

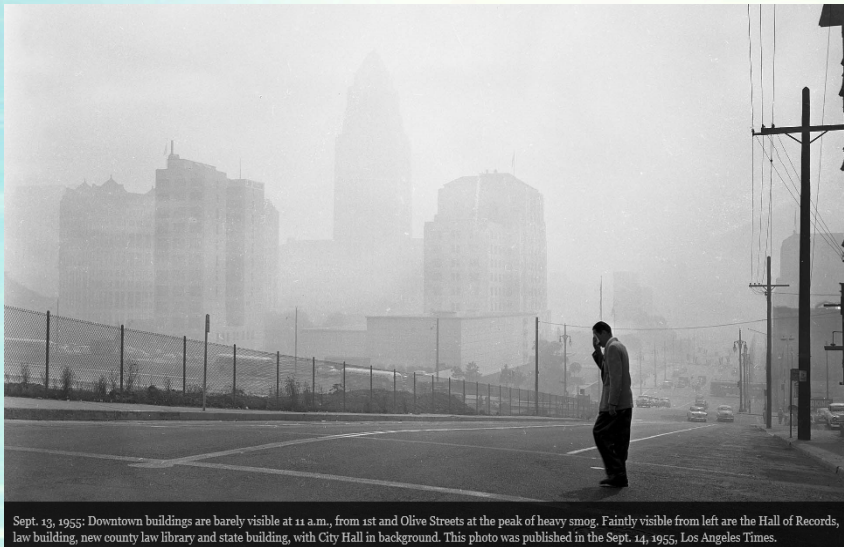
CARB'S HEAVY-DUTY IN-USE COMPLIANCE TESTING PROGRAM

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

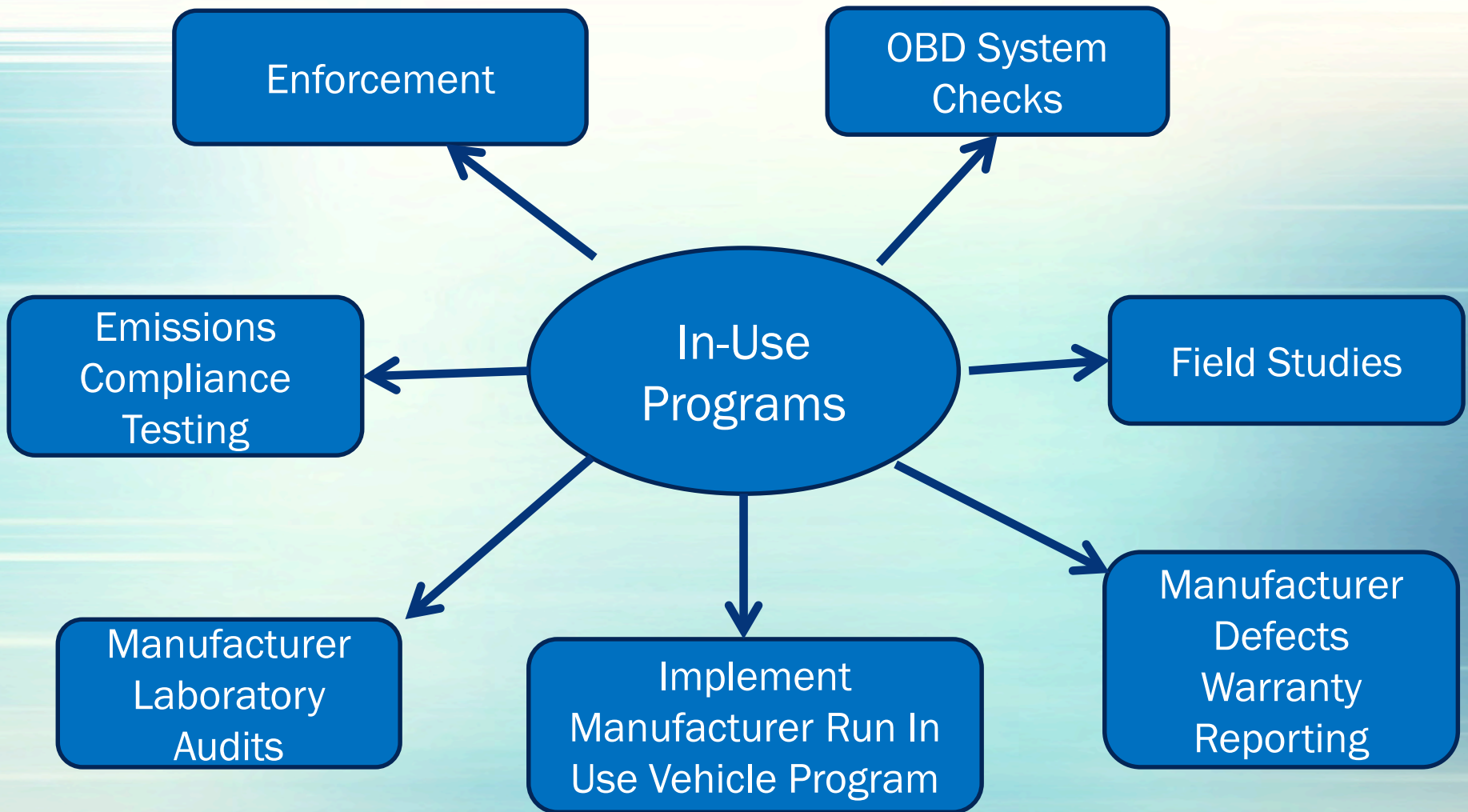
- In-Use Compliance (IUC) Programs
- Manufacturer-Run Heavy-Duty In-Use Testing (Mfr. HDIUT) Program
- CARB's Heavy-Duty In-Use Compliance (HDIUC) Program

□ CARB's HDIUC Program

- Program Implementation & Testing Results
- Comparisons with Mfr. HDIUT data

□ Conclusions

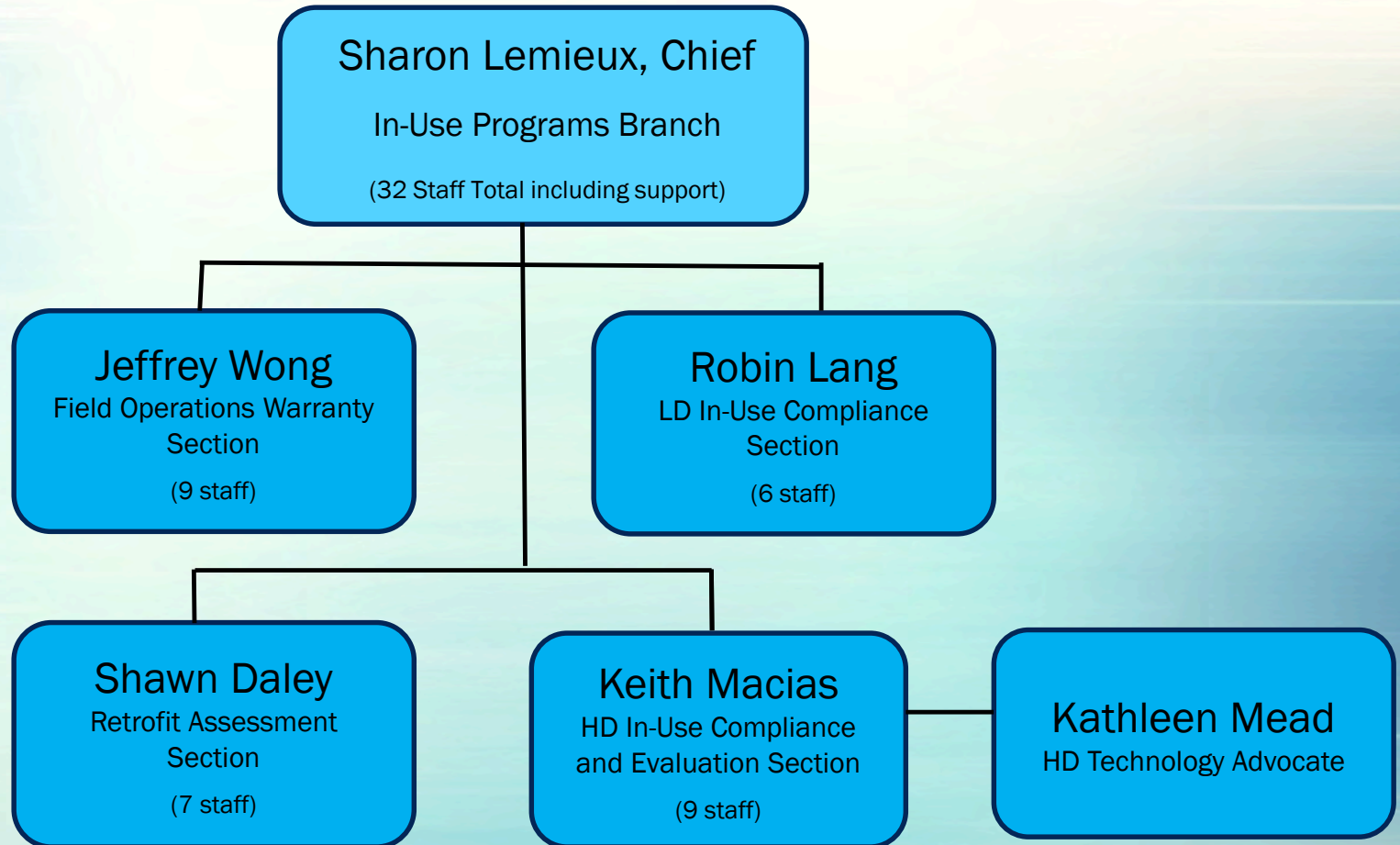
In-Use Programs Activities



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



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: CISC-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

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

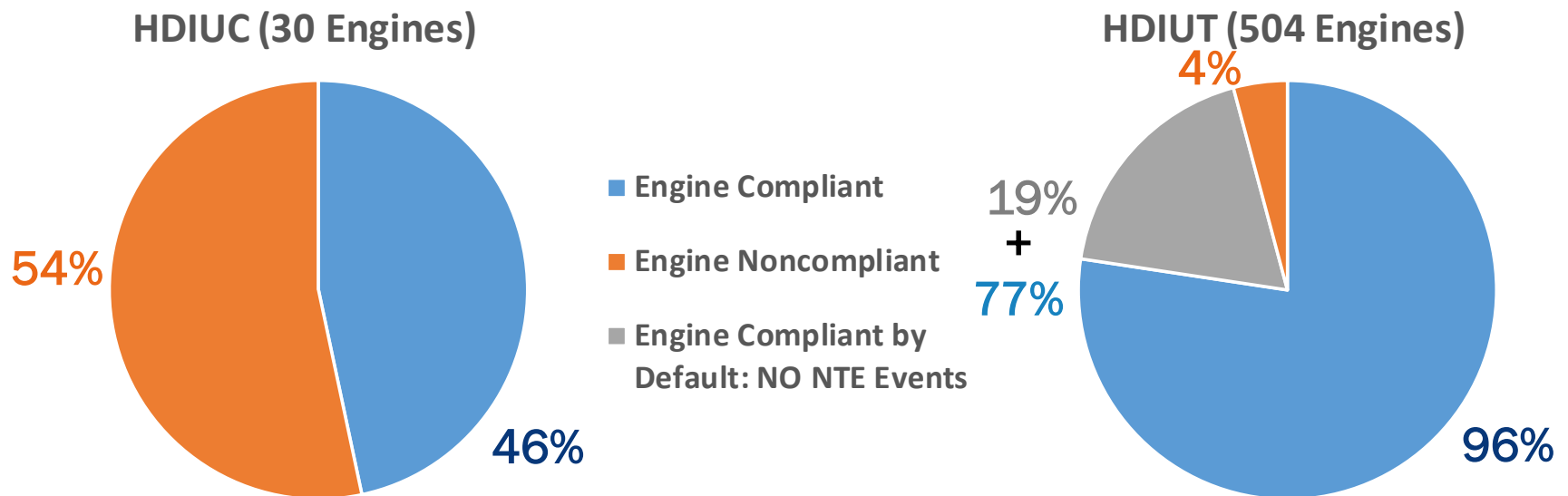
* N/A: Not Applicable, yet.

** TBD: To Be Determined

PM, NMHC, & CO emissions results for all vehicles were compliant with the corresponding NTE emissions requirements; that is, R_{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

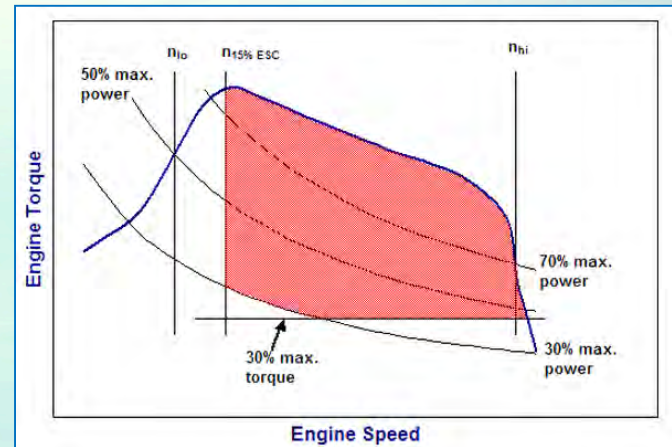
Thank you!

Questions?

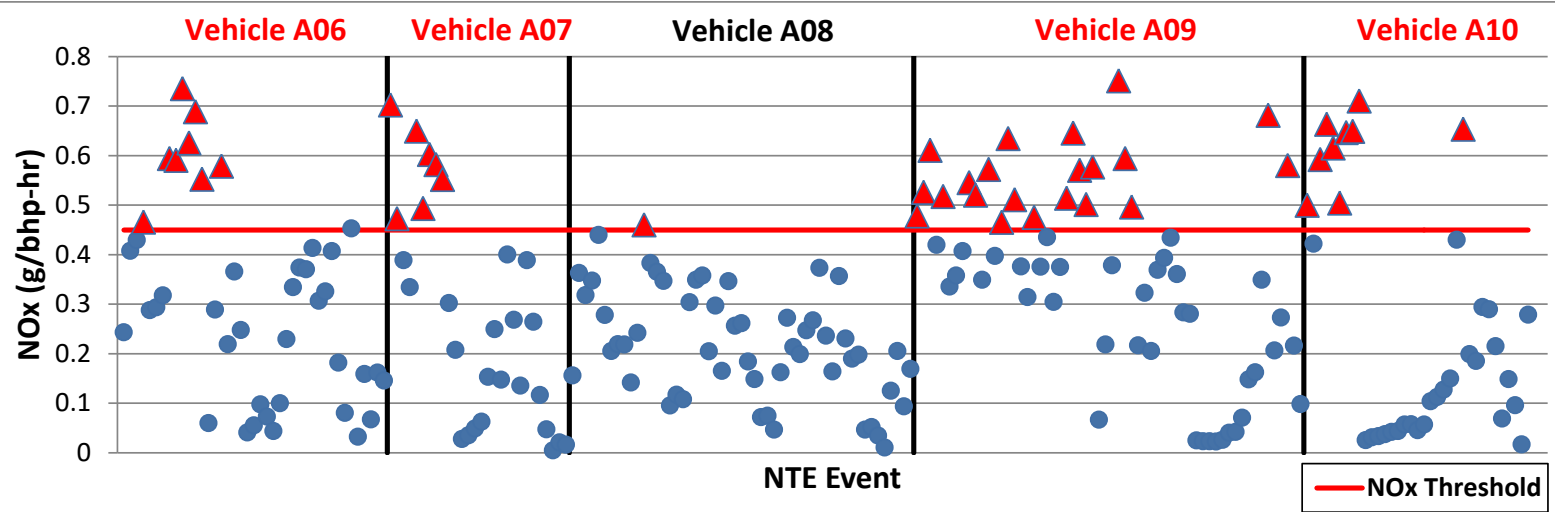
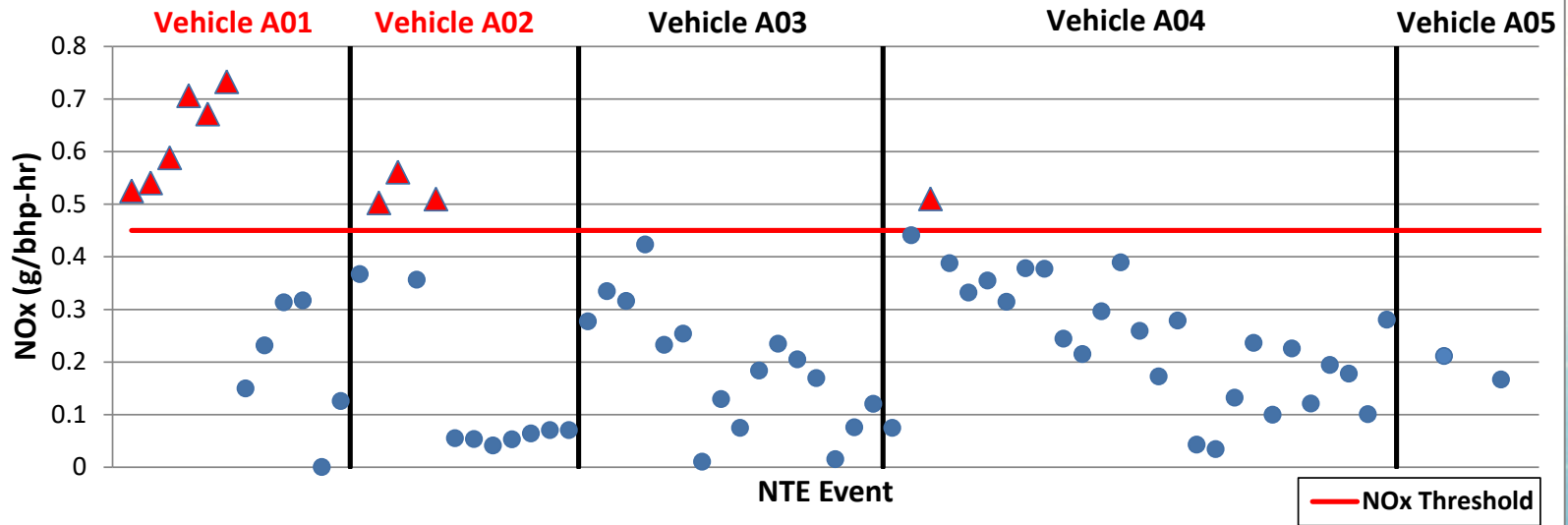
Backup Slides

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

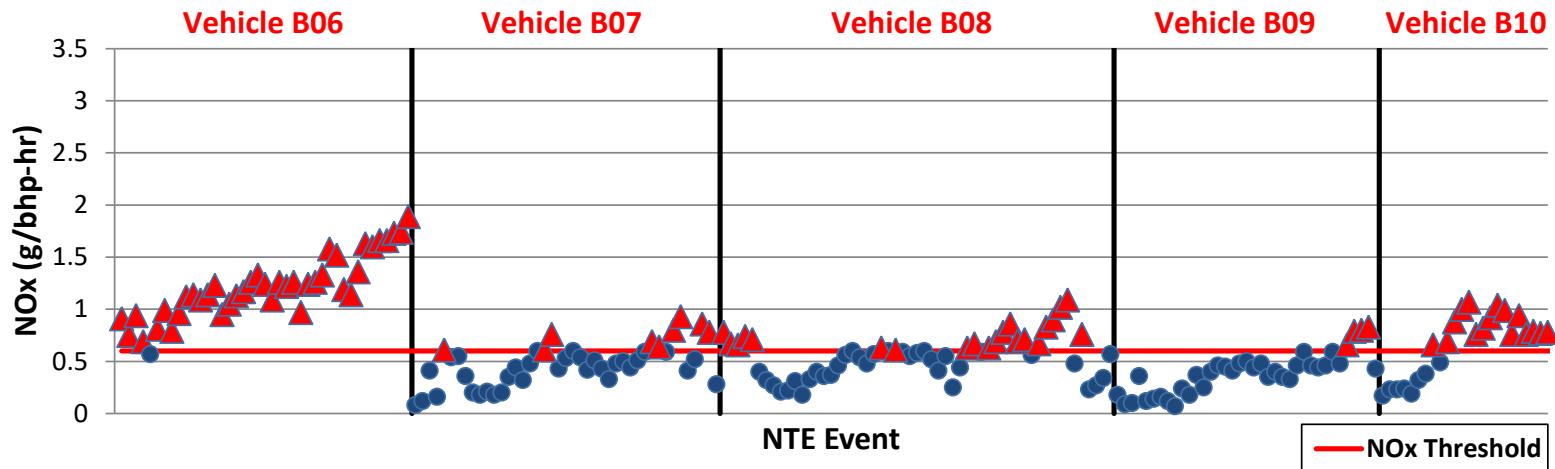
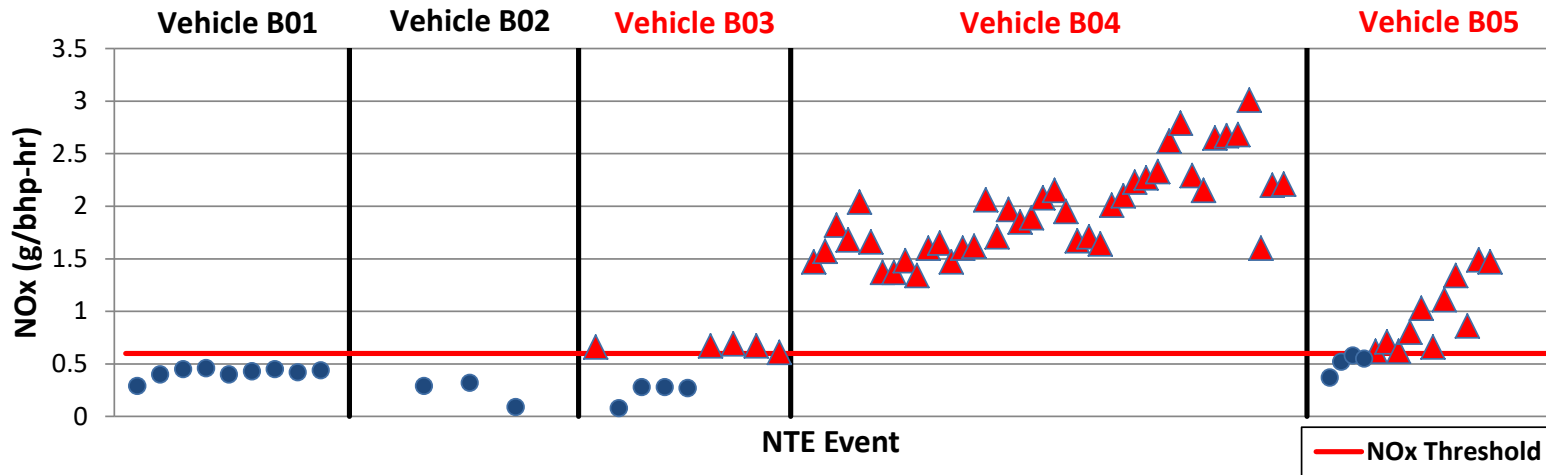


EF A – PEMS Testing Results



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

EF B – PEMS Testing Results



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

HDIUC Program - Test Route

