

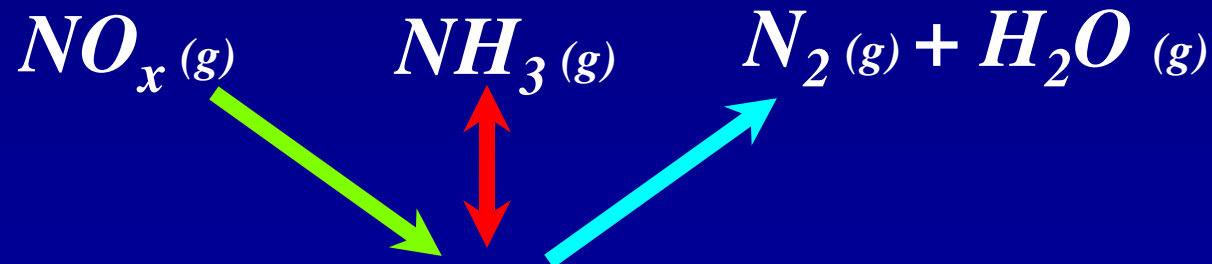
COMPACT SCR™ SYSTEMS FOR HARBOR CRAFT

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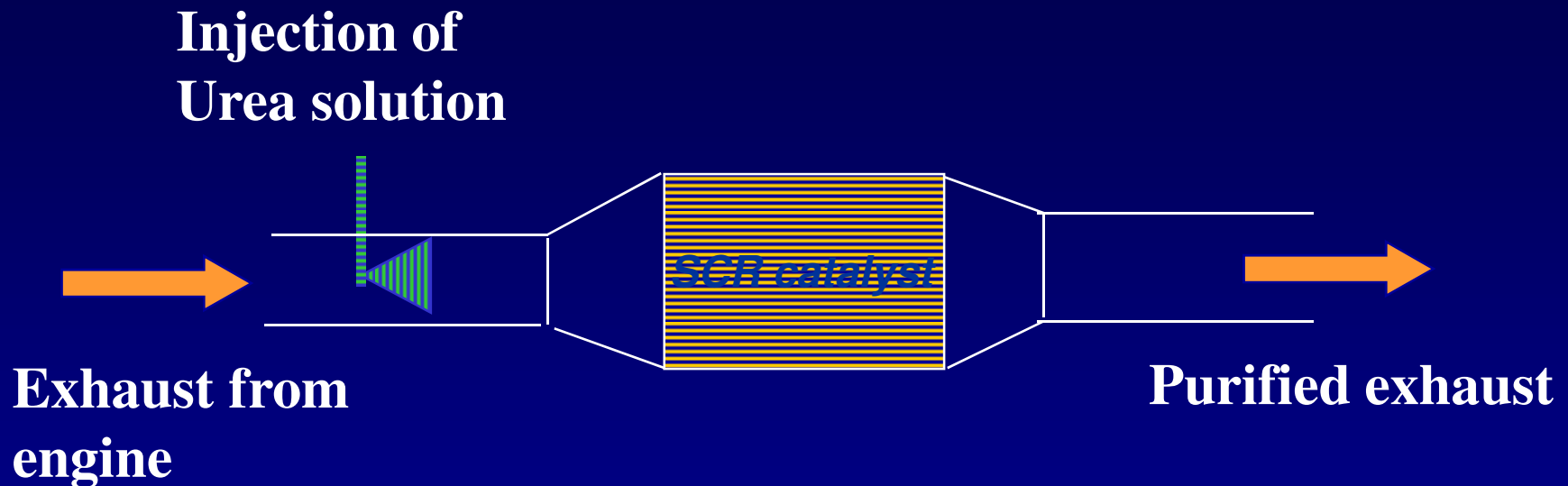
Selective Catalytic Reaction (SCR)

- Widely used in power plants, stationary sources
- Like a three-way catalyst for diesel / lean-burn engines
- Oxidizes HC, CO, and organic fraction of PM
- Reduces NO_x in presence of O₂, but requires ammonia (NH₃) to drive the reaction
- Urea (NH₂)₂CO + H₂O + heat → 2 NH₃ + CO₂



