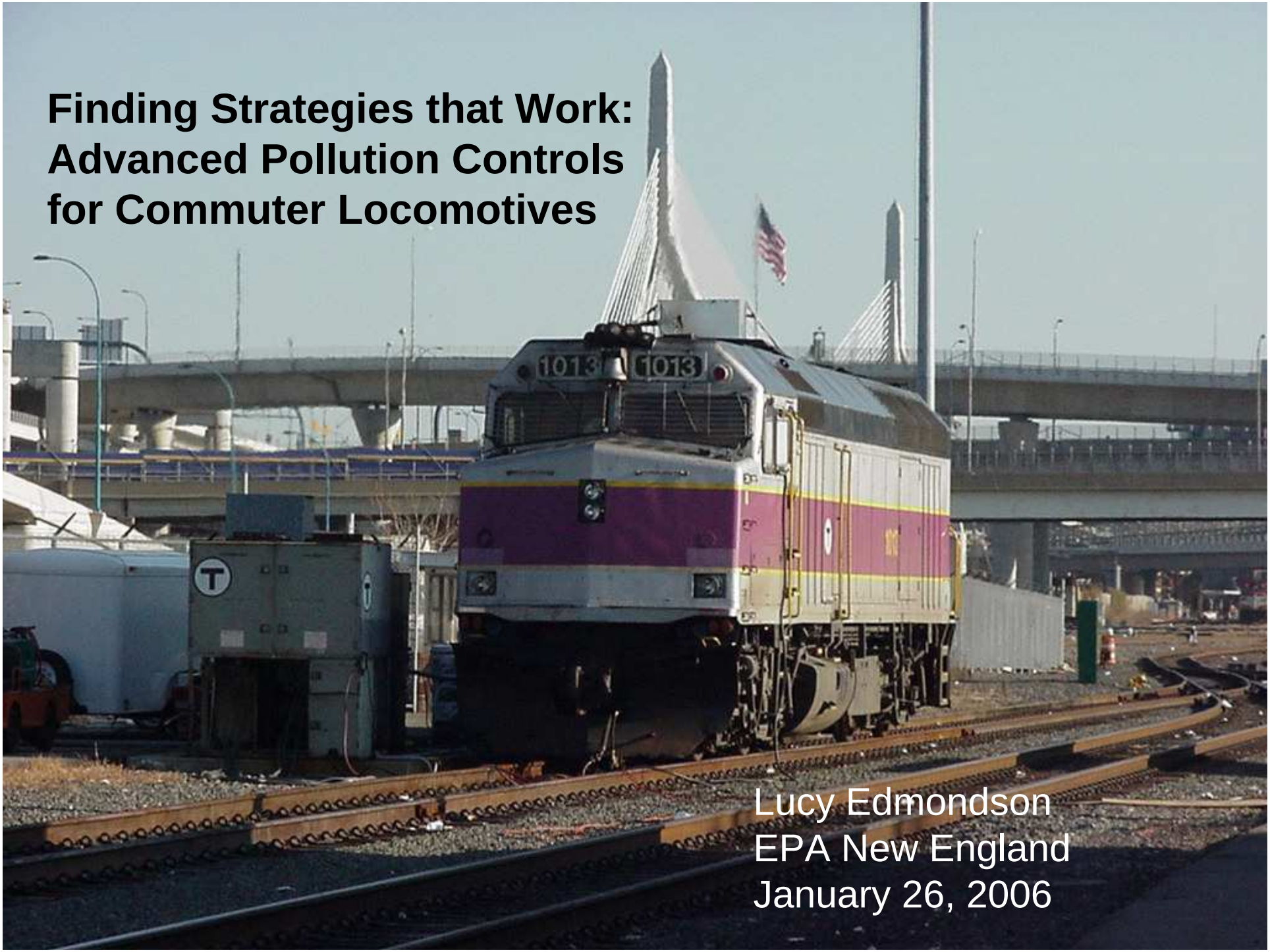
Finding Strategies that Work: Advanced Pollution Controls for Commuter Locomotives



