State of California
AIR RESOURCES BOARD

PUBLIC HEARING TO CONSIDER PROPOSED AMENDMENTS TO CALIFORNIA EMISSION CONTROL SYSTEM WARRANTY REGULATIONS AND MAINTENANCE PROVISIONS FOR 2022 AND SUBSEQUENT MODEL YEAR ON-ROAD HEAVY-DUTY DIESEL VEHICLES AND HEAVY-DUTY ENGINES WITH GROSS VEHICLE WEIGHT RATINGS GREATER THAN 14,000 POUNDS AND HEAVY-DUTY DIESEL ENGINES IN SUCH VEHICLES

STAFF REPORT: INITIAL STATEMENT OF REASONS

DATE OF RELEASE: May 8, 2018
SCHEDULED FOR CONSIDERATION: June 28, 2018

Location**:**

California Environmental Protection Agency
Air Resources Board
Coastal Hearing Room
1001 I Street
Sacramento, California 95814

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List of Acronyms and Abbreviations

ABT	Averaging, Banking, and Trading
BAU	Business as Usual
Board	Air Resources Board
CA	California
CARB	California Air Resources Board
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
DEF	Diesel Exhaust Fluid
DPF	Diesel Particulate Filters
DR	(Emission) Deterioration Rate
EA	Environmental Analysis
ECU	Electronic Control Unit
ECM	Electronic Control Module
EGR	Exhaust Gas Recirculation
EMA	Truck and Engine Manufacturers Association
EMFAC	Emission Factors Model – a modeling tool developed by the California Air Resources Board for estimating emissions in California (e.g., EMFAC2017 is the most recent update, adopted in 2017)
EPA	United States Environmental Protection Agency
ER	Emission Rate
EWIR	Emission Warranty Information Reporting
g/bhp-hr	Grams per brake horsepower-hour
GHG	Greenhouse Gas
GSP	Gross State Product
GVWR	Gross Vehicle Weight Rating
HD	Heavy-duty
HD I/M	Heavy-Duty Vehicle Inspection and Maintenance
HDDE	Heavy-duty diesel engine
HDV	Heavy-duty vehicle
HHD	Heavy heavy-duty
HHDV	Heavy heavy-duty vehicle
HSC	Health and Safety Code
ICCT	International Council on Clean Transportation
ISOR	Initial Statement of Reasons
ISR	Sacramento Institute for Social Research
LEV	Low Emission Vehicle
LHD	Light heavy-duty
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MFR	Manufacturer
MHD	Medium heavy-duty
MHDV	Medium heavy-duty vehicle

MI	Miles
MIL	Malfunction Indicator Light
MY	Model year
NHTSA	National Highway Traffic Safety Administration
NOx	Oxides of nitrogen
NTE	Not-To-Exceed
OBD	On-Board Diagnostics
PCU	Powertrain Control Unit
PCM	Powertrain Control Module
PM	Particulate matter
PM2.5	Particles up to 2.5 microns in diameter
PSIP	Periodic Smoke Inspection Program
REMI	Regional Economic Models, Inc.
SCF	Speed Correction Factor
SCR	Selective Catalytic Reduction
SIP	State Implementation Plan
SRIA	Standardized Regulatory Impact Assessment
TAC	Toxic air contaminants
TCU	Transmission Control Unit
TCM	Transmission Control Module
TPD	Tons per day
TM&M	Tampering, mal-maintenance, and malfunctioning
UDDS	Urban Dynamometer Driving Schedule
U.S. EPA	United States Environmental Protection Agency
VMT	Vehicle Miles Traveled
ZMR	Zero-Mile Emission Rate

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EXECUTIVE SUMMARY

A. Why is Staff Proposing Amendments to the Warranty Regulations for 2022 and Subsequent Model Year On-Road Heavy-Duty Diesel Vehicles and Heavy-Duty Diesel Engines, and to the Maintenance Provisions for 2022 and Subsequent Model Year Heavy-Duty Diesel Engines?

a. Emission Reductions are Needed for National Ambient Air Quality Standards (NAAQS) Attainment

Heavy-duty diesel vehicles with a gross vehicle weight rating (GVWR) over 14,000 pounds are one of the largest sources of air pollution in California. They contribute approximately 45 percent of total statewide mobile source oxides of nitrogen (NOx) emissions and 19 percent of mobile source particulate matter (PM 2.5) emissions (CARB, 2017c).

The California Air Resources Board's (CARB) Mobile Source Strategy (CARB, 2016b) will deliver broad environmental and public health benefits, and provide support for necessary efforts to modernize and upgrade California's transportation infrastructure, and enhance system-wide efficiency and mobility options, and promote clean economic growth in the mobile sector. One key measure in the Mobile Source Strategy is the "Lower In-Use Emission Performance Level" measure, which seeks to ensure that in-use heavy-duty vehicles continue to operate at their cleanest possible level. That measure envisions amendments to several existing regulatory programs applicable to in-use heavy-duty diesel vehicles, including the Periodic Smoke Inspection and Heavy-Duty Vehicle Inspection Programs, adopting a comprehensive inspection and maintenance program for heavy-duty vehicles, and extending the current warranty provisions for heavy-duty vehicles and heavy-duty engines. The proposed amendments to the existing warranty periods for new 2022 and subsequent model year heavy-duty vehicles and for new 2022 and subsequent model year heavy-duty diesel engines described in this staff report are an element of CARB's Lower In-Use Emission Performance Level measure. The discussion that follows provides a more detailed description of how and why lengthening the warranty periods would result in the anticipated emission benefits.

Since the 2007 model year, all new California certified on-road heavy-duty diesel engines have been subject to stringent PM and NOx emission standards (13 CCR 1956.8), which manufacturers have met by equipping new heavy-duty vehicle engines with diesel particulate filters (DPF) for control of PM, and Exhaust Gas Recirculation (EGR) systems and selective catalytic reduction (SCR) systems (beginning with the 2010 model year) for control of NOx. Modern diesel exhaust aftertreatment systems reduce emissions by more than 95 to 99 percent (MECA, 2007), therefore if they fail, an individual engine's emissions can dramatically increase. It is therefore crucial that these emission control systems continue to function as designed throughout the engine's life

to ensure emissions remain low. The California State Implementation Plan (SIP) is relying on the emission benefits associated with the current emission standards applicable to 2007 and subsequent model year on-road heavy-duty engines to attain the federal ambient air quality standards in California.

b. Current Warranty Periods are Insufficient

On-road heavy-duty diesel vehicles and the engines used in such vehicles are currently required to be covered by only a 5 year, 100,000 mile, or 3,000 hour emissions warranty period, whichever first occurs. This requirement has not substantially changed in California in almost 40 years. Emissions warranties are intended to provide a level of assurance to owners that their vehicles, engines, and associated emission control systems are free from defects in materials and workmanship that would cause warranted parts to not be identical to the parts as described in the manufacturers' applications for certification. If such defects do occur during the warranty period, the manufacturers are liable for fixing them.

The current warranty periods are disproportionate to the actual service lives of modern on-road heavy-duty vehicles, and engines, which can operate for as long as 1.2 million miles. In fact, many line haul trucks fall out of warranty within the first year of ownership because they are driven in excess of 100,000 miles per year. Without a warranty period sufficient to help ensure that a vehicle's or an engine's emission control performance will remain effective and durable throughout the applicable useful life,[1] Californians may be subject to increased emissions and associated adverse health impacts. Figure ES-1 illustrates the differences between current warranty periods, useful life, and the typical service life of the various classes of heavy-duty vehicles (see Table II-4 in this staff report for the actual service life values depicted in the figure). The "B10 life" and "B50 life" statistics are provided by manufacturers as a gauge to predict when 10 percent or 50 percent, respectively, of an engine family will need a major overhaul (International Trucks, 2016; Diesel Hub, 2018a; Fletcher & Lyden, 2009). As shown, engines currently operate far longer than their emissions warranty periods.

[1] In the emission certification process, "useful life" means the period during which the engine is required to demonstrate compliance with applicable emission standards.

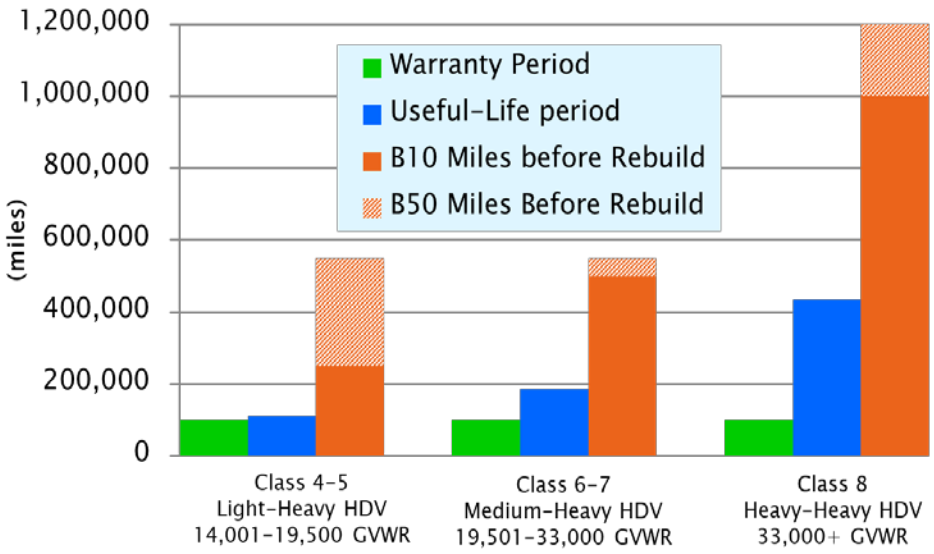

Figure ES-1. Warranty vs. Real World Longevity

c. Longer Warranty Periods Would Incentivize Timely Repairs

Staff estimates that, once they are beyond the warranty period, only 30 percent of heavy-duty vehicle and engine owners currently repair emission-related problems that do not significantly impact a vehicle's fuel economy or performance. Lengthening the warranty period for heavy-duty vehicles and heavy-duty engines would reduce emissions by incentivizing the repair of malfunctioning emission-related components that vehicle owners would not otherwise repair if they had to pay out-of-pocket. Staff estimates the proposed amendments would achieve a 0.75 tons per day reduction in statewide NOx by 2030, as well as a 16 pounds per day reduction in PM2.5. Further, in light of the crucial need to obtain any NOx reductions in both the San Joaquin Valley and South Coast Air Basins, staff estimates that the proposed amendments would reduce NOx in the San Joaquin Valley Air Basin and South Coast Air Basin by 0.18 and 0.24 tons per day, respectively, by 2030.

Longer heavy-duty vehicle warranty periods may also reduce incidences of tampering and mal-maintenance. There would be little incentive for a vehicle owner to bypass a DPF or SCR, for example, if the manufacturer were responsible for paying for repairs. Finally, with longer warranties, vehicle owners would also have more of an incentive to perform scheduled maintenance on time so as not to void their warranty due to delaying required routine maintenance, such as an oil change or filter replacement.

d. Longer Warranties Would Help Address Current Problems with Inadequate Durability of Emission Control Components and Systems

Warranty claims data obtained by CARB in recent years indicate that durability of emission control components and systems is a concern. Some engine models are experiencing warranty claims of over 100 percent[2] for turbochargers, and 40 percent for DPFs, fuel injectors, and EGR components. For the most recent model year for which CARB has received five full years of data, expensive components such as turbochargers and EGR systems, which can have a catastrophic effect on emissions, have warranty claim rates over 10 percent of total vehicle sales.

As further evidence of inadequate durability, two-thirds of the vehicles in CARB's ongoing New Heavy-Duty Vehicle In-Use Compliance Testing Program have exceeded "Not-To-Exceed" (NTE) testing thresholds. These exceedances occurred outside of applicable warranty periods, but still within the useful lives of the engines. In fact, some of these NTE testing results were as high as 4.5 g/bhp-hr NOx (i.e., over 22 times the applicable NOx emission certification standard). Furthermore, data from CARB's ongoing Truck and Bus In-Use Surveillance Program show two-thirds of heavy-duty vehicles exceed equivalent NOx emission certification standards based on Urban Dynamometer Driving Schedule (UDDS)[3] testing, some with levels multiple times the applicable NOx standard.

In a recent survey[4] of over 500 owner/operators of 2007 through 2017 model year California heavy-duty vehicles, respondents reported over $2,200 per vehicle (on average) in emission-related repairs that were not covered under warranty, and over $1,500 per vehicle (on average) in lost revenue due to downtime from those same repairs (ISR, 2017). The average cost of downtime because of all repairs per vehicle was over $3,000. These expenditures are indicative of costly durability issues. The duration of vehicle downtime from repairs was significant for many of these respondents, with over 15 percent of them experiencing downtime events of over a month per vehicle (on average).

The warranty, NTE, in-use surveillance, and survey data described above indicate that heavy-duty engines, vehicles, and emission control systems are not remaining as durable in the real world as intended, and that emissions are therefore not as well

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[2] A failure rate of 100 percent means that the number of warranty claims reported for an emission-related component is equal to the number of engines in the engine family for which the claims have been reported. A failure rate in excess of 100 percent means that the number of warranty claims reported for an emission-related component is greater than the number of engines in the engine family for which the claims have been reported.

[3] The "UDDS" was developed for chassis dynamometer testing of heavy-duty vehicles and was the basis for the development of the Federal Test Procedure's (FTP) transient engine dynamometer cycle, which is used for engine certification testing.

[4] Survey data collected between February 2017 and November 2017.

controlled as they should be. Lengthening the warranty periods is one important step to mitigate these durability issues, by encouraging manufacturers to produce more durable products and by helping ensure emission-related repairs are made in a timely manner. Lengthened warranty periods may encourage manufacturers to develop more durable components, especially because the cost of frequent repairs will likely outweigh the cost of procuring and installing more durable parts in new engines. More durable components would translate into less vehicle downtime, and less loss of revenue to vehicle operators who depend on properly operating vehicles for their livelihoods. Overall, either through ensuring the timely replacement of malfunctioning emission-related components, or through encouraging the redesign of more durable components, the proposed amendments would help ensure that emissions from heavy-duty vehicles and engines are controlled and will remain at or below applicable emission standards for longer periods of time.

e. Longer Warranties Would Protect Consumers from Excessive Costs

A by-product of staff's proposal for lengthening warranty periods is that it would help keep heavy-duty vehicle owners from paying excessive costs to replace emission-related components that already should remain durable throughout the useful life of the engine. In particular, lengthened warranty periods will be needed in the near-term to help keep heavy-duty vehicle owners, whose vehicles are still under warranty, from having to pay out-of-pocket for future repair costs under the requirements of CARB's planned amendments to the Periodic Smoke Inspection Program (PSIP) and Heavy-duty Vehicle Inspection Program (HDVIP) (CARB, 2018g), and any potential future California heavy-duty vehicle inspection and maintenance (HD I/M) program. So while purchasers would probably pay more when purchasing their new vehicles and engines, many would receive a cost savings by virtue of more repairs being covered under warranty.

