Outline

• Background
• Current Heavy-Duty Requirements
• Staff Proposal
• Benefits and Costs
• 15-Day Changes
• Staff Recommendations
Background

Air Quality Challenges

• Over 12 million Californians breathe unhealthy air

• Key challenges:
  • South Coast ozone
  • San Joaquin Valley PM2.5

• Significant NOx reductions needed to meet ozone standards in South Coast
  • ~80% reduction by 2031
Reducing Heavy-Duty Truck NOx: Critical for SIP Attainment

- Even with existing programs, heavy-duty trucks remain largest source under CARB authority
- Heavy-duty vehicles emit nearly one third of total statewide NOx
- Further NOx reductions needed from heavy-duty trucks to attain air quality goals
- Most significant NOx regulation the Board has adopted in more than a decade
- Necessary for achieving our SIP commitments
Federal Action Also Critical for SIP Attainment

- Federal trucks contribute 40% of heavy-duty NOx
  - U.S. EPA action to reduce emissions from federal certified trucks is critical
- U.S. EPA Cleaner Trucks Initiative (CTI) announced Nov. 13, 2018
- Advanced Notice of Proposed Rule – Published January 21, 2020
- Notice of Proposed Rulemaking – Delayed but expected next year
- U.S. EPA is required to provide minimum of 4 years lead time and 3 years of stability between standards
  - CTI to start with 2027 model year (MY) engines
- Close coordination with U.S. EPA staff with goal of a harmonized 2027 and beyond national program
Heavy-Duty Low NOx & Advanced Clean Trucks (ACT) Regulations

• The Board approved ACT requirements in June 2020

• ACT mandates percentage of sales for ZEVs

• Omnibus rulemaking complements this effort:
  • Provides incentive mechanism by creating NOx credit generation pathway for heavy-duty Zero-Emission technologies in early years of ACT rule
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Overview of Current Heavy-Duty Program

• Standards Compliance Throughout Useful Life
• Durability Demonstration during Certification
• Averaging, Banking, and Trading (ABT) Program
• Heavy-Duty In-Use Testing (HDIUT) Program
• Emissions Warranty
• Emissions Warranty Information Reporting (EWIR)
NOx and PM Certification Standards

- **FTP/RMC Test Cycles**
  - NOx: 0.20 g/bhp-hr
  - PM: 0.01 g/bhp-hr
  - Optional NOx:
    - 0.02/ 0.05/ 0.10 g/bhp-hr
- **NOx idling standard**
  - 30 grams/hour

- **Diesel Engine Technology**
  - Diesel Oxidation Catalyst (DOC)
  - Diesel particulate filter (DPF)
  - Urea or diesel exhaust fluid (DEF) based selective catalytic reduction (SCR)
  - Ammonia slip catalyst (ASC)

- **Otto-Cycle Engine Technology**
  - Three-way Catalyst
Certification Test Cycles

- FTP and RMC test cycles
  - Do not account for sustained low load operations
  - Do not require adequate thermal management of aftertreatment system

- Low load duty cycles have lower exhaust temperatures
  - SCR not functional at low exhaust temperatures
  - Prevalent in urban stop-and-go operation in communities near congested transportation corridors

- Need for low load certification cycle (LLC)
  - Ensure engine and aftertreatment system controls needed for low load operations are functional
Durability Demonstration Program

• Manufacturers must demonstrate emissions compliance for the full useful life at time of certification
• Current durability procedures require partial useful life durability demonstration with some field data evaluation
• Partial useful life aging methodology is insufficient
Heavy-Duty In-Use Programs and Methods

• Heavy-Duty In-Use Testing (HDIUT) program: manufacturer self testing

• Testing based on the Not-to-Exceed (NTE) in-use test method
Not-to-Exceed (NTE)

• The NTE method evaluation captures only a portion of real-world operation and emissions.