SCR catalyst

Urea-SCR System



- **> 95% NO_x reduction possible**
- **diesel PM reduced 30-60%, VOC ~80%**
- **Temperature range 200 - 550°C**
- **Slight increase in back pressure**
- **Combination with particle filter if desired**
- **Sulfur tolerant**

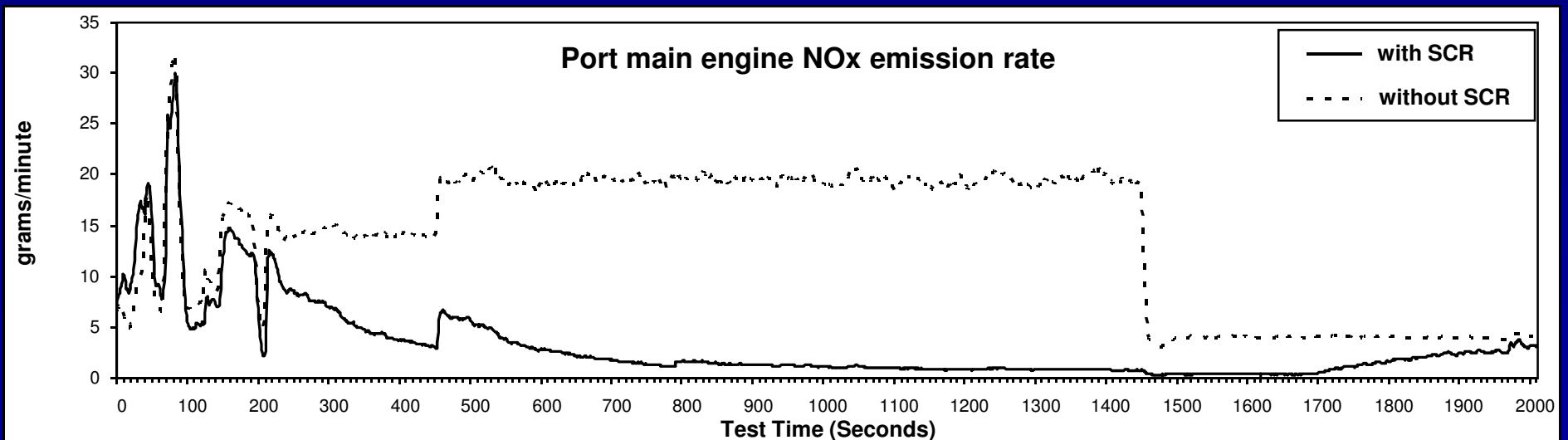
Monohull Ferry Project – Private Operator

- **Compact SCR systems for four 625-hp main engines and four 30-39 kW gensets on two monohull ferries**
 - Delivered December 2007 and February 2008
 - Calibration and limited emission testing on first vessel February 2008
 - > 2800 engine hours so far
 - Minor fixes and design improvements
 - Second vessel entered service September,
 - >1800 engine hours so far



Preliminary Testing of Monohull Ferry SCR

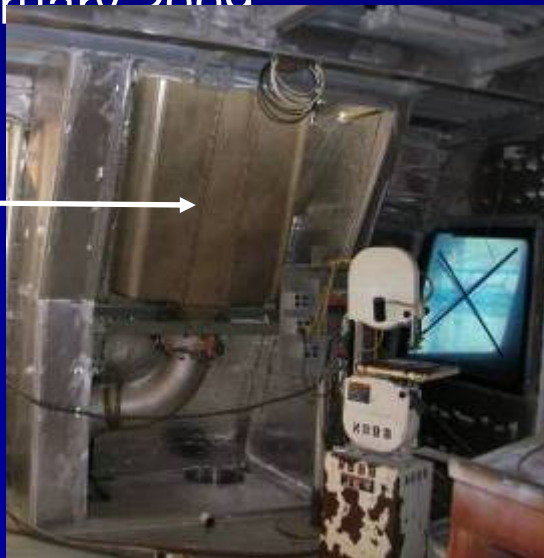
- Main engines: 2 x DDC Series 60, 625 HP Tier 2 marine diesels
- 6 catalyst modules per engine, reactor wt ~350 lb
- Gensets: 2 x Onan 39 kW
- One catalyst module per genset, one urea injection system shared between both gensets
- Preliminary measurements conducted to set urea injection rates and verify system performance.
- NOx reduction > 90% at all but lowest power settings