Without a lengthened warranty period to help reduce defects that could cause emissions to exceed allowable levels, more vehicle owners would be forced to pay for repairs detected by CARB's HDVIP and/or PSIP programs early in vehicles' lives. In staff's view, this would not be appropriate, especially for an owner who properly maintains their vehicle and hence expects their vehicle to perform as designed throughout its useful life.

B. What Regulatory Amendments are being Proposed by Staff?

a. Lengthened Warranty Periods

Staff is proposing that the minimum emission warranties for heavy-duty diesel vehicles with a GVWR greater than 14,000 pounds and the heavy-duty engines powering such vehicles be lengthened as shown in Table ES-1.

Table ES-1. Current and Proposed Minimum Warranty Periods

HEAVY-DUTY CATEGORY	CURRENT WARRANTY (miles)[5]	PROPOSED WARRANTY (miles)
	Diesel	Diesel
Heavy Heavy-Duty Engine	100,000 / 5 years / 3,000 hours	350,000 / 5 years
Medium Heavy-Duty Engine	100,000 / 5 years / 3,000 hours	150,000 / 5 years
Light Heavy-Duty Engine	100,000 / 5 years / 3,000 hours	110,000 / 5 years

Staff initially considered lengthening the warranty periods to coincide with the actual operational periods of modern heavy-duty trucks ,which can approach one million miles. However, staff is now proposing that the Board approve for adoption the lengthened warranty periods set forth in Table ES-1. Staff may subsequently propose, as part of CARB's comprehensive Low NOx rulemaking scheduled for Board consideration in late 2019, extending both useful life periods and warranty periods for heavy-duty vehicles with heavy heavy-duty engines. (See Chapter III, section B, for further discussion of this proposed approach).

The proposed minimum warranties would apply to new 2022 and subsequent model year California certified and registered heavy-duty vehicles and engines; they would not apply retroactively to any in-use heavy-duty vehicles or engines. Federal-only certified vehicles operating in California would also not be subject to the amended requirements. The proposed lengthened warranty period amendments would not apply to vehicles propelled by battery electric systems, fuel cells, hybrid-electric systems, or other hybrid systems.

Warranty coverage would remain applicable to the vehicle, but the length of the new warranty periods under staff's proposal would be based on the "primary intended service class" of the engine installed in the vehicle. (40 CFR 1036.140). Typically, heavy-duty engine and heavy-duty vehicle combinations[6] are straightforward, that is, a heavy heavy-duty (HHD) engine is installed in a Class 8 heavy-duty vehicle greater than 33,000 pounds, for which the warranty period under staff's proposal would be 5 years/350,000 miles. However, there are instances where a medium heavy-duty (MHD) engine is installed in a Class 8 heavy-duty vehicle, such as when an engine

[5] Manufacturers are currently required to warrant heavy-duty vehicles and engines for a period of 100,000 miles, 5 years, or 3,000 hours, whichever comes first. Under the proposal, manufacturers would be required to warrant heavy-duty vehicles and engines for a period of 5 years, or the mileage indicated in the right-hand column of Table ES-1, whichever comes first.

[6] HHD engines are typically installed in Class 8 vehicles with a GVWR greater than 33,000 pounds, MHD engines are typically installed in Class 6-7 vehicles with a GVWR between 19,501 to 33,000 pounds, and LHD engines are typically installed in Class 4-5 vehicles with a GVWR between 14,001 to 19,500 pounds.

downsizing strategy is employed by the manufacturer to enhance fuel efficiency and reduce emissions. In this case, the warranty period under staff's proposal would be limited to the MHD engine requirement of 5 years/150,000 miles. The 150,000 mile warranty period would be applicable because the warranty period is dependent on the certified primary intended service class of the MHD engine.

b. Elimination of the 3,000 Engine Operating Hour Warranty Limit

As shown in Table ES-1, manufacturers are currently required to warrant heavy-duty vehicles and heavy-duty engines for a period of 100,000 miles, 5 years, or 3,000 hours, whichever comes first. The 3,000 hour provision was intended to apply to vehicles with engines that idle for many hours or that are driven very few miles at low speeds. Under the current warranty provisions, a manufacturer is only required to honor warranty obligations up to 3,000 hours regardless of age or miles travelled. Under staff's proposal, the 3,000 hour limit would no longer be applicable under California's amended warranty period provisions for heavy-duty vehicles. This elimination would align with existing federal requirements (i.e., the 3,000 hour provision does not exist in federal heavy-duty warranty regulations (40 CFR 86.004-2).

c. Increasing the Minimum Allowable Maintenance Intervals

Staff is also proposing to increase the minimum scheduled maintenance intervals for heavy-duty diesel engines to reflect existing service intervals. Under California's existing regulations, the majority of minimum scheduled maintenance intervals are equal to or exceed the 100,000 mile warranty period; therefore, the existing maintenance intervals have no practical effect on current warranty periods. However, under staff's proposal, the lengthened warranty periods would typically exceed the current minimum allowable maintenance intervals by significant margins, raising the potential that the existing maintenance intervals could indirectly shorten warranty periods and decrease the projected emission benefits from this rulemaking.

To address this issue, staff is proposing to update the allowable minimum repair and replacement maintenance intervals in section 86.004-25, of the "California On-Road Heavy-Duty Diesel Test Procedures," based on the least stringent (shortest) interval currently designated by any certifying manufacturer for its emission-related components. Staff reviewed every manufacturer's owners manuals for the 2016 model year and compiled the results for all scheduled maintenance resulting in staff's proposal in Table ES-2 (See Chapter II, section 7; and Chapter III, section A.3, of this staff report for more information on current and proposed maintenance intervals). When no replacement interval was designated by the manufacturer in its owners manuals, staff proposed the new proposed minimum replacement interval as the applicable maintenance interval. By a large margin, most manufacturers currently do not schedule repairs or replacement through useful life of the engine for the majority of emission-related components. It is important to note that staff is proposing to change the minimum maintenance intervals only for components that the manufacturer schedules

to be repaired or replaced. The minimum maintenance intervals for cleaning and adjustments would remain unchanged.

13 CCR 2036(d)(3) states that warranty coverage ends after the first scheduled replacement of any emission-related component, even if the warranty period for that component has not yet been exceeded. Under the existing 100,000 mile warranty requirement, 13 CCR 2036(d)(3) has little practical effect because the minimum allowable maintenance intervals for almost all emission-related components are at least 100,000 miles. Therefore, manufacturers are generally unable to require the replacement of an emission-related component during the warranty period.

However, staff is proposing to lengthen the warranty period for heavy-duty diesel vehicles well beyond 100,000 miles; therefore, without amending this provision, any replacement maintenance scheduled at 100,000 miles would effectively shorten the lengthened warranty period back to the original 100,000 miles. Consequently, increasing the warranty period would provide no additional incentive to vehicle owners to seek more timely repairs because they would still have to pay after the first replacement interval for a replaced part.

Staff is proposing to amend this provision to specify that any part replaced during the lengthened warranty period would continue to remain covered throughout the remainder of the warranty period. This action would align California's warranty requirements regarding the continuation of warranty coverage after scheduled maintenance with those of the U.S. Environmental Protection Agency (U.S. EPA).

a. Special Provisions for Turbochargers and EGR Systems

As mentioned in section A.d, above, warranty claims data suggest that turbochargers and EGR systems do not remain adequately durable in-use (despite turbochargers being designed to last for a million miles in-use). Given the relatively high cost of turbochargers and EGR systems, and the concern that they can negatively impact emissions, and damage downstream components when they malfunction, it is important that these devices either last the useful life of the engine or be replaced at the

Table ES-2. Proposed Minimum Repair / Replacement Intervals

Component or System	Minimum Repair / Replacement Interval		
	Light Heavy-Duty Diesel Engine **14,000 lbs. < GVWR ≤ 19,500 lbs.**	**Medium Heavy-Duty Diesel Engine** **19,500 lbs. < GVWR ≤ 33,000 lbs.**	**Heavy Heavy-Duty Diesel Engine** **GVWR > 33,000 lbs.**
Exhaust Gas Recirculation (EGR) System (valves & cooler - not including hoses)	Not Replaceable[1]	Not Replaceable[1]	Not Replaceable[1]
Exhaust Gas Recirculation (EGR) System (other than valves & cooler)	110,000 miles or 3 years	185,000 miles	435,000 miles
Crankcase Ventilation System	50,000 miles	60,000 miles or 2,000 hours or 1 year	60,000 miles or 2,000 hours or 1 year
Diesel Exhaust Fluid (DEF) Filter	110,000 miles or 2 years	125,000 miles or 3,000 hours or 10 years	125,000 miles or 3,000 hours
Fuel Injectors	110,000 miles	185,000 miles	435,000 miles
Turbochargers	Not Replaceable[1]	Not Replaceable[1]	Not Replaceable[1]
Electronic Control Unit, Sensors, and Actuators	100,000 miles or 3,000 hours	150,000 miles or 4,500 hours	150,000 miles or 4,500 hours or 5 years
Diesel Particulate Filter System (element only)	Not Replaceable[1]	Not Replaceable[1]	Not Replaceable[1]
Diesel Particulate Filter System (other than element)	110,000 miles	185,000 miles or 3 years	435,000 miles or 3 years
Catalytic Converter (bed only)	Not Replaceable[1]	Not Replaceable[1]	Not Replaceable[1]
Catalytic Converter (other than catalyst bed)	110,000 miles	185,000 miles	435,000 miles
Any other add-on or new technology emission-related component or system whose primary purpose is to reduce emissions or whose failure will significantly degrade emissions control	110,000 miles or 3,300 hours[2]	185,000 miles or 5,550 hours[2]	435,000 miles or 13,500 hours[2]

1. For components or systems designated in the table as “Not Replaceable,” manufacturers shall not schedule any repair / replacement maintenance intervals throughout the applicable useful life of the heavy-duty diesel engine except as noted in 86.004-25 (b)(7)(i), of the “California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles.”
2. Manufacturers may request more frequent repair / replacement maintenance intervals for add-on or new technology emission-related components provided that the manufacturer demonstrates to the Executive Officer’s satisfaction that such intervals are technologically necessary and appropriate.

manufacturer's cost. This requirement would be similar to existing U.S. EPA and CARB requirements for DPF elements and SCR substrates.[7]

b. Clarifying the Link Between Heavy-Duty Warranty and HD OBD

All on-road heavy-duty diesel vehicles and engines since the 2013 model year have been equipped with a heavy-duty on-board diagnostic (HD OBD) system that continuously monitors the vehicle for any malfunction that can affect emissions. When such a malfunction is discovered, the HD OBD system notifies the vehicle operator by illuminating a Malfunction Indicator Light (MIL), and stores diagnostic trouble codes that specifically identify the malfunction.

Some of the benefits of HD OBD include rapidly identifying emission malfunctions, eliminating unnecessary repairs by specifically diagnosing the source of the malfunction, reducing the costs of repairs and inspections, and ensuring that emission controls continue to reduce emissions in-use as designed.

California regulations currently provide no formal regulatory link between HD OBD MIL illumination and on-road heavy-duty vehicle warranty coverage, although this link exists currently for light-duty vehicles, as codified in Section 2037(b)(2) of Title 13, of the California Code of Regulations (CCR).

Staff proposes to formally clarify the link between HD OBD and heavy-duty warranty by specifying, that "any defects in materials or workmanship that cause the vehicle's OBD MIL to illuminate" would be considered a warrantable condition. This provision is analogous to 13 CCR 2037(b)(2) for light-duty vehicles. Many manufacturers already submit HD OBD reports to CARB in conjunction with the required Emissions Warranty Information Reporting data.

Other minor amendments that staff is proposing include clarify the definition of a warranted part in the newly created subsection 13 CCR 2035(c)(2)(D) to include "any part that can affect emissions." This is already the case for light-duty vehicles per 13 CCR 2035(c)(2)(B). This clarification is supported by the definition of an "emissions-related part" in 13 CCR 1900(b)(3), which is currently applicable to heavy-duty vehicles and includes the language in question.

Staff also proposes to clarify the language in 13 CCR 2040 to be consistent with the requirement in 13 CCR 2036(d)(2) that requires manufacturers to pay to replace defective components discovered during inspections during the warranty period. Section 2040 does not currently differentiate the liability between manufacturers and vehicle owners in this case.

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[7] 40 CFR 86.004-25(b)(4)(iii)(D) and (F); 13 CCR 86.004-25(b)(4)(iii)(D) and (F), of the "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles."

C. What Benefits Would Result from the Proposed Amendments?

Staff estimates the proposed amendments would result in a statewide reduction in NOx emissions of 0.75 tons per day in the year 2030, as well as a small reduction in PM2.5 emissions (16 pounds per day in 2030).

The reduction of NOx and diesel PM emissions would lead to health benefits. Reduction of diesel PM emissions has been directly correlated with a reduction in the risk of premature deaths and hospital visits, especially for sensitive groups such as children, elderly, and people with chronic heart or lung disease. Reducing NOx emissions is important to reduce ozone levels. Exposure to ozone results in premature aging of the lungs and chronic respiratory illnesses such as bronchitis, asthma, and emphysema. Health benefits were estimated for the years 2022 to 2040, as shown in Table ES-3.

Table ES-3. Cumulative Statewide Avoided Health Impacts from 2022 to 2040 due to the Proposed Amendments

	Premature Mortalities Avoided	ER Visits Avoided	Hospitalizations Avoided
Statewide	40 (31 – 49)*	17 (11 – 23)*	6 (1 – 14)*

*Values in parentheses represent the 95 percent confidence interval.