• Analysis of the HDIUT data by staff revealed only 4.9% of testing time was captured by the NTE method.

• CARB’s testing has identified significant problems, resulting in mandated recalls of hundreds of thousands of heavy-duty trucks.
# Useful Life and Warranty Periods

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Heavy-Duty Diesel (HHDD)</td>
<td>Class 8, GVWR &gt;33,000 lbs.</td>
<td>435,000</td>
<td>100,000</td>
<td>350,000</td>
</tr>
<tr>
<td>Medium Heavy-Duty Diesel (MHDD)</td>
<td>Class 6-7, 19,500&lt;GVWR ≤ 33,000 lbs.</td>
<td>185,000</td>
<td>100,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Light Heavy-Duty Diesel (LHDD)</td>
<td>Class 4-5, 14,000 &lt; GVWR ≤ 19,500 lbs.</td>
<td>110,000</td>
<td>100,000</td>
<td>110,000</td>
</tr>
<tr>
<td>HD Otto (HDO)</td>
<td>GVWR &gt;14,000 lbs.</td>
<td>110,000</td>
<td>50,000</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Heavy-Duty Useful Life Compared to Engine Rebuild/Replacement Mileages

- **HHDD** (Class 8) GVWR > 33,000 lbs.: 854,616 miles
- **MHDD** (Class 6-7) 19,500 < GVWR ≤ 33,000 lbs.: 432,652 miles
- **LHDD** (Class 4-5) 14,000 < GVWR ≤ 19,500 lbs.: 326,444 miles
- **HDO** (GVWR > 14,000 lbs.): 217,283 miles

Current Useful Life: 435,000 miles
Engine Rebuild/Replacement Miles: 185,000, 110,000, 110,000 miles

Gross Vehicle Weight Rating (GVWR) categories:
- **HHDD**: GVWR > 33,000 lbs.
- **MHDD**: 19,500 < GVWR ≤ 33,000 lbs.
- **LHDD**: 14,000 < GVWR ≤ 19,500 lbs.
- **HDO**: GVWR > 14,000 lbs.
Emissions Warranty Information Reporting (EWIR)

• Goal is to ensure that defective emission components are expeditiously identified and remedied through corrective action (i.e., recall or extended warranty)

• Requires manufacturers submit reports when components warranty claims rates reach 25 warranty claims or 1%

• Manufacturers subject to corrective action when failure rates reach 4%
Outline

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• **Staff Proposal**
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• 15-Day Changes
• Staff Recommendations
Broad Applicability

- **Medium-duty diesel engines (MDDE)**
  - $10,000 < GVWR \leq 14,000\text{ pounds}$

- **Heavy-duty diesel engines (HDDE)**
  - $\text{GVWR} > 14,000\text{ pounds}$

- **Medium-duty Otto-cycle engines (MDOE)**
  - $10,000 < \text{GVWR} \leq 14,000\text{ pounds}$

- **Heavy-duty Otto-cycle engines (HDOE)**
  - $\text{GVWR} > 14,000\text{ pounds}$

- **2024 and subsequent MY**
## NOx Emissions Standards

### 2024 – 2026 MY

<table>
<thead>
<tr>
<th>MYs</th>
<th>DIESEL</th>
<th>OTTO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FTP (g/bhp-hr)</td>
<td>RMC (g/bhp-hr)</td>
</tr>
<tr>
<td>Current</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>2024 - 2026</td>
<td><strong>0.050</strong></td>
<td><strong>0.050</strong></td>
</tr>
</tbody>
</table>

- **Proposed PM standard:** 0.005 g/bhp-hr applies to all 2024 and subsequent MY engines
- **FTP/RMC:** 75% below current standard
## Optional 50-State-Directed Engine NOx Emissions Standards

