Development of Heavy-Duty On-Highway Engine Regulations in the U.S.

The 4th SINO-US Workshop on Motor Vehicle Pollution Prevention and Control

U.S. Environmental Protection Agency
Office of Transportation and Air Quality

Heavy-Duty On-Highway Industry

- Heavy-duty vehicles in the U.S. have gross vehicle weight ratings (GVWR) of 8501 pounds and greater
  - Some vehicles in the 8501 – 14,000 GVWR can optionally certified to passenger car and light-duty truck test procedures
    - Heavy-duty pick up trucks and cargo vans which are similar to light-duty vehicles
  - Engine testing for all vehicles with GVWR > 14,000 pounds
    - Vocational Vehicles
      - Small delivery trucks, dump trucks, school and transit buses
    - Line Haul
      - Long haul tractor trailers
- 10 -12 manufacturers who certify in the U.S.
  - Typically 400,000-500,000 engines a year
  - 30 to 40 engine families
  - Accounts for approximately 20% of PM, 35% of NOX inventories in the U.S.
# Intended Service Classes Covered by Emission Standards

<table>
<thead>
<tr>
<th>Light Heavy-Duty Diesel Engines</th>
<th>Medium Heavy-Duty Diesel Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,500 – 19,500 lbs GVWR</td>
<td>19,500 – 33,000 lbs GVWR</td>
</tr>
<tr>
<td><strong>Pickups</strong></td>
<td><strong>Utility Trucks</strong></td>
</tr>
<tr>
<td><strong>Step Vans</strong></td>
<td><strong>Parcel Delivery Trucks</strong></td>
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<tr>
<td><strong>Refuse Haulers</strong></td>
<td><strong>Line-haul Trucks</strong></td>
</tr>
</tbody>
</table>

## Timeline for Heavy-Duty Diesel Engine Standards

- **1970-1973** Only smoke opacity standard for diesel engines over test cycle still used today
- **1974** – For emission standard for HC+NOx (16 g/hp-hr) and CO (40 g/hp-hr) over 5 year and 100,000 mile useful life
  - 13 mode, 10 non-idle modes, steady state test
- **1978** Lower steady state NOx, HC and CO emissions
  - Also provisions for optional lower NOx but higher CO standard
- **1985** 10.7 g/hp-hr NOx, 1.3 g/hp-hr HC, and 15.5 gphp-hr CO standard measured over new transient test cycle
  - Useful lives
    - Heavy-heavy engines in vehicles with GVWR > 33,000 pounds - 8 years, 290,000 miles
    - Medium-heavy engines in vehicles with GVWR between 19,500 and 33,000 pounds - 8 years, 185,000 miles
    - Light-heavy engines in vehicles with GVWR < 19,500 pounds - 8 years, 110,000 miles
- **1988** first PM standard for diesel engines - 0.60 g/hp-hr
- **1988-1990** Development of first electronically controlled diesel heavy-duty engines

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Timeline for Heavy-Duty Diesel Engine Standards

• 1990 - NOx lowered from 10.7 to 6.0 g/hp-hr
• 1991 - 5.0 NOx Standard, 0.25 PM standard
  – New low sulfur, 300-500 ppm diesel fuel
  – Averaging, Banking and Trading (ABT) for NOx and PM Emissions
• 1994 - New 0.10 g/hp-hr PM standard
  – First Diesel Oxidation Catalyst (DOCs)
• 1998 - New 4.0 g/hp-hr NOx standard
  – End of mechanically fuel injected engines
• 1998 Heavy-Duty Consent Decree
  – A large number of manufacturers controlling emissions to standard only in the test cell, NOx emissions 2-3 times higher in-use
  – Led to development of Not-to-Exceed (NTE) standards and use of Supplemental Emissions test
  – Consent decree manufacturers required to certify early to 2004 standards

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Timeline for Heavy-Duty Diesel Engine Standards

- 2010 – NOx standard 0.20 g/hp-hr 100% phased in
  - Selective Catalytic Reduction (SCR)
    - Heavy-duty vehicles limited to 5 miles per hour if SCR not working
- 2010 – Heavy-duty On-Board Diagnostics (OBD) begin
- 2014 – Heavy-duty Greenhouse Gas Standards for engines and vehicles
  - Separate standards for vocational and tractor trailer engines and vehicles
  - Vehicle standards are model based reduction not actual measurements from vehicles
  - Applied technologies result in modeled reduction in greenhouse gases

<table>
<thead>
<tr>
<th>Year</th>
<th>NOx</th>
<th>HC+NOx</th>
<th>HC</th>
<th>PM</th>
<th>CO</th>
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<tbody>
<tr>
<td>1974</td>
<td>16</td>
<td>40</td>
<td>2000-5000 ppm sulfur</td>
<td>Diesel fuel</td>
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<tr>
<td>1979</td>
<td>16</td>
<td>25</td>
<td>25</td>
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<td>1985</td>
<td>10.7</td>
<td>1.3</td>
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<td>10.7</td>
<td>0.60</td>
<td>15.5</td>
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<tr>
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<td>15.5</td>
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<tr>
<td>2010</td>
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<td>0.14</td>
<td>15.5</td>
<td>SCR</td>
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</table>
2007-2010 Standards Were a Major Step Change

- Previous standards focused only on engine improvements
- A new approach: regulate vehicle and fuel as a system to gain order-of-magnitude reductions
- Low sulfur fuel enables advanced aftertreatment technology
  - Diesel particulate filters
  - NOx catalysts
- 95%+ emission reductions in PM and NOx
- Also very large secondary benefits
  - Truck program provided springboard for parallel programs
    - Nonroad diesels (farm, construction), locomotives, marine vessels, voluntary retrofits of older trucks
  - Low sulfur highway diesel fuel also enabled light-duty diesels to meet stringent passenger car standards
Certification Test Cycles

FTP

SET

NTE Control Area

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