

Reducing Emissions From Railroad Locomotives

Presented to the
South Coast Air Quality Management District
Offroad Emission Reduction 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
- **Passenger Rail (AMTRAK / Metrolink)**
 - 39 locomotives presently
 - 15 more locomotives to be purchased
- **Locomotive servicing, maintenance, and testing**
- **Many locomotives have two-stroke diesel engines**
 - Higher organic carbon (from lube oil)
 - Lower elemental carbon



EPA/CARB/UP/BNSF

Memorandum of Understanding

- **Average emissions equivalent to Tier 2 by 2010**
- **Weak penalty provisions**
- **“Poison pill” provision – any further regulation cancels MOU**
- **Ultra-low emission locomotive (ULEL) loophole**
 - 50 ULEL switchers w SCR can generate 5 g/BHP-hr year of fleet average credit through 2014
 - Credit can be used to increase fleet-average emission limit from 5.5 g/BHP-hr to 10.5 g/BHP-hr for one year, or to 6.5 g/BHP for five years

Locomotive Contribution to SCAQMD Emissions Inventory

	2004 Emissions TPD	
	NO _x	PM
Total	37.3	1.03
Metrolink	3.04	0.10



State inventory (based on MOU) predicts freight rail emissions of 18.3 TPD in 2014 and 22.6 TPD in 2023

- Unlikely to be achieved due to weakness of MOU
- **Port of LA Clean Air Plan projects freight rail traffic to double by 2020 (58 trains/day to 130)**

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**
- **Excellent candidates for DPF and SCR retrofit**



Servicing/Maintenance Emissions

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



Potential Emission Controls for Line-Haul Locomotives

- **New locomotive emission standards**
 - EPA Tier 3 NO_x same as present Tier 2 standard
 - Tier 4 NO_x proposal of 1.3 g/BHP-hr would be effective in 2017
 - 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

