CALIFORNIA
AIR RESOURCES BOARD

Proposed Heavy-Duty Engine and Vehicle Omnibus Regulation

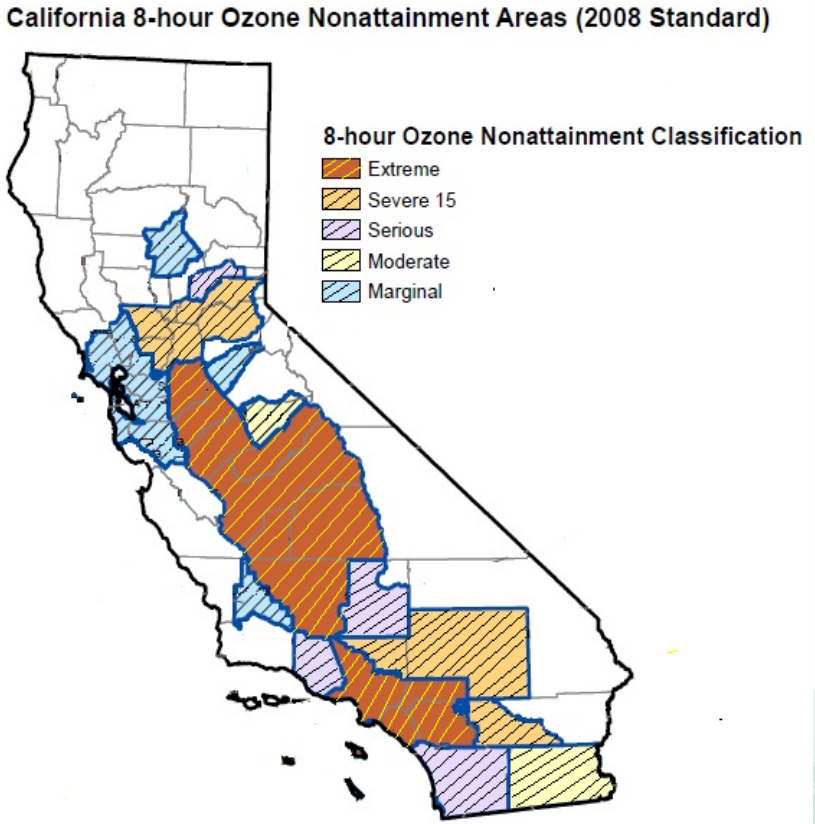
August 27, 2020

CARB

Outline

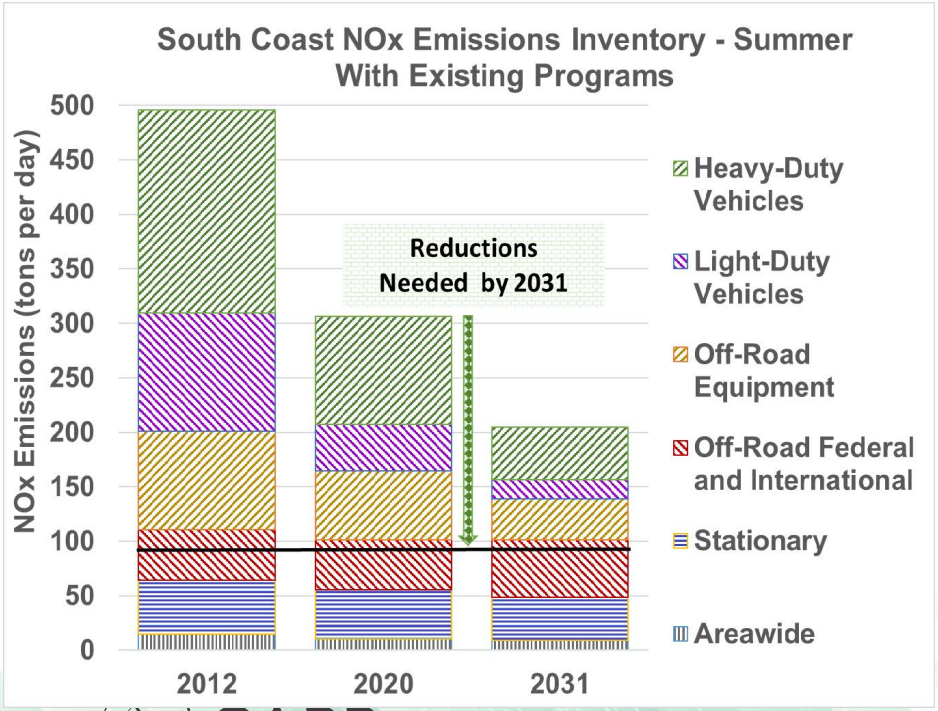
- **Background**
- Current Heavy-Duty Requirements
- Staff Proposal
- Benefits and Costs
- 15-Day Changes
- Staff Recommendations

