SELECTIVE CATALYTIC REDUCTION

“Nuking the NOx”

Volvo 2009 No-Regen Tour
2007 Was About Reducing Particulates the Final Step – It Took Aftertreatment

Emission Reduction, % (1974 = 0)

Units: g/hp-hr

0.25

0.1

aftertreatment

0.01
2010 Will Be About Reducing Oxides of Nitrogen (NOx) the Final Step – It Will Take Aftertreatment

Emission Reduction, % (1974 = 0)


Massive EGR
SCR+EGR

Units: g/hp-hr

“The technology does not exist to achieve 0.2 without aftertreatment”
How Will Volvo Meet The Near-Zero Levels of 2010 with Good Fuel Economy??

Volvo’s Solution for 2010:

- Ultra High Pressure Fuel Injection to reduce the soot
- DPF aftertreatment for Near-Zero Soot
- A little less EGR than 2007 to knock down the NOx
- SCR aftertreatment for Near-Zero NOx
All About Selective Catalytic Reduction

- Why use SCR? (NOx Aftertreatment)
  - SUPERIOR FUEL ECONOMY, compared to other solutions for EPA’10. Total fuel costs will be significantly reduced, even allowing for the DEF.
  - Improved engine performance. Less EGR needed, less heat rejection into cooling system results, greater power density, and higher efficiency.
  - Very little maintenance required
  - Reliable, proven approach (High volume production in other markets)

- What additions to the truck will be included?
  - DEF tank, on the driver’s side. Heated. Various sizes depending on fuel capacity. Includes pump and filter.
  - Heated lines, pump to injector
  - DEF injector, mounted to today’s frame-mounted Diesel Particulate Filter
  - SCR catalyst, behind DPF or vertically mounted
VOLVO’S SCR TECHNOLOGY ELIMINATES ACTIVE REGENERATION FOR 2010 HIGHWAY TRUCKS*

* In normal operation, i.e., except in “extremely severe” duty cycles
EPA’10 Hardware: Injector and Catalyst
EPA’10 Hardware
EPA’10 Hardware
DEF Indicator – a Real Gauge
How Far Can I Go on a Tank of DEF?

Los Angeles to NYC and Back to Chicago
Changes for EPA’10

- What about the base engine?
  - Base engine will only experience minor changes.
    - Same proven injection system
    - Same camshaft
    - Same cylinder head
    - Same block

- Volvo is the only manufacturer who is going into 2010 with essentially the same engine as 2007
Diesel Exhaust Fluid (Urea)

- The main component of DEF is an organic nitrogen-rich compound called **urea**.
- Urea is synthesized from natural gas and carbon dioxide.
- Urea is very widely used in agriculture as a fertilizer, most often distributed in wax-coated pellets. (Not a water solution)
- Urea is a compound of nitrogen that turns to ammonia (NH$_3$) when heated.

**Why call it DEF?**
- Automotive industry wanted a generic name

**What is Diesel Exhaust Fluid made from?**
- 32.5% urea, 67.5% demineralized water
- Must be kept extremely pure

**Why 32.5%?**
- Water solution with lowest freezing point, 12°C.

**DEF is governed by DIN 70700 and the ISO 22241-1 specifications.**
So This Stuff Freezes?

- DEF Freezes at 12°F.
- **THERE IS NO DELAY IN DRIVING A TRUCK WITH A FROZEN DEF TANK.**
- You can walk up to a truck that has been standing over a frigid weekend and drive it away with no additional warm-up time.
- A few cc’s will melt immediately due to the heat from the exhaust.
- The tank heater will eventually melt the rest as you drive.
- Oh, by the way – one of the other uses for urea is as a de-icer. Google it.
Volvo In-Tank Heater / Pickup

- Fits inside DEF tank from top
- Circulates engine coolant through the Diesel Exhaust Fluid to maintain proper temperature – 60°F
- All stainless steel, high-quality
- DEF level gage float (in center), with wiring harness
- DEF pickup with intake filter
- No tank insulation is required
- By the way – Volvo Group has already delivered over 225,000 of this part. Like the rest of the SCR system, it’s proven. It works.
Cold Weather Testing

-40°, bobtail (light loading maximizes exhaust after-treatment system issues)

All systems performed as expected: PASSED
We Were the First to Test 2010 with Customers

October 2, 2007 -- FIRST FIVE EPA’10 TEST TRUCKS DELIVERED
**EPA’10 Testing Experience**

- Volvo has three winters on 2010 test trucks
- Volvo has over 30 EPA’10 Customer Function 2010 Trucks
  ~ 2+ Million Miles

---

- Volvo has ~40 more 2010 engineering trucks
- Volvo has 23 SCR Evaluation Trucks since 2002 in N.A.
  ~ 9 Million Miles

---

- Volvo has ~225,000 SCR Euro IV and Euro V trucks globally
  ~ 7.5 Billion Miles
No Active Regeneration

- A Major Advance in diesel emission systems
  - Better Fuel Economy
  - No Driver Involvement
  - Near Zero Emissions
Alternative fuels & drivetrains
Seven alternatives

- Biodiesel
- Synthetic diesel
- Methanol/Ethanol
- DME - Dimethylether
- Hydrogen + Biogas
- Biogas + Biodiesel

Produced from organic sources

90% Biogas and 10% Biodiesel
Hybrid drivelines for long haul

- **5-8%** fuel economy improvement possible with hybrid technology
- Substantial real fuel savings due to high annual miles traveled
- Requires different technical strategy than vocational stop/start applications
- Vehicle electrification to reduce parasitic loss and eliminate idling
Vehicle Electrification/Hybrid

Electric Auxiliaries for Long-Haul
- Modulate pumping, fans, air compressor, air conditioning, power steering
- Improved fuel economy
- Improved cooling
- Facilitate reduced idling
- Hotel loads
Electric Turbocompound with Electric Auxiliaries and Mild Hybrid for Long-Haul Trucks

- Electric auxiliaries can be modulated to meet system demand
- Mild hybrid motor takes electric capacity above auxiliary requirements
- Energy storage can be used to run auxiliaries needed for hotel function to avoid idling for driver needs.
- Fuel savings up to **8%** depending on idling reduction savings
- Significant increase in cost and complexity

Volvo Trucks North America
Discussion / Questions?