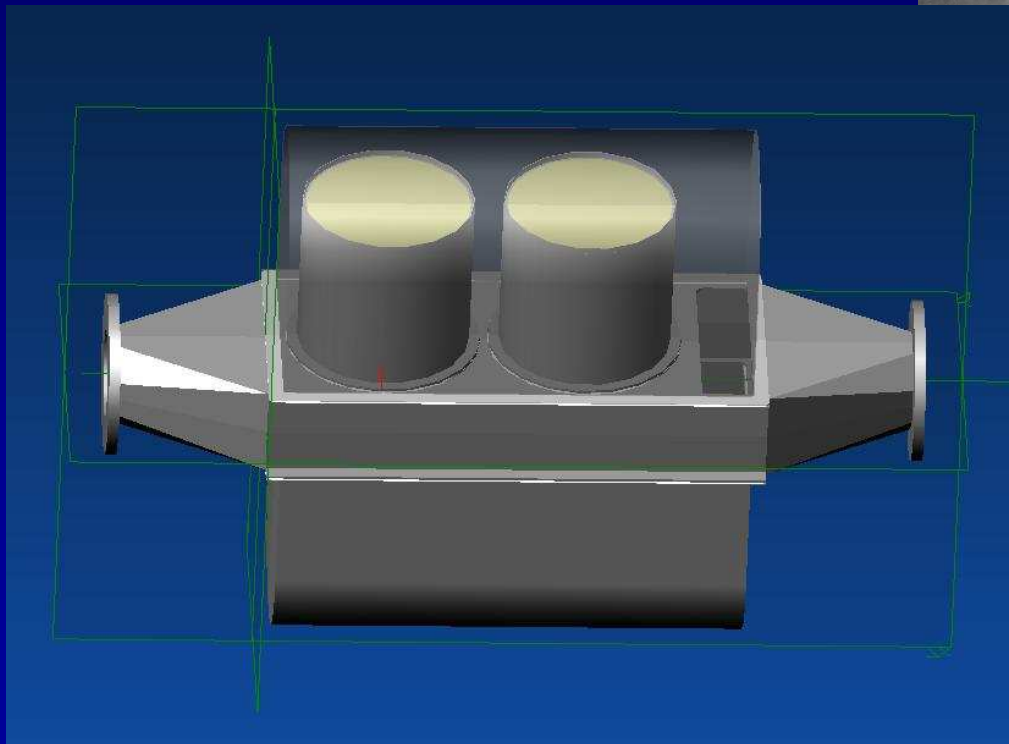


Ferryboat Engine SCR System

Sized for 450 to 600 HP engine

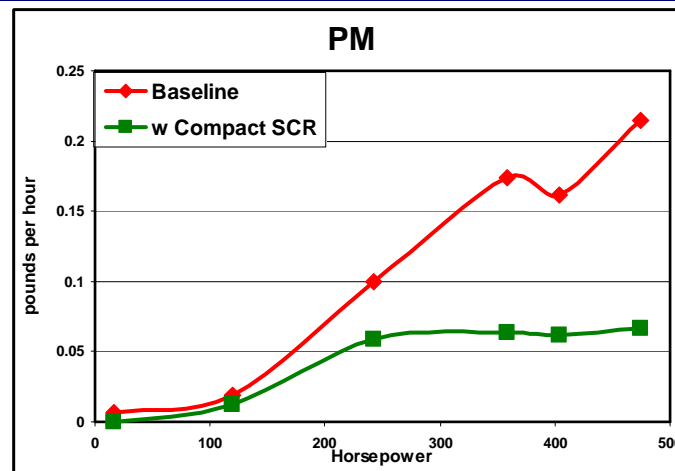
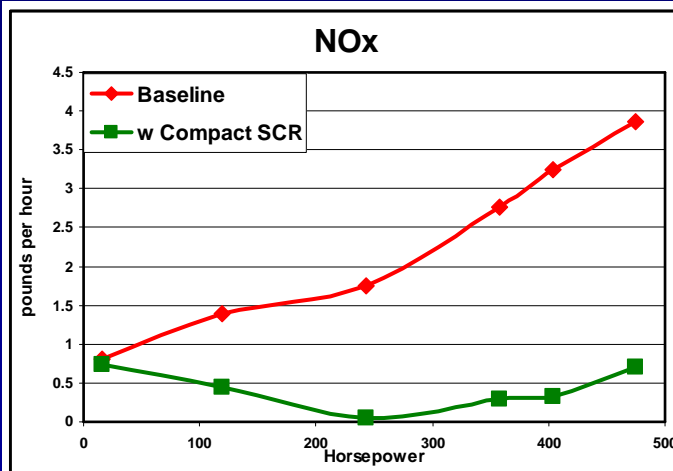
Dyno tested March 6-8 in Seattle