Water Emergency Transportation Authority New Fast Ferries

- Compact SCR™ systems for eight 1410-hp main propulsion engines on four new fast ferries
 - System weight ~ 900 lb/engine
 - M.V. *Gemini* in service December 2008
 - > 370 hours so far
 - M.V. *Pisces* completed acceptance testing February 2009

EF&EE
SCR
Reactor



THE WATER TRANSIT AUTHORITY INTRODUCES THE MOST ENVIRONMENTALLY FRIENDLY FERRIES IN THE NATION



Merging Selective Catalytic Reduction with Renewable Solar Energy on our New Hybrid Commuter Vessels

ABOUT THE FERRIES:

- Two 25 knot, 149 passenger-only ferries
- 85% cleaner than 2007 EPA regulations
- Incorporates SCR and solar (renewable energy) technology
- Low wake, low wash hulls
- Room for 34 bikes with fresh water rinse
- WiFi provided
- Several seating options included to maximize passenger comfort
- Whale detection system with Farsounder forward searching radar
- Two ADA compliant restrooms
- Fitted with voyage data recorder

SCHEDULE & SERVICE:

- Scheduled delivery dates are September and December 2008
- Will be spare vessels for emergency response, but will also be put into service to launch the South San Francisco to Oakland ferry route until the boats specified for that route are delivered

THE BOAT BUILDING TEAM:

- The team of Nichols Brothers Boat Builders and Kvichak Marine Industries is constructing the vessels at their Washington state shipyards
- Incat/Crowther from Australia is leading the design effort

COSTS & FUNDING SOURCES:

- Cost will be \$16 million for 2 vessels
- Funding from local Regional Measure 2 bridge toll

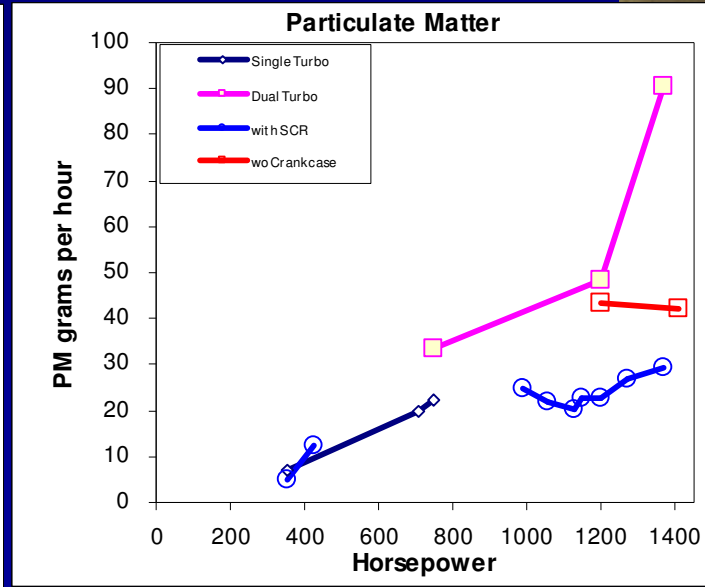
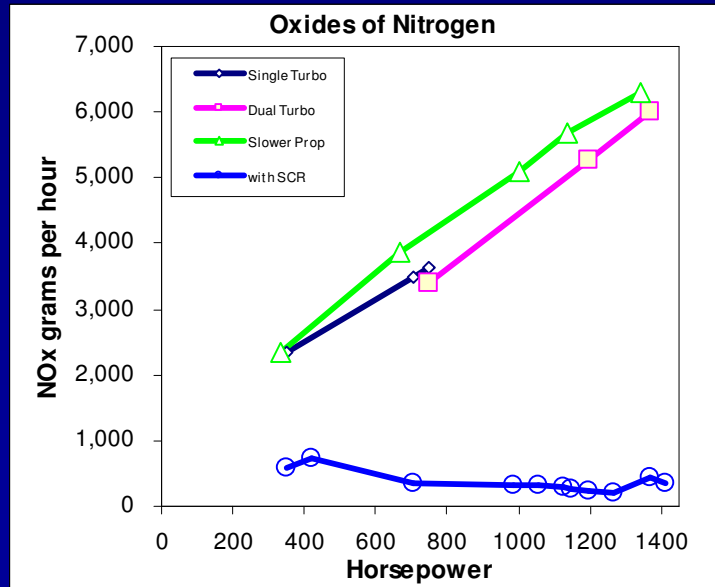
The San Francisco Bay Area Water Transit Authority is a regional agency mandated to build and operate a comprehensive public water transit system of ferries, feeder buses, and terminals. The Authority's mission is to expand existing routes and add 8 new ferry routes to triple ferry ridership by 2025.