D. What Costs Would the Proposed Amendments Impose?

Staff determined the overall net cost of the proposed amendments by subtracting estimated statewide repair cost savings from estimated statewide costs. Table ES-4 shows total estimated net regulatory costs. Total regulatory costs would range from $34,600,000 to $92,100,000, depending on how much profit manufacturers add to the cost of warranty.

Table ES-4. Total Net Regulatory Costs due to the Proposed Amendments

Minimum Net Regulatory Costs (Combined NOx and PM)	Maximum Net Regulatory Costs (Combined NOx and PM)
$34,600,000	$92,100,000

Staff expects that manufacturers would at least make up for the costs of providing warranties by marking up the initial purchase price of vehicles and engines. Staff expects that warranty packages could also be marked up to include a profit, potentially by as much as 45 percent (Fullbay, 2018). Although the vehicle and engine purchasers

would likely experience an increase in capital costs at the time of purchase, many would also experience a cost savings resulting from additional repairs being covered under warranty. Table ES-5 indicates the total net increase in costs for the vehicle and engine purchasers, including capital costs and repair savings throughout the proposed warranty period.

To determine the overall cost-effectiveness of the proposed warranty amendments, staff estimated the total net regulatory costs for each pollutant by subtracting repair cost savings from the estimated minimum and maximum statewide costs. Dividing the total costs by the total NOx and PM emission benefits yields a cost-effectiveness range of $2.97 to $7.91 per pound of NOx and $18.35 to $48.81 per pound of PM reduced for the proposed amendments. These cost-effectiveness estimates are well within the range of previous regulations adopted by CARB. For example, CARB's public fleets rule (CARB, 2005a) resulted in a cost-effectiveness of $11.47 per pound of NOx and $159 per pound of PM, and CARB's Drayage Truck Regulation (CARB, 2007) resulted in a cost-effectiveness of $6 to $8 per pound of NOx and $57 to $77 per pound of PM.

Table ES-5. Estimated Increase in Costs on a Per-Vehicle Basis for the End User as a Result of the Proposed Warranty Amendments

Vehicle Category[8]	Minimum Net Increase in Costs	Maximum Net Increase in Costs
HHDV	$45	$173
MHDV	$82	$315
LHDV	$28	$108

E. How does Staff's Proposal Compare to U.S. EPA Regulations?

Staff's proposal would lengthen the mileage warranty periods for heavy-duty vehicles to 350,000 miles for vehicles equipped with heavy heavy-duty engines, 150,000 miles for vehicles equipped with medium heavy-duty engines, and 110,000 miles for vehicles with light heavy-duty engines. U.S. EPA heavy-duty vehicle warranty requirements would remain less stringent at 100,000 miles. Staff is also proposing to amend the minimum allowable maintenance interval requirements for scheduling repairs and replacements of emission-related components. This is a necessary complement to ensure that staff's proposed lengthened warranty periods will realize their projected emission reduction benefits. U.S. EPA may align with these more stringent warranty and maintenance amendments in the future.

[8]Medium heavy-duty vehicle (MHDV) means a vehicle with an engine with medium-duty certified primary intended service class. Heavy heavy-duty vehicle (HHDV) means a vehicle with an engine with heavy-duty certified primary intended service class.

F. How Would Staff's Proposal Impact Stakeholders?

a. Impacts to Engine and Vehicle Manufacturers

The proposed amendments would require engine and vehicle manufacturers to provide longer emission-related warranty periods for new 2022 and subsequent model year California certified heavy-duty diesel vehicles and heavy-duty diesel engines. Manufacturers would not be allowed to sell vehicles with shorter than the required minimum warranty periods in California.

Engine manufacturers would be required to pay for the repair or replacement of any emission-related part not scheduled for maintenance throughout the amended warranty periods. It is expected that engine manufacturers would increase the cost of their engines to accommodate the longer emissions warranty periods required by staff's proposal. This increase in engine costs would likely result in an increase in vehicle cost as well. The engine manufacturer is responsible for resolving any warranty-related noncompliance issues with CARB, and it is the engine manufacturer who is responsible for reporting warranty claims under CARB's Emission Warranty Information and Reporting program.

b. Impacts to Engine and Vehicle Owners

As pointed out in subsection D. above, staff expects that heavy-duty vehicle and engine purchasers would experience increased capital costs at the time of purchase due to the proposed amendments. Engine and vehicle owners may have to pay a slightly higher purchase price for new vehicles and engines that comply with staff's proposed lengthened warranty period requirements as manufacturers will likely pass on their increased costs to the purchaser. However, the proposed amendments would also benefit heavy-duty vehicle and engine owners by reducing their out-of-pocket costs at the time of repair. Furthermore, staff's proposal would reduce heavy-duty vehicle owners' potential costs from future California PSIP and HD I/M requirements, which would avoid the unfairness of vehicle owners being forced to pay for repairs on engines and emission control systems that should be designed and built to be durable throughout useful life. Finally, to the extent manufacturers make parts more durable as a result of the proposed amendments, vehicle owners would also benefit from reduced repair downtime.

I. INTRODUCTION AND BACKGROUND

This report presents staff's proposal for amending the warranty provisions for on-road heavy-duty diesel vehicles with a gross vehicle weight rating (GVWR) over 14,000 pounds and the heavy-duty diesel engines in such vehicles. Chapter I presents an introduction to California's regulatory authority for adopting the proposed warranty amendments, why emission warranties are needed, and why current warranty periods need to be lengthened, as well as some descriptions about the technologies and strategies manufacturers have used to meet the increasingly stringent emission standards, the currently required warranty periods and currently applicable allowed maintenance intervals; and current heavy-duty on-board diagnostic requirements. Chapter II describes the specific problems that the proposal will address. Chapter III presents staff's proposed solutions to the specific problems. Chapter IV discusses the specific purpose and rationale for staff's determination that each proposed amendment is reasonably necessary to carry out the purposes as well as address the problems described. Chapter V details the anticipated benefits from the proposal, while Chapter VI provides a summary of the expected air quality emission benefits associated with the proposed warranty amendments. Chapter VII presents an environmental analysis of the proposal, and Chapter VIII explains the environmental justice aspects. Chapter IX includes the proposal's economic impact analysis/assessment, including a cost effectiveness determination, and its fiscal impacts. Chapter X contains an evaluation of the regulatory alternatives. Chapter XI presents the justification for the adoption of regulations that differ from federal regulations. Chapter XII includes a description of the public process used for developing the proposal. Chapter XIII indicates the references for sources of information used to develop the proposal. In addition, Appendix A contains the proposed regulation orders; Appendix B includes the proposed amendments to the applicable test procedures; Appendix C includes details on the economic analysis; Appendix D elaborates on the public process for the rulemaking; Appendix E presents technical details on the failure modes of EGR systems and turbochargers; Appendix F explains the emissions inventory modeling of the estimated emission benefits; Appendix G provides a description of the estimated health benefits analysis; Appendix H describes the heavy-duty vehicle warranty survey; Appendix I contains the summary and rationale of the proposed amendments; and lastly, Appendix J provides a real-world example of current manufacturer-specified minimum maintenance intervals outlined in a vehicle owners manual.

A. Introduction

This report presents the California Air Resources Board (CARB or Board) staff's proposed amendments to the warranty and maintenance provisions applicable to on-road heavy-duty diesel vehicles with a gross vehicle weight rating (GVWR) over 14,000 pounds and the heavy-duty diesel engines in such vehicles. This action serves as one of the elements of a key measure in CARB's 2016 Mobile Source Strategy (CARB, 2016b), the Lower In-Use Emission Performance Level measure. In general warranty

applies to both heavy-duty vehicles and heavy-duty engines. Thus, the proposed amendments apply to both.[9]

1. Regulatory Authority for Adopting the Proposed Amendments

CARB has been granted both broad and specific authority under the Health and Safety Code (HSC) to adopt the proposed amendments. The California Legislature has designated CARB as the state agency that is "charged with coordinating efforts to attain and maintain ambient air quality standards, to conduct research into the causes of and solution to air pollution, and to systematically attack the serious problem caused by motor vehicles, which is the major source of air pollution in many areas of the State" (HSC 39003), and has authorized CARB to adopt standards, rules and regulations needed to properly execute the powers and duties granted to and imposed on CARB by law (HSC 39600 and 39601). HSC 43013 and 43018 broadly authorize and require CARB to achieve the maximum feasible and cost-effective emission reductions from motor vehicles, including the adoption of regulations that will reduce in-use vehicle emissions by improving emission system durability and performance (HSC 43018(c)(2)), and that will expeditiously reduce emissions of nitrogen oxides from diesel vehicles, "which significantly contribute to air pollution problems" (HSC 43013(h)).

Regarding CARB's specific authority to impose warranty requirements applicable to heavy-duty vehicles and engines, HSC 43205.5 requires manufacturers of 1990 and subsequent model year motor vehicles and motor vehicle engines to warrant that such vehicles and engines are (1) designed, built, and equipped to conform with applicable emission standards for a period of use determined by CARB, and (2) are free from defects in materials and workmanship which cause such vehicles and engines to fail to conform with applicable requirements for up to the period of use determined by CARB.

2. The Need for Heavy-Duty Engine and Vehicle Emissions Warranties

CARB has adopted emission-related regulations applicable to new California certified on-road heavy-duty engines and vehicles that require such engines and vehicles to meet applicable emission standards for the "useful life" of the engine (13 CCR 1956.8, 1971, and 1976). However, as an engine ages, its engine-out emissions tend to increase due to many factors, including normal wear. Manufacturers must account for this deterioration in emission performance when they initially design engines. To certify an engine, an engine manufacturer establishes an engine's durability by conducting durability testing of the engine with all the emission control systems installed and operating, including any exhaust aftertreatment devices (e.g., selective catalytic reduction [SCR] for oxides of nitrogen [NOx] control, and a diesel particulate filter [DPF] for particulate matter [PM] control). The durability tests are intended to demonstrate that the engine and its associated emission control systems are sufficiently durable to comply with the emission standards over the engine's full useful life. However, the

[9] For the purposes of clarity, reference to "vehicle" in this report includes the entire vehicle including the engine and the chassis, unless specifically stated otherwise.

durability demonstration constitutes an idealized simulation of reality, because it only replicates the situation when the vehicle, engine, and aftertreatment devices are well-maintained, and are not tampered.

From the vehicle owner's viewpoint, the inclusion of a warranty provides a level of assurance that the engine and its associated emission control system are free from defects in materials and workmanship and will perform as required. From an air quality regulatory agency perspective, emission-related warranties help control emissions and protect air quality. Air quality regulatory agencies including CARB and the United States Environmental Protection Agency (U.S. EPA) require that heavy-duty manufacturers offer minimum warranties for emission-related parts to (1) help ensure that emission control systems are properly designed and built properly and will function as intended during the warranty period, and (2) make it more likely that, during the warranty period, any needed emissions-related repairs will be completed.

3. Why Today's Minimum Warranties Should Be Lengthened

California has adopted emission warranty and durability provisions that parallel the U.S. EPA provisions for on-road heavy-duty engines to help ensure adequate durability and proper maintenance of the engine and emission controls. The current warranty periods for heavy-duty diesel vehicles and motor vehicle engines used in such vehicles having gross vehicle weight ratings of 14,001 pounds and above are 100,000 miles, a period of 5 years, or 3,000 hours of operations, whichever first occurs.

Heavy-duty diesel vehicles today are built to last longer and be driven longer than in the past. In 1982, the average mileage of heavy-duty diesel vehicles having a gross vehicle weight rating[10] (GVWR) greater than 33,000 pounds before an engine rebuild was 276,000 miles (Rondini, 2015). But today, well-maintained on-road diesel engines can operate upwards of 1,000,000 miles before rebuild (Cannon, 2015; HDT, 2006). Thus, today's heavy-duty vehicle mileages before rebuild render a 100,000 mile warranty inadequate to protect air quality.

As discussed in greater detail in Chapter II, further evidence for the need for longer minimum warranties comes from recent CARB testing of in-use heavy-duty vehicles, as well as warranty claim data for heavy-duty vehicles. Test programs have identified numerous heavy-duty vehicles with mileages within their applicable regulatory useful life periods, but beyond their warranty period, that have NOx emission levels significantly above the applicable certification standards. Also, recent CARB reviews of manufacturer warranty claims show high warranty claim rates for major heavy-duty diesel engine components. Statements at public meetings with fleet owners, retrofit installers, and equipment dealers confirm these findings, and suggest that some fleets

[10] "Gross Vehicle Weight Rating" means the maximum operating weight of a vehicle as specified by the manufacturer including the vehicle's chassis, body, engine, engine fluids, fuel, accessories, driver, passengers and cargo but excluding that of any trailers.

are experiencing significant vehicle downtime due to parts failures. A survey conducted between February 2017 and November 2017 of California truck owners/operators by the Sacramento Institute for Social Research (ISR) found over half of respondents reported having experienced downtime with their California heavy-duty vehicles manufactured between 2007 to 2017 because of repairs (ISR, 2017). In fact, survey respondents reported over $1,500 per vehicle (on average) in lost revenue due to downtime from emission-related repairs. The average cost of downtime because of all repairs per vehicle was over $3,000. Further, over 15 percent of these respondents experienced downtime events of over a month per vehicle (on average).

The proposed amendments lengthening emissions warranty would reduce emissions in two ways. First, they would make it more likely that emission-related repairs are completed (because vehicle owners could get them done for free). Specifically, a lengthened warranty period would result in fewer incidences of tampering and mal-maintenance because the cost of repairs would be covered longer by the manufacturer, resulting in a reduction of emissions. Second, increasing the emission warranty periods would encourage manufacturers to improve the durability of their engines and emission control systems through the development and use of higher quality parts and materials. Improving overall engine durability is critical to preventing component failures that can damage emission control system components and result in excess emissions.

B. Background

This section begins with a chronology of regulations adopted by California to reduce heavy-duty emissions. After the chronology, additional subsections are included as follows:

- Subsection 1 describes the technologies and strategies heavy-duty manufacturers have used to meet the increasingly stringent emission standards;
- Subsection 2 describes current heavy-duty required warranty periods;
- Subsection 3 describes current allowed heavy-duty maintenance intervals; and
- Subsection 4 describes current heavy-duty on-board diagnostic requirements.