Four vessels planned for San Francisco Bay



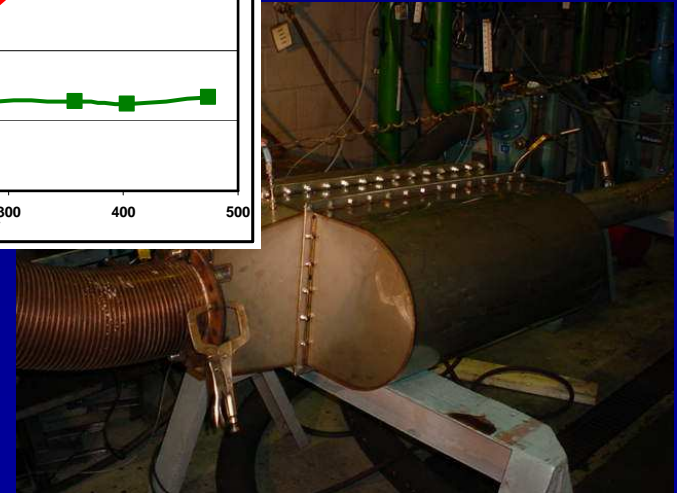
Emission Test Results of Ferryboat SCR

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%

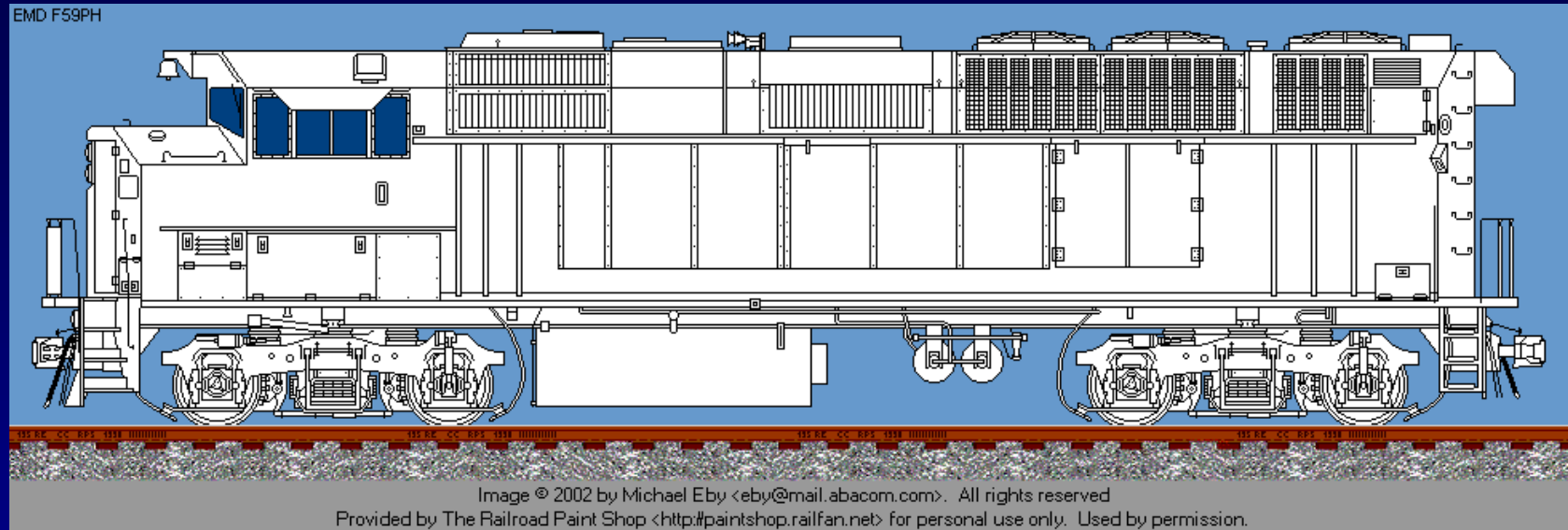


Tested at Pacific Power Products

Kent, WA March 3-6, 2006



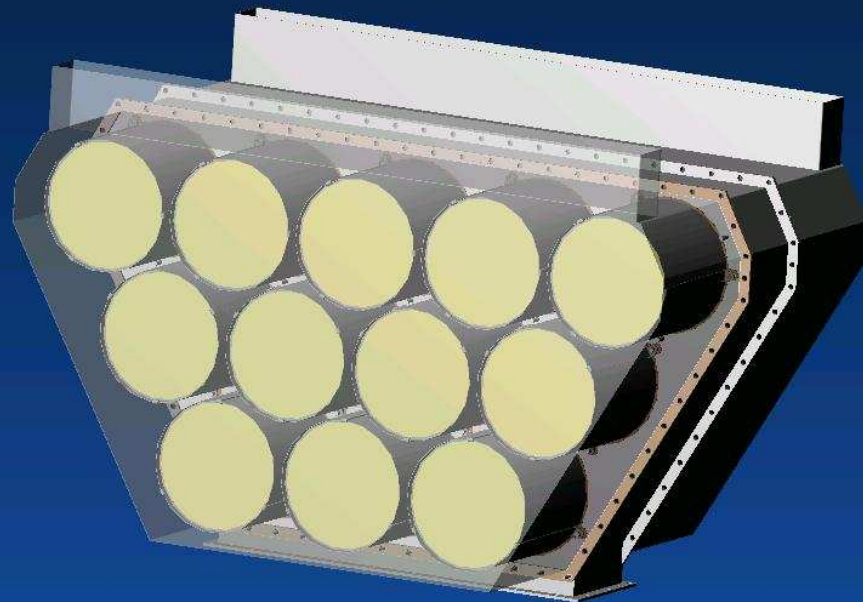
Locomotive Profile



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

Locomotive SCR Demonstration

- \$430 K grant funding – SCAQMD and TCEQ
- CARB and SCAQMD considering another \$250 K for emission testing at SWRI
- Target the propulsion engine of Metrolink F59 PH locomotive
 - EMD 710 - 3000 HP
- Goal is to achieve 90% NO_x reduction above Notch 3
- PM reduction estimated at 50 to 70%

