Reducing Emissions From Railroad Locomotives

Presented to the
South Coast Air Quality Management District
Container Movement Technology Forum
and Roundtable Discussion

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Locomotive Emissions

- **Line-haul into/out of LA basin**
- **Local train service within basin**
- **Switch locomotives**
  - Railyards
  - Ports and intermodal facilities
  - Industrial plants
- **Locomotive servicing, maintenance, and testing**
- **Many locomotives have two-stroke diesel engines**
  - Higher organic carbon (from lube oil)
  - Lower elemental carbon

Locomotive Contribution to SCAQMD Emissions Inventory

	2004 Emissions TPD	
	NOx	PM
Total	37.3	1.03
Metrolink	3.04	0.10

Locomotive Emissions Issues

- **Switching vs. line-haul vs. local train operation**
  - Most switching and short-haul locomotives were retired from line-haul service
  - Common locomotive designs ill-suited for switching duty cycle
- **Power requirements and dimensional constraints**
- **Emission standards well behind truck and other non-road engines**
- **Slow turnover of locomotives**
- **Prevalence of idle operation**
  - Present inventories/test methods understate idle PM emissions by 25 to 50%
- **Industrial locomotives**

EPA/CARB/UP/BNSF Memorandum of Understanding

- Average emissions equivalent to Tier 2 by 2010
- Week penalty provisions
- “Poison pill” provision – any further regulation cancels MOU
- ULEL loophole

Switch Locomotives

- **Dedicated units designed for switch duty cycle**
  - "Green Goat" diesel/battery-electric series hybrid
  - Multi-engine locomotives using smaller nonroad engines
- **Engines have modern control technology**
- **Engines run only when needed**
- **Much better candidates for DPF and SCR retrofit**

Servicing/Maintenance Emissions

- Stationary source control technologies may be applicable
- Roseville Adanced Locomotive Emision Control System (ALECS) demonstration

Potential Emission Controls for Line-Haul Locomotives

- **New "Tier 3" locomotives**
  - Standards not yet defined, indications are they will include SCR, DPFs
  - Existing locomotive inventory, operating patterns an obstacle
- **Retrofit existing locomotives**
  - Diesel oxidation catalysts
  - Selective catalytic reduction
  - Diesel particulate filters
- **Ultra-clean shuttle locomotives**
  - Ports/intermodal facilities to railyards outside basin
  - Congestion and operating advantages in port area as well as lower in-basin emissions
- **Anti-idling systems**
- **Alternate fuels, electric traction NOT recommended**

Status of SCR for Locomotives

- **Widely used on similar engines in stationary applications**
- **1994 ARB report identified SCR as most cost-effective measure for locomotives**
  - Conceptual design based on stationary SCR systems
- **Railroads have strongly resisted SCR proposals**
  - Cost
  - Volume requirements on locomotive
- **New emission control system at Roseville rail yard will capture locomotive emissions in a stationary hood and apply SCR**
- **But, new compact SCR systems provide major improvements in both cost and space demand, and would allow SCR control on-board**
- **Prototype under development for Metrolink locomotive**

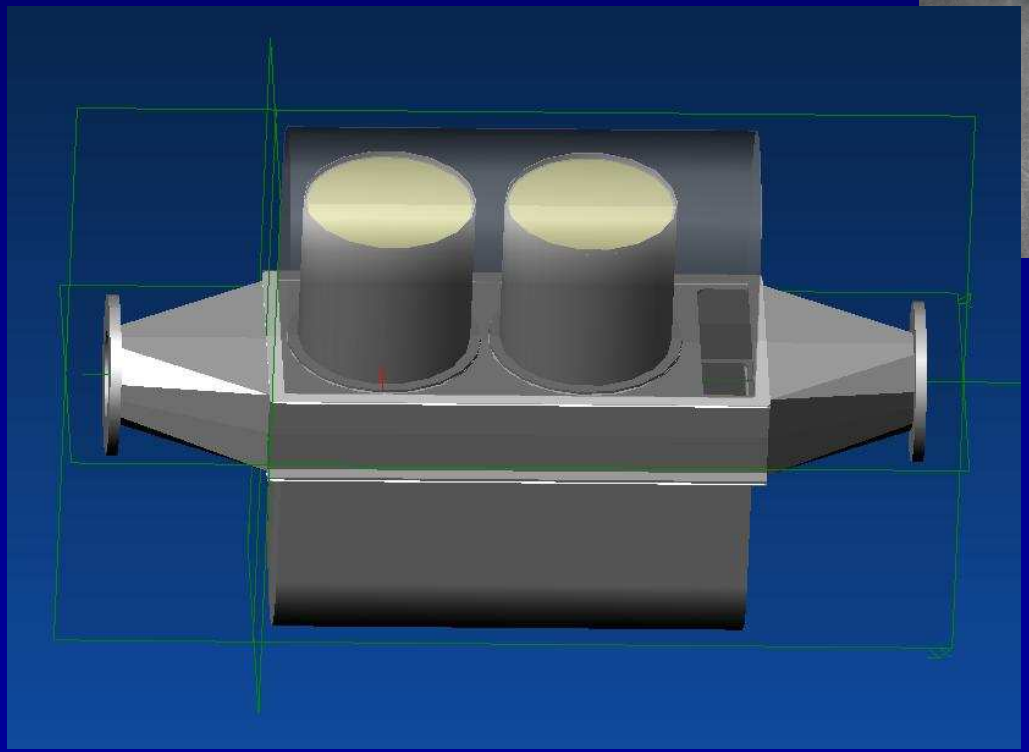
Compact Urea SCR System for Mobile Sources