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

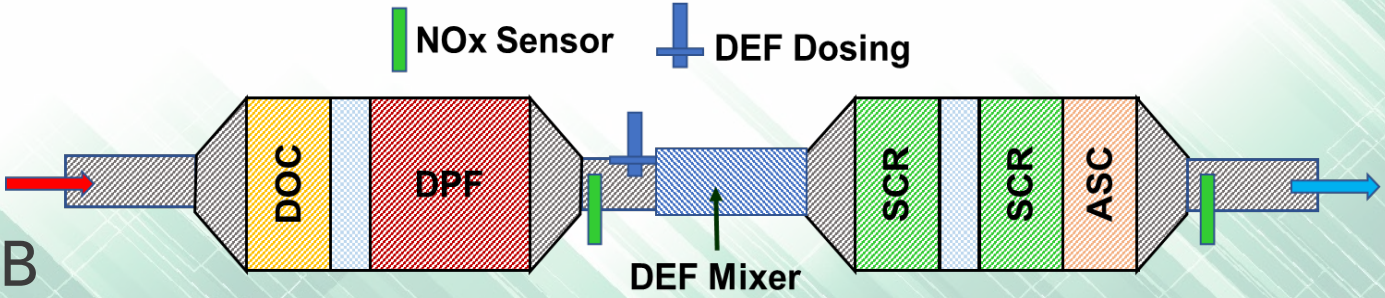
- Standards Compliance Throughout Useful Life
- Durability Demonstration during Certification
- Averaging, Banking, and Trading (ABT) Program
- Heavy-Duty In-Use Testing (HDIUT) Program
- Emissions Warranty
- Emissions Warranty Information Reporting (EWIR)

Current Program

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



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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

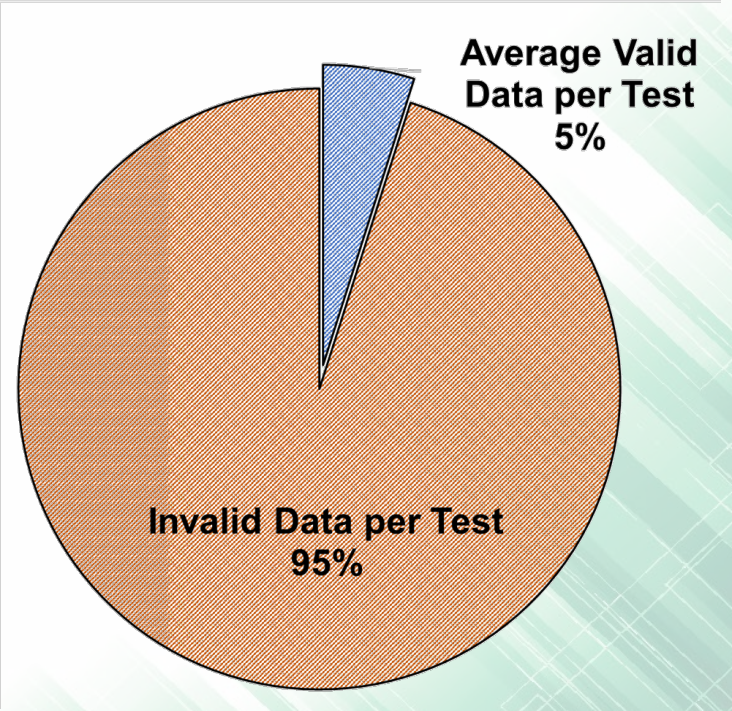
- Manufacturers must demonstrate emissions compliance for the full useful life at time of certification
- Current durability procedures require partial useful life durability demonstration with some field data evaluation
- Partial useful life aging methodology is insufficient