<table>
<thead>
<tr>
<th>MYs</th>
<th>DIESEL</th>
<th></th>
<th></th>
<th></th>
<th>OTTO</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FTP</td>
<td>RMC</td>
<td>LLC</td>
<td>Idling</td>
<td>FTP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(g/bhp-hr)</td>
<td>(g/bhp-hr)</td>
<td>(g/bhp-hr)</td>
<td>(g/hr)</td>
<td>(g/bhp-hr)</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>0.20</td>
<td>0.20</td>
<td>---</td>
<td>30</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>2024 - 2026</td>
<td>0.10</td>
<td>0.10</td>
<td>0.30</td>
<td>10</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>

- Manufacturer required to certify all their engines nationally
- Must meet all other proposed requirements applicable for the MY
  - PM standard, warranty and useful life periods, etc.
## NOx Emissions Standards

### 2027 and Subsequent

<table>
<thead>
<tr>
<th>MYs</th>
<th>DIESEL ENGINES ≤ 33,000 lbs GVWR</th>
<th>OTTO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FTP/RMC (g/bhp-hr)</td>
<td>LLC (g/bhp-hr)</td>
</tr>
<tr>
<td>2027 and later</td>
<td>0.020</td>
<td>0.050</td>
</tr>
</tbody>
</table>

- FTP/RMC: 90% below current standard
Proposed Changes

NOx Emissions Standards 2027 and Subsequent

- FTP/RMC: Intermediate standards 90% below current
- New standard at proposed longer useful life

<table>
<thead>
<tr>
<th>HEAVY-DUTY DIESELS (&gt;33,000 lbs GVWR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MY</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>Mileage (miles)</td>
</tr>
<tr>
<td>FTP/RMC (g/bhp-hr)</td>
</tr>
<tr>
<td>LLC (g/bhp-hr)</td>
</tr>
<tr>
<td>Idling (g/hr)</td>
</tr>
</tbody>
</table>

*Proposed useful life
Optional Low NOx Standards

<table>
<thead>
<tr>
<th>MY</th>
<th>DIESEL FTP/RMC (g/bhp-hr)</th>
<th>DIESEL LLC (g/bhp-hr)</th>
<th>OTTO FTP (g/bhp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2024 - 2026</td>
<td>0.020</td>
<td>0.080</td>
<td>0.020</td>
</tr>
<tr>
<td>2027 and subsequent</td>
<td>0.010</td>
<td>0.025</td>
<td>0.010</td>
</tr>
</tbody>
</table>

• Must meet all other proposed requirements applicable for the MY
  • PM standard, warranty and useful life periods, etc.
Standards are Technically Feasible

- Extensive CARB-sponsored demonstration programs supported by federal / local air agencies and industry

- Results at full useful life indicate:
  - FTP ≈ 0.025 g/bhp-hr NOx
  - RMC ≈ 0.022 g/bhp-hr NOx
  - LLC ≈ 0.050 g/bhp-hr NOx
  - Idling ≈ 1.6 - 2.8 g/hr NOx
  - Engine calibration / CDA / split SCR /DEF injection controls
Proposed Changes

Standards are Technically Feasible (cont’d)

• Related work by manufacturers/suppliers

• MECA Modelling of engine calibration/CDA/ split SCR:
  • 0.014 - 0.016 g/bhp-hr FTP NOx

• Other strategies not yet fully demonstrated
  • Dynamic Cylinder Deactivation
  • Mild hybrids/ 48 V system electrification
  • Advanced turbochargers (e.g., SuperTurbo)
  • Opposed piston engine

• Lead time for further research and development
  CARB
More Comprehensive, Effective In-Use Test Method

• Binned MAW method would replace the deficient NTE method

• Diesel engine operation would be evaluated over three bins based on certification test cycles and standards (i.e. idle, LLC, and FTP/RMC)

• 3B-MAW method includes nearly all operation

• Otto-cycle engines are only certified to the FTP so they would be evaluated by a single bin based on the FTP standard