California is the only state with the authority to adopt and enforce emission standards and test procedures for new motor vehicles and new motor vehicle engines that differ from federal emission standards and test procedures (Federal Clean Air Act, 209(b)(1) [42 U.S.C. 7543] as last amended, November 15, 1990). Since the 1960's, CARB has established increasingly stringent fuel and motor vehicle emission standards. Further, since 1990, CARB has typically aligned California's heavy-duty engine emission standards with U.S. EPA standards (California Achievements, 2006).

With respect to warranty provisions, in 1978, CARB initially adopted emission warranty regulations for California-certified 1979 and subsequent model year motorcycles, passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty vehicles, registered in California, regardless of their original point of registration, and California-certified motor vehicle engines used in such vehicles, to clarify the rights of individual

motor vehicle and engine owners, motor vehicle and engine manufacturers, and the service industry (CARB, 1978). The emission warranty is used to cover any repairs needed to correct defects in materials or workmanship that would cause an engine or vehicle not to meet its applicable emission standards.

In 1982, CARB adopted regulations that established California's first vehicle in-use recall program (CARB, 1982). These regulations, which applied to California-certified 1982 and subsequent model year passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty vehicles (as well as other mobile sources) were intended to reduce vehicular emissions by ensuring that noncompliant vehicles were identified, recalled, and repaired to comply with the applicable emission standards and regulations during customer use. In addition, these regulations were intended to encourage manufacturers to improve the design and durability of emission control components to avoid the expense of a recall.

In 1982 and 1984, U.S. EPA promulgated heavy-duty vehicle useful life and warranty requirements identical to those adopted in California (FR, 1982; FR, 1984). Both CARB and U.S. EPA require that heavy-duty vehicles meet emission standards throughout their useful life periods.

In 1988, CARB adopted the Emission Warranty Information Reporting (EWIR) regulations for tracking emission control component defects affecting on-road vehicles (CARB, 1988a; CARB, 1988b). Applicable starting in 1990 for heavy-duty vehicles, the EWIR regulations require manufacturers to review all emission-related warranty claims on a quarterly basis to determine the number of repairs or replacements made for each component. Each manufacturer must report "unscreened"[11] warranty claim activity for a specific emission-related component failure that exceeds a one percent level with respect to the number engines in an engine family or vehicle test group, as applicable, and has additional reporting requirements when a component's "unscreened" warranty claim rate exceeds a four percent level.

In the late-1990's, several heavy-duty engine manufacturers were found to be violating certification regulations by turning off, or defeating, emission control devices during in-use highway driving. This calibration strategy was deemed a defeat device[12] by both U.S. EPA and CARB, which prompted both agencies to seek remedial action and penalties against the offending manufacturers. This also prompted U.S. EPA to develop a "not-to-exceed" (NTE) emissions protocol, which established an emissions limit covering virtually all driving conditions (i.e., including those conditions outside the FTP

[11] "Unscreened" refers to the tabulation of dealership emission warranty service records for emission-related components as they apply to individual engine families or test groups without verification that the part is actually defective.

[12] A defeat device is a device which senses or responds to operating variables such as engine speed, temperature, intake pressure etc., for the purpose of activating, delaying, or deactivating the operation of any component or emission control system, so that the effectiveness of the system is reduced under normal operating conditions. (http://www.gpo.gov/fdsys/pkg/CFR-2013-title40-vol34/xml/CFR-2013-title40-vol34-sec1039-115.xml).

drive cycle). Manufacturers have to attest, as a certification requirement, that their engines would not exceed this limit, or face penalties/remedial action. Subsequent negotiations with manufacturers ensued which led (in 2001) to legal challenges brought forth, on behalf of the manufacturers, by the Truck and Engine Manufacturers Association (EMA). These negotiations ultimately led to a settlement agreement with all parties, including CARB. As part of this settlement agreement, all affected parties were directed to work together to further develop the NTE test protocol. The development effort was successful, and the NTE requirement is in effect today (CARB, 2017h).

In 1997, U.S. EPA adopted lower NOx and non-methane hydrocarbons emission standards, to be effective in 2004, along with changes to the existing federal averaging, banking, and trading (ABT) program, for heavy-duty diesel engines sold in the other 49 states, and requirements for durability, maintenance intervals, recordkeeping, warranties, certification test fuel, and engine useful life. In 1998, CARB adopted amendments to harmonize with U.S. EPA's provisions, except for the ABT program (CARB, 1998).

CARB's adopted changes to the emission-related maintenance intervals, which began with the 2004 model year, were the same as federal intervals, and were listed in miles or hours, whichever occurs first. In addition, a definition of "add-on emissions-related component"[13] was included in the maintenance interval amendments.

CARB adopted warranty requirements for heavy-duty vehicles and heavy-duty engines that were largely identical to the corresponding federal warranty requirements for heavy-duty engines used in heavy-duty vehicles. The existing California provisions for emissions defect warranties were retained, while the emission defect and performance warranties were harmonized with the federal rule. Also, CARB adopted additional manufacturer requirements for service manuals that were the same as U.S. EPA's requirements. Engine manufacturers were required to provide vehicle owners with manuals specifying maintenance needed to ensure proper engine operation. Specifically to be included in the engine service manual was any maintenance that may be needed for emissions-related components after the end of the engine's regulatory useful life, including mileage/hours intervals, and procedures for determining whether maintenance or repair is needed.

1. Heavy-duty Control Technology Evolution

Since 1990, heavy-duty diesel engine manufacturers have adopted several technologies and strategies to meet increasingly stringent NOx and PM emission standards. In the early 1990's, most manufacturers implemented fuel injection timing retard, increased fuel injection pressure, and reduced the engine intake manifold temperatures. To meet the 1998 emission standards, engine manufactures employed those previous

[13] An "add-on emissions-related component" is a component whose sole or primary purpose is to reduce emissions or whose failure will significantly degrade emissions control and whose function is not integral to the design and performance of the engine.

technologies, and added improved engine combustion chamber designs, electronic engine controls, EGR, and charge air cooling. To meet the even lower 2004 standards, manufacturers used the aforementioned technologies, along with cooled EGR, variable geometry turbochargers, and common rail fuel injection systems. To comply with the 2007 emission standards, the previously indicated technologies were used in conjunction with ultralow sulfur diesel fuel, and higher EGR flow rates (with a diesel oxidation catalyst), and a diesel particulate filter to control PM. To satisfy the current 2010 requirements, SCR was added to further control NOx. Not all engine manufacturers used all these techniques at the specific times noted, but in general these are the emission controls that have been used to dramatically lower heavy-duty engine NOx and PM emissions since the early 1990's.

2. Current Heavy-Duty Engine/Vehicle Required Warranty Periods

Both CARB and U.S. EPA require that heavy-duty engines demonstrate compliance with emissions standards throughout their useful lives, and both CARB and U.S. EPA have separate requirements for minimum emissions warranties as well (13 CCR 1956.8, 1971, and 1976; 40 CFR 86.004-2). For heavy-duty diesel engines, the useful life period ranges from 110,000 miles up to 435,000 miles depending on a vehicle's GVWR, as shown in Table I-1.

Table I-1. Current Heavy-Duty Engine/Vehicle Emissions Useful Life and Warranty Periods (CCR, 2017f)

HEAVY-DUTY CATEGORY	CURRENT WARRANTY (miles)	CURRENT USEFUL LIFE (miles)
	Diesel	Diesel
Class 8 Heavy Heavy GVWR >33,000 lbs.	100,000 5 years / 3,000 hours	435,000 10 years / 22,000 hours
Class 6- 7 Medium Heavy 19,500 lbs. < GVWR ≤ 33,000 lbs.	100,000 5 years / 3,000 hours	185,000 10 years
Class 4- 5 Light Heavy 14,000 lbs. < GVWR ≤ 19,500 lbs.	100,000 5 years / 3,000 hours	110,000 10 years

California's emission warranty period requirements for heavy-duty diesel vehicles and heavy-duty engines are codified in 13 CCR 2036. Currently, the same emissions warranty period mileage requirement, 100,000 miles, applies to all heavy-duty diesel vehicles.

On-road heavy-duty diesel vehicle or engine manufacturers must offer a minimum 5 year and 100,000 mile warranty. As included in Table I-1, California's existing regulations specify that the warranty period must cover "5 years, 100,000 miles, or 3,000 hours for compression-ignition heavy-duty vehicles," whichever occurs first. California's hour provision is applicable only when an accurate hours meter is provided by the manufacturer with the engine and only when the hours meter can reasonably be expected to operate properly over the useful life of the engine. The hour provision allows shorter warranty coverage for vehicles that accumulate engine operating hours faster than they accumulate miles (e.g., vehicles often used in power takeoff mode where the engine runs for many hours while the vehicle is stationary). The current federal warranty regulations do not include the hour provision.

While the California warranty provisions indicate specific required periods of coverage with respect to accumulated mileage, time in service, and operational hours, the provisions also state that in no case may the warranty period be less than the "basic mechanical" warranty that the manufacturer provides to the purchaser of the engine (13 CCR 2036; 40 CFR 1037.120). "Basic mechanical" warranties, which are also known as "commercial" warranties, cover defects of the "basic" or "major" engine components (e.g., cylinder block, cylinder head, camshafts, rocker arms, manifolds, etc.) but not necessarily any the emission control system components. However, if the basic mechanical warranty provided has greater coverage than that specified by the emission warranty regulations, then the emission control system components are automatically required to be provided the same amount of coverage.

Usually, heavy-duty engine and heavy-duty vehicle combinations are straightforward. For example, a heavy heavy-duty engine is usually installed in a Class 8 heavy heavy-duty vehicle greater than 33,000 pounds GVWR. However, sometimes a medium heavy-duty engine is installed in a Class 8 heavy-duty vehicle, such as when a manufacturer uses an engine downsizing strategy to enhance fuel efficiency and reduce carbon dioxide emissions. Currently, the emissions warranty requirements are the same for all heavy-duty vehicles with a GVWR greater than 14,000 pounds. Thus, there is currently no need to differentiate between heavy-duty engine service classes because the warranty period is the same for each of them.

3. Current Heavy-Duty Engine/Vehicle Maintenance Intervals

In order for a heavy-duty diesel-cycle engine to function properly throughout its useful life, routine maintenance is required. Maintenance includes any type of adjustment, cleaning, repair, or replacement that needs to be performed on components or systems. Simple examples of routine maintenance include: oil, oil filter, and air filter changes at pre-defined mileage intervals.

Modern heavy-duty diesel engines are complex systems that require fine-tuned calibration of engine operations in tandem with downstream aftertreatment systems. With more system complexity and upstream-downstream interactions, a rigorous

maintenance schedule becomes even more critical for proper engine and aftertreatment system functionality (CCDET, 2016).

Maintenance can be designated as either “emission-related” or as “non-emission-related.” For example, an oil change at the manufacturer-specified interval is considered non-emission-related, whereas the ash cleaning of a diesel particulate filter at the manufacturer-specified interval is considered emission-related. Emission-related maintenance can further be designated as “critical” or “non-critical” depending on the specific component which is undergoing maintenance. Table I-2 lists critical emission-related components, as provided in 40 CFR 86.004-25 (b)(6)(i), as last amended on October 25, 2016.

Table I-2. Critical Emission-Related Components

1.	Catalytic converter
2.	Air injection system components
3.	Electronic engine control unit and associated sensors and actuators
4.	EGR system (including all related filters, coolers, control valves, and tubing)
5.	Crankcase ventilation valves and filters
6.	Evaporative and refueling emission control system components (excluding the canister air filter)
7.	Particulate trap or trap-oxidizer system
8.	Components comprising the selective catalytic reduction system (including the Diesel Exhaust Fluid tank)
9.	Any other component whose primary purpose is to reduce emissions or whose failure would commonly increase emissions of any regulated pollutant without significantly degrading engine performance

Before an engine manufacturer can sell or offer for sale in California a new heavy-duty diesel engine, it must first go through an emission certification process to demonstrate that engine complies with all applicable new engine certification requirements, before it can obtain an Executive Order from CARB. One of the key components of the certification process requires the submittal of a durability demonstration plan that is intended to provide assurances that all engine and aftertreatment system components are durable and that the engine and aftertreatment system will comply with the applicable emission standards at the end of useful life. The plan also requires information on the required maintenance (both emission-related and non-emission related) that is needed for proper engine and aftertreatment system operation. While the durability tests demonstrate that the engine and its emission control systems are durable over the engine’s useful life, this durability demonstration period may sometimes require the repair or replacement of some components. Thus, a manufacturer is allowed by the current California regulations to schedule the repair or replacement of some components at specific intervals during the tests, as long as they similarly schedule such repairs or replacements on production vehicles. This maintenance schedule becomes the “official” maintenance schedule (13 CCR 2036(e)) instructions for the engine family, and subsequent to its approval, is required to be

distributed to the initial vehicle purchaser. The maintenance schedule includes all emission-related and non-emission-related maintenance requirements for each specific engine and aftertreatment system.

Manufacturers are also required to submit a copy of the engine and aftertreatment system warranty statement to CARB for review as part of their emission certification application. The warranty statement must adhere to the requirements specified in 13 CCR 2035 and 2036. Further, the repair or replacement of any parts covered under the warranty provisions is to be performed at no cost to the vehicle or engine owner (13 CCR 2036(j)(1)).

It should be noted that proper engine and aftertreatment system maintenance is the responsibility of the engine or vehicle owner, and manufacturers typically recommend that vehicle owners retain records and receipts for any maintenance that is performed. If the engine or vehicle owner fails to keep the maintenance receipts or records, or does not perform the necessary maintenance on time or at all, the warranty coverage is not automatically revoked. However, if it is determined that a part failure (during the warranty period) is due to abuse, neglect, improper maintenance, tampering or unapproved modifications, the warranty for that part may be revoked by the manufacturer (13 CCR 2036(j)(1)).

Given the intertwined relationship between maintenance (which is the vehicle owner's responsibility) and warranty coverage (which is the manufacturer's responsibility), regulatory requirements regarding minimum emission-related maintenance intervals for heavy-duty diesel-cycle engines based on technological necessity have been developed (40 CFR 86.004-25, last amended Oct. 25, 2016). The objective of these existing intervals is to ensure a minimum required durability, both during the certification of heavy-duty engines and while engines are in use. The maintenance schedule identifies the minimum maintenance intervals for certain types of adjustments, cleaning, repairs, replacements, etc., that can be needed for different parts. The intervals specified in the manufacturer's maintenance schedule must be greater than or equal to the minimum intervals shown in Table I-3 (see section 86.004-25 of the "California On-Road Heavy-Duty Test Procedures").

