



**2021 Truck and Engine Manufacturers Association
Compliance Workshop: Off-Road Breakout Session**

April 28, 2021

Outline

- Off-Road In Use Compliance Update
- Off-Road Tier 5 Update
- EMA Q+A



Off-Road In-Use Compliance Program

Nonroad/Marine/Locomotive/Stationary
Breakout Session - 04/28/2021

Off-Road HDIUC Status

- Similar to HD on-road program, the Heavy-Duty In-Use Compliance (HDIUC) section is developing an in-use compliance program for off-road equipment
- Objective is to ensure manufactured vehicle/equipment is in all material respects as certified (AECD, inducements, etc.) and maintains emission compliance throughout useful life
- Title 13 CCR 2139, 40 CFR 1039, etc. provide the authority for CARB to conduct in-use testing of HD off-road engines and require corrective action in case of nonconformity



California Code of Regulation Title 13

CHAPTER 9. OFF-ROAD VEHICLES AND ENGINES POLLUTION CONTROL DEVICES



- ARTICLE 1. **SMALL OFF-ROAD ENGINES**
(Current Regulation: Sections 2400 – 2409)
- ARTICLE 3. **OFF-HIGHWAY RECREATIONAL VEHICLES AND ENGINES**
(Current Regulation: Sections 2410 – 2415)
- ARTICLE 4. **OFF-ROAD COMPRESSION-IGNITION ENGINES AND EQUIPMENT**
(Current Regulation: Sections 2420 – 2427)
- ARTICLE 4.5. **OFF-ROAD LARGE SPARK-IGNITION ENGINES**
(Current Regulation: Sections 2430 – 2439)
- ARTICLE 4.7 **SPARK-IGNITION MARINE ENGINES**
(Current Regulation: Sections 2440 – 2448)

Recap of 2020 HDIUC Activities

- A pilot program was initiated to assist with the development of the official IUC program
- Pilot program elements
 - Data logging
 - PEMS testing
- Manufacturers' support was needed for on data logging due to off-road engines' non-standardized communication

Pilot Program

- Performed data logging completed using generic and proprietary tools
 - 11 engines
 - 4 different engine manufacturers
- Next steps:
 - PEMS testing
 - Inducement testing
 - Develop an OFCI IUC standard operating procedure (SOP)
- Objectives:
 - Begin the first official off-road ICU program
 - Inform the proposed Tier 5 off-road regulation

CARB's Request to Manufacturers

- Support for data logging equipment
 - Provide support to read, record, and interpret all the information broadcast by an engine's onboard computers and electronic control units (1039.205 (t) & 13 CCR § 2421 (a)(4)(B))
 - Collect any parameters similar to the targeted list*, even if they are not supported by SAE J1939
 - The CAN bus communications: through both private or/and public networks
 - Data logging method: non-invasive method
- On-going engineering support on torque curves, warranty history, and responding to other questions
- Provide diagnostic tool(s): to ensure equipment is operating as intended

Conclusion

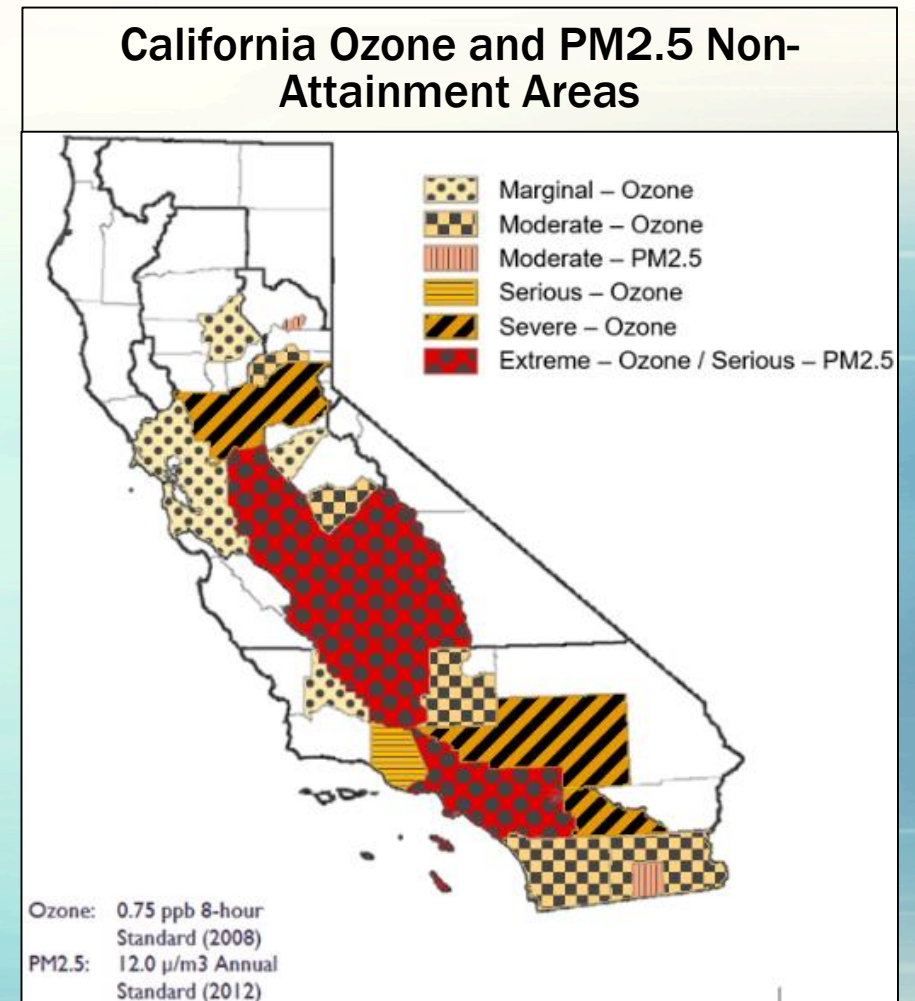
- CARB's Off-road IUC program will be developed for CI
 - In the near future: IUC programs for SI, and SI marine engines
- CARB made progress and will continue with the development of the Off-Road IUC program
- CARB requests manufacturer support with data logging, engineering support, and diagnostic tools
- Off-road OEM support is essential and required
- This program will support the development of the Tier 5 off-road regulation



Possible Elements of the Proposed Amendments to the Off-Road Diesel Engine Emission Standards (Tier 5 criteria pollutant and CO₂ standards)

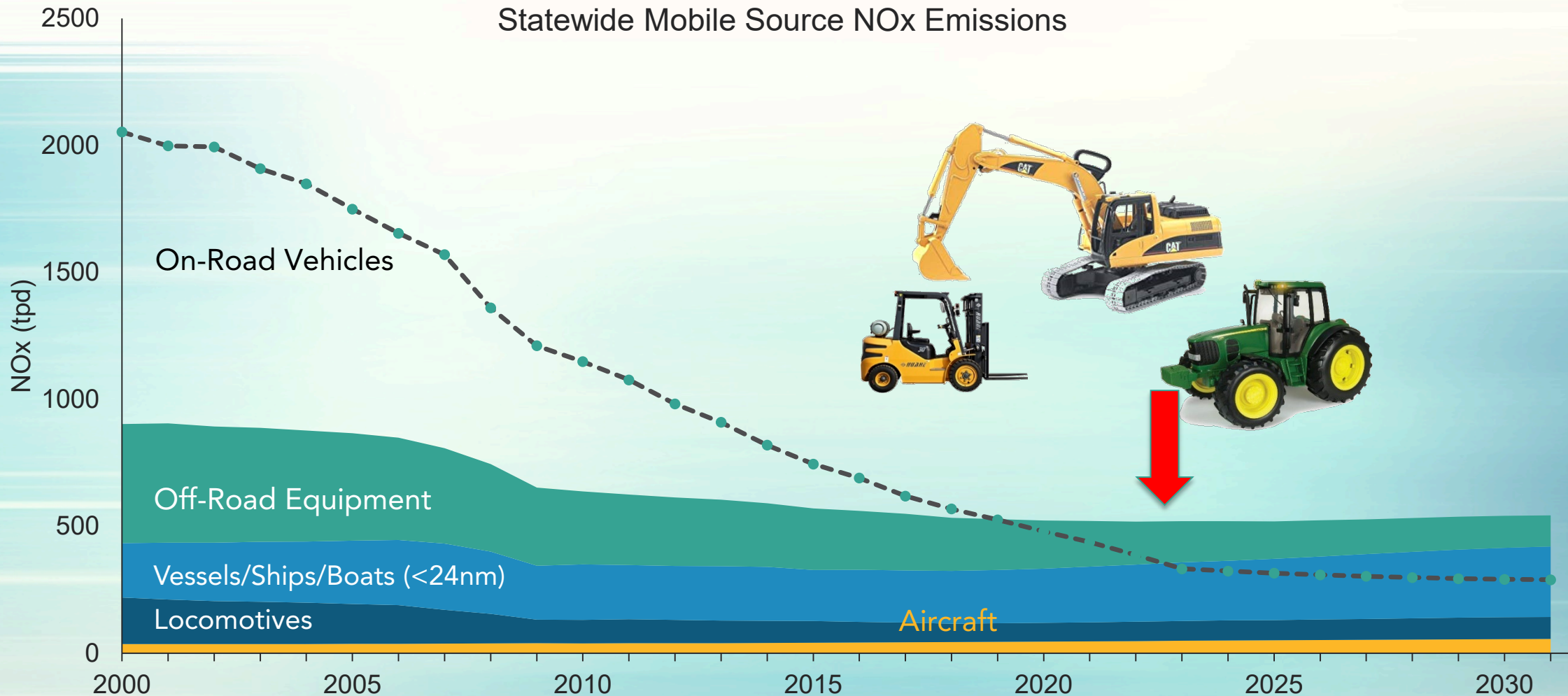
Major NO_x and PM_{2.5} Emission Reductions Needed

- California has the worst air quality in the nation
- Key challenges
 - San Joaquin Valley – PM_{2.5}
 - South Coast - ozone
- Off-road equipment are one of the largest contributors
- Action beyond current programs needed to meet air quality goals in various regions



Growing Importance of Off-Road

Statewide Mobile Source NOx Emissions



Summary: Off-Road Tier 4 Standards

Tier 4 Final Exhaust Emission Standards after 2014 Model Year (g/kW-hr)						
Power Category	Application	PM	NOx	NMHC	NOx+NMHC	CO
< 19 kW (< 25 HP)	All	0.40			7.5	6.6
19 ≤ kW < 56 (25 ≤ HP < 75)	All	0.03			4.7	5.0
56 ≤ kW < 130 (75 ≤ HP < 175)	All	0.02	0.40	0.19		5.0
130 ≤ kW ≤ 560 (175 ≤ HP ≤ 750)	All	0.02	0.40	0.19		3.5
> 560 kW (> 750 HP)	Gen Sets	0.03	0.67	0.19		3.5
	Mobile Machines	0.04	3.5	0.19		3.5

Summary: Off-Road Tier 4 Useful Life

Current Useful Life Periods			
Engine Type	Maximum Power	Rated Engine Speed	Useful Life
Variable or Constant Speed	< 19 kW (< 25 HP)	Any	3,000 hrs or 5 yrs
Constant Speed	$19 \leq \text{kW} < 37$ ($25 \leq \text{HP} < 50$)	$\geq 3,000$ rpm	3,000 hrs or 5 yrs
Constant Speed	$19 \leq \text{kW} < 37$ ($25 \leq \text{HP} < 50$)	< 3,000 rpm	5,000 hrs or 7 yrs
Variable Speed	$19 \leq \text{kW} < 37$ ($25 \leq \text{HP} < 50$)	Any	5,000 hrs or 7 yrs
Variable or Constant Speed	> 37 kW (> 50 HP)	Any	8,000 hrs or 10 yrs

Proposed Elements of the Off-Road Diesel Regulatory Amendments

- Upcoming Tier 5:
 - Staff will be amending the off-road diesel regulation
 - Considering proposing significantly more stringent NO_x standards that are up to 90% lower than current Tier 4 standards
 - Considering proposing PM standards up to 75% more stringent than current Tier 4 standards to drive deployment of DPFs and get maximum feasible toxic diesel PM reductions
 - Considering proposing CO₂ standards to reduce engine GHG emissions from 5 to 10 % below current levels
 - Regulations were last updated in 2004

Possible Elements of Tier 5 Continued

- Low-load and low-temperature NO_x emissions
- Work-based in-use compliance procedures
- First-time off-road diesel OBD requirements
- Test procedure modifications to include measurement protocols for off-road diesel CO₂ emissions
- Proposing to go to the Board in 2024 with implementation beginning in 2028

Southwest Research Institute (SwRI)

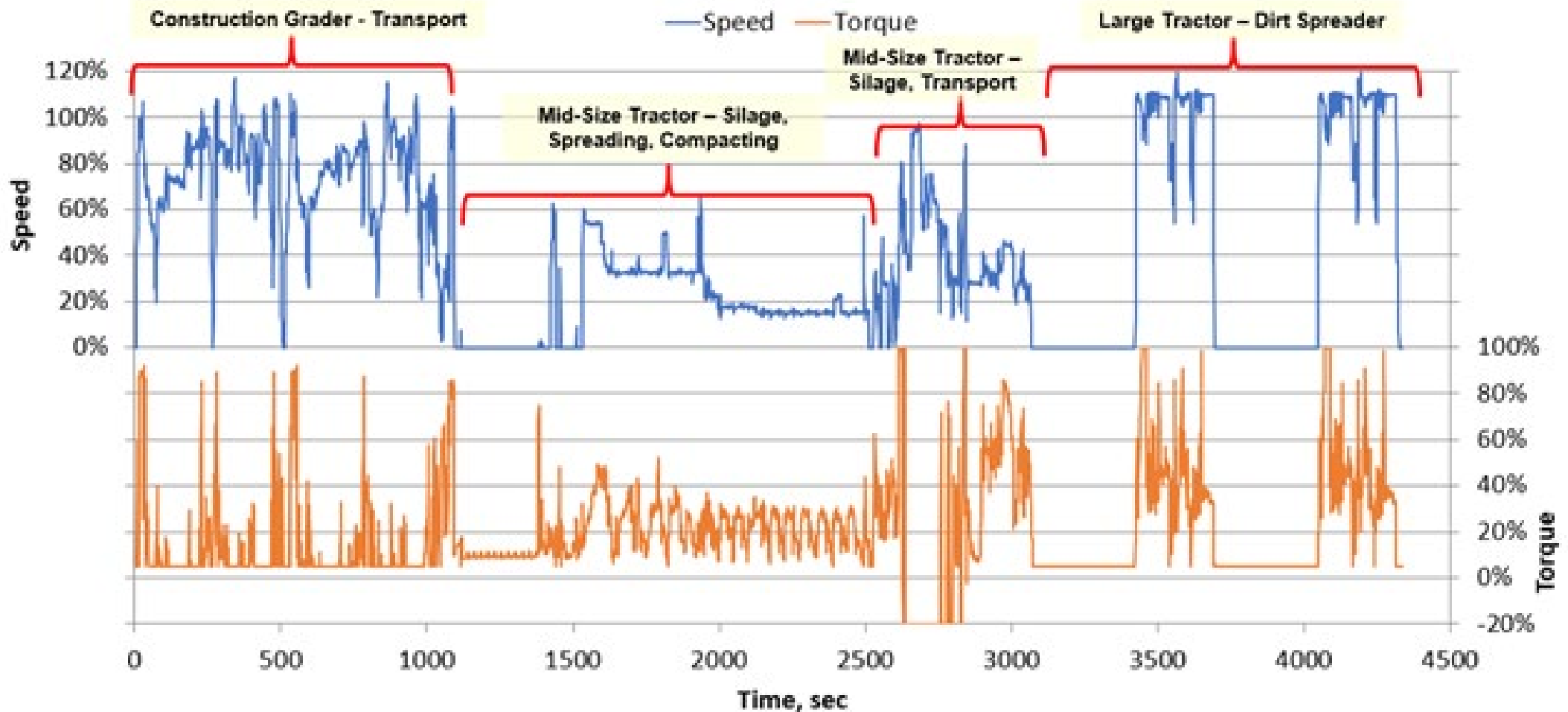
Off-Road Demonstration Program: 19RD025

- Optimize a Deere 6068 engine for low-NO_x performance
- Reduce NO_x emissions by 90% to 0.04 g/kW-hr
- Reduce PM Emissions by 75% to 0.005 g/kW-hr
- Supplemental demonstration tasks include:
 - Reducing CO₂ emissions by 5-10% below current levels in support of a first ever CO₂ exhaust standard for off-road diesel engines
 - Full useful-life aging (DAAAC) for emissions aftertreatment components
 - Demonstrating an off-road idle reduction system
 - Demonstrating emissions performance over 12,000-hour useful life

Question on the Off-Road LLAC

- Q: The Nonroad Low Load Application Cycle (LLAC) is a composite cycle made up of low load operations from four different machine applications – what four types of nonroad CI equipment were in the test?
- A: LLAC was constructed by SwRI from real-world data provided by John Deere to demonstrate NO_x performance during extended low load operation. The equipment types that produced the data for the LLAC were a Construction Grader, two Mid-sized Tractors, and a Large Tractor. LLAC is not intended as a certification cycle, but as a tool for SwRI to demonstrate NO_x control during low load operating conditions.

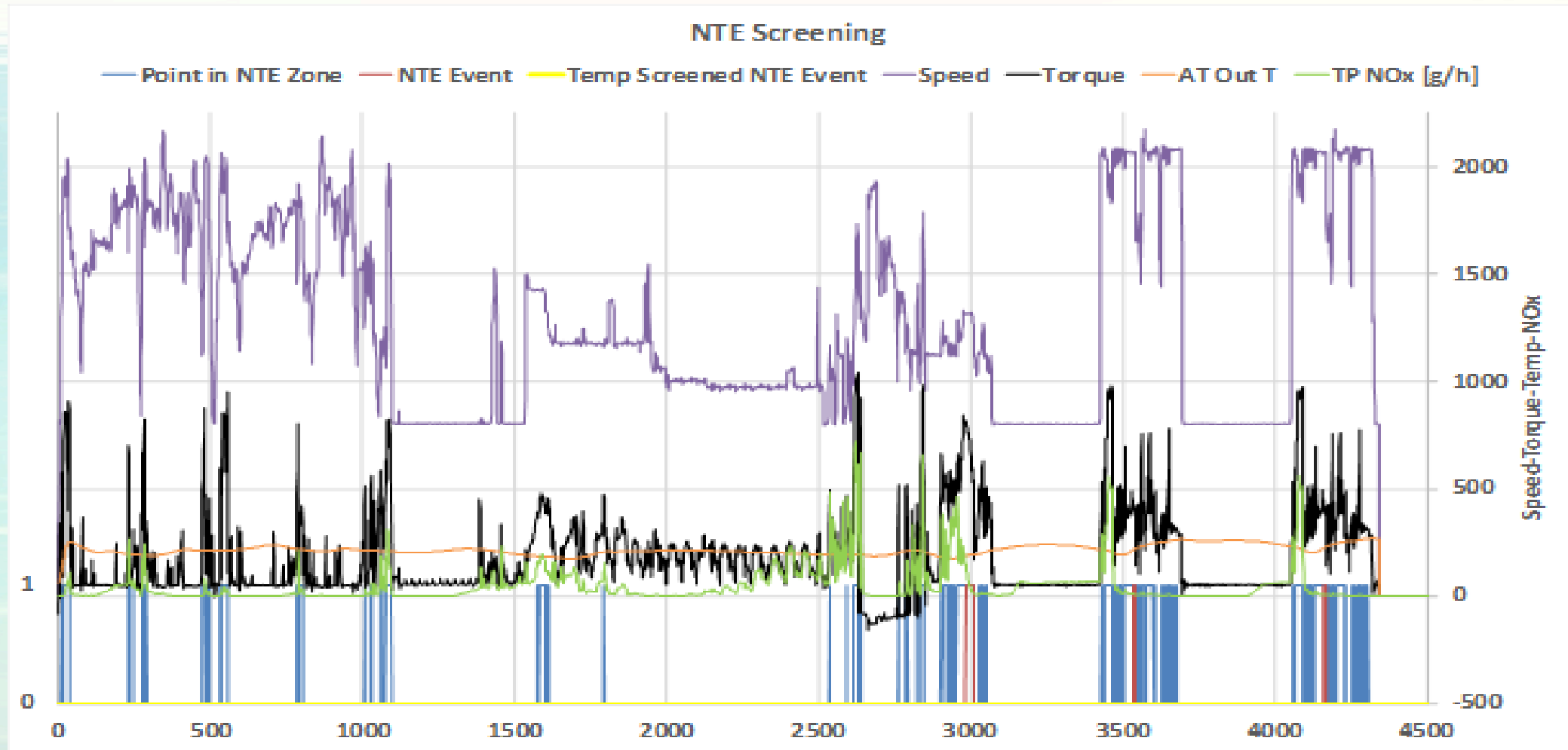
LLAC Composition Cycles



Question on NTE and the Off-Road LLAC

- Q: Does normal NTE usually capture these [LLAC] low load points?
- A:
 - No. Out of the 4,339 seconds of the LLAC, 630 seconds (14.5%) are within the NTE zone, however the vast majority do not last longer than 30 seconds at a time and are not valid NTE events.
 - There are 3 potential NTE events that occur during the LLAC (one in a mid-size tractor and two in the large tractor). Durations are 57 secs, 39 secs, and 39 secs, respectively.
 - All of these potential short events are disqualified by the aftertreatment (AT) outlet temperature being less than 250°C.

NTE Events on the Off-Road LLAC Cycle



Why is the LLAC Necessary

- Q: What is the "driver" for potentially utilizing LLAC regarding nonroad CI engines?
- A:
 - SCR requires exhaust temperature to remain above a threshold ($\approx 250^{\circ}\text{C}$) to function properly and reduce NOx.
 - Extended low load operation can reduce exhaust temperature to the point that NOx emissions aren't adequately controlled.
 - LLAC provides SwRI a platform for designing off-road aftertreatment configurations that continue to control NOx during extended low load operation.
 - CARB staff does not intend to propose the LLAC as certification test cycle.

EMA Q+A

- Q: Does CARB regulate underground mining equipment? If so, do they need a waiver from the U.S. Mine Safety and Health Administration (MSHA)? If not, does underground mining equipment fall into the scope of the off-road fleet rule?
- A: There is no exemption for underground mining equipment. If this equipment uses off-road engines, it must be CARB certified prior to being introduced into commerce in CA. MSHA may have additional requirements.

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Questions

