

Advanced After-Treatment Emission Control Technologies for Locomotives



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Breakout Session 2 – Rail Track: Innovative Technology and Programs
Faster Freight Cleaner Air Conference
Long Beach, CA
February 27, 2007

Aftertreatment Technologies

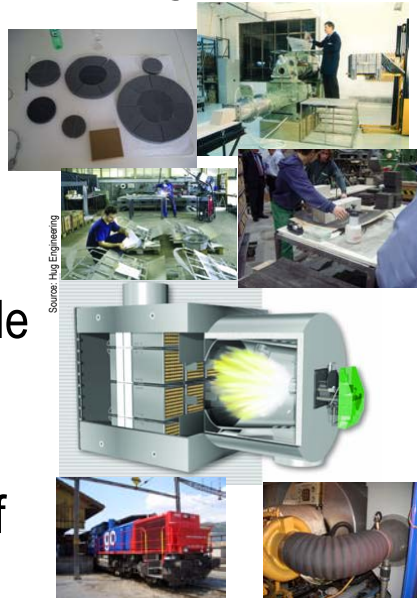
- Particulate Matter
 - Diesel Oxidation Catalysts (20-30% Red.)
 - Diesel Particulate Filters (>85% Red.)
- NO_x
 - In-Cylinder Technologies
 - Selective Catalytic Reduction (90% Red.)
 - Other (NO_x Absorber)

Swiss Rail Experience

- Planned Delivery of 73 New Diesel Locomotives (2000 Hp) Equipped with Diesel Particulate Filters (DPFs)
- Ultimate Replacement of 800 Diesel Locomotives with 450 New Diesel Locomotives with DPFs
- Use of 50 ppm Sulfur Content Diesel Fuel and Synthetic Lubrication Oils
- One Smaller Locomotive Equipped with DPF and SCR

Hug Engineering

- Leading European Manufacturer of PM and NOx After-Treatment Devices
- Use of Silicon Carbide Based Materials
- Modularized Units Capable of Variety of Applications



Potential Application to U.S. Locomotives

- After-Treatment PM and NOx Technologies Are Feasible on Locomotives
- Need to Use Low-Sulfur Content Diesel Fuel
- Retrofits Being Tested
- New Locomotive Considerations for After-Treatment Devices

Switcher Locomotives

- New Swiss Rail Locomotives Similar to Switchers
- DPF Integrated into Carbody
- Retrofits Currently Underway – UP/BNSF



Feasible PM Retrofit Technologies

- Diesel Particulate Filters
 - Extruded Wall Flow with **Modular** Ceramic Assembly
 - **Fibrous** Ceramic Media with Depth of Filtration
- Retrofits Within Car-Body or Above
 - Engine Room, Vent Wings, Silencer/Muffler



Source: Hug Engineering



Line-Haul Locomotives

- Existing Locomotive Retrofit Demonstration
- DPF Integrated into Carbody
- Vossloh Locomotive Offering 3,600 Hp Locomotives with DPFs



Source: Hug Engineering



Source: Hug Engineering

Retrofitting Line-Haul Locomotives

- Space Consideration
- Potential Muffler Replacement
- Ability to Retrofit Above Carbody



SCAQMD Locomotive Projects

Three Locomotive Retrofit Project Proposals:

- Demo DPF + SCR on Head End Power
- Demo DPF on Switch Locomotive
- Demo SCR on EMD Passenger Locomotive

DPF: Diesel Particulate Filter (PM)

SCR: Selective Catalyst Reduction (NO_x, PM)

DPF + SCR on Head End Power Locomotive Demonstration

- Passenger Locomotives Use Gen-sets called Head End Power (HEP) to Provide Passenger Hotel Power (~500 HP)
- Accounts for about 30% Emissions Due to Continuous Full Power Operation
- Expect 90% reductions in NOx and PM



DPF on Switch Locomotive Demonstration

- Pacific Harbor Line (PHL) Repowering 16 Switch Locomotives Under Agreement with Ports
- Switch Locomotive Engines with 4-cycle DDC/ MTU 12V4000 engines (2000 HP)
- Expect 90%+ PM reduction



SCR on Passenger Locomotive Demonstration

- EMD F59PH Locomotives Use 12-cyl engines Similar to 16-cyl Freight Engines
- Hardened High-Cell-Density SCR Catalyst Developed for On- and Off-Road Applications
- SCR Catalysts to Replace Muffler



GE Proposal

- Submitted to CARB ICAT Grant Program
- Retrofitting Line-Haul Locomotives
- “Our Proposal is to Use a Fibrous Ceramic Media Type Filter Using the Principle of Depth Filtration to **Reduce Size, Weight, Cost, and Backpressure** of the Filter.”

GE Proposal

- “The Technical Goals of the Proposed Project Are to **Design a DPF for a 4500 Hp Locomotive Engine** that will **Reach 90% PM Filtration Efficiency** with a **Maximum Duty Cycle Fuel Consumption Penalty of 1%**, With **No Adverse Impact on System Reliability**, While **Minimizing the Initial Cost of the System**. The System Should be **Retrofittable to Most Existing GE Locomotives That Use Electronic Fuel Injection**”

Summary of Retrofit Technologies

- Modular Approach to Address Space
- Diesel Particulate Filters
 - Ceramic Pleated Filters
 - Ceramic Fiber Filters
- NOx Reduction Potential - SCR
- Retrofits Within Car-Body or Above