Ferryboat Engine SCR System

Sized for 450 to 600 HP engine

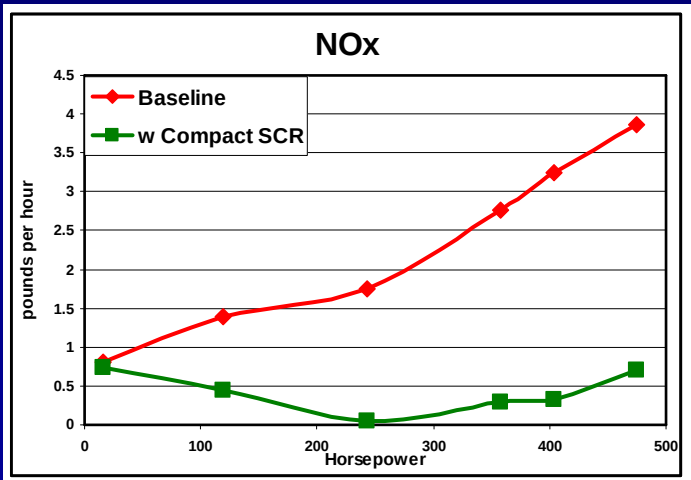
Dyno tested March 6-8 in Seattle

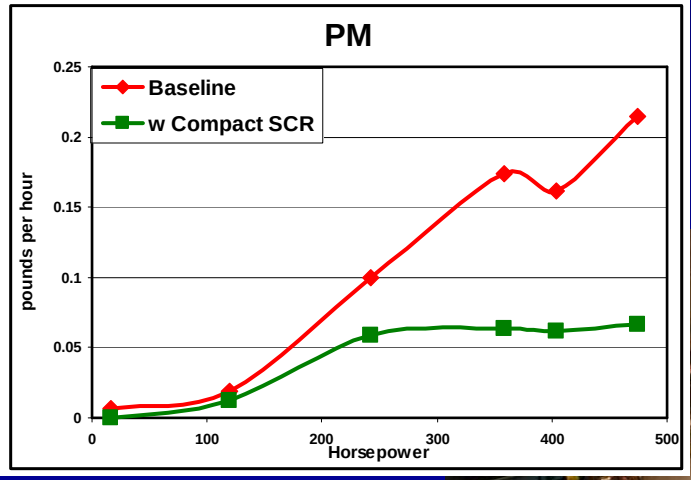
Four vessels planned for San Francisco Bay