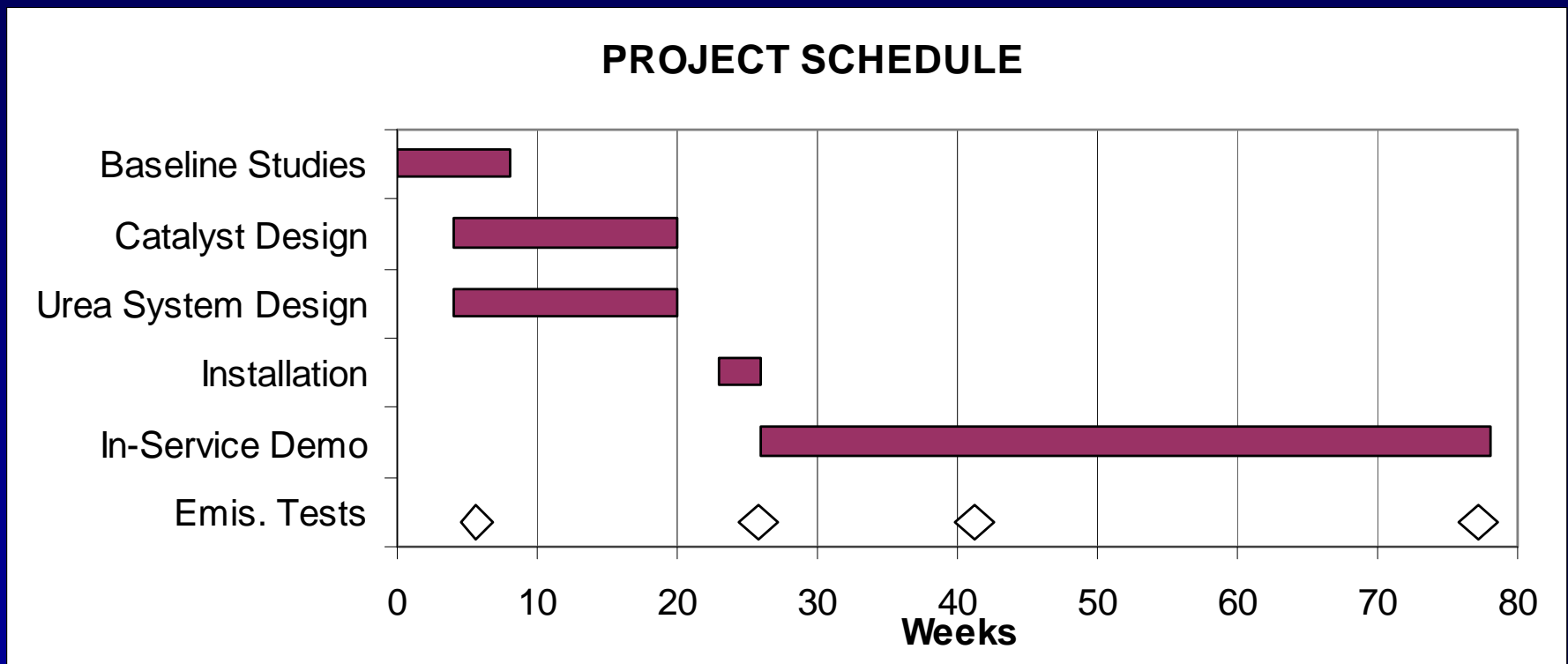


Metrolink SCR Demonstration

Technical Challenges

- **Shock/vibration environment of locomotive**
 - Catalysts and injection systems use technology developed for HD trucks
- **Low backpressure tolerance of engine (6 inches H₂O)**
 - Multiple parallel catalysts reduce backpressure
- **High oil consumption / high oil content of exhaust**
 - Retrofit with low-oil cylinder packages
 - Ti-V-W catalyst functions as DOX cat, burns SOF
 - Catalyst elements replaceable when poisoned
- **Crankcase vent eductor in exhaust stream**
 - Add coalescing filter to crankcase vent
 - Move crankcase vent eductor or replace with pump

Metrolink SCR Demo - Schedule



Cost-Effectiveness of SCR in Metrolink Locomotives (Main Propulsion Only)

	NOx	PM
Annual Emissions (tpy)	29.2	0.9
Emission Reduction (tpy)	26.3	0.5
Capital Cost (est.)	\$ 300,000	
Annualized	73,167	
Liters Urea/Year	47,304	
Operating Cost	\$ 52,304	
Total Annual Cost	125,471	
Cost-Effectiveness	\$ 3,544	\$/ton

SCR Application to Freight Locomotives

- **SCR highly cost-effective**
- **Nearly 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 NO_x control for nonattainment regions**
- **PM benefits would be experienced throughout area of operation**
- **ARB considering second demonstration in a freight locomotive**