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



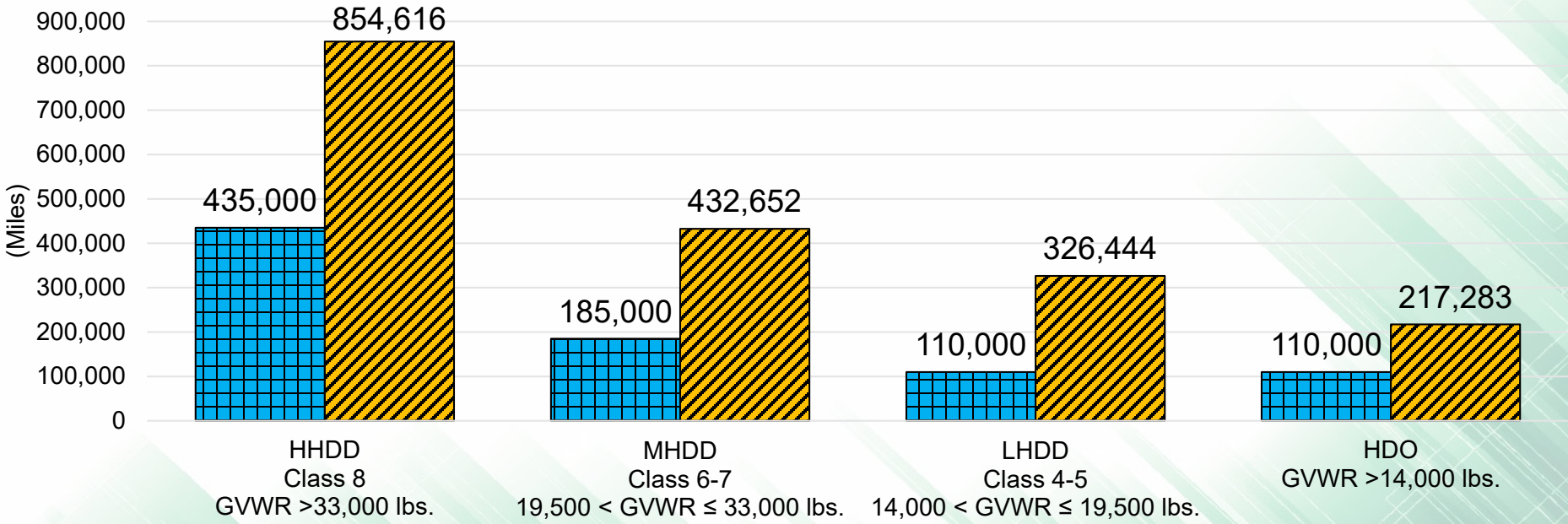
Current Program

Useful Life and Warranty Periods

Vehicle / Engine Category Gross Vehicle Weight Rating (GVWR)	Useful Life Current Periods (Miles)	Warranty Current Periods (Miles)	June 2018 Warranty Amendments Effective 2022 MY (Miles)
Heavy Heavy-Duty Diesel (HHDD) Class 8 GVWR >33,000 lbs.	435,000 10 years / 22,000 hours	100,000 5 years / 3,000 hours	350,000 5 years
Medium Heavy-Duty Diesel (MHDD) Class 6-7 19,500<GVWR ≤ 33,000 lbs.	185,000 10 years	100,000 5 years / 3,000 hours	150,000 5 years
Light Heavy-Duty Diesel (LHDD) Class 4-5 14,000 < GVWR ≤ 19,500 lbs.	110,000 10 years	100,000 5 years / 3,000 hours	110,000 5 years
HD Otto (HDO) GVWR >14,000 lbs.	110,000 10 years	50,000 5 years	N/A

Current Program

Heavy-Duty Useful Life Compared to Engine Rebuild/Replacement Mileages



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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%

