



# Heavy-Duty Low NOx Program

## Proposed Heavy-Duty Engine Standards

Public Workshop  
Diamond Bar, CA  
September 26, 2019

MSCD/ECCD



# Outline

- **Applicability**
- **Summary of Proposed Certification Standards**
- **Feasibility of Proposed Standards**
  - Heavy-Duty Diesel-Cycle
  - Heavy-Duty Otto-cycle
- **Option for a National Program**

# 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

Model Year	Proposed NO <sub>x</sub> Exhaust Emissions Standards			
	HDDE			HDOE
	FTP / RMC (g/bhp-hr)	LLC (g/bhp-hr)	Idling (g/hour)	FTP (g/bhp-hr)
2024 - 2026	0.05	0.20	10	0.05
2027 and subsequent	0.015 - 0.030	(1 - 3) x FTP	≤ 10	0.015-0.030

Model Year	Proposed PM Exhaust Emissions Standards			
2024 and subsequent	0.005	---	---	0.005

# HDDE Feasibility of the 2024 Standards - FTP/RMC

- **FTP/RMC: 0.05 g/bhp-hr**

- SwRI Stage I: **0.09 g/bhp-hr** NO<sub>x</sub> 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 CO<sub>2</sub> emissions levels below the 2024 Phase 2 GHG standards

- **MECA's tailpipe emissions modeling assessments**

- Using as input: SwRI Stage I calibration strategy and current commercially available SCR systems
  - 0.04 g/bhp-hr composite FTP NO<sub>x</sub> – with lower SCR volume than is in the market today
  - 0.03 g/bhp-hr composite FTP NO<sub>x</sub> - with average SCR volume than is in the market today
  - 0.02 g/bhp-hr composite FTP NO<sub>x</sub> - 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 MDI3TC)
- Adding load to idle portion of the LLC will assist in reducing emissions on the LLC

- **MECA's modeling assessments<sup>a</sup>**

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

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

# HDDE Feasibility of the 2024 Standards – Idling

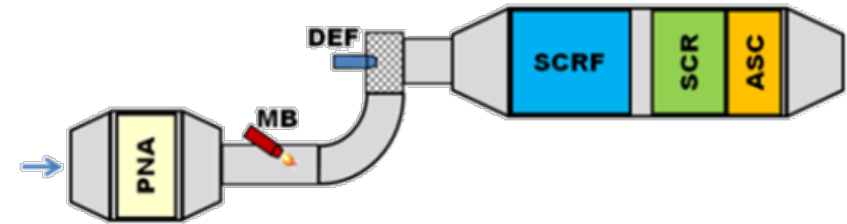
- **Idling NOx Standard: 10 g/hr**
  - SwRI Stage 2
    - Low NOx idle calibration: high EGR rate, intake throttling, and late combustion phasing
    - Demonstrated engine-out emissions of 2.8 g/hr NOx (on idle segment of the LLC)
- **Potential revisions to the existing requirements**
  - Make clean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

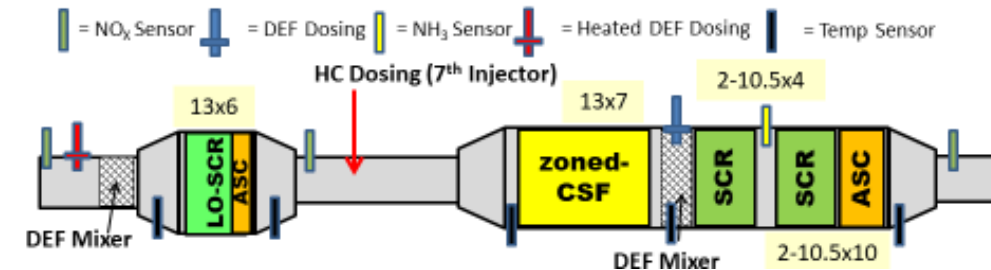
- SwRI Stage 1b: **0.023 g/bhp-hr FTP**

- 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:

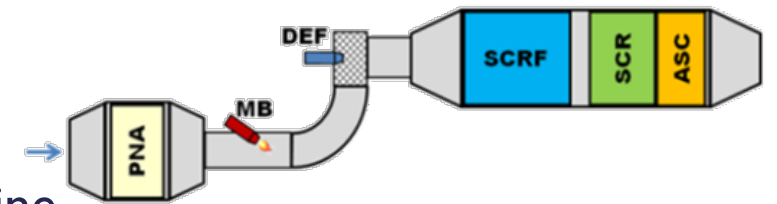
- SwRI Stages 2 and 3 calibration test results and
- Potential GHG emission impacts

### ■ SwRI Stage 2

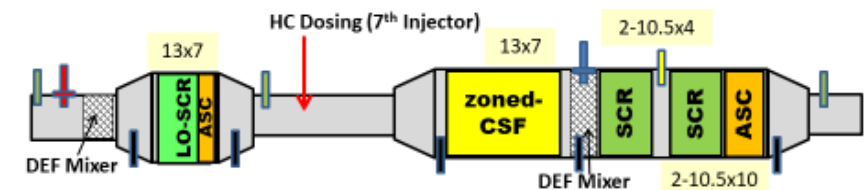
- 0.07 g/bhp-hr NO<sub>x</sub> with no change in CO<sub>2</sub> emissions from baseline
- 0.02 g/bhp-hr NO<sub>x</sub> with 2% GHG penalty

### ■ SwRI Stage 3:

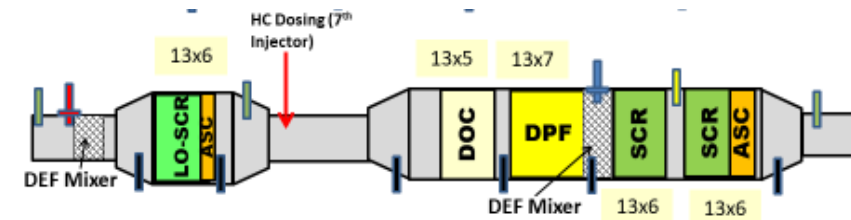
- Currently in progress, will determine feasibility
- Screening results of two systems
  - 0.053 g/bhp-hr (System 2B)
  - 0.036 g/bhp-hr (System 1A)



**System 1A**



**System 2B**



# HDDE Feasibility of the 2027 Standards - Idling

- **Idling NOx Standard:  $\leq 10$  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 NO<sub>x</sub> 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 NO<sub>x</sub> 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**