Emission Test Results of Ferryboat SCR

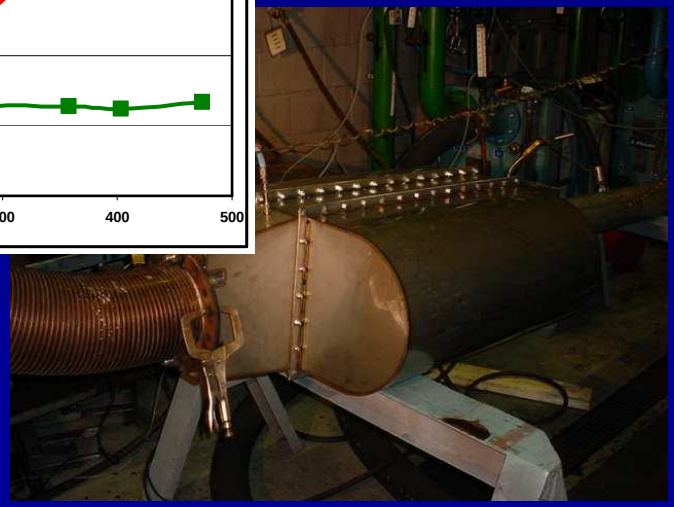
Pct Power	Cat Inlet Temp. (oC)	NOx Emissions (g/BHP-hr)			PM Emissions (g/BHP-hr)		
		Baseline	w SCR	% Red	Baseline	w SCR	% Red
Ultra-Low Sulfur Diesel							
100%	271	3.29	0.64	80.4%	0.18	0.06	66.3%
85%	266	3.28	0.35	89.3%	0.16	0.07	58.9%
75%	264	3.17	0.35	89.0%	0.20	0.07	62.7%
50%	273	3.11	0.10	96.8%	0.18	0.11	38.6%
25%	206	5.04	1.71	66.0%	0.07	0.05	34.2%
Idle	86	15.6	15.6	0.0%	0.14	0.00	100.0%