WATER TRANSIT AUTHORITY

Dyno Test Results for WETA Ferry SCR

- MTU 16V2000 M70 -- 16-cylinder, sequential turbo, 1410 hp high-speed marine diesel
- Measured emissions were 1/3 of contract limit, ~95% reduction from baseline
- Cruise NOx 0.2 g/BHP-hr, PM 0.02 g/BHP-hr
- Tier 2 engine → Tier 4 compliance w SCR
- Exhaust backpressure at full power 42% below engine manufacturer's limit

Testing at Pacific Power Products
Kent, WA Jan. 10-12 2008

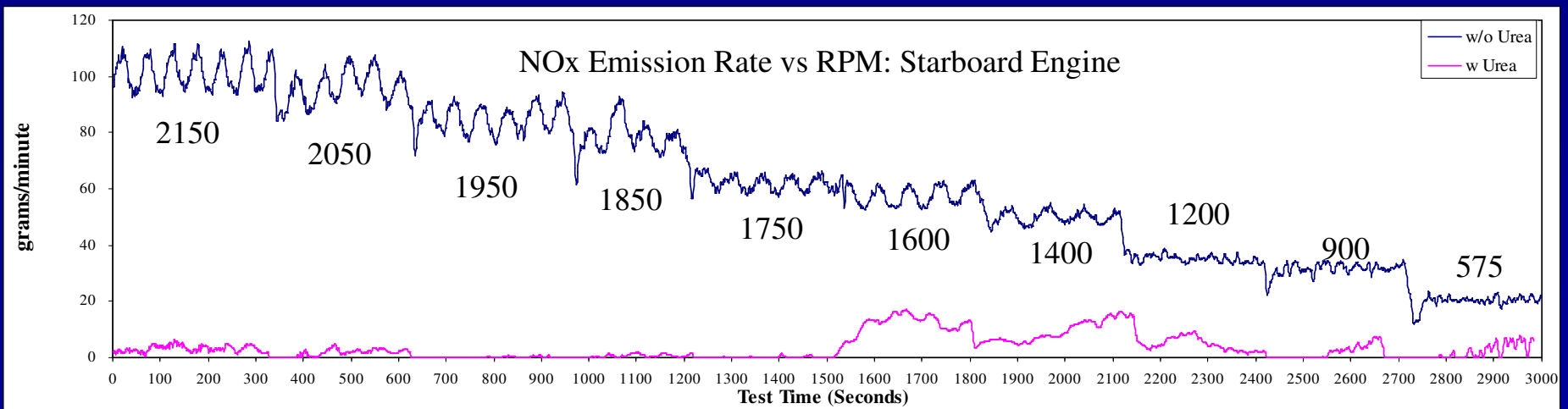


Sea-Trial Emission Results for M.V. Gemini

Acceptance Condition
85% Power Cruise



	Emissions (g/kWh)	
	Port	Starboard
NOx	0.01	0.18
PM	0.048	0.021
CO	0.04	0.10
HC est.	0.02	0.02
NOx+PM+HC	0.08	0.22
Contract Limit	1.11	1.11