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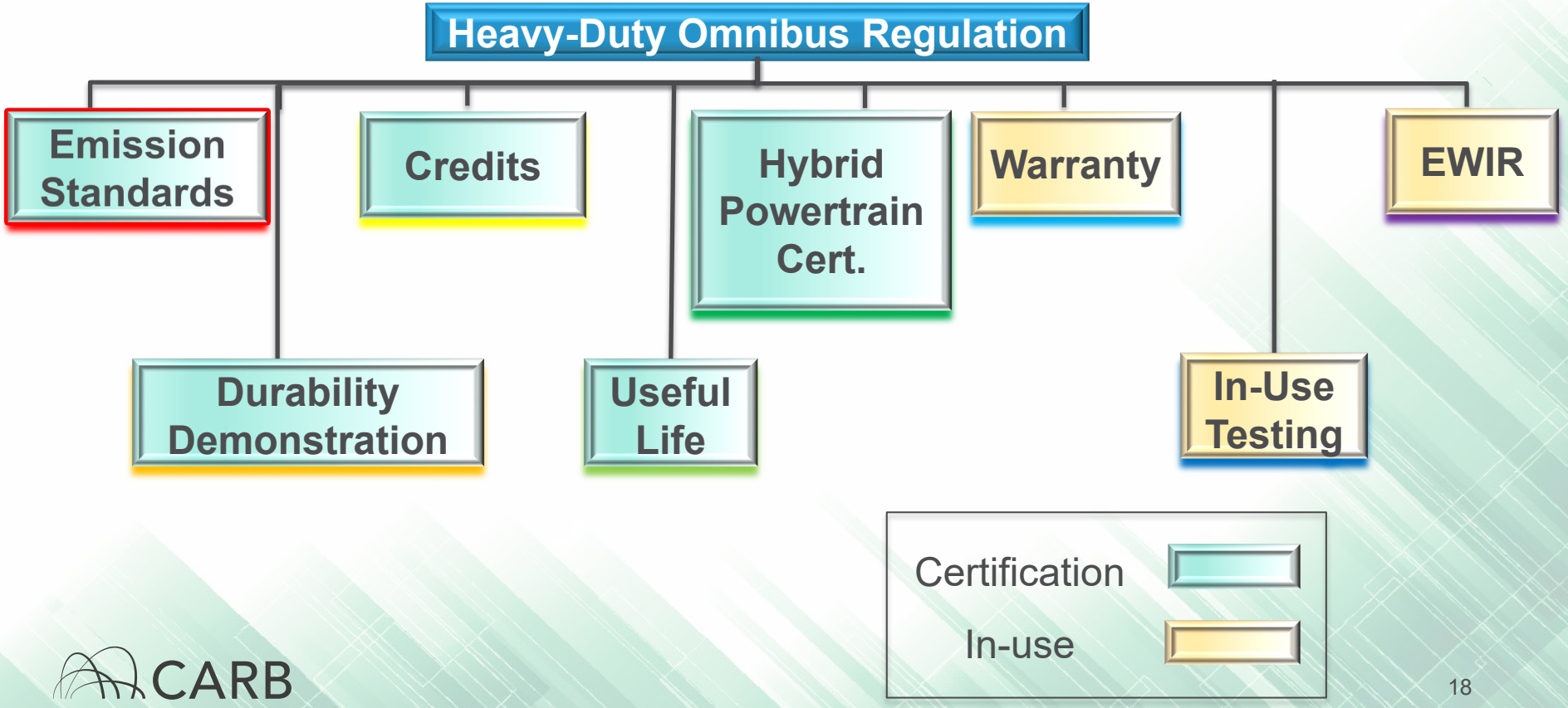
Major Program Elements



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Broad Applicability

- **Medium-duty diesel engines (MDDE)**
  - 10,000 < GVWR ≤ 14,000 pounds
- **Heavy-duty diesel engines (HDDE)**
  - GVWR > 14,000 pounds
- **Medium-duty Otto-cycle engines (MDOE)**
  - 10,000 < GVWR ≤ 14,000 pounds
- **Heavy-duty Otto-cycle engines (HDOE)**
  - GVWR > 14,000 pounds
- **2024 and subsequent MY**

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NOx Emissions Standards 2024 – 2026 MY

MYs	DIESEL				OTTO
	FTP (g/bhp-hr)	RMC (g/bhp-hr)	LLC (g/bhp-hr)	Idling (g/hr)	FTP (g/bhp-hr)
Current	0.20	0.20	---	30	0.20
2024 - 2026	**0.050**	**0.050**	**0.200**	**10**	**0.050**

- **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

MYs	DIESEL				OTTO
	FTP (g/bhp-hr)	RMC (g/bhp-hr)	LLC (g/bhp-hr)	Idling (g/hr)	FTP (g/bhp-hr)
Current	0.20	0.20	---	30	0.20
2024 - 2026	**0.10**	**0.10**	**0.30**	**10**	**0.10**

- **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

	DIESEL ENGINES ≤ 33,000 lbs GVWR			OTTO
MYs	**FTP/RMC** (g/bhp-hr)	**LLC** (g/bhp-hr)	**Idling** (g/hr)	**FTP** (g/bhp-hr)
2027 and later	**0.020**	**0.050**	**5**	**0.020**