Thus, for example, a maintenance schedule for a heavy-duty engine used in a Class 8 heavy-duty diesel vehicle may require a scheduled maintenance of its EGR system-related filters and coolers, crankcase ventilation valves and filters, fuel injector tips, and diesel exhaust fluid (DEF) filters at 50,000 miles or greater but not less (or 1,500 hours or greater but not less), and at 50,000 mile or greater but not less (or 1,500-hour or greater but not less) intervals thereafter.

Table I-3. 86.004-25 (b)(4) Current Intervals for Adjustment, Cleaning, Repair, or Replacement for Diesel-Cycle Heavy-Duty Engines

Interval	Vehicle GVWR*	Citation	Items For Which Minimum Adjustment, Cleaning, Repair, or Replacement Intervals Are Specified
Every 50,000 miles for:	All heavy (> 14,000 lb.)	86.004-25(b)(4)(i)	(A) Exhaust gas recirculation system related filters and coolers (B) Crankcase ventilation valves and filters (C) Fuel injector tips (cleaning only) (D) DEF filters
Every 100,000 miles (or 3,000 hours)	Light-heavy (14,000-19,500 lb.)	86.004-25(b)(4)(iii)	(A) Fuel injectors (B) Turbocharger (C) Electronic engine control unit and its associated sensors and actuators. (D) Particulate trap or trap oxidizer systems including related components (adjustment and cleaning only for filter element, replacement of the filter element is not allowed during the useful life) (E) Exhaust gas recirculation system (including all related control valves and tubing) except for related filters and coolers (F) Catalytic converter (adjustment and cleaning only for catalyst beds, replacement of the bed is not allowed during the useful life) (G) Any other add-on emissions-related component (i.e., a component whose sole or primary purpose is to reduce emissions or whose failure will significantly degrade emissions control and whose function is not integral to the design and performance of the engine)
Every 150,000 miles (or 4,500 hours)	For Medium-Heavy and Heavy-Heavy (>19,501 lb.)	86.004-25(b)(4)(iii)	(A) Fuel injectors (B) Turbocharger (C) Electronic engine control unit and its associated sensors and actuators. (D) Particulate trap or trap oxidizer systems including related components (adjustment and cleaning only for filter element) (E) Exhaust gas recirculation system (including all related control valves and tubing) except for related filters and coolers. (F) Catalytic converter (adjustment and cleaning only for catalyst beds, replacement of the bed is not allowed during the useful life) (G) Any other add-on emissions-related component (i.e., a component whose sole or primary purpose is to reduce emissions or whose failure will significantly degrade emissions control and whose function is not integral to the design and performance of the engine)

*This column identifies the vehicle types usually powered by engines for which the applicable maintenance is indicated.

4. Current Heavy-Duty Engine/Vehicle On-Board Diagnostic Requirements

On-board diagnostic (OBD) systems are self-diagnostic systems incorporated into a vehicle's on-board computer. They are comprised mainly of software designed to detect emission-control system malfunctions as they occur. This is done by monitoring virtually every component and system that can cause increases in emissions, thus maintaining low emissions throughout the vehicle's life. The OBD system continuously works in the background during vehicle operation to monitor emission-related components and alerts the vehicle operator of detected malfunctions by illuminating the malfunction indicator light (MIL) on the vehicle's instrument panel. Additionally, the OBD system stores important information, including identification of the faulty component or system and the nature of the fault, which allows for quicker diagnosis and proper repair of the problem by technicians. This helps vehicle owners experience less expensive repairs, and promotes repairs being done correctly the first time.

The first generation of OBD systems intended for passenger cars, light- and medium-duty vehicles with three-way catalysts and feedback control (referred to as OBD I) was implemented by CARB in 1988, and required monitoring of only a few of the emission-related components on the vehicle (CARB, 1985). In 1989, CARB adopted regulations requiring a second generation of OBD systems (referred to as OBD II) that standardized the system and addressed the shortcomings of the OBD I requirements. OBD II required all 1996 and newer passenger cars, light-duty trucks, and medium-duty vehicles and engines to be equipped with OBD II systems (CARB, 1989b).

In 2004, CARB adopted regulations requiring OBD systems for heavy-duty vehicles and engines (i.e., vehicles with a GVWR greater than 14,000 pounds). CARB first adopted the Engine Manufacturer Diagnostic (EMD) regulation, which required manufacturers of heavy-duty engines and vehicles to implement diagnostic systems on all 2007 and subsequent model year on-road heavy-duty engines. The EMD regulations were much less comprehensive than the OBD II regulations, and were intended for heavy-duty manufacturers to achieve a minimum level of diagnostic capability (CARB, 2004). In 2005, CARB adopted HD OBD requirements for 2010 and subsequent model year heavy-duty engines and vehicles, which phased in with full implementation required for the 2013 model year (CARB, 2005b).

Heavy-Duty OBD Component Monitoring

While the HD OBD provisions are applicable to both Otto- and diesel-cycle engines, staff's proposal is applicable to only diesel-cycle engines. Table I-4 lists the heavy-duty engine components that can contribute to an increase in emissions if they malfunction and hence which are required to be monitored by HD OBD systems. For the components shown in regular font (not in italics) in Table I-4, the OBD system is required to monitor the components and indicate a fault code when emissions exceed the emission standards by a certain amount. Emission "thresholds" for faults are

typically either a multiple of the exhaust emission standard (e.g., 2.0 times the applicable standard, etc.), or an additive value above the standards (e.g., 0.2 g/bhp-hr above the applicable standards, etc.). The components and/or systems whose monitors are calibrated to a threshold limit include the fuel system, the EGR system, the boost pressure control, and other aftertreatment devices (e.g. catalysts, particulate traps, etc.).

Table I-4. Components for Heavy-Duty OBD System Monitoring [14]

• Fuel System	• *Misfire Detection*	• EGR System
• Boost Pressure Control	• NMHC Catalyst	• NOx Catalyst
• NOx Adsorber	• PM Filter	• Exhaust Gas Sensors
• Variable Valve Timing/Control	• Cold Start Strategies	• *Crankcase Ventilation*
• *Engine Cooling System*	• *Comprehensive Component*[15]	• Secondary Air System
• Catalyst Monitoring	• Evaporative System	• *"Other Controls"*[16]

The use of a threshold emissions limit is not applicable for some components, and so a different malfunction criteria is used to identify emission problems. For example, in diesel engines, the detection of engine misfires occurs when the percentage of misfire is equal to or exceeds five percent, regardless of the pattern of misfire events (e.g., random, equally spaced, continuous). These components that do not rely on a threshold limit are identified in *italics* in Table I-4.

In addition to the components that have a direct impact on the emissions, the HD OBD system also monitors components that are not currently warranted because they do not directly affect emissions, what in this report we refer to as "indirectly emission-related components." Monitoring these components, however, is still important because a malfunction of one of these input or output sensors, if undetected, could lead to incorrect diagnosis of emission malfunctions or even prevent the OBD system from checking for malfunctions.

Given that the HD OBD regulation lists very specific requirements for most of the current emission controls used today, flexibility for future innovations, and refinements of existing technology, have been included via the "other controls" component category.

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[14] Components in *italics* are not correlated to an emission threshold limit. The components not in italics are correlated to a threshold limit that can be a multiple of, or additive to, the emission standards.
[15] Secondary electronic powertrain component/system that monitors the major emissions-related components.
[16] Any other emission control systems that are either: (1) not identified or addressed by other systems, or (2) are identified but are not compensated for by an adaptive control system.

HD OBD Malfunction Indicator Light Requirements for Illumination

The MIL serves as a visual communication method through which the HD OBD system alerts the vehicle operator that an emission-related fault or malfunction has occurred. If malfunction criteria are triggered, the HD OBD system alerts the vehicle operator to the problem by illuminating the MIL. So, for example, a system that relies on a threshold limit will trigger MIL illumination once the emissions exceed the threshold limit.

The conditions to illuminate the MIL for detected malfunctions consist of several steps to ensure that a fault truly exists. When a malfunction occurs, a pending fault code is generated and stored within 10 seconds indicating the likely area of the malfunction. At this point, the MIL does not illuminate. If the identified malfunction is again detected before the end of the next driving cycle[17] in which monitoring occurs, the OBD system will keep the pending fault code stored, and then store a "confirmed" fault code within 10 seconds. At this point, the MIL will be continuously illuminated. A technician would use the confirmed fault code to determine what system or component has failed, what is the exact problem, and how to fix the problem. If, on the other hand, the identified malfunction is not detected before the end of the next driving cycle in which monitoring occurs (i.e., there is no indication of the malfunction at any time during the driving cycle), the corresponding pending fault code will be erased at the end of the driving cycle.

The HD OBD regulations also require that manufacturers only use the MIL for purposes related to OBD (i.e., emissions-related issues), and not for any other non-emission related purposes.

[17] "Driving cycle" is defined as a trip that meets any of the four conditions below: (1) Begins with engine start and ends with engine shutoff; (2) Begins with engine start and ends after four hours of continuous engine-on operation; (3) Begins at the end of the previous four hours of continuous engine-on operation and ends after four hours of continuous engine-on operation; or (4) Begins at the end of the previous four hours of continuous engine-on operation and ends with engine shutoff.

II. THE PROBLEMS THAT THE PROPOSAL IS INTENDED TO ADDRESS

A. Description of Problems

California Government Code section 11346.2(b)(1) requires a description of the problems that staff's proposed amendments intend to address.

1. Additional NOx Reductions are Needed for SIP Attainment

The California State Implementation Plan (SIP) relies in part on the emission benefits attributable to the current emission standards applicable to 2007 and subsequent model year on-road heavy-duty diesel engines and heavy-duty vehicles to attain the federal ambient air quality standards (CARB, 2016b). Substantial progress has been achieved in reducing NOx emissions through implementation of CARB's existing mobile source programs, and it is expected that these programs will continue to provide further reductions through 2031, contributing significantly to meeting air quality standards. However, challenges still remain in meeting the ambient air quality standards for ozone and PM2.5 in two areas of the state with the most critical air quality challenges - the South Coast Air Basin (CARB, 2017k) and the San Joaquin Valley Air Basin (CARB, 2017l; CARB, 2017m). The South Coast Air Basin has the highest ozone levels in the nation, while the San Joaquin Valley has the greatest PM2.5 challenge. To meet the 2023 and 2031 ambient air quality standards for ozone (currently 75 parts per billion; adopted in 2008 (U.S. EPA, 2017)), the South Coast Air Basin will require an approximate 70 percent NOx reduction from today's levels by 2023 and an overall 80 percent NOx reduction by 2031. Since NOx is also a precursor to secondary PM2.5 formation, reductions in NOx emissions will also provide benefits for meeting the PM2.5 standards. In addition, in October, 2015, U.S. EPA adopted a more stringent 70 parts per billion ozone standard with an attainment date of 2037 (U.S. EPA, 2015a). This ozone standard will result in additional areas being classified as nonattainment areas, as well as require even further emission reductions in California's existing nonattainment areas.

As shown in Figure II-1, over half of the needed reductions in the South Coast Air Basin are expected to come from existing mobile source programs. However, even with the expected emission reductions, heavy-duty vehicles are projected to remain the largest contributors to the state's NOx emissions inventory. As a result, significant additional NOx reductions are needed from these sources in order to meet the federal ambient air quality standards for ozone.

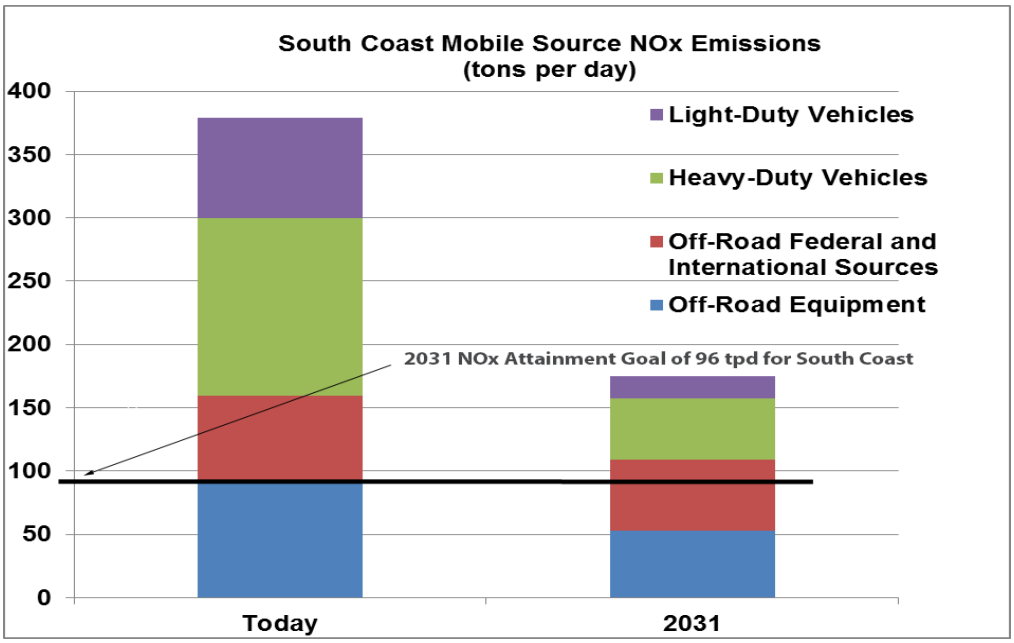

Figure II-1. South Coast Mobile Source Emissions

2. Reductions of Other Criteria Pollutants Are Also Needed

In addition to NOx reductions, HC and PM reductions are also required to protect public health. HC emissions are a major contributor to the formation of ozone, which can irritate the respiratory system, causing coughing, choking, and reduced lung capacity. Some components of HC are toxic volatile organic compounds such as benzene, toluene, naphthalene, and formaldehyde. These compounds can cause dizziness, headaches, and loss of consciousness, and in the case of benzene, leukemia (U.S. EPA, 1991).

Diesel PM is a toxic air contaminant, known carcinogen, for containing both PM10 and PM2.5 particles that easily penetrate into the airways and lungs where they may produce harmful health effects such as the worsening of heart and lung diseases. The risk of these health effects is greatest in the elderly and the very young. Exposure to elevated concentrations of PM is also associated with increased hospital and doctor visits and increased numbers of premature deaths (CARB, 2016b).