Lucy Edmondson
EPA New England
January 26, 2006

EPA's National Clean Diesel Campaign – New Engines

- EPA has set standards for **new diesel engines and diesel fuel** that will result in the use of advanced pollution control technology
  - In Dec. 2000, EPA set very stringent standards for new heavy-duty trucks and buses that take full effect beginning in 2007
  - In May 2004, EPA set very stringent standards for new nonroad diesel engines which will take effect beginning in 2008
- These regulations will result in very large public health and environmental benefits:
  - By 2030, particulate matter reduced by ~250,000 tons/year, nitrogen oxides by ~4 million tons/year
  - Annual benefits expected to exceed $150 billion, with a cost of approximately $7 billion

EPA's Clean Diesel Campaign - Regulations for Diesel Fuel

Sulfur content of Diesel Fuel (PPM)

Source Category	Compliance Deadline				
	Current	June 2006	June 2007	June 2010	June 2012
On-Road	500	15	15	15	15
Off-Road	3,000	3,000	500	15	15
Marine/Rail	3,000	3,000	500	500	15

Diesel fuel terminology:

Ultra-Low Sulfur Diesel (ULSD) - contains 15 ppm sulfur

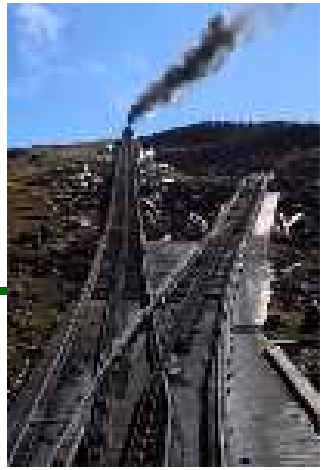
ULSD facilitates DPF emission controls for PM

Low-sulfur diesel (LSD) - contains 500 ppm sulfur

LSD facilitates most DOC emission controls for PM

Off-Road Diesel/Distillate Oil (HSD) - currently about 3,000 ppm sulfur

EPA's Clean Diesel Campaign - Regulations for Locomotives



Duty Cycle	Tier	Year of Original Manufacture	Emission Standards			
			THC (g/bhp-hr)	**CO** (g/bhp-hr)	**NOx** (g/bhp-hr)	**PM** (g/bhp-hr)
Switchyard	**0**	**1973 – 2001**	**2.1**	**8.0**	**14.0**	**0.72**
	1	**2002 – 2004**	**1.2**	**2.5**	**11.0**	**0.54**
	2	**2005 – 2012**	**0.6**	**2.4**	**8.1**	**0.24**
Line-Haul	**0**	**1973 – 2001**	**1.0**	**5.0**	**9.5**	**0.6**
	1	**2002 – 2004**	**0.55**	**2.2**	**7.4**	**0.45**
	2	**2005 – 2012**	**0.3**	**1.5**	**5.5**	**0.2**

Tier 0 standards apply to remanufactured locomotives after certain deadlines

- *EPA is developing New Tier 3 and 4 Standards*

EPA's Clean Diesel Campaign - SmartWay Transport Partnership

- A voluntary collaboration between U.S. EPA and the freight industry to increase energy efficiency while reducing greenhouse gases and air pollution.
- EPA provides benefits and services to partners including fleet management tools, technical support, information, public recognition, and, for exceptional performers, use of the SmartWay Transport Partner logo
- For more information visit www.epa.gov/smartway

SmartWay and Rail

- Participating Smartway Rail Carriers
  - Burlington Northern Santa Fe Railway Company
  - Canadian National Railway Company
  - Canadian Pacific Railway
  - CSX Transportation
  - Kansas City Railway Company
  - Norfolk Southern Corporation
  - Pacific Harbor Line, Inc.
  - Union Pacific Railroad

EPA's Clean Diesel Campaign – Voluntary Diesel Retrofit Program

- EPA is implementing a robust voluntary diesel retrofit program to reduce pollution from **existing diesel engines** through the use of pollution controls and cleaner fuels
- Retrofit options include:
  - Cleaner diesel fuel
    - Low sulfur diesel fuel (300 ppm) reduces PM emissions 10 -15% compared to non-road diesel fuel
    - Ultra low sulfur diesel fuel (15 ppm) reduces PM emissions an additional 5 -10%
  - Advanced pollution controls
    - Diesel Oxidation Catalyst reduces PM emissions 20 - 40%
    - Diesel Particulate Matter Filter used in combination with ULSD reduces PM emissions 90 percent