- FTP/RMC: 90% below current standard

NOx Emissions Standards 2027 and Subsequent

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

HEAVY-DUTY DIESELS (>33,000 lbs GVWR)					
MY		2027-2030		2031 and subsequent	
Mileage	(miles)	**@435,000**	**@600,000***	**@435,000**	**@800,000***
FTP/RMC	(g/bhp-hr)	**0.020**	**0.035**	**0.020**	**0.040**
LLC	(g/bhp-hr)	**0.050**	**0.090**	**0.050**	**0.100**
Idling	(g/hr)	**5**	**5**	**5**	**5**

***Proposed useful life**

Optional Low NOx Standards

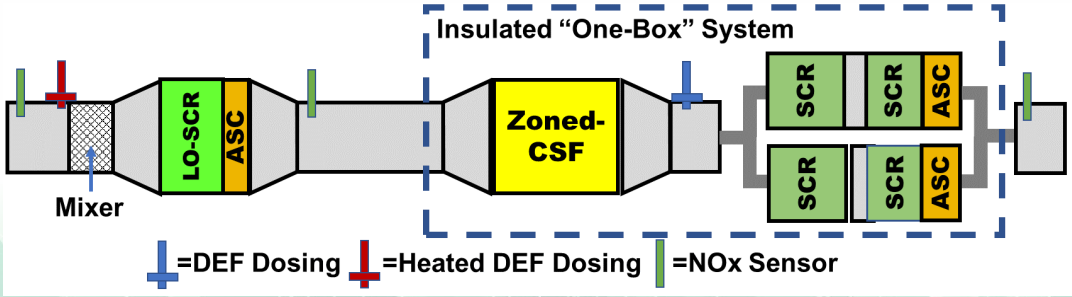
	DIESEL		OTTO
MY	FTP/RMC (g/bhp-hr)	LLC (g/bhp-hr)	FTP (g/bhp-hr)
2024 - 2026	0.020	0.080	0.020
2027 and subsequent	0.010	0.025	0.010

- **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

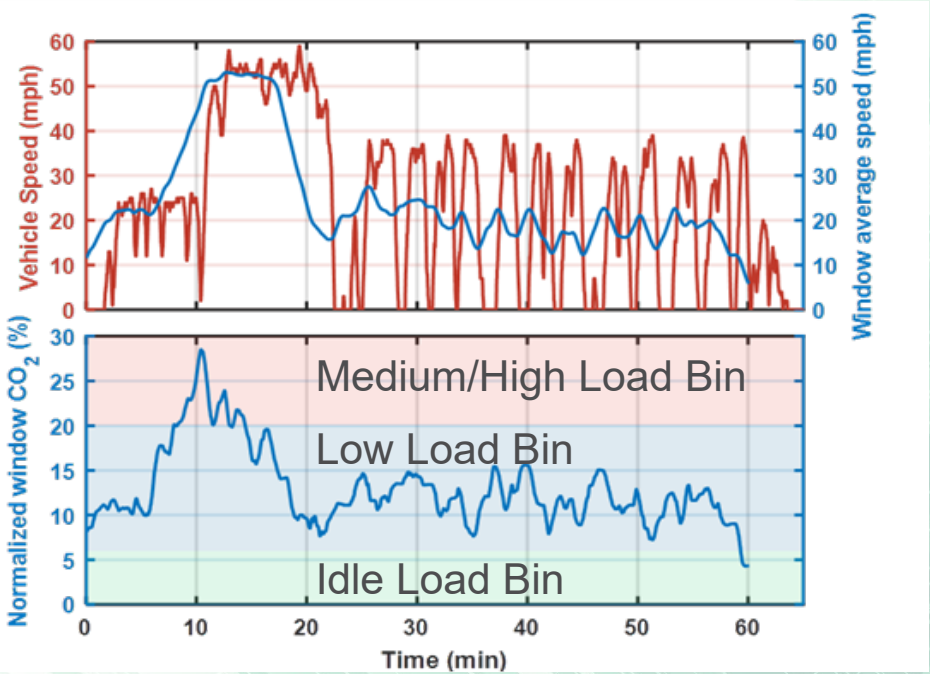


Standards are Technically Feasible (cont'd)

- **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**

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



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Durability Demonstration Program

