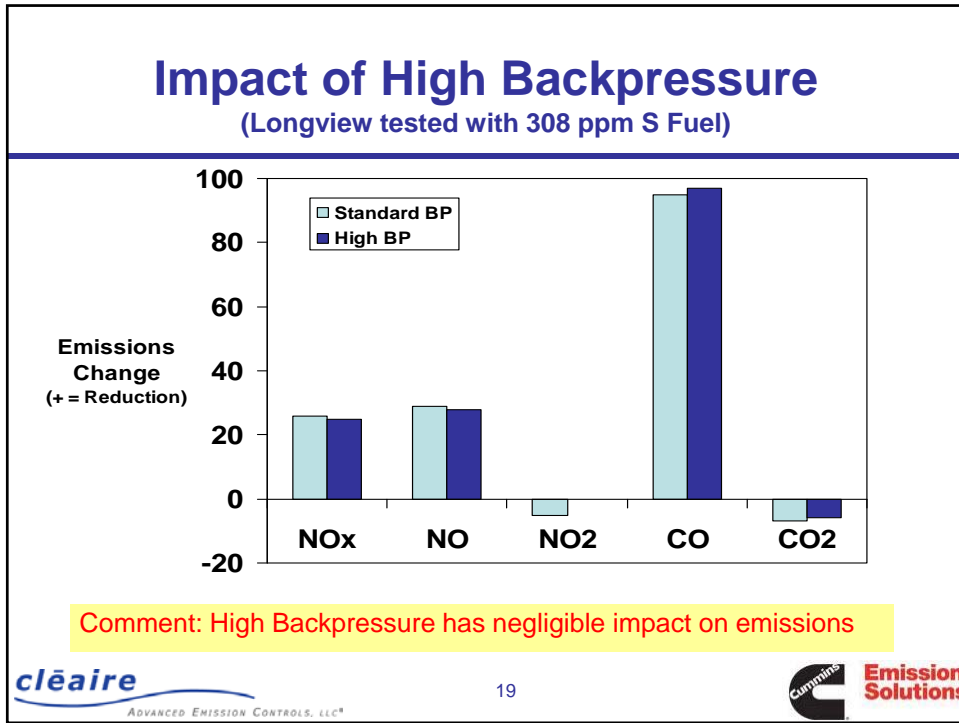


Comment: NO<sub>2</sub> below baseline in all modes except mode 4 (high idle)

## Impact of HC dosing on NO<sub>x</sub> by Mode



Comment: NO<sub>x</sub> is reduced not just shifted between NO and NO<sub>2</sub>



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## Summary: Data

### Cycle averaged emissions from Longview System using ULSD

- NO<sub>x</sub> reduction of 40%
- NO<sub>2</sub> reduction of 50%
- CO almost completely removed
- CO<sub>2</sub> increase of 5%

## Summary: Comments

The system's fuel injection and NOx reduction catalysts play an important role on NO, NO2, and NOx emissions.

The catalyzed DPF plays an important role in CO (and HC & PM) reductions.

Artificially high backpressure levels showed no adverse effects on emissions, in fact NO2 emissions were reduced.

Baseline and system emissions showed little difference when operated with #2 diesel and ULSD fuel.

## Summary: Next Steps

Longview systems currently operating in underground mining field trials.

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