CARB’S HEAVY-DUTY IN-USE COMPLIANCE TESTING PROGRAM

Presentation for
Chinese Ministry of Ecology and Environment

November 28, 2018
Haggen-Smit Laboratory
El Monte, California
Look How Far We have Come
Much Work Still Ahead

September 13, 1955

September 9, 2014
Outline

Background
- In-Use Compliance (IUC) Programs
- Manufacturer-Run Heavy-Duty In-Use Testing (Mfr. HDIUT) Program
- CARB’s Heavy-Duty In-Use Compliance (HDIUC) Program

CARB’s HDIUC Program
- Program Implementation & Testing Results
- Comparisons with Mfr. HDIUT data

Conclusions
In-Use Programs Activities

- Enforcement
- OBD System Checks
- Emissions Compliance Testing
- Manufacturer Laboratory Audits
- Implement Manufacturer Run In Use Vehicle Program
- Field Studies
- Manufacturer Defects Warranty Reporting
In-Use Compliance Programs

- One of CARB’s key air quality improvement strategies
- Helps guarantee vehicles and engines meet emission standards throughout their useful lives as certified

Very successful Light-Duty (LD) IUC Program
- Emission recalls over 3 million vehicles: Fixes vehicles emissions back to applicable standards

Current regulation for Heavy-Duty (HD) in-use compliance: Mfr. HDIUT according to EPA/CARB Regulations established Sept 2006

CARB’s HDIUC Program initiated August 2016
- Pilot program: Resulted in noncompliance for a certain engine family (EF), presented at CRC Workshop in 2016 (O’Cain et al.)
- Noncompliance results of the first EF tested, presented at CRC Workshop in 2017 (Lee et al.)
- Noncompliance HDIUC results and comparisons of OEM testing (Mfr. HDIUT) and CARB testing (HDIUC), presented at CRC Workshop in 2018 (Lee et al.)
- As a result, over 500,000 HD trucks identified in an emissions recall program in 2018
In-Use Programs Branch Organization

Sharon Lemieux, Chief
In-Use Programs Branch
(32 Staff Total including support)

Jeffrey Wong
Field Operations Warranty Section
(9 staff)

Robin Lang
LD In-Use Compliance Section
(6 staff)

Keith Macias
HD In-Use Compliance and Evaluation Section
(9 staff)

Shawn Daley
Retrofit Assessment Section
(7 staff)

Kathleen Mead
HD Technology Advocate
Current Mfr. HDIUT Program

- Manufacturer-run HDIUT program intended to “...assess compliance with the Not-to-Exceed (NTE) requirements...” and help ensure overall compliance with “...all applicable emission standards throughout the engine’s useful life...” (CARB ISOR 2006)

- Has not fulfilled program goals of enacting needed corrective actions such as recalls and/or extended warranties despite high warranty claims, consumer complaints and high emissions observed in surveillance and roadside testing

- Mfr. HDIUT data show insignificant amount of valid NTE events with many data excluded

- Due to Mfr. HDIUT shortcomings, CARB initiated HDIUC testing using similar protocol to the manufacturer-run program
HDIUC Program – Overview

- Over the road testing using the NTE protocol
- With 1065 Compliant Portable Emissions Measurement Systems (PEMS)
- A minimum of 10 engines for each EF are tested
  - Candidate vehicles are subject to thorough screening and selected based on:
    - HDIUT in-use engine selection and screening requirements: 40 CFR 86.1908
    - U.S. EPA’s HDIUT Program Vehicle Screening Guidance Document: CI SD-06-010 (HD)
    - CARB’s rigorous procurement process used in LD IUC programs
    - Properly maintained and used (CCR 2137)
    - Perform Restorative Maintenance

- Vehicles driven over a common route used for freight movement
- Same Mfr. HDIUT compliance criteria used: 3 or more of test vehicles failing vehicle-pass ratios (i.e., failing to meet emissions requirements during greater than 90% of time of NTE events)
HDIUC Program – Test Route

- Designed to garner maximum number of NTE Events to help ensure representative engine assessment
- Exercised the engine in a variety of load conditions within the NTE zone
- Heavily travelled California goods movement routes
  - Distance: 292 Miles
  - Elevation: 0 to 4285 ft.
  - Driving time: Around 6.5 hours depending on traffic
  - A non-idle operation time: The average of 5.6 hours (over 3 hours, a NTE regulation requirement)
Restorative Maintenance

- Check OBD system for stored codes
- Check for obvious tampering
- Adjust all parameters to manufacturer specifications
- Verify or perform scheduled maintenance
- Prepare vehicle for test
HDIUC Program – Testing Vehicle
HDIUC Program – Implementation

