Retrofit Emission Controls for On-Road Diesel Engines

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Strategies to Reduce Emissions from In-Use Diesel Engines

• Retrofit – installing a verified emission control device on an existing diesel engine
• Refuel
• Repair/Rebuild
• Repower
• Replace
Experience with Diesel Retrofits Spans a Variety of On-Road Vehicle Applications…

... Construction Equipment...
... Mining...

... and Other Off-Road Vehicle and Stationary Engine Applications
Wall-Flow Diesel Particulate Filters Offer the Highest PM Filtration Efficiency

- >85% PM reduction (ARB Level 3)
- Catalyzed DPFs require operation on ULSD
- Large reduction in toxics from catalyzed DPFs
- >200,000 retrofits worldwide
- >5 million OE applications
- Same technology as on MY 2007 OE trucks

Passively regenerated DPFs employ catalysts and available exhaust heat to burn captured soot – specified exhaust temperature requirements

DPFs with Active Regeneration Available for Retrofits

- Suited for on- and off-road applications with low exhaust temperatures, including construction equipment, locomotives, and marine engines
- Example: Uncatalyzed wall-flow filter with electrical regeneration
- Example: Uncatalyzed wall-flow filter with a fuel burner
Flow-Through Filter Technologies

- 50-75% PM reduction (ARB Level 2)
- Can be catalyzed or used with a DOC
- Has applicability on older engines
- Resistant to plugging
- Ash cleaning generally not necessary due to open structure

Metal Substrate with Sintered Metal Sheets

Diesel Oxidation Catalysts

- 25-40% PM reduction (ARB Level 1)
- “Soluble” PM species are oxidized
- Large reduction in toxics
- DOCs have been retrofitted on on- and off-road vehicles for over 30 years
- Nearly universal application with >1 million retrofits worldwide
- Tens of millions of OE applications

Flow-through monolith with catalytic coating
Crankcase Filters Can Provide Additional PM Control

- Most existing diesel engines vent crankcase emissions directly to the atmosphere
  - Health concerns related to in-cabin air quality (e.g., school buses)
- Crankcase filters can reduce crankcase PM emissions by 90+%
  - On DPF-equipped vehicles, crankcase PM can represent up to 70% of total PM

Integrated Retrofit Solutions Emerging for Combined PM+NOx Reductions

- Lean NOx Catalyst (LNC) + DPF
  - 25% NOx reduction
- Low-Pressure Exhaust Gas Recirculation (EGR) + DPF
  - 40-50% NOx reduction
- DPF + Urea Selective Catalytic Reduction (SCR)
  - 60%+ NOx reduction
Challenges for Off-Road Retrofits

• Higher emissions than on-road heavy-duty engines
  – Uncontrolled before 1996
• More diverse engine/equipment applications than on-road
  – More older equipment
  – Wide horsepower range
  – Equipment stability
• More rigorous operating environment (vibrations, dust, uneven surfaces)
  – Can require extensive use of high-grade vibration isolators, especially in track-drive equipment
• Packaging constraints
  – Maintaining driver visibility

Policy Choices Have Significant Impact on Development of Retrofit Market

• Incentive funding important to get retrofits on engines early, but won’t pay for everything
• Demonstration programs/funding help fill the retrofit verification pipeline
  – ARB/SCAQMD Off-Road Showcase Program
  – Texas NTRD funding for NOx retrofits
• Verification process needs adequate technical resources
• Regulatory certainty defines market opportunity
Summary/Issues

• Retrofit technology provides a cost-effective option for cleaning up PM and NOx emissions from a range of in-use diesel fleets
• A variety of retrofit technologies have been verified by both the U.S. EPA and California ARB for on-road and off-road diesel vehicles and equipment
• Significant experience with retrofit technologies exists for on-road vehicles; retrofit experience is growing for many off-road applications

Summary/Issues

• Application engineering is a necessary step to matching a diesel engine with the correct retrofit solution
• Even “passive” solutions need maintenance (e.g., filter cleaning, urea for SCR)
• Retrofit technologies are generally compatible with biodiesel (typically, B20 or less; biodiesel blend needs to meet existing specifications)

➢ Successful Retrofits Require a Cooperative Effort Between Fleet Owners, Vehicle Operators, and Technology Providers