The State of California has established ambient air quality standards for PM. These standards define the maximum amount of particles that can be present in outdoor air to minimize the threat to the public's health. The current annual ambient standards in California are 20 micrograms per cubic meter ($\mu g/m^3$) for PM10 and 12 $\mu g/m^3$ for PM2.5 (CARB, 2015a). Although significant progress has been made in recent years regarding the control of PM from vehicular sources, much of the State remains in nonattainment with ambient standards, and further reductions of PM are needed.

Furthermore, diesel PM is a major source of black carbon. Black carbon absorbs sunlight and generates heat in the atmosphere, which warms the air and can affect regional cloud formation and precipitation patterns. As such, black carbon plays a critical role in global climate change (CCES, 2010).

3. On-Road Heavy-Duty Vehicles Remain Significant Polluters

On-road heavy-duty vehicles, especially those powered by diesel engines, are some of the most significant sources of NOx emissions. As shown above in Figure II-2, heavy-duty vehicles remain the largest polluters, with heavy-duty vehicles over 14,000 pounds GVWR being responsible for almost 45 percent of statewide mobile source emissions of NOx.

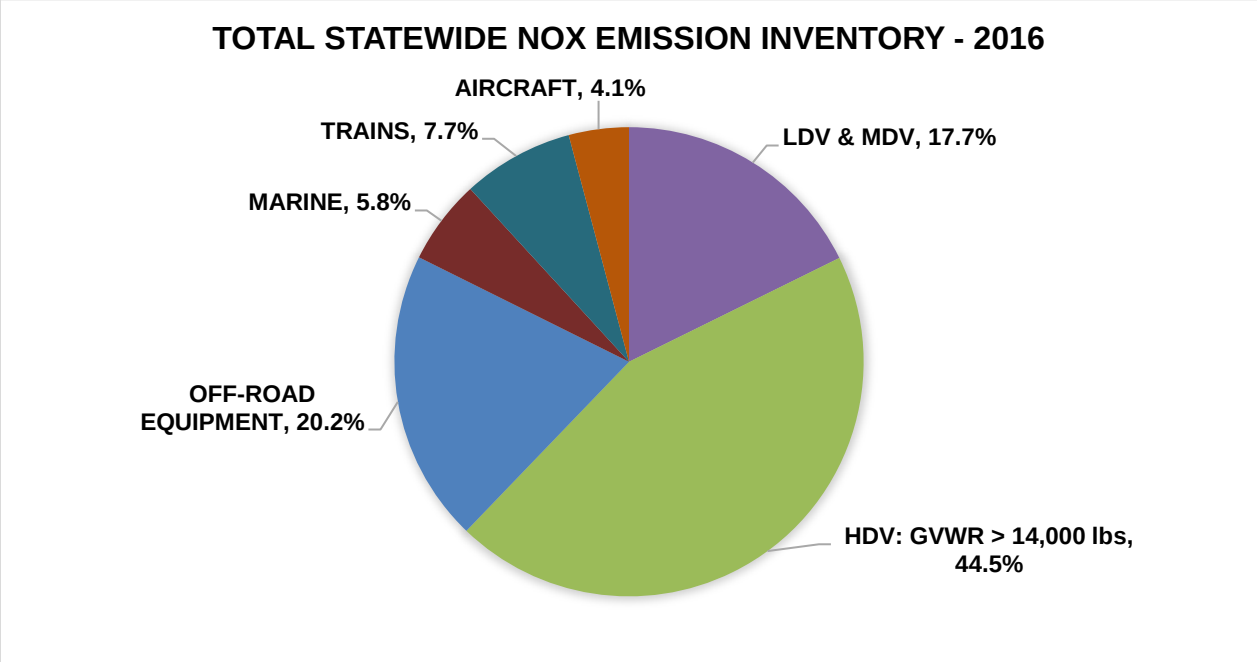

Figure II-2. Mobile Source Statewide NOx Emission Inventory For 2016[18]

Diesel-powered heavy-duty vehicles are also significant sources of HC and PM emissions in California. Although not nearly as significant a problem in California as NOx emissions with respect to attainment with federal ozone standards, excess HC and PM emissions are present in air basins throughout the State including the San Joaquin Valley. Figures II-3 and II-4 illustrate the HC and PM contributions from all heavy-duty vehicles in California including those with diesel and spark-ignition engines. Heavy-duty vehicles over 14,000 pounds GVWR are responsible for almost 14 percent of mobile source HC and almost 19 percent of mobile source PM2.5 statewide.

[18] (CEPAM: 2016 SIP – Standard Emission Tool, BY2012, Oxides of Nitrogen, Annual Average, Year: 2016, grown and controlled, All Sources except Natural, Stationary, and Area Wide, https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php)

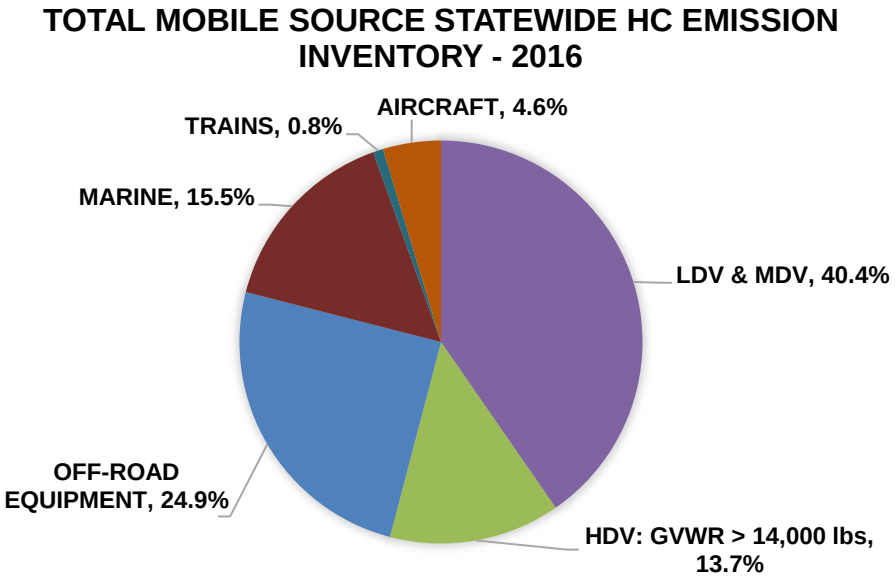

Figure II-3. Mobile Source Statewide Hydrocarbon Emissions Inventory For 2016[19]

In order to meet air quality goals in the South Coast Air Basin, an overall NOx reduction of 80 percent is needed by 2031.

Under the Mobile Source Strategy, the "Lower In-Use Emission Performance Level" measure seeks to ensure that in-use heavy-duty vehicles continue to operate at their cleanest possible level (CARB, 2016b). This measure requires the development of new requirements to address in-use emissions and compliance, and to decrease engine deterioration from in-use heavy-duty vehicles. The measure includes amending the existing Periodic Smoke Inspection and Heavy-Duty Vehicle Inspection Programs to revise the current opacity limit; amending the durability demonstration provisions within the certification requirements for heavy-duty engines; amending the "Not-To-Exceed" supplemental test procedures for heavy-duty diesel engines; adopting a comprehensive heavy-duty vehicle inspection and maintenance program; and amending the current warranty and useful life provisions. The proposed amendments to extend the current warranty provisions accordingly implement an element of CARB's Lower In-Use Emission Performance Level measure.

[19] (CEPAM: 2016 SIP – Standard Emission Tool, BY2012, Total Organic Gases, Annual Average, Year: 2016, grown and controlled, All Sources except Natural, Stationary, and Area Wide, https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php)

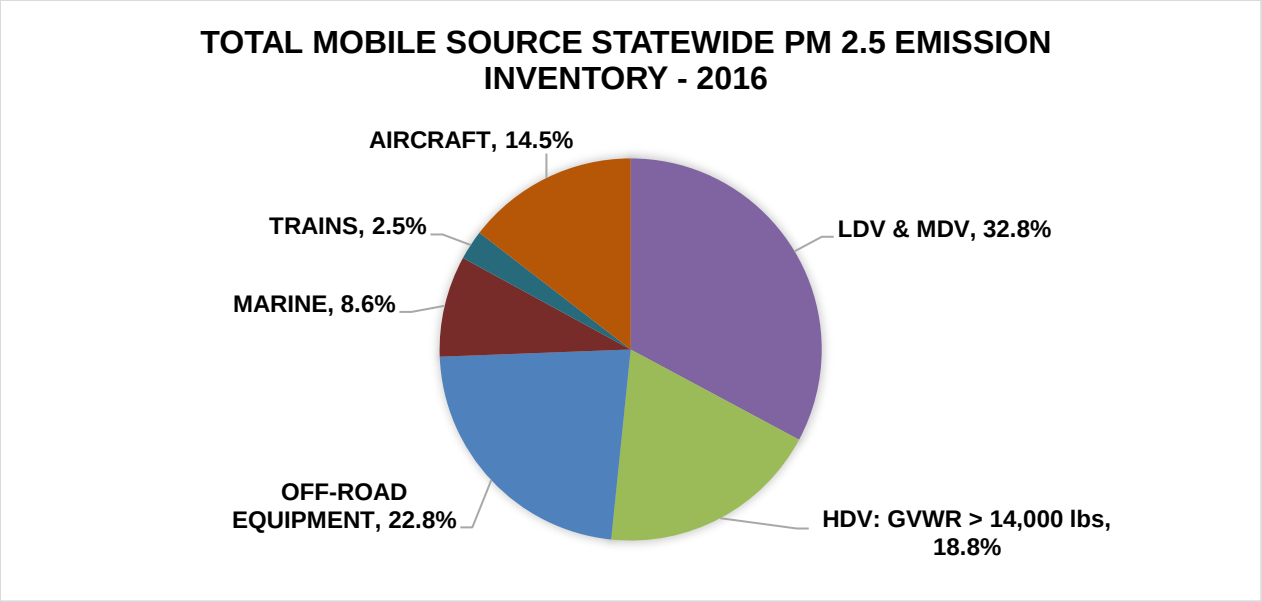

Figure II-4. Mobile Source Statewide PM Emission Inventory For 2016[20]

4. On-Road Heavy-Duty Vehicle Emission-Related Parts are Not Adequately Durable

Since the 2010 model year, new California certified heavy-duty diesel engines have been subject to strict PM and NOx emission standards (13 CCR 1956.8), which manufacturers have met by equipping new vehicle engines with DPFs for control of PM and SCR systems for controlling NOx emissions. Because these exhaust aftertreatment systems reduce NOx emissions by more than 95 percent and PM emissions by more than 99 percent (MECA, 2007), if they fail, an individual vehicle's emissions can return to "engine out" levels, which are magnitudes higher than the applicable emission standards. It is therefore crucial that these aftertreatment systems properly function throughout an engine's life. As previously mentioned, the California SIP incorporates the emissions benefits associated with the current emission standards for 2007 and subsequent model year on-road heavy-duty diesel engine and vehicle standards to attain the federal ambient air quality standards in nonattainment areas of the State (CARB, 2016b).

When engine manufacturers certify an engine for use in California, they must conduct durability testing intended to demonstrate compliance with applicable emission standards throughout the engine's useful life (CARB, 2017a). However, many indicators show that in reality, engines and aftertreatment do not always remain durable under real-world usage. For instance, high warranty reporting claim rates for several recent model year California heavy-duty vehicles show worst-case failure rates greater

[20] (CEPAM: 2016 SIP – Standard Emission Tool, BY2012, Particulate Matter < 2.5 microns, Annual Average, Year: 2016, grown and controlled, All Sources except Natural, Stationary, and Area Wide, https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php)

than 100 percent reported within the warranty periods for turbochargers, and failure rates as high as up 40 percent for DPFs, fuel injectors, and EGR components (CARB, 2016a). A failure rate in excess of 100 percent means that the number of warranty claims reported for an emission-related component is greater than the number of engines in the engine family for which the claims have been reported during the reporting period. Although these are worst-case findings, they are nonetheless indicative of durability issues for at least some manufacturers, and average claim rates for the most recent model year for which full reporting has occurred, model year 2012, are also concerning. For model year 2012, warranty claim rates exceed 10 percent for components including EGR valves and coolers, injectors, turbochargers, other sensors, and the ECM. (Section II.A.6 discusses reported warranty claim rates further.)

The range of claim rates discussed above for turbochargers is especially concerning in light of the fact that staff was recently assured by several OEM turbocharger manufacturers that their turbochargers are designed to survive for a minimum of 1,000,000 miles in the on-road heavy-duty vehicle environment. This same assurance was also reiterated during CARB's third public heavy-duty warranty amendment workshop conducted on January 18, 2018. In this case, there appears to be a disconnect between supplier-rated durability and real-world durability.

Further evidence of problems relating to inadequate heavy-duty vehicle emission-related durability has been documented by CARB's ongoing New Heavy-Duty Vehicle In-use Compliance Testing Program, which showed that 12 out of 18 of the heavy-duty vehicles tested failed NTE testing outside of the applicable warranty period, but while still within the emission control systems' useful lives (CARB, 2017e). In fact, some of these NTE testing results were as high as 4.5 g/bhp-hr NOx (i.e., over 22 times the applicable NOx emission certification standard, and indicative of a completely non-functional SCR system). Additional data from CARB's ongoing Truck and Bus In-Use Surveillance Program (CRC, 2015) showed a large percentage of heavy-duty vehicles with NOx emission levels above their applicable NOx emission certification standards within their useful lives, some with levels multiple times the applicable NOx standard of 0.20 g/bhp-hr (based on Urban Dynamometer Driving Schedule [UDDS][21] testing). The warranty, NTE, and in-use surveillance data mentioned above all indicate that heavy-duty vehicle emission-related parts, including aftertreatment, are not remaining as durable during real world operation as intended, and that emissions are therefore not as well controlled as they need to be.