CARB
Durability Demonstration Program

• Applicable to 2024+ MY engines
• Use standardized engine or chassis cycles for aging
• Age engine and aftertreatment system to full useful life
• Allowance for accelerated aftertreatment aging for a portion of useful life
• Accelerated aftertreatment aging requires annual submittal of NOx sensor (REAL) emissions data on thousands of trucks
# Useful Life and Warranty Amendments

<table>
<thead>
<tr>
<th>Vehicle / Engine Category Gross Vehicle Weight Rating (GVWR)</th>
<th>Useful Life Phase-in MY 2027 (Miles)</th>
<th>Useful Life Phase-in MY 2031 (Miles)</th>
<th>Warranty Phase-in MY 2027 (Miles)</th>
<th>Warranty Phase-in MY 2031 (Miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHDD Class 8 GVWR &gt;33,000 lbs.</td>
<td>600,000 11 yrs./ 30,000 hrs.</td>
<td>800,000 12 yrs./ 40,000 hrs.</td>
<td>450,000 7 yrs./ 22,000 hrs.</td>
<td>600,000 10 yrs./ 30,000 hrs.</td>
</tr>
<tr>
<td>MHDD Class 6-7 19,500 &lt; GVWR ≤ 33,000 lbs.</td>
<td>270,000 11 yrs.</td>
<td>350,000 12 yrs.</td>
<td>220,000 7 yrs./ 11,000 hrs.</td>
<td>280,000 10 yrs./ 14,000 hrs.</td>
</tr>
<tr>
<td>LHDD Class 4-5 14,000 &lt; GVWR ≤ 19,500 lbs.</td>
<td>190,000 12 yrs.</td>
<td>270,000 15 yrs.</td>
<td>150,000 7 yrs./ 7,000 hrs.</td>
<td>210,000 10 yrs./ 10,000 hrs.</td>
</tr>
<tr>
<td>HDO GVWR &gt;14,000 lbs.</td>
<td>155,000 12 yrs.</td>
<td>200,000 15 yrs.</td>
<td>110,000 7 yrs./ 6,000 hrs.</td>
<td>160,000 10 yrs./ 8,000 hrs.</td>
</tr>
</tbody>
</table>
Longer Warranties Required

Heavy-Duty Engines & Vehicles (GVWR > 33,000 lbs.)

- Current Warranty Period
- June 2018 Warranty Amendments Effective MY 2022
- Proposed Warranty Amendments MY 2027 Phase-in
- Proposed Warranty Amendments MY 2031 Phase-in
Useful Life and Warranty Amendments (cont’d)

• Expand maintenance interval applicability to diesel-fueled engines used in hybrid vehicles and powertrains, and engines that are fueled by gasoline and alternative fuels

• Expand useful life and warranty provisions to include heavy-duty hybrid vehicles

• Enable already purchased warranty coverage to stay with vehicles even if they are no longer registered in California
Emissions Warranty Information Reporting Amendments

• Effective for 2024 and Later Model Years
• Streamlines corrective action to be based solely on failure rate
• Provides longer reporting periods consistent with longer warranty periods
• Lowers warranty reporting and corrective action thresholds for small volume engine families
• Eliminates the ability to use defective parts in subsequent years if no improvements were made for current model year
Averaging, Banking & Trading (ABT)

• Since 2004 MY, CARB & U.S. EPA have used the same 50-State pool of credits for ABT

• Under the Omnibus regulation:
  • Re-establish CA-ABT program starting with 2022 MY
  • Limit credit life to 5 years
  • Credit multipliers for meeting future emission requirements early
  • Heavy-Duty Zero-Emission products would be eligible to generate NOx credits starting with 2022 MY
Credits for HD ZEV, Clean Natural Gas & Diesels (Opportunity for Early Action/Over-compliance)

