Heavy-Duty Low NOx Program

Proposed Heavy-Duty Engine Standards

Public Workshop
Diamond Bar, CA
September 26, 2019

MSCD/ECCD
Applicability

- **MD and HD diesel-cycle engines (HDDE)**
  - GVWR > 10,000 pounds

- **MD and HD Otto-cycle engines (HDOE)**
  - GVWR > 10,000 pounds

- **2024 and subsequent model years**
### Summary of Proposed Exhaust Emissions Standards

<table>
<thead>
<tr>
<th>Model Year</th>
<th>Proposed NOx Exhaust Emissions Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HDDE</td>
</tr>
<tr>
<td></td>
<td>FTP / RMC (g/bhp-hr)</td>
</tr>
<tr>
<td>2024 - 2026</td>
<td>0.05</td>
</tr>
<tr>
<td>2027 and subsequent</td>
<td>0.015 - 0.030</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model Year</th>
<th>Proposed PM Exhaust Emissions Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>2024 and subsequent</td>
<td>0.005</td>
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</table>
HDDE Feasibility of the 2024 Standards - FTP/RMC

- FTP/RMC: 0.05 g/bhp-hr
  - SwRI Stage 1: 0.09 g/bhp-hr NOx composite FTP – engine calibration changes only
    - Baseline: 0.14 g/bhp-hr

- 2019 MY certification emission levels
  - ~ 40% of engine families (EF) have certification levels < 0.1 g/bhp-hr with some close to 0.05 g/bhp-hr
  - Most EFs today have CO2 emissions levels below the 2024 Phase 2 GHG standards

- MECA’s tailpipe emissions modeling assessments
  - Using as input: SwRI Stage 1 calibration strategy and current commercially available SCR systems
    - 0.04 g/bhp-hr composite FTP NOx – with lower SCR volume than is in the market today
    - 0.03 g/bhp-hr composite FTP NOx - with average SCR volume than is in the market today
    - 0.02 g/bhp-hr composite FTP NOx - with average SCR volume and commercially available next generation ASC
HDDE Feasibility of the 2024 Standards – LLC

- **LLC:** 0.20 g/bhp-hr
  - **SwRI Stage 2 program**
    - Baseline: with stock 2014 MY aftertreatment calibration: 0.34 g/bhp-hr (2014 Volvo MD13TC)
    - Adding load to idle portion of the LLC will assist in reducing emissions on the LLC

- **MECA’s modeling assessments**
  - Currently available emission controls
  - Heated urea dosing, and
  - 20% - 50% ammonia storage level on the SCR
    - 0.18 - 0.38 g/bhp-hr NOx

<table>
<thead>
<tr>
<th>Model Run on Low Load Cycle</th>
<th>DPF PGM Loading</th>
<th>SCR Prestorage with NH3</th>
<th>Urea Dosing Temp (°C)</th>
<th>Tailpipe NOx (g/bhp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>X</td>
<td>20%</td>
<td>170</td>
<td>0.40</td>
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<tr>
<td>Scenario 1</td>
<td>2X</td>
<td>20%</td>
<td>170</td>
<td>0.38</td>
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<tr>
<td>Scenario 2</td>
<td>2X</td>
<td>50%</td>
<td>170</td>
<td>0.23</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>2X</td>
<td>50%</td>
<td>150</td>
<td>0.18</td>
</tr>
</tbody>
</table>

HDDE Feasibility of the 2024 Standards – Idling

**Idling NOx Standard: 10 g/hr**
- SwRI Stage 2
  - Low NOx idle calibration: high EGR rate, intake throttling, and late combustion phasing
  - Demonstrated engine-out emissions of 2.8 g/hr NOx (on idle segment of the LLC)

**Potential revisions to the existing requirements**
- Make clean idle standard requirement mandatory (Remove “optional”)
- Remove exemptions for buses, school buses, armored cars, and workover rigs
- Include in-use compliance requirement
- Potential revisions to the test procedure – load, preconditioning, etc.
### HDDE Feasibility of the 2027 Standards - FTP/RMC

- **FTP/RMC: 0.015 to 0.030 g/bhp-hr**
  - **SwRI Stage 1b: 0.023 g/bhp-hr FTP**
    - Engine calibration: higher EGR rates and high idle speed (cold start strategy)
    - Advanced aftertreatment system:
      - PNA, mini-burner, SCRF, SCR, and ASC
      - Chemical and thermally aged aftertreatment system)

- **SwRI Stage 3: 0.019 g/bhp-hr FTP**
  - Model-based DEF dosing, cylinder deactivation, split SCR system, and exhaust insulation (hydrothermally aged aftertreatment system)
  - Currently in progress, will determine feasibility on thermally and chemically aged aftertreatment system

- Potentially adjust standard up to account for longer UL
HDDE Feasibility of the 2027 Standards - LLC

- **LLC: (1 – 3) x FTP**
  - LLC standard will be based on:
    - SwRI Stages 2 and 3 calibration test results and
    - Potential GHG emission impacts
  - **SwRI Stage 2**
    - 0.07 g/bhp-hr NOx with no change in CO2 emissions from baseline
    - 0.02 g/bhp-hr NOx with 2% GHG penalty
  - **SwRI Stage 3:**
    - Currently in progress, will determine feasibility
    - Screening results of two systems
      - 0.053 g/bhp-hr (System 2B)
      - 0.036 g/bhp-hr (System 1A)
Idling NOx Standard: ≤ 10 g/hr

- **SwRI Stage 2**
  - Low NOx idle calibration: high EGR rate, intake throttling, and late combustion phasing
  - Demonstrated engine-out emissions of 2.8 g/hr NOx (on idle segment of the LLC)

- **SwRI Stage 3**
  - Currently in progress
  - Will determine feasibility
HDOE Feasibility of 2024 and 2027 Standards

- **2024-2026 MY**  FTP: 0.05 g/bhp-hr
- **2027+ MY**  FTP: (0.01 to 0.03) g/bhp-hr
  - 2019 MY certification data
    - 6 HDOEs certified to the 0.02 g/bhp-hr optional NOx standard on the FTP
Feasibility of the PM Standard

- **FTP/RMC: 0.005 g/bhp-hr**
  - Proposed to prevent backsliding
  - Engines currently certified close to PM = 0.001 g/bhp-hr
  - Maintain current robust PM emission control performance
What about Federally Certified Trucks?

- **U.S. EPA Cleaner Trucks Initiative Notice of Proposed Rulemaking expected later in 2020**
  - National heavy-duty low NOx program is critical for California
  - Out-of-state trucks contribute significantly to California vehicle miles traveled
  - CARB staff has coordinated closely with U.S. EPA technical staff

- For MY 2027+, hope for a nationally harmonized program

- For MY 2024-2026, CARB staff may propose a voluntary option for manufacturers:
  - Certify to a less stringent standard in California in exchange for committing to certify cleaner trucks nationwide
Next Steps

- **SwRI Stage 3 Final calibration and Demonstration – January 2020**
  - Will determine final proposed NOx standards – FTP/RMS-SET/LLC/Idle
  - Based on a full useful life aging of 435,000 miles

- **Potential adjustments to take into account the proposed lengthened useful life**

- **Will continue to work with EMA, individually with engine manufacturers, and other stakeholders to develop technologically feasible and cost-effective requirements**