Heavy-duty vehicle purchasers and owners seem aware of the aforementioned problems with heavy-duty engine and aftertreatment durability, and several findings indicate heavy-duty vehicle owners are dissatisfied with the minimum warranty periods required. First, many vehicle owners are choosing to purchase "extended" warranties, which are warranties provided by dealers or independent third-parties that supplement

[21] The UDDS was developed for chassis dynamometer testing of heavy-duty vehicles and was the basis for the development of the FTP transient engine dynamometer cycle, which is used for engine certification testing.

the regulatory required warranty period, that last well beyond the required minimum 100,000 miles. According to a survey conducted by the Sacramento ISR, approximately 40 percent of all new heavy-duty vehicle purchasers either opt to separately purchase, or receive as part of the vehicle purchase, warranty extensions; the average length of the warranty extensions is to 417,000 miles (ISR, 2017). This correlates well with an estimate from the EMA that 50 percent of new heavy-duty Class 8 vehicles are sold with a 500,000 mile extended warranty (EMA, 2017). The ISR survey also found that a majority of heavy-duty vehicle owners are dissatisfied with the current mandatory warranty period of 100,000 miles. The ISR survey also found that over half of the vehicle operators surveyed experience over a week of downtime annually per vehicle due to needed repairs, with a majority of those repairs being emissions aftertreatment related. Additional conclusions from the Sacramento ISR survey are discussed further in Chapter III, section C, as well as in Appendix H.

Another area of concern with respect to durability involves the high claims rates exhibited by the EWIR submissions from manufacturers. As mentioned in Chapter I, section A.3, manufacturers are required to submit warranty claims data to CARB when the "unscreened" warranty claim rate for a specific component in an engine family is greater than or equal to one percent of the number of engines sold per engine family, or 25 parts, whichever is greater. For example, if a manufacturer sells 1,000 engines of a particular engine family, warranty claims data must be submitted for any part used in the engine family that has 25 or more warranty claims. Each warranty claim represents an incident where a vehicle operator removed the vehicle from service in order to have repairs performed at a maintenance facility, and the part in question was replaced under warranty. Manufacturers submit "unscreened" warranty data to CARB on a quarterly basis if they reach the reporting thresholds.

Staff examined "unscreened" warranty claims data submitted by manufacturers for all 2012 model year California-certified heavy-duty diesel engines sold in California. The 2012 model year engine data set was selected for analysis because it was the most recent model year data set to have completed the "typical" five-year warranty period (i.e., expiring in 2017). Table II-1 shows the "unscreened" warranty claims for a select group of 2012 model year heavy-duty diesel engines above 14,000 pounds GVWR.

The warranty claims data suggest that engine durability is a concern, even within the warranty period. Several engine components have warranty claim rates that are near or exceed 10 percent of the total engine sales (as shown in Table II-1 in bold), including expensive replacement components such as turbochargers and EGR systems. Many "upstream" engine components with high warranty claim rates also have the potential to cause significant damage to the downstream aftertreatment systems. For example, damaged fuel injectors can significantly increase PM emissions which can contribute to overloading and overtaxing the DPF.

Table II-1. "Unscreened" Warranty Claims for all 2012 Model Year Heavy-Duty Diesel Engines

Engine Component	Total Claims	Percent of Total Vehicle Sales
DPF Filter	493	2.6%
DPF Doser	864	4.5%
EGR Valve/Cooler	4,080	**21.6%**
Injector	2,802	**14.9%**
SCR	1,603	8.5%
Turbocharger	2,061	**10.9%**
Other Sensors	3,804	**20.2%**
ECM[22]	2,084	**11.1%**

5. Heavy-Duty Diesel Engine Part Failures and Their Impact on Emissions

"Critical emission-related components," as discussed previously in Chapter I, section B.3., are a concern because when they fail, they can significantly increase emissions, sometimes without significantly impairing the performance of an engine or vehicle. Hence their failures may potentially be ignored by the driver. Table II-2 lists the "Critical Diesel Emission-Related Components," along with a brief description of the purpose and function of each part, and how malfunction of each can cause emission increases. Many of the identified components experience deterioration during their lifetime and operation that causes increases in emissions of HC, NOx, PM, and to a lesser extent, carbon monoxide (CO).

[22] "ECM" is the acronym for "engine control module," which is an electronic control unit that manages various actuators within an internal combustion engine to optimize engine performance.

Table II-2. Critical Diesel Emission-Related Component Descriptions and Engineering Rationale for the Emissions Impact during Component Malfunction

Components	Description of Component	Engineering Rationale for Emissions Impact during Component Malfunction
Catalytic converter	Device that chemically reduces exhaust gases and pollutants into less harmful emissions	Proper conversion capability can be hindered by deteriorated catalyst and can result in increased HC, and NOx emissions. Catalyst deterioration can occur from engine misfire, fuel system and secondary air injection malfunctions, complete ignition system failure, physical damage, and poisoning from oil and fuel additives.
Electronic Control Unit	Module which manages various sensors and actuators to ensure optimal engine performance	Faulty signals showing erroneous or out-of-range values can affect the system from determining the operation condition to send out the correct controls for the vehicle at a particular moment. Consequently, incorrect reductant dosing or timing can affect the performance of emissions-control devices and increase NMHC, CO, NOx, and PM.
Exhaust Gas Recirculation (EGR) system	System designed to allow the exhaust gases to flow back into the intake manifold	Excessive EGR flow can cause increased PM emissions, and insufficient EGR flow can cause increased NOx emissions.
Crankcase Ventilation Valves	Controls the flow of the crankcase vapors which are mixed with fresh air to be routed back to the engine for combustion	Malfunctions contribute to excess emissions from improper service or tampering of the crankcase ventilation system. Hose disconnections on the vapor vent side of the systems and/or missing valves can cause emissions to be vented to the atmosphere.
Particulate trap or trap oxidizer systems	Device for lowering the diesel PM emissions from exhaust gas by collecting the exhaust particulates and burning them through oxidization	A decrease in the filtering capability of the PM filter (e.g., cracking, etc.) would cause an engine's PM emissions to increase and possibly exceed the standards.
SCR system	Catalytic device that uses a reducing agent to selectively convert NOx into less harmful nitrogen, water, and small amounts of carbon dioxide	Deterioration of the catalyst can lower the conversion capability to the point that would cause an engine's NOx emissions to increase and exceed the standards. Additionally, reductant delivery deterioration can cause improper regulation of the reductant delivery to the system and hinder NOx conversion.

Accordingly, for the critical emission-related components for heavy-duty diesel vehicles, the effects of the component failures are quantified, and shown in Table II-3 as percentage increases in NOx and PM emissions. These percent increases were derived from analysis of manufacturers' submitted emission test data from one or more durability demonstration vehicle test engines under the certification process for their HD OBD systems (CARB, 2018f).

Table II-3. Emissions Increase From Failed Heavy-Duty Diesel Emission-Related Components

Component/System	Emissions Increase[23]	
	NOx	PM
Catalytic Converter[24]		
DOC Catalyst	108%	
SCR Catalyst	304%	
Reductant Delivery	202%	
Electronic Controls and associated sensors and actuators		
Cold start enrichment system	106%	
NOx Sensor	114%	
Exhaust Gas Recirculation system including all related control valves and tubing		
EGR Valve	102%	
EGR Cooler		
EGR Tube		
Diesel particulate trap or trap oxidizer systems including related components		4,766%
PM Filter	83%	
PM Filter Catalyst	282%	
PM Filter Freq. Regen.	36%	
Fuel System Monitoring	99%	
Fuel injection system		
Turbocharger systems	147%	

The “Component / System” column shows the emission-related component in general terms, but also provides a further breakdown of sub-components that are either 1) included under the general category type (e.g., the “DOC” and “SCR” are types of catalytic converters, etc.), or 2) individual sub-components that make up the complete system (e.g., the “EGR” system consists of valves and coolers). The “Emissions Increase” column is a sales-weighted percentage emissions increase caused by a single part failure or malfunction, and not a combination of multiple-part failures. In other words, only one component at a time was induced with faults, and the consequent

[23] Emissions increase due to faulty part or malfunction. Percentages based on sales-weighted increase compared to baseline values for six engine families.

[24] Components comprising the selective catalytic reduction system (including Diesel Exhaust Fluid (DEF) tank). “DEF” is used as a consumable in SCR to lower NOx concentrations in the diesel exhaust emissions.

emissions impact was noted. The data does not reflect the emissions impact from a complete part failure, but only failures that were sufficient to illuminate the HD OBD system's MIL. That means that the components were deteriorated to a point to cause the emissions to exceed the threshold limit (e.g., detect the fault before the emissions exceed the specified percentage of the standards for each regulated pollutant, etc.). The emissions increase percentage differences were calculated based on baseline emissions values from an intact system over the applicable certification cycle.

Many components in Table II-2, such as catalytic converter and EGR system components have a major impact on controlling NOx emissions. When these systems fail, potential NOx emission increases in excess of 100 percent can be expected. Likewise, the control of PM emissions is primarily dependent on the DPF system. When this system fails, large increases of almost 5,000 percent can be expected.

Table II-2 also includes the turbocharger system as a component that, when failed, has been shown to cause almost a 150 percent increase in the NOx emissions. The turbocharger is not primarily designed as an emissions-control device, but instead is used in internal combustion engines to enhance performance by increasing the mass and density of the intake air. The added air (i.e., oxygen) from the turbocharger boosts the pressure in the intake manifold. Proper boost control is essential to optimize emission levels because short periods of over- or under-boost can result in undesired air-fuel ratios, and corresponding emission increases.

The effect of the boost pressure from the turbocharger also directly affects the performance of the EGR system. The EGR system uses the pressure differential between the exhaust and the intake manifold to force exhaust gas into the intake manifold. If the boost control system is not operating correctly, the exhaust or intake pressures may not be as expected, and the EGR system may not function as designed. A malfunction that causes excessive exhaust pressures (e.g., waste gate stuck closed at high engine speed), for example, can produce higher EGR flowrates at high load conditions and have an adverse impact on emissions.

6. Heavy-duty Vehicles Travel Many More Miles than Their Current Minimum Warranty Periods

The service lives of modern heavy-duty diesel vehicles have increased significantly since warranty requirements were first enacted in California. Over thirty-five years ago the average mileage before heavy-duty diesel vehicles greater than 33,000 GVWR needed an engine rebuild was 276,000 miles (Rondini, 2015). Comparatively, nowadays well-maintained on-road heavy-duty diesel vehicles can operate upwards of 1,000,000 miles before a rebuild is needed (Cannon, 2015; HDT, 2006).

To describe some of the improvements for engine durability, engine manufacturers use the "B-life" value (PACCAR Powertrain, 2016; DDC, 2017b; Isuzu, 2017; Kenworth, 2013). The "B-life" value for an engine is an industry standard metric used to statistically predict when a certain percentage of the units in the engine family will fail. Often noted as "B10 life" or "B50 life," the "B-life" value indicates the operational miles

before which 10 percent or 50 percent of the engines in operation will require major repairs, overhaul, or replacement, respectively. Alternatively, another way of interpreting the metric is that a “B10 life” means that 90 percent of an engine family is still in service, and a “B50 life” value represents when 50 percent of an engine family is still in service. In essence, it gives a measure of the life expectancy of an engine.

As shown in Table II-4 for vehicle classes 4-8, many heavy-duty vehicle engine manufacturers provide the “B10 life” and/or “B50 life” mileage in their product specifications. Generally, the values show that the engines are capable of operating anywhere from 250,000 to over 1.2 million miles before requiring a major overhaul. The “B-life” periods shown in Table II-4 illustrate that the current warranty coverage of 100,000 miles for diesel engines is inadequate, with B10 values ranging from 2.5 to 12 times the current 100,000 mile emissions warranty, and B50 values ranging from 3.5 to 12 times the current 100,000 mile emissions warranty. In other words, the emissions warranty has ceased to apply long before the engine is overhauled, leaving lots of opportunity for emission-related parts to fail and emissions to degrade.

Table II-4. Manufacturer B10 and B50 Life Values for Various HD Diesel Engines

Engine Manufacturer	B10 Life (miles)	B50 Life (miles)	Engine Displacement (liters)	Vehicle Class
Class 8 Heavy-Heavy GVWR > 33,000 lbs.				
Detroit Diesel[25]	-	1,000,000	12.8	8
Detroit Diesel[26]	-	1,200,000	14.8	8
International / Navistar[27]	1,200,000	-	12.4	7, 8
Paccar[28]	1,000,000	-	12.9	8
Class 6-7 Medium-Heavy 19,500 lbs. < GVWR ≤ 33,000 lbs.				
Ford Motor Co.[29]	500,000	-	6.7	6, 7
International / Navistar[30]	-	550,000	9.3	4, 5, 6
Class 4-5 Light-Heavy 14,000 lbs. < GVWR ≤ 19,5000 lbs.				
Cummins[31,32,33]	250,000	350,000	6.7	4, 5
Detroit Diesel[34]	400,000	-	5.1	5, 6
International / Navistar[35]	-	550,000	9.3	4, 5, 6
Isuzu[36,37]	375,000	-	5.2	4

[25] (DDC, 2017b) https://detroitads.azureedge.net/9276-detroit_dd13_ghg17_product_ove-2017-04-20.pdf
[26] (Fletcher & Lyden, 2009) http://www.worktruckonline.com/fc_resources/wt0109engines.pdf
[27] (International Trucks, 2016) https://www.internationaltrucks.com/-/media/navistar/trucks/spotlight/engine-detail-pages/navistar-n13/enginedetailgallery_n13_1.pdf
[28] (PACCAR Powertrain, 2017) https://www.paccarpowertrain.com/media/2662/2017-mx-13-spec-sheet-092216.pdf
[29] (Ford, 2017) http://www.fleet.ford.com/resources/ford/general/pdf/brochures/2018/19314%20InternationalDuraStar%20wo%20crops.pdf
[30] (International Trucks, 2018) https://www.internationaltrucks.com/engines/navistar-n9
[31] (Cummins Hub, 2018) http://www.cumminshub.com/67.html
[32] (Diesel Hub, 2018b) http://www.dieselhub.com/tech/truck-classifications.html
[33] (Ram Trucks, 2018) https://www.ramtrucks.com/ram-chassis-cab.html
[34] (DDC, 2017a) https://detroitads.azureedge.net/3045-detroit_dd5_product_overview_g-2017-12-07.pdf
[35] (International Trucks, 2018) https://www.internationaltrucks.com/engines/navistar-n9
[36] (Isuzu, 2018) https://www.isuzucv.com/en/app/site/pdf?file=npr-hd_diesel_specs.pdf
[37] (Isuzu, 2017) https://www.isuzucv.com/en/news/headlines?storyId=4637

Figure II-5 illustrates a comparison of values of warranty periods and useful life periods indicated in Table II-4, for on-road heavy-duty diesel vehicle classes 4 to 8 based on representative “B10 life’ and “B50 life” values. As previously described, the current warranty period is 5 years/100,000 miles/3,000 hours, whichever occurs first, for heavy-duty diesel vehicles. CARB’s EMFAC emissions modeling tool, most recently updated in 2017 (CARB, 2018d), indicates that the median mileage for Class 8 vehicles is approximately 410,000 during the first five years of ownership. The current heavy-duty vehicle emission warranty period of 100,000 miles is reached relatively early in the vehicle life, and well before engine rebuild typically occurs. In this case, Class 8 vehicles provide the most striking comparison, with their real-world longevity being between 8 to 12 times the current warranty period mileage requirement based on “B10 life” and “B50 life” statistics.