• In 2022-2023 model years:
  • Zero-emission HD vehicle could generate
    o **0.44 Mg NOx credit** for manufacturer
  • A single clean combustion engine meeting 2031 requirements could generate
    o **1.6 Mg NOx credit** for manufacturer
    o **1.6 Mg of NOx credits** could be used to certify **14 engines** at 0.100 g/bhp-hr (instead of 0.050 g/bhp-hr) during the 2024-2026 model years
Hybrid Powertrain Certification Test Procedure

• Optional pathway using powertrain dynamometer
• Utilize and align with U.S. EPA powertrain test procedures (40 CFR Parts 1036, 1037)
• Combustion engine and hybrid system components certified as a complete system
• Able to assess fuel efficiency and emission benefits
• Certified hybrid powertrains must comply with OBD, warranty, useful life, durability and other certification requirements
• Flexible, efficient, cost-effective

Source: ORNL, July 2016
Phase 2 GHG and Other Minor Amendments

- Phase 2 GHG Standards
  - Clarify definition of medium-duty vehicle, end-of-year report requirements
  - Environmental performance label specifications
  - Trailer-specific amendments to clarify warranty, in-use compliance, recall provisions
- Adopt federal standards for auxiliary power units used in sleeper cabs to ensure CARB enforcement authority
- Clarify medium-duty engine requirements
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NOx Emissions Benefits (tons per day)

- Projected benefits from a California-only action:

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Statewide</th>
<th>South Coast</th>
<th>San Joaquin Valley</th>
</tr>
</thead>
<tbody>
<tr>
<td>2031</td>
<td>23.2</td>
<td>7.0</td>
<td>5.7</td>
</tr>
<tr>
<td>2040</td>
<td>54.5</td>
<td>16.3</td>
<td>13.6</td>
</tr>
<tr>
<td>2050</td>
<td>75.9</td>
<td>23.0</td>
<td>19.0</td>
</tr>
</tbody>
</table>

- Critical 2031 SIP measure for achieving air quality goals
  - Contributes >30% of total NOx reductions from CA SIP measures
## Lifetime Health Benefits

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Avoided Incidents (2024-2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature Mortality</td>
<td>3,894</td>
</tr>
<tr>
<td>Cardiovascular Hospitalizations</td>
<td>616</td>
</tr>
<tr>
<td>Acute Respiratory Hospitalizations</td>
<td>735</td>
</tr>
<tr>
<td>Emergency Room Visits</td>
<td>1,801</td>
</tr>
</tbody>
</table>

- Omnibus benefits value (2018$): $36.8 billion
Cost of the Regulation (2018$)

• Regulation estimated to cost $4.49 Billion
• Estimated cost of 2031 MY compliant engines

<table>
<thead>
<tr>
<th>DIESEL</th>
<th>Lifetime increase in Cost</th>
<th>Percent increase cost of ownership over lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAVY-DUTY</td>
<td>$8,841</td>
<td>5.2%</td>
</tr>
<tr>
<td>MEDIUM-DUTY</td>
<td>$5,814</td>
<td>5.6%</td>
</tr>
<tr>
<td>Population Average</td>
<td>$5,912</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

• Total Regulation: $5.45 per lb of NOx
  • Within range of previous CARB measures
• **Expected benefits of $36.8 billion are over eight times above expected costs**

CARB
Outline

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- **15-Day Changes**
- Staff Recommendations
15-Day Changes

- Add temporary exemption for heavy-haul engines > 525 hp
- Modify LLC for alternative-fueled engines
- Allow Zero-Emission powertrain manufacturers to generate engine NOx credits instead of vehicles
- Allow Zero-Emission NOx credits only until 2026 MY
- Expand OBD flexibility to include 2022-2023 MY Otto-cycle engines
- Shorter durability demonstration option for 2024 to 2026 MY
- Minor editorial corrections and clarifications to Phase 2 GHG standard tractor and trailer requirements and environmental performance labels
Outline

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Staff Recommendation

• Approve Resolution 20-8-2 with the staff-proposed 15-day changes.