- Trucks are obtained and screened with cooperation from fleets and engine manufacturers
  - Fleet – Test vehicle and maintenance history
  - Engine manufacturer
    - Candidate vehicle warranty history checks
    - Technical support for and observation of the program with data logging during the testing

- Collected HDIUC testing data
  - Used for compliance determination – Noncompliance for EF tested
    - Chassis and engine dynamometer (dyno) test results has confirmed noncompliance
  - Emission recall discussions with manufacturers
  - Informs certification, OBD and regulatory programs
HDIUC Program – Status

- **HDIUC PEMS Testing**
  - Four (4) EFs – Total of 33 engines
    - 3 EF: Testing completed (10 engines for each EF)
    - 1 EF: On-going (3 engines tested as of October 2018)

- **Extra testing:** Chassis and/or engine dynamometer testing to support PEMS noncompliant findings, including tests conducted at manufacturer test facility
# PEMS Testing Results – Overview

<table>
<thead>
<tr>
<th></th>
<th>EF A</th>
<th>EF B</th>
<th>EF C</th>
<th>EF D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model Year</strong></td>
<td>2013</td>
<td>2012</td>
<td>2014</td>
<td>2012</td>
</tr>
<tr>
<td><strong>R\textsubscript{pass}</strong></td>
<td>0.29 ~ 1.00</td>
<td>0.00 ~ 1.00</td>
<td>0.15 ~ 1.00</td>
<td>0.69 ~ 1.00</td>
</tr>
<tr>
<td><strong>NO\textsubscript{x} Emission Standard (g/bhp-hr)</strong></td>
<td>0.20</td>
<td>0.30</td>
<td>0.20</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Average NTE NO\textsubscript{x} Emission for Noncompliant Engines (g/bhp-hr)</strong></td>
<td>0.59</td>
<td>1.02</td>
<td>0.47</td>
<td>N/A*</td>
</tr>
<tr>
<td><strong>Compliance</strong></td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>TBD**</td>
</tr>
<tr>
<td><strong>Number of Noncompliant Vehicles</strong></td>
<td>6 (out of 10 tested)</td>
<td>8 (out of 10 tested)</td>
<td>2 (out of 10 tested)</td>
<td>2 (out of 3 Tested)</td>
</tr>
<tr>
<td><strong>Odometer (Miles)</strong></td>
<td>258 ~ 326 K</td>
<td>71 ~ 414 K</td>
<td>145 ~ 413 K</td>
<td>236 ~ 267 K</td>
</tr>
</tbody>
</table>

* N/A: Not Applicable, yet. ** TBD: To Be Determined

PM, NMHC, & CO emissions results for all vehicles were compliant with the corresponding NTE emissions requirements; that is, $R\textsubscript{pass}$ were 0.90 or higher.
Findings – HDIUC vs. Mfr. HDIUT

Based on data collected as of October 2018, CARB’s HDIUC testing more effective than Mfr. HDIUT program in identifying noncomplying engines in need of corrective actions.
Conclusions

- CARB’s HDIUC testing using NTE protocol
  - A valuable tool to identify and correct noncomplying HD EFs and defective emissions control components

- Chassis and engine dyno testing support PEMS noncompliant findings

- Current Mfr. HDIUT program needs improvement
  - Not fulfilling its intended program goals

- HD in-use influenced corrective actions initiated: Both OEMs for EF A and B

- On-going testing: Fourth EF (EF D) and more EFs

- Engine manufacturers should conduct testing programs similar to CARB’s HDIUC program to better assess in-use performance of engines
Thank you!

Questions?
Backup Slides
NTE Testing Requirements

Heavy-duty in-use engine compliance program is designed to control diesel truck emissions during “normal vehicle operation and use” consistent with the not-to-exceed (NTE) requirements (40CFR86.1910(e))

- **Test duration**
  - At least 3 hours of non-idling vehicle operation for testing of a shift-day or two days

- **NTE zone definition**
  - Above 30% max engine power
  - Above 30% max engine torque
  - Above 15% ESC RPM

- **Duration and temperature (T) limits**
  - At least 30 consecutive seconds
  - > 250 °C for Aftertreatment (AT)/SCR T
  - EGR (Cold T Operation) Exclusion: IMT & ECT
  - Ambient T Exclusion

- **Other provisions**: BSFC, LTR/TWCOLTR, EMD/OBD, Deficiency, Regeneration, Zero Check
EF A – PEMS Testing Results

Vehicles/NTE events that failed to meet NOx NTE requirements/threshold are shown in red.
Vehicles/NTE events that failed to meet NOx NTE requirements/threshold are shown in red.