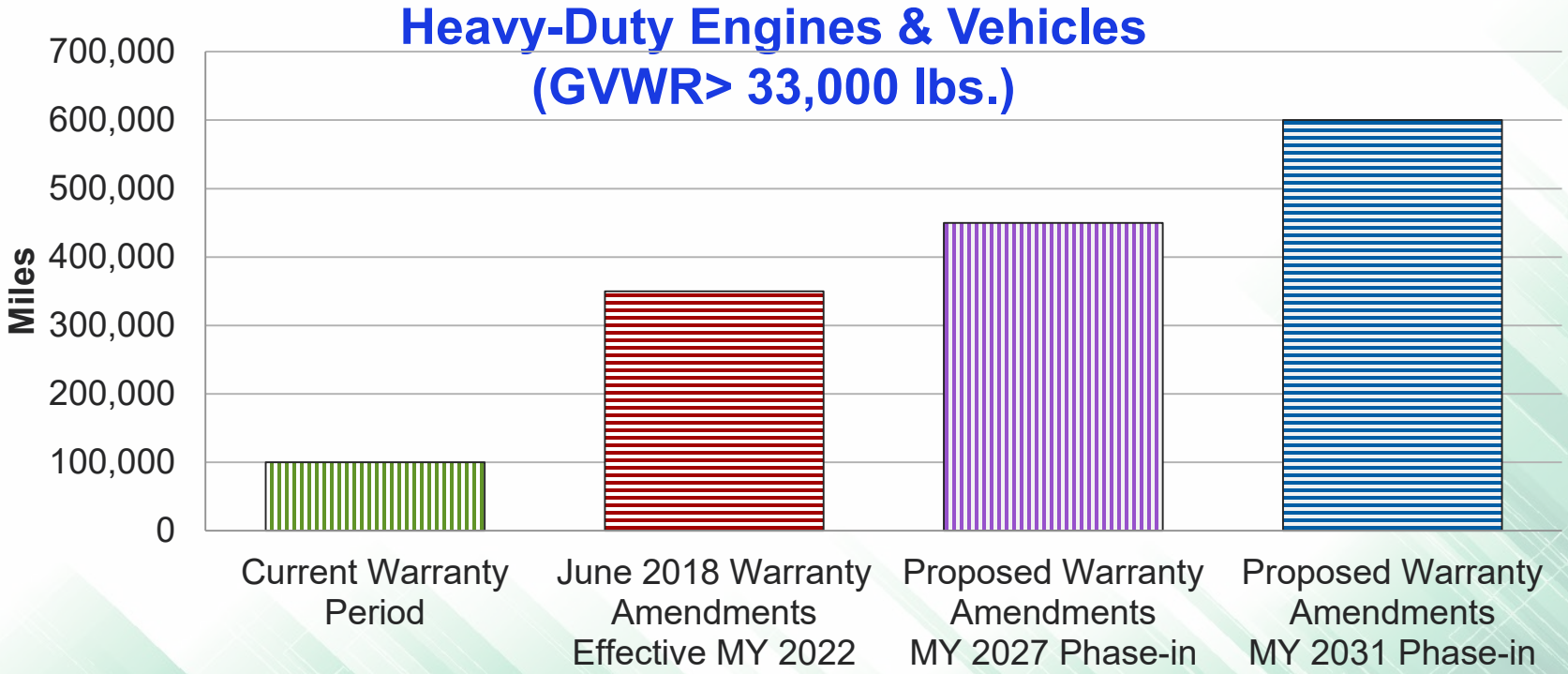
- Applicable to 2024+ MY engines
- Use standardized engine or chassis cycles for aging
- Age engine and aftertreatment system to full useful life
- Allowance for accelerated aftertreatment aging for a portion of useful life
- Accelerated aftertreatment aging requires annual submittal of NOx sensor (REAL)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

Proposed Changes

Useful Life and Warranty Amendments

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

Longer Warranties Required



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
    - 0.44 Mg NOx credit for manufacturer
  - A single clean combustion engine meeting 2031 requirements could generate
    - **1.6** Mg NOx credit for manufacturer
    - 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:

Calendar Year	Statewide	South Coast	San Joaquin Valley
2031	23.2	7.0	5.7
2040	54.5	16.3	13.6
2050	75.9	23.0	19.0

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

Lifetime Health Benefits

Outcome	Avoided Incidents (2024-2050)
Premature Mortality	3,894
Cardiovascular Hospitalizations	616
Acute Respiratory Hospitalizations	735
Emergency Room Visits	1,801

- **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

DIESEL	Lifetime increase in Cost	Percent increase cost of ownership over lifetime
HEAVY-DUTY	$8,841	5.2%
MEDIUM-DUTY	$5,814	5.6%
Population Average	$5,912	5.8%

- 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**

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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

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Staff Recommendation

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