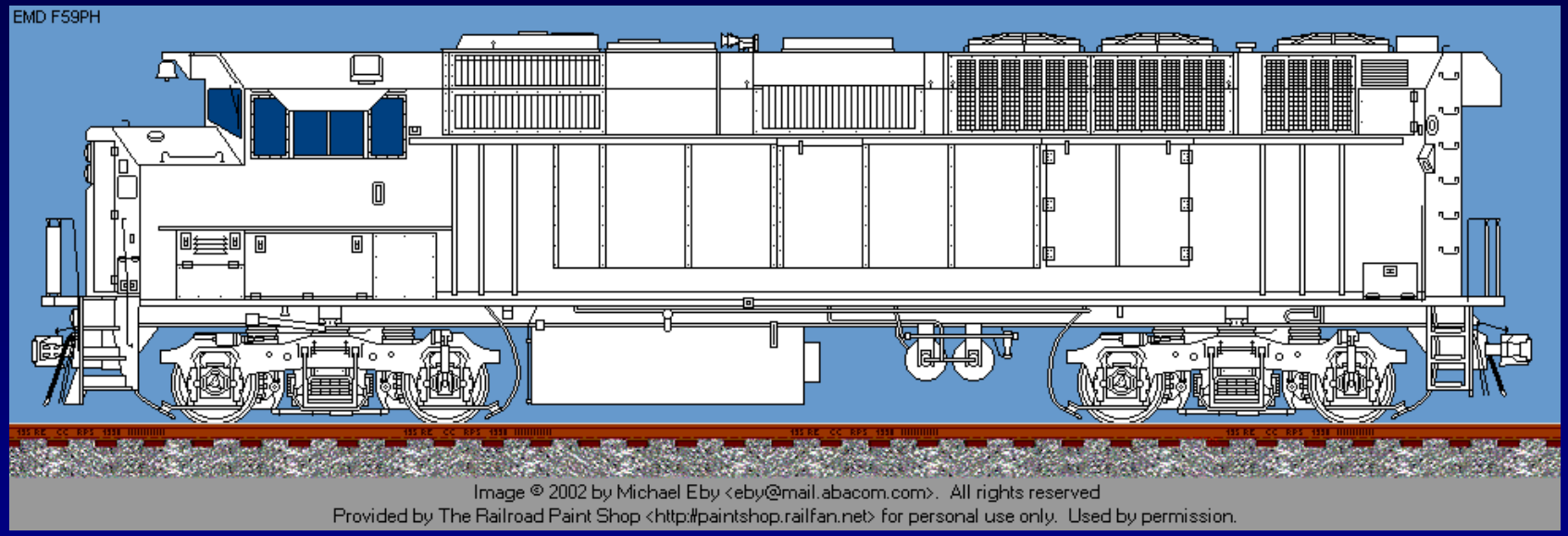


Tested at Pacific Power Products

Kent, WA March 3-6, 2006

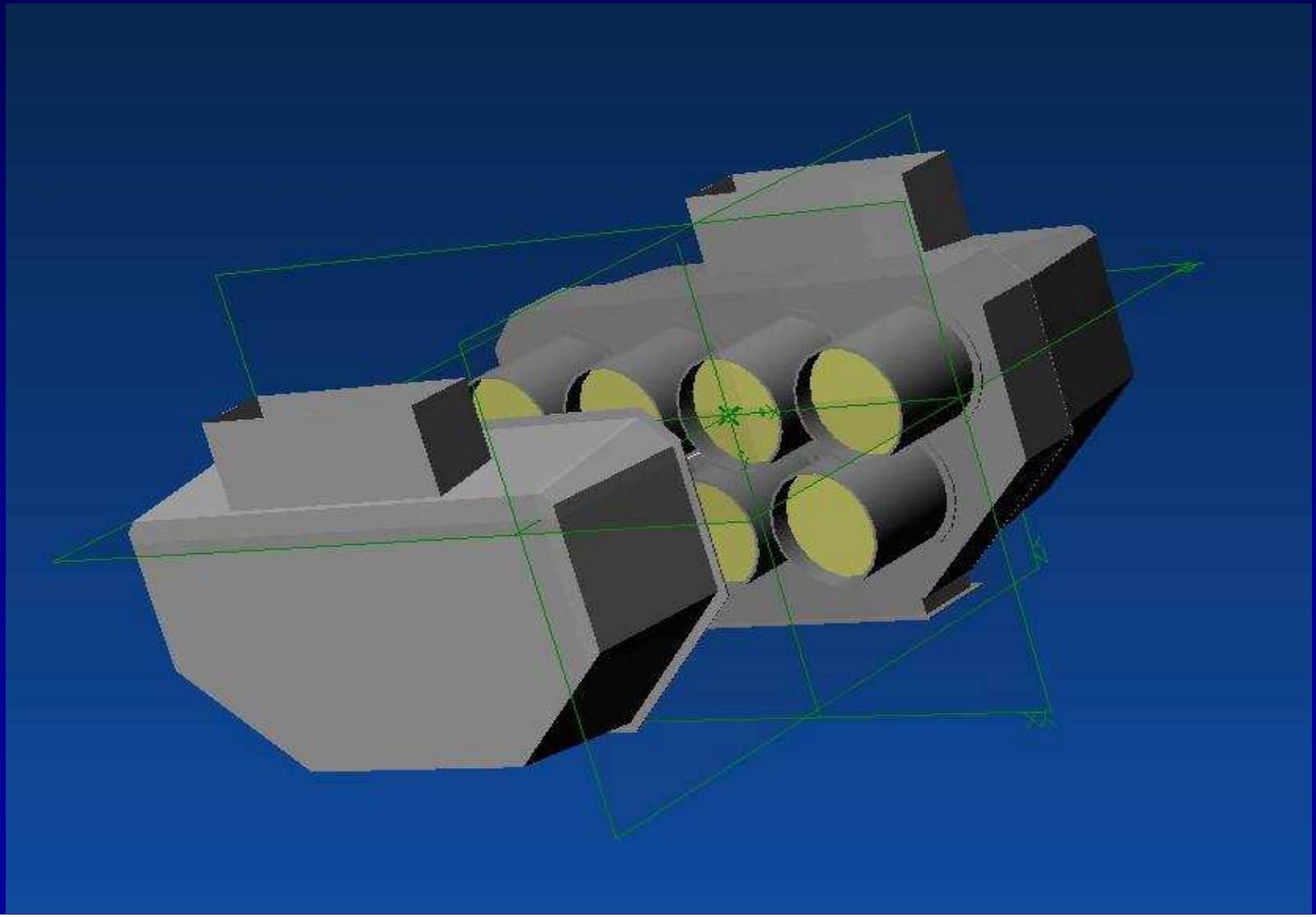


Locomotive Profile



- **Exhaust system configuration on Metrolink F59s is the same as on SD60 freight locomotives**
- **Same SCR retrofit system could be used on both**

SCR Catalytic Converter



Cost-Effectiveness of SCR in Metrolink Locomotives

	NOx	PM
Annual Emissions (tpy)	29.2	1.0
Emission Reduction (tpy)	23.4	0.5
Capital Cost	$ 150,000	
Annualized	36,584	
Liters Urea/Year	42,048	
Operating Cost	$ 47,048	
Total Annual Cost	83,632	
Cost-Effectiveness	$ 2,949	$/ton

SCR Application to Freight Locomotives

- **SCR highly cost-effective**
- **More than half the cost is for urea consumption**
  - Can be turned on and off when entering/leaving pollution control areas
  - Automatic control based on GPS
- **Cost-effective NOx control for nonattainment regions**
- **PM benefits would be experienced throughout area of operation**