Non-Road Engine Retrofits in the Northeast

As we make progress in reducing emissions from on-road vehicles, focus broadens to non-road vehicles and equipment

- Construction Equipment
  - More than 500 pieces of construction equipment used on major construction projects throughout Northeast have been retrofitted with diesel oxidation catalysts
    - Projects include the Big Dig, 7 World Trade Center, New Haven Q-Bridge
- Ferry Boats
  - Every ferry fleet in New York harbor is being retrofitted with innovative emission control technologies,
  - SCR on one of the Staten Island ferries
- Tugboats
  - Engines of 5 tugboats in New York harbor will be replaced with new, cleaner engines
- Locomotives
  - MBTA is using low sulfur diesel (500 ppm) in all its commuter trains

Advanced Pollution Controls for Locomotives

Locomotive Demonstration Project Goals:

- Show that a diesel oxidation catalyst can reduce PM emissions from heavy duty diesel locomotive engines
- Quantify baseline exhaust emissions and emissions following the application of cleaner fuel and the oxidation catalyst
- Assess the durability of an oxidation catalyst for normal use in locomotive operations
- Determine the steps needed to commercialize the use of catalysts in locomotive operations

Commuter Locomotives

- MBTA operates 76 commuter locomotives
  - 12 commuter lines
    - 119 stations
    - 400 plus line miles
  - Diesel-electric powered
  - 3000+ HP
    - EMD 2 Stroke Engines
- Engines consume between 3 - 11 gallons of fuel per hour
- Baseline fleet emissions

  HC - 17.4 tons per year (tpy)

  PM - 41.4 tpy

  CO - 50.4 tpy

  NOx -1265.6 tpy

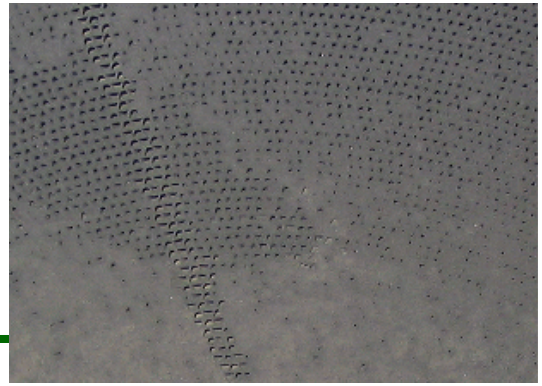
Engines operate in one of eleven notches/modes

Notch Setting	Weight Factor	THC (g/hr)	TPM (g/hr)	NOX (g/hr)	CO (g/hr)
Low Idle	0.19	7.46	2.28	153.62	33.28
High Idle	0.19	46.91	21.21	1120.15	236.19
Notch 1	0.065	181.63	272.07	7149.91	496.16
Notch 2	0.065	184.13	343.78	7842.17	384.22
Notch 3	0.052	158.68	384.15	9116.58	288.04
Notch 4	0.044	163.23	439.14	10536.49	287.66
Notch 5	0.038	183.71	529.02	12528.75	174.67
Notch 6	0.039	150.96	561.87	14782.81	175.43
Notch 7	0.03	180.14	583.15	19260.01	825.25
Notch 8	0.162	198.41	572.88	21036.79	685.36
Dynamic Brake setting excluded from testing					

Locomotive Demonstration Project - Round One

- In 2004, construction-type DOC installed on MBTA Locomotive #1013 as a replacement for the sound attenuator
  - Uses low sulfur diesel fuel (500 ppm)
- Emissions testing confirms DOC effectiveness
  - Using weighting factors for each notch, DOC reduces:
    - HC emissions by 16 %
    - PM emissions by 47 %
- Three weeks after putting the retrofitted locomotive into service, engine problems emerge
- After assessing all potential causes, MBTA mechanics remove the DOC – plugging is evident
- After removal of DOC, engine runs fine again

