U.S. EPA’s New Program to Control Pollution from Locomotives and Marine Diesels

Office of Transportation and Air Quality

GRPE, June 2008
Overview

• This Rule’s Context in EPA’s National Clean Diesel Campaign

• A Comprehensive 3-Part Program

• Key Elements of the Program
  – Locomotives
  – Marine Diesels

• A Collaborative Process Enabled a Strong Final Rule
Reconciling Diesels with the Environment: EPA’s National Clean Diesel Campaign

**Tier 2 Light-Duty**
- final rule 1999
- fully phased in 2009
- Diesels held to same stringent standards as gasoline vehicles

**Heavy-Duty**
**Highway**
- sales 800,000 / yr
- 40B gallons / yr
- final rule 2000
- fully phased in 2010

**Nonroad Diesel**
- sales over 650,000 / yr
- 12B gallons / yr
- final rule 2004
- fully phased in 2015

**Locomotive/Marine**
- sales 40,000 marine engines, 1,000 locomotives / yr
- 6B gallons / yr
- final rule 2008
- fully phased in 2017

Note: sales and diesel fuel usage vary year-to-year; these figures are for comparison purposes only.
Clean Locomotives and Marine Diesels
A Comprehensive 3-Part Program

1. Standards for remanufactured existing engines
   starts 2008

2. Tier 3 for newly-built engines
   starts 2012
   (engine-based)

   2009 for marine
   <75 kW

3. Tier 4 for newly-built engines
   starts 2014 (marine),
   2015 (locomotive)
   (aftertreatment-based)
What the Rule Covers-- Locomotives

**Line-Haul**
(>2300 hp)

**Switch**
(<2300 hp)

**Passenger**

Sales ~700-1200 / year
Typically rebuilt every 5-7 years
The Significance of Locomotive Remanufacturing

A sizeable part of the fleet gets remanufactured annually.

Locomotive fleet mix in 2010

Typical annual sales

New locomotives sold annually
PM:
Effective Control for Existing and Newly-Built Locomotives

- Tier 0 today: 0.22 g/hp-hr
- Tier 1 today: 0.22 g/hp-hr
- Tier 2 today: 0.10 g/hp-hr
- Tier 3: 0.10 g/hp-hr (2012*)
- Tier 4: 0.03 g/hp-hr

Additionally for all tiers: Idle emissions controls

* for switchers: Tier 3 in 2011; equivalent standards apply to switchers in all tiers
NOx:
Targets High-Emitting Existing Locomotives (Tier 0) + Early Tier 4

- Tier 0 today: 8.0
- Tier 0+: 7.4
- Older engines without split-loop cooling:
  - Tier 0 today: 8.0
  - Tier 0+: 7.4
- Engines with split-loop cooling:
  - Tier 4 2015: 1.3

- A new Tier 2 locomotive today.
Encouraging Low-Emission Switchers

- Stringent new standards alone could prove counterproductive
  - Added cost could drive RRs to continue maintaining old switchers

- Streamlined certification using “nonroad” engines – no limit on sales
- Standards allow for traditional “medium-speed” engines too
- Revised credit calculations to properly credit replacing old switchers with refurbished ones
Environmental Justice and Neighborhood Impacts

- Rulemaking analyzed 47 ports, 37 railyards
  - >13 million people living nearby are exposed to diesel PM levels >0.2 μg/m³ above urban background levels.
  - Including high % of low-income households, African-Americans, Hispanics.

- Finding under Executive Order 12898—
  - The rule will have no disproportionate adverse impacts on minority or low-income populations.

- In fact, this rule has large health benefits for communities near ports, railyards, etc
- Some provisions are especially helpful--
  - Example: requirement for locomotive idle reduction controls, starting 2008
Streamlined Switch Locomotive Program
Using Clean Nonroad Engines
Certified Below Locomotive Levels

PM

NOx

Tier 2 switch standard

Tier 3

Tier 4

<750 hp
>750 hp

Switcher designs can team nonroad engines of any size

Available nonroad engines

Certified Below Locomotive Levels

<750 hp
750-1200 hp
>1200 hp
Diversity In Vessel Applications
Calls for Targeted Diesel Emissions Standards

Category 1 Commercial (<7 liter/cylinder)
~15,000/year (about half are aux engines)

- workboats
- police boats
- fishing vessels

Category 2 (7 to 30 liter/cyl) <300/year

- tugboats
- ferries
- auxiliary power for ocean-going vessels

Category 3 (>30 liter/cyl)
Covered in separate initiative

Recreational ~15,000/year

- cruisers
- sailboats
- gen sets

- yachts

Great Lakes freighters

ocean-going ships
Diversity In Marine Diesel Engines
Calls for Targeted Emissions Standards

Category 1 Commercial
<7 liters/cylinder

Recreational
high power-to-weight ratios
to enable vessel planing

Category 2
7–30 liters/cylinder
many derived from locomotive engines

<75 kW
marinized nonroad engines
Effective Control Across the Wide Spectrum of Marine Diesels

PM:

- **Tier 3**: Phases in 2009-2014
- **Tier 4**: Phases in 2014-2017

*higher #'s are for hi-power density (≥35 kw/L) engines.** 0.06 for the very largest (>3700 kw) engines.

* category 1
* category 2
NOx: Effective Control Across the Wide Spectrum of Marine Diesels

Indicated standards are NOx+HC, except Tier 4 (NOx). For ≥2000 kw: no Tier 3 NOx (early Tier 4 instead). * 5.8 for hi-power density (≥35 kw/L) engines.
How Does the New Program for Existing Marine Engines Work?

- Existing marine diesels are considered “new” and subject to EPA standards when they are remanufactured (starting November 2008)

- Requirement: At the time of remanufacture, engine must be certified to the remanufacture standard if a certified remanufacture system is available
  - If a remanufacture system has not been certified, there is no requirement

- Standard: 25% reduction in PM emissions from measured baseline, no NOx increase
  - Expected to be met through “better” versions of parts normally replaced at rebuild
  - Systems subject to a cost cap of $45K/ton PM
  - Simplified certification for locomotive kits that can be used on marine engines
  - Program allows certified fuel-based systems as an alternative if an engine system has also been certified
Program for Existing Marine Engines Likely To Have Large Impact

• Program applies to existing commercial marine diesel engines >600 kW manufactured from 1973 up through Tier 2
  – These engines produce the vast majority of marine diesel emissions
  – Are routinely remanufactured multiple times

• Certification is voluntary; the program is market driven
  – There is a clear market incentive for engine manufacturers to certify reasonable-cost systems
    • If a competitor certifies and you don’t, your parts can’t be used

• EPA will review this market-driven approach in ~2012
  – If remanufacture systems have not been certified, we may consider changes to the program
  – We may also consider extending the program to more engines
- Streamlined switcher certification
- Non-OEM parts verification program
- New test and compliance flexibilities
- Remanufacture kits begin to certify to new standards
- Remanufactured locomotives must use new kits
- Remanufactured marine diesels subject to standards for 1st time ever
- Marine diesels <75 kW start Tier 3

Hitting the Ground Running
Some Parts of the New Program Start Within Months
Extensive Collaborative Effort Following March 2007 Proposal

- **Major Comments--**
  - Program doesn’t get reductions early enough for SIP targets
  - NOx catalyst durability unproven for high temperature operation
  - Need to include smaller RRs in Tier 0+ program
  - Certain specialized vessel applications cannot do Tier 4
  - EPA should add an existing marine fleet program

- **Many constructive meetings** with stakeholders over past year
  - Exploring ways to pull-ahead earlier NOx benefits
  - And address other comments
Final Rule Substantially Strengthens the Program

- 2 year pull-ahead of locomotive Tier 4 NOx (to 2015)
  - Also alternative compliance program focused on more in-use testing

- 2 year pull-ahead of Tier 4 NOx for 2000-3700 kW marine engines (to 2014)
  - skips to early Tier 4 NOx directly from Tier 2-- more NOx tons at less overall cost

- Standards adopted for existing marine fleet

- Tier 4 exclusions/exemptions for special marine applications with uncertain feasibility—recreational, migratory, emergency

- Class II (regional) railroads included in remanufactured locomotive program
Final Rule Substantially Strengthens the Program

PM (thousands of tons/year)

NOx (thousands of tons/year)
Large Health Benefits

- premature deaths
- chronic bronchitis
- hospital admissions
- ER visits for asthma

# prevented annually (in 2030)
## Annual Costs and Benefits in 2030

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<tr>
<th></th>
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<th>NO\textsubscript{x}</th>
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<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>$180 M</td>
<td>$580 M</td>
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<tr>
<td><strong>Inventory reduction, tons</strong></td>
<td>27,000</td>
<td>800,000</td>
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<td><strong>Cost per ton</strong></td>
<td>$6600</td>
<td>$700</td>
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<td><strong>Unit cost as % of typical new locomotive price</strong> (similar for marine vessels, but varies vessel to vessel)</td>
<td>3%</td>
<td></td>
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<td><strong>Monetized benefits</strong></td>
<td>$8.4B to $11B</td>
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<tr>
<td><strong>Benefit to cost ratio</strong></td>
<td>11:1 to 15:1</td>
<td></td>
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</table>
How does this rule stack up?
Mobile Source Program Impacts in 2030

**NOx**

- Light Duty Tier 2: 2500 tons reduced
- Heavy-Duty Highway: 3000 tons reduced
- Nonroad Diesel: 500 tons reduced
- Locomotive / Marine: 1000 tons reduced

**PM**

- Light Duty Tier 2: 100 tons reduced
- Heavy-Duty Highway: 400 tons reduced
- Nonroad Diesel: 800 tons reduced
- Locomotive / Marine: 1200 tons reduced

**Cost**

- Light Duty Tier 2: $5B/year
- Heavy-Duty Highway: $4B/year
- Nonroad Diesel: $2B/year
- Locomotive / Marine: $1B/year

**Benefits**

- Light Duty Tier 2: 5:1
- Heavy-Duty Highway: 17:1
- Nonroad Diesel: 40:1
- Locomotive / Marine: 15:1

How does this rule stack up?
Mobile Source Program Impacts in 2030
Appendix:
Emissions Standards
Summaries
# The New Line-Haul Locomotive Standards (g/bhp-hr)

<table>
<thead>
<tr>
<th>Locomotive Group</th>
<th>Date</th>
<th>PM Previous Standard</th>
<th>NOx Previous Standard</th>
<th>NOx New Standard</th>
<th>HC Previous Standard</th>
<th>HC New Standard</th>
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<tr>
<td>Tier 0 &amp; 1</td>
<td>2008 as available 2010 required</td>
<td>0.60</td>
<td>0.22</td>
<td>9.5 (Tier 0) 7.4 (Tier 1)</td>
<td>7.4 (8.0 if no SLAC)</td>
<td>1.00 (Tier 0) 0.55 (Tier 1)</td>
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<tr>
<td>Tier 2</td>
<td>2008 as available 2013 required</td>
<td>0.20</td>
<td>0.10</td>
<td>5.5</td>
<td>5.5</td>
<td>0.30</td>
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<td><strong>Newly-built</strong></td>
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</tr>
<tr>
<td>Tier 3</td>
<td>2012</td>
<td>--</td>
<td>0.10</td>
<td>--</td>
<td>5.5</td>
<td>--</td>
</tr>
<tr>
<td>Tier 4</td>
<td>2015</td>
<td>--</td>
<td>0.03</td>
<td>--</td>
<td>1.3</td>
<td>--</td>
</tr>
</tbody>
</table>

SLAC = separate loop intake air cooling.

Additionally, in all locomotive groups:
- Idle emissions control– must equip locomotive with automatic engine stop/start.
- HC standards are Total HC, except Tier 4 (NMHC).
- Part 92 smoke standards apply if PM FEL >0.05 g/bhp-hr, but are generally waived from testing.
- Part 92 CO standards continue to apply (at Tier 2 levels for Tiers 3&4); notch caps also apply.
- Must also meet switch-cycle standards of the same tier (of Tier 2 for Tier 3 line-haul locomotive) except for Tier 4.
## The New Switch Locomotive Standards (g/bhp-hr)

<table>
<thead>
<tr>
<th>Locomotive Group</th>
<th>Date</th>
<th>PM Previous Standard</th>
<th>PM New Standard</th>
<th>NOx Previous Standard</th>
<th>NOx New Standard</th>
<th>HC Previous Standard</th>
<th>HC New Standard</th>
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<td>Tier 0</td>
<td>2008 as available; 2010 required</td>
<td>0.72</td>
<td>0.26</td>
<td>14.0</td>
<td>11.8</td>
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<td>2.10</td>
</tr>
<tr>
<td>Remanufactured</td>
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</tr>
<tr>
<td>Tier 1</td>
<td>2008 as available; 2010 required</td>
<td>0.54</td>
<td>0.26</td>
<td>11.0</td>
<td>11.0</td>
<td>1.20</td>
<td>1.20</td>
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<tr>
<td>Remanufactured</td>
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</tr>
<tr>
<td>Tier 2</td>
<td>2008 as available; 2013 required</td>
<td>0.24</td>
<td>0.13</td>
<td>8.1</td>
<td>8.1</td>
<td>0.60</td>
<td>0.60</td>
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<tr>
<td>Newly-built</td>
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</tr>
<tr>
<td>Tier 3</td>
<td>2011</td>
<td>--</td>
<td>0.10</td>
<td>--</td>
<td>5.0</td>
<td>--</td>
<td>0.60</td>
</tr>
<tr>
<td>Tier 4</td>
<td>2015</td>
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<td>0.03</td>
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<td>1.3</td>
<td>--</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Additionally, in all locomotive groups:

Idle emissions control—must equip locomotive with automatic engine stop/start.

HC standards are Total HC, except Tier 4 (NMHC).

Part 92 smoke standards apply if PM FEL >0.05 g/bhp-hr, but are generally waived from testing.

Part 92 CO standards continue to apply (at Tier 2 levels for Tiers 3&4); notch caps also apply.

Can also use alternative nonroad engine-based program.
# EPA’s New Marine Diesel Standards (p.1 of 2)

## New Marine Diesel Standards: Standard Power Density Commercial

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<tbody>
<tr>
<td>Category 1: 75-600 kW</td>
<td>0.80</td>
<td>0.30</td>
<td>0.40</td>
<td>0.30</td>
<td>0.40</td>
<td>0.30</td>
<td>0.40</td>
<td>0.30</td>
<td>0.40</td>
<td>0.30</td>
<td>0.40</td>
<td>0.30</td>
</tr>
<tr>
<td>Category 1: &lt;75 kW</td>
<td>7.5</td>
<td>5.6</td>
<td>7.5</td>
<td>5.6</td>
<td>7.5</td>
<td>5.6</td>
<td>7.5</td>
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<td>7.5</td>
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<td>7.5</td>
<td>5.6</td>
</tr>
<tr>
<td>Category 1: 19 - &lt;75 kW</td>
<td>6.04</td>
<td>0.30</td>
<td>0.30</td>
<td>0.22</td>
<td>0.30</td>
<td>0.22</td>
<td>0.30</td>
<td>0.22</td>
<td>0.30</td>
<td>0.22</td>
<td>0.30</td>
<td>0.22</td>
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<tr>
<td>Category 2: 1500-3700 kW</td>
<td>7.27</td>
<td>5.45</td>
<td>5.8</td>
<td>4.3</td>
<td>5.8</td>
<td>4.3</td>
<td>5.8</td>
<td>4.3</td>
<td>5.8</td>
<td>4.3</td>
<td>5.8</td>
<td>4.3</td>
</tr>
</tbody>
</table>

**Notes:**

1. option for 19-75 kW starting in 2014: 0.20 and 5.8 g/kW-hr (0.10 and 4.3 g/hp-hr) PM and NOx+HC.
2. option for C2 >1400kW: Tier 3 in 2012: 0.14/7.8 g/kw-hr PM/NOx+HC; Tier 4 in 2015, including 0.06 PM for >3700kW.
3. manufacturer may delay compliance within indicated 2017 compliance model year: to 10/1/2017 for 600-1000 kW.
4. manufacturer may delay compliance within the indicated 2016 compliance model year: to 12/31/2016.
5. any <75 kW engines with displacement above 0.9 L/cyl are subject to corresponding 75-600 kW standards.
6. Tier 3 PM standards/dates apply for 2000-3700 kW, but not Tier 3 NOx+HC (Tier 2 NOx+HC levels apply through 2013).

## Tier 4 standards and start dates for 600-3700 kW Category 2 engines are the same as those for Category 1 600-3700 kW (including see note 6)

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<tbody>
<tr>
<td>Category 2: 600-3700 kW</td>
<td>0.27</td>
<td>0.20</td>
<td>0.27</td>
<td>0.19</td>
<td>0.27</td>
<td>0.19</td>
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<td>0.19</td>
<td>0.27</td>
<td>0.19</td>
<td>0.27</td>
<td>0.19</td>
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<tr>
<td>Category 2: &gt;13000 kW</td>
<td>7.8</td>
<td>5.8</td>
<td>7.8</td>
<td>5.8</td>
<td>7.8</td>
<td>5.8</td>
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</tbody>
</table>

### Tier 4

**Same Tier 2 & 3 standards, displacement categories, and start dates as for 75-600 kW (see note 6)**

<table>
<thead>
<tr>
<th>Tier 4</th>
<th>2000-3700 kW (see note 6)</th>
<th>1400-2000 kW</th>
<th>600-&lt;1400 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 2</td>
<td>1.8</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Tier 3</td>
<td>1.8</td>
<td>1.3</td>
<td>1.8</td>
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**Notes:**

1st MY for new standards are boxed in red.
### New Marine Diesel Standards: High Power Density (>=35 kW/L) Commercial & Recreational

<table>
<thead>
<tr>
<th>Category</th>
<th>1 75-600kW</th>
<th>Tier 2</th>
<th>Tier 3</th>
<th>Tier 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9 - &lt;1 PM NOx+HC</td>
<td>7.5</td>
<td>0.15</td>
<td>0.11</td>
<td>0.15</td>
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<td>0.9 - &lt;1 PM NOx+HC</td>
<td>7.2</td>
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<td>0.10</td>
<td>0.14</td>
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<td>0.9 - &lt;1 PM NOx+HC</td>
<td>6.6</td>
<td>0.12</td>
<td>0.09</td>
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<td>0.9 - &lt;1 PM NOx+HC</td>
<td>5.4</td>
<td>0.12</td>
<td>0.09</td>
<td>0.12</td>
</tr>
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<td>0.9 - &lt;1 PM NOx+HC</td>
<td>4.0</td>
<td>0.12</td>
<td>0.09</td>
<td>0.12</td>
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<td>0.9 - &lt;1 PM NOx+HC</td>
<td>3.5</td>
<td>0.15</td>
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<td>0.9 - &lt;1 PM NOx+HC</td>
<td>3.0</td>
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### Notes:
1) any <75 kW engines with displacement above 0.9 L/cyl are subject to the corresponding 75-600 kW standards

Tier 2 and 3 standards and dates are the same as for high power density 75-600 kW engines (except see note 6 on standard power density summary)

Tier 4 standards and dates are the same as for standard power density engines (except no Tier 4 for recreational)

1st MY for new standards are boxed in red