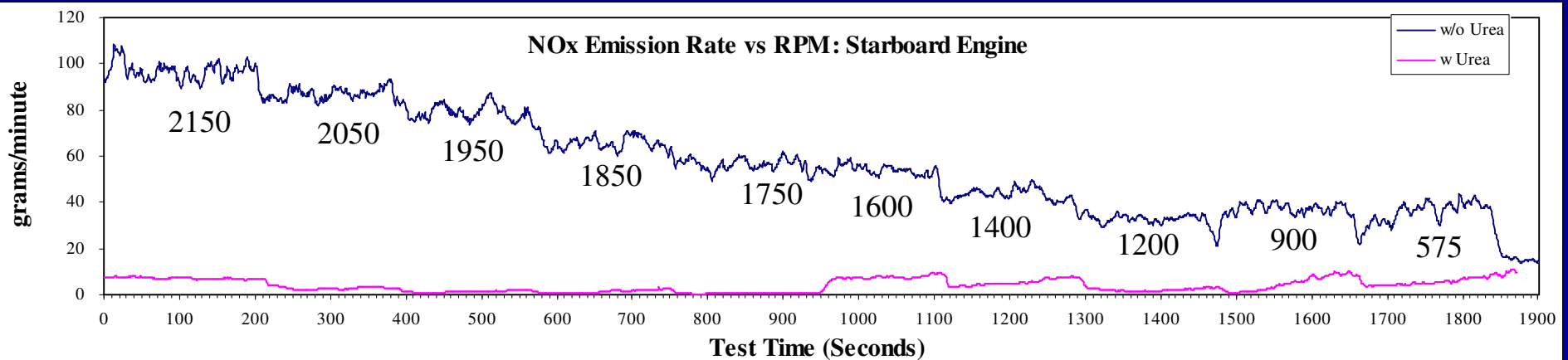


Sea-Trial Emission Results for M.V. *Pisces*



Acceptance Condition
85% Power Cruise

	Emissions (g/kWh)	
	Port	Starboard
NOx	0.18	0.28
PM	0.023	0.022
CO	0.02	0.03
HC est.	0.02	0.02
NOx+PM+HC	0.22	0.32
Contract Limit	1.11	1.11



Other Compact SCR Applications

LOCOMOTIVE

- EMD 12-710G3 engine: 3000 hp
- In-service demo under way
 - 5 weeks / 300 hours
- Emission reductions (initial tune)
 - EPA line-haul cycle
 - 72% NO_x / 77% PM



EARTHMOVING

- Cat D9 Dozer / 657E Scraper
- 370 hp / 632 + 457 hp
- System fabrication underway
- Est. D9 installation April 2009



CARB Harborcraft Rule and Carl Moyer Program

Opportunities for Compact SCR

- **Carl Moyer program has funded many vessel repowers**
- **With CARB adoption of mandatory retrofit/repower rules, only emission reductions sooner than or in excess of mandated level count toward Moyer cost-effectiveness**
- **If present engines don't need replacement**
 - **Compact SCR → CARB compliance at lower cost**
 - **Potential Carl Moyer funding for early installation (3 years before required)**
- **If present engines need replacement, adding Compact SCR to a Moyer repower proposal benefits the vessel owner two ways**
 - **Lower NOx/PM after installation → better cost-effectiveness → better chance of funding , and/or possible funding for 100% of costs**
 - **Compact SCR meets future ARB Tier 3 requirement → no owner cost for additional retrofit/repower in future**

Next Steps

Carl Moyer Program Grant Applications

- Application deadlines April-May 2009
- Three-year window → even boats subject to harborcraft rule may qualify

CARB Verification of Compact SCR™ Technology

- Build on present installed base
- Expected late summer, 2009

Compact SCR plus Diesel Particulate Filters

- Wallflow monolith DPFs intercept PM, protect SCR catalysts from clogging
- Tier 0 → Tier 4 without repowering
- CARB harborcraft rule compliance option
- First vessel installation planned for May, 2009