Locomotive Demonstration Project – Round One

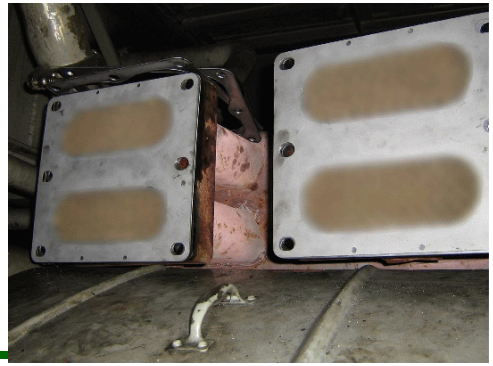


- What Happened?
  - Exhaust from a 2-stroke engine at low temperatures (which is how the commuter rail engine spends a lot of its time) is often wet because of unburned fuel and lubricating oil.
  - Wet soot stuck on the face of the DOC and clogged it – i.e. face plugging
  - This led to back pressure on the engine and operational problems, more PM, further plugging
    - Referred to as a “cascade” failure

Locomotive Demonstration Project – Round Two

- Close-Coupled Oxidation Catalyst
  - Installed October 2005 in MBTA Locomotive #1013
    - DOC is placed within the exhaust manifold between engine and turbocharger
      - Exhaust temperature is substantially higher
      - Exhaust pressure is greater, less sensitive to backpressure
    - DOC is expected to reduce particulate matter emissions 25 - 45%
  - December 2005:
    - Locomotive taken out of service for normal maintenance and to check the DOC
      - 900 hours of durability testing, no plugging evident
      - Thermal and vibration stress resulted in physical degradation
  - January 2006:
    - Redesigned catalyst installed and will run for 45 days
    - Emission testing anticipated in March 2006

Locomotive DOC – From Demonstration to Application



1. "Proof of Concept" successful (2004)
   - Catalyst can be located between engine and turbo
2. Physical Durability Demonstration (2005)
   - Evaluate plugging resistance, power and physical life
     - 900-hour turbo in use testing - some physical degradation
3. Catalytic Durability Testing (Early 2006)
   - Catalyst redesign complete, testing ongoing
   - Evaluate impact of lube oil contaminant on catalyst
   - Verify emission performance post 900-hours

Locomotive DOC – From Demonstration to Widespread Application

4. Medium-Scale Durability (Mid 2006)

   Optimize:

   – Physical design of catalyst
   – Location within engine
   – Composition of lube oil – eliminate catalyst fouling or poisoning agents

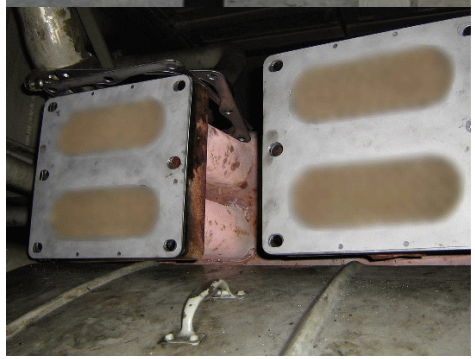
5. Pursue Verification/Certification (Early 2007)

   – Verify long term physical durability
   – Verify long term catalytic activity (emission testing)
   – Optimize catalyst in combination with low NOx components (i.e. injectors and power assemblies)

6. Commercial Availability

   – Will target commercial availability for Tier 2 program
   – Also available as a retrofit technology

Reducing Emissions from Locomotives – Conclusions

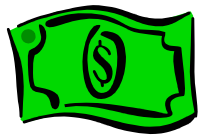


There are many cost-effective ways to reduce pollution from locomotives:

- Cleaner Fuel
  - LSD standard in 2007, ULSD 2012
- Idle Reduction
  - Auxiliary power units
- Low NOx and PM Retrofit Components
  - Low Oil consumption rings
  - Low NOx Injectors
  - Optimized power assemblies
  - Diesel oxidation catalyst
- Hybrid Locomotives

The Northeast Diesel Collaborative invites you to work with us to develop and launch new projects

Funding Opportunities



- **EPA's Appropriations Act for FY 06**
  - $5 million for National Clean Diesel Campaign
- **Energy Policy Act of 2005**
  - Authorizes $1 billion over 5 years for Diesel Emissions Reductions
  - Authorizes $45 million over three years for anti-idling programs locomotives

Note: all authorized funds have to be appropriated by Congress

For More Information…

Visit:

www.epa.gov/ne/eco/diesel

www.epa.gov/otaq/retrofit

www.northeastdiesel.org

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