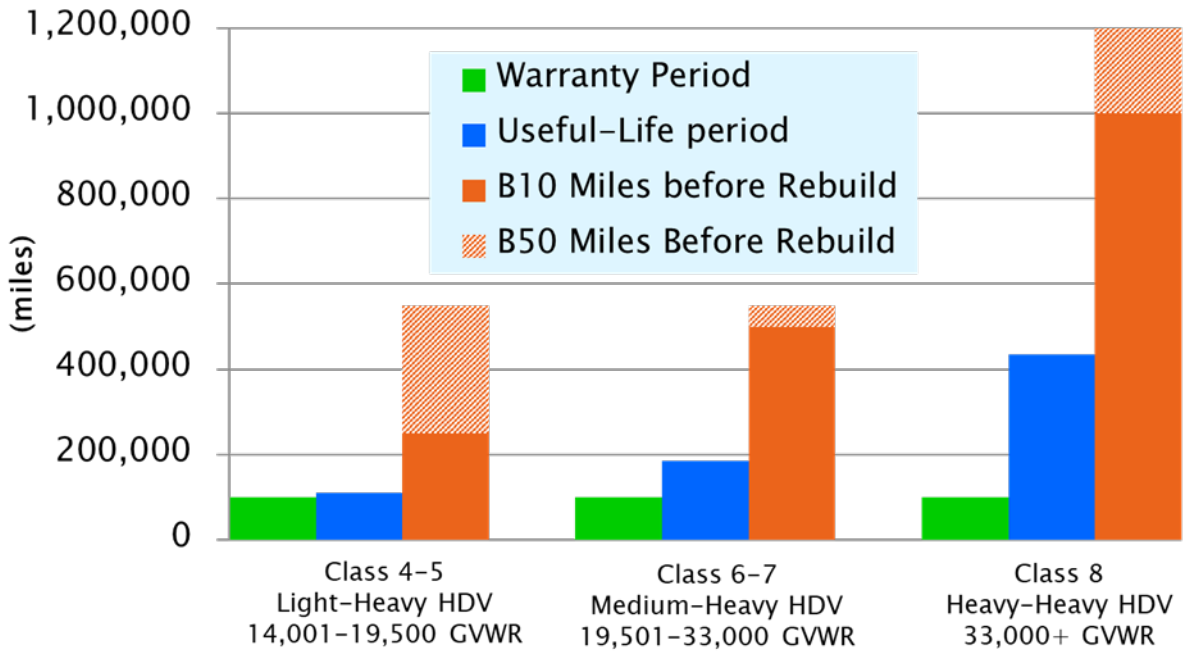

Figure II-5. Comparison of Warranty and Useful-Life to Real-World Longevity

7. Current Maintenance Interval Issues, Warranted Part Definition Update, and Manufacturer/Owner Maintenance Liability Clarification

This section describes three issues with the current warranty regulations: scheduled replacements effectively shortening warranty, the outdated definition of a warranted part, and a lack of clarity regarding who is liable for repair and replacements resulting from routine scheduled inspections.

Scheduled Replacement Intervals Could Shorten Warranty

As previously explained in Chapter I, section B.3, section 86.004-25 of the "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy Duty Diesel Engines and Vehicles" specifies the minimum allowable maintenance intervals for specific emission-related components. These intervals were established as a result of manufacturers realizing that certain emission-related components needed maintenance to complete the durability testing requirements needed for certification. These provisions currently place the burden of maintaining on-road heavy-duty diesel vehicles on owners after the current warranty period has expired, and even during the warranty period if repair or replacement is specified at that time by the manufacturer. Currently, virtually all minimum maintenance intervals, with the exception of non-emission-related scheduled maintenance requirements (i.e., for oil changes, filter replacements, etc.) and EGR coolers, occur at or after the end of the current 100,000 mile warranty period; hence, the current minimum maintenance intervals have little effect on current warranty requirements. EGR coolers, being the exception, have a minimum maintenance interval of 50,000 miles during which the manufacturer can require replacement of the cooler at the vehicle owner's expense (see section 86.004-25 (b)(4)(i)(A) of the "California On-Road Heavy-Duty Diesel Test Procedures").

Especially problematic is an existing maintenance provision that has the potential to supersede, and truncate, the proposed lengthened warranty periods. Specifically, 13 CCR 2036 (d)(3) states that warranty coverage ends after the first scheduled replacement of any emission-related component, even if the warranty period for that component has not yet been exceeded. Currently, this provision has little practical effect because, as mentioned, the minimum allowable maintenance intervals for almost all emission related components are at least 100,000 miles, which is equivalent to the current emissions warranty period for heavy-duty diesel vehicles. The provision is a remnant from the original warranty regulations adopted in California on December 14, 1978.

This existing provision, however, could inadvertently circumvent the benefits of the proposed lengthened warranty periods because it would allow manufacturers to schedule replacement of components during the proposed lengthened warranty periods of this rulemaking. This could potentially reduce or completely undermine the proposed lengthened warranty coverage, even reverting back, in some cases, to the original 100,000 mile limit of the existing regulations. As an example, the minimum allowable replacement interval for fuel injectors on a heavy heavy-duty diesel engine is currently 150,000 miles (40 CFR 86.004-25 (b)(4)(iii)(A)). Under staff's proposal, the amended warranty period for fuel injectors on a heavy heavy-duty diesel engine would increase to 350,000 miles (staff's proposal is discussed in greater detail in Chapter III). However, should a manufacturer schedule the fuel injector to be replaced at 150,000 miles, as the regulations currently allow, the vehicle or engine owner would be required to pay for that replacement and any subsequent replacement of the fuel injector, scheduled or non-scheduled, throughout the remaining warranty period (e.g., 150,001 through 350,000 miles. A large portion of the projected benefits from staff's proposal to lengthen heavy-

duty warranty periods would be due to the vehicle or engine owner being incentivized to repair emission-related malfunctions in a timely manner. Staff currently estimates that only 30 percent of vehicle and engine owners will address nonperformance-related repairs outside of warranty because of the out-of-pocket costs. Consequently, if a vehicle or engine owner would still have to pay out-of-pocket costs to replace a part during the lengthened warranty periods, the likelihood would diminish that the vehicle or engine will be repaired in a timely manner, and thus the benefits from lengthening warranty would not be fully realized.

Definition of Heavy-Duty Warranted Part Outdated

Under existing California regulations, a heavy-duty "warranted part" is defined as a part found on the "Emissions Warranty Parts List" referenced in 13 CCR 2036 (f) (13 CCR 2035 (c)(2)(A)). This parts list was last updated on February 22, 1985, and no longer reflects the full complement of emission-related parts found on modern heavy-duty vehicles (e.g., DEF tanks, etc.). Today's heavy-duty engines and vehicles are computer controlled and utilize sensors, actuators, and other components that were not in wide circulation 30 years ago. For example, many components have been incorporated to support the monitoring of emission-related systems and components by HD OBD systems, which, as stated above, were not in use until recent years. Therefore, staff is proposing to clarify the definition of a warranted part as "any part that can affect the regulated emission of criteria pollutants." Although essentially a clarification of existing practices, this change is necessary to ensure that all emission-related components, now and in the future, are covered by warranty coverage, which is already the case for light- and medium-duty engines and vehicles.

Liability for Repair/Replacements Resulting From Routine Scheduled Inspections Unclear

Vehicle and engine owner obligations with respect to the performance of, and liability for, scheduled maintenance as specified in the vehicle owners manual, are contained in 13 CCR 2040. However, 13 CCR 2040 does not specifically address the liability for maintenance when an emission-related part is required to be replaced during the warranty period as the result of an inspection scheduled by the manufacturer at periodic intervals throughout the life of the vehicle. Rather, the section requires the vehicle owner to pay for all "scheduled" maintenance documented in the owners manual. This has the potential to be confusing because manufacturers could "schedule" routine inspections in the manual for which the vehicle owner is liable, but then remain silent with respect to which party is liable when a repair is needed because of the inspection, or in some cases could even direct the vehicle owner to make the repair at the owners cost. Staff believes that such a repair would fall into the category of "unscheduled" maintenance for which the engine or vehicle manufacturer is liable under the provisions of 13 CCR 2036 (d)(1). Furthermore, 13 CCR 2036 (d)(2) states that the warranty period shall not be reduced in such case as when a manufacturer states that a component must be repaired or replaced "as necessary" in the owners manual. However, the section does not specifically require the manufacturer to be liable for such repairs, even though that is the case for "unscheduled" maintenance as previously mentioned.

8. On-Board Diagnostic System Not Connected to Warranty

The emissions defect warranty for each of the on-road light-, medium-, and heavy-duty vehicles requires manufacturers to warrant that their vehicles or engines are free from defects in design, material and workmanship that would cause a warranted part to differ in any aspect from the same part as described in the application for certification application. Defects of these parts used in production vehicles could contribute to an increase in emissions. Therefore, any such defective parts covered under warranty need to be repaired or replaced.

The definition of a "warranted part" for on-road light- and medium-duty vehicles was amended in 1990 to include any part, "…which affects any regulated emission...," as well as to require the illumination of the OBD system's MIL whenever an emission-related part failed or functioned outside of its specified tolerance (CARB, 1989a).

As described in Chapter I, section B.4, all 2013 and later model year on-road heavy-duty vehicles are equipped with an HD OBD system that constantly monitors the vehicle and engine for malfunctions that can affect emissions of criteria pollutants, and notifies the vehicle operator by illuminating a MIL, and by storing fault codes that specifically identify the malfunction. However, although HD OBD has been fully implemented in California for over five years, the existing warranty regulation currently does not specifically extend warranty coverage to parts required to be monitored by HD OBD systems, as is currently the case for light- and medium-duty vehicles (13 CCR 2037 (b)(2)).

Both the emissions warranty and the HD OBD system are intended to ensure proper and timely repair of defective emission-related parts. However, although while the connection between emissions warranty and OBD has long been explicitly established for light- and medium-duty vehicles, no such explicit connection currently exists between the emissions warranty and the HD OBD system.

Because of this lack of connection, components that affect emissions (and which therefore must be monitored by HD OBD systems) are not always expressly identified as emission-related components subject to coverage under the emissions warranty. For example, indirectly emission-related components that are monitored by the HD OBD system but not covered under warranty include the pedal position sensor, vehicle speed sensor, coolant level sensor, oil pressure sensor, crankcase pressure sensor, thermostat, battery voltage, data link, and inlet air heater (EMA, 2018).

These components are not currently warranted because they do not directly affect emissions, but are monitored nonetheless by the HD OBD system because they provide necessary input for the monitoring of other components and systems that can directly affect emissions (e.g., engine misfire monitoring, fuel system monitoring, selective catalytic reduction (SCR), etc.), and because they can be used to enable Auxiliary

Emission Control Device operations.[38] Thus, should any of these indirectly emission-related components malfunction, the monitors they enable would not be allowed to perform properly. This would decrease the likelihood that other, potentially more significant malfunctions (e.g., the SCR, DPF, etc.) would be detected and repaired in a timely manner and hence would contribute to emissions increases due to the improper monitoring of direct emission-related components and systems.

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[38] An Auxiliary Emission Control Device is a design element which senses temperature, vehicle speed, engine RPM, transmission gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the emission control system.

III. PROPOSED SOLUTION TO THE PROBLEM

This chapter presents staff's proposed solution to the problems laid out in Chapter II. Section A explains and justifies staff's proposal. The main elements of staff's proposal include the following, each of which is discussed further in a corresponding subsection to Section A:

1. Longer minimum warranty periods to better match the longer service lives of modern heavy-duty vehicles, to achieve emission reductions, by incentivizing better vehicle maintenance by vehicle owners and encouraging manufacturers to make more durable parts. As an added benefit, the longer warranties would better protect vehicle owners from unfair repairs costs.
2. Removal of the current California 3,000 hour warranty period limit to align with the federal heavy-duty warranty requirements in this aspect.
3. Updating the minimum maintenance intervals so that they do not inadvertently negate the proposed lengthened warranty periods.
4. Explicitly linking HD OBD to the definition of warranted parts, as has been the case for light-duty vehicles since the 1990 model year.
5. Restricting the allowable scheduled repair or maintenance for turbochargers and EGR systems because of their relative high price and severe emission impacts under failure.
6. Revising exiting regulatory language that unintentionally shortens warranty periods, and other clarifications.

Besides these main elements of staff's proposal, subsection 7 also describes proposed changes for clarifying some existing language in 13 CCR 2035 and 2040.

Lastly, staff proposes to amend the warranty period requirements for heavy-duty engines in a two-step process, with the first step the subject of this staff report. Section B describes staff's recommended "two-step" rulemaking approach. Section C summarizes results of the Sacramento ISR warranty survey.

A. Staff's Proposal

1. Longer Warranty Periods for Heavy-Duty Engines Used in Heavy-Duty Vehicles

To address the need for additional emission reductions and for more durable emission control systems described above, staff proposes to amend the criteria pollutant warranty regulations in 13 CCR 2036 for 2022 and subsequent model year California-certified heavy-duty diesel vehicles and diesel engines, by lengthening the minimum warranty mileage periods. Subsection 1.1 describes the proposed lengthened warranties and why the length of a vehicle and engine's warranty is proposed to be based on engine service class. Subsection 1.2 describes why lengthened warranties are needed. Subsection 1.3 describes how staff knows lengthened warranties are feasible. Subsection 1.4 provides further information regarding the applicability of the proposed

lengthened warranties.

1.1 Staff's Proposed Lengthened Warranties

The proposed lengthened warranties are shown in Table III-1 below

Table III-1. Current and Proposed Minimum Heavy-Duty Diesel Warranty Periods

HEAVY-DUTY CATEGORY	CