Midwest Clean Diesel Initiative Presents

Learn More About It:
Marine and Locomotive Repowers

Repowering line-haul/switcher locomotives and heavy-duty marine engines can achieve significant emissions reductions while extending the life of the vehicle.
Agenda

• Introduction
• EPA Marine and Locomotive regulations overview (Tony Maietta)
• Locomotive Repowers
  – Cummins
  – Progress Rail
• Marine Repowers
  – EMD
  – Cummins
• Q&A
EPA’s Marine & Locomotive Regulations

• Final rule signed March 14, 2008
  – Full phase in by 2017

• Unique remanufacture aspect
  – Durability of equipment
  – Long working life
  – Environmental benefits
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 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**

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: 0.6 g/hp-hr
- **Tier 1** today: 0.5 g/hp-hr
- **Tier 2** today: 0.3 g/hp-hr
- **Tier 3** 2012*: 0.22 g/hp-hr
- **Tier 4** 2015: 0.03 g/hp-hr

- Tier 0+ Tier 1+: 0.22 g/hp-hr
- Tier 2+ Tier 3: 0.1 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
What the Rule Covers – Marine
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
- Workboats
- Police boats
- Fishing vessels
- Recreational
- ~15,000/year
- Cruisers
- Yachts
- Great Lakes freighters
- Tugboats
- Ferries

**Category 3 (>30 liter/cyl)**
- Covered in separate initiative
- Ocean-going ships

<75 hp
<10,000/year

Gen sets
Sailboats
Diversity In Marine Diesel Engines
Calls for Targeted Emissions Standards

Category 1 Commercial
<7 liters/cylinder

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

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

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

- **<19 kw**: 0.40
- **19-75 kw**: 0.30
- **≥75 kw**: 0.14

**Tier 3** (Phases in 2009-2014)
- <3300 kw: 0.04
- ≥3300 kw: 0.27

**Tier 4** (≥600 kw) (Phases in 2014-2017)
- 7-15: 0.10-0.12
- 15-20: 0.14
- 20-25: 0.34
- 25-30: 0.27

- **category 1**
- **category 2**

- * higher #s are for hi-power density (≥35 kw/L) engines.
- ** 0.06 for the very largest (>3700 kw) engines.
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.
...and for reference:
The New **Line-Haul** Locomotive Standards (g/bhp-hr)

<table>
<thead>
<tr>
<th>Locomotive group</th>
<th>Date</th>
<th>PM</th>
<th>NOx</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>previous</td>
<td>new</td>
<td>previous</td>
<td>new</td>
</tr>
<tr>
<td>Remanufactured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier 0 &amp; 1</td>
<td>2008 as</td>
<td>0.60</td>
<td>9.5 (Tier 0)</td>
<td>7.4 (Tier 1)</td>
</tr>
<tr>
<td></td>
<td>available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2010 required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier 2</td>
<td>2008 as</td>
<td>0.20</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2013 required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newly-built</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier 3</td>
<td>2012</td>
<td>--</td>
<td>0.10</td>
<td>5.5</td>
</tr>
<tr>
<td>Tier 4</td>
<td>2015</td>
<td>--</td>
<td>0.03</td>
<td>1.3</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>
</tr>
</thead>
<tbody>
<tr>
<td>Remanufactured 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>
<td>2.10</td>
<td>2.10</td>
</tr>
<tr>
<td>Remanufactured 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>
</tr>
<tr>
<td>Remanufactured 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>
</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>
<td>--</td>
<td>0.03</td>
<td>--</td>
<td>1.3</td>
<td>--</td>
<td>0.14</td>
</tr>
</tbody>
</table>

### Remanufactured Switch Locomotive Standards

### Newly-built Switch Locomotive Standards

**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

<table>
<thead>
<tr>
<th>Displacement (L)</th>
<th>Tier 2 (g/kW-h)</th>
<th>Tier 3 (g/kW-h)</th>
<th>Tier 4 (g/kW-h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.9 PM</td>
<td>0.80</td>
<td>0.60</td>
<td>0.40</td>
</tr>
<tr>
<td>0.9 - &lt;1.2 PM</td>
<td>7.5</td>
<td>5.6</td>
<td>7.5</td>
</tr>
<tr>
<td>1.2 - &lt;2.5 PM</td>
<td>0.30</td>
<td>0.22</td>
<td>0.12</td>
</tr>
<tr>
<td>2.5 - &lt;3.5 PM</td>
<td>0.20</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>3.5 - &lt;7.0 PM</td>
<td>0.20</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>Category 4: 600-1200 kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>NOx</td>
<td>NOx+HC</td>
<td>PM</td>
</tr>
<tr>
<td>7.0 - &lt;15.0 PM</td>
<td>0.27</td>
<td>0.20</td>
<td>0.14</td>
</tr>
<tr>
<td>15.0 - &lt;25.0 PM</td>
<td>0.50</td>
<td>0.37</td>
<td>0.34</td>
</tr>
<tr>
<td>20.0 - &lt;25.0 PM</td>
<td>0.50</td>
<td>0.37</td>
<td>0.27</td>
</tr>
<tr>
<td>25.0 - &lt;30.0 PM</td>
<td>0.50</td>
<td>0.37</td>
<td>0.27</td>
</tr>
<tr>
<td>&gt;3700 kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>NOx</td>
<td>NOx+HC</td>
<td>PM</td>
</tr>
<tr>
<td>&lt;15.0 PM</td>
<td>0.27</td>
<td>0.20</td>
<td>0.12</td>
</tr>
<tr>
<td>&gt;15.0 PM</td>
<td>0.50</td>
<td>0.37</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Notes:
1) option for 19-75 kW starting in 2014: 0.20 and 5.8 g/kW-h PM and NOx+HC.
2) option for C2 >1400kW: Tier 3 in 2012: 0.14/7.8 g/kW-h 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).
EPA’s New Marine Diesel Standards (p.2 of 2)

### New Marine Diesel Standards: High Power Density (>=35 kW/L) Commercial & Recreational

<table>
<thead>
<tr>
<th>Displacement L/cyl</th>
<th>Tier 2</th>
<th>Tier 3</th>
<th>Tier 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1 &lt;75kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;0.9 PM NOx+HC</td>
<td>0.40</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>0.9 - &lt;1.2 PM NOx+HC</td>
<td>0.30</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>1.2 - &lt;2.5 PM NOx+HC</td>
<td>0.20</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>2.5 - &lt;3.5 PM NOx+HC</td>
<td>0.20</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>3.5 - &lt;7.0 PM NOx+HC</td>
<td>0.29/27</td>
<td>0.15/0.20</td>
<td></td>
</tr>
<tr>
<td>Category 1 75-600kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>all</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1) any <75 kW engines with displacement above 0.9 L/cyl are subject to the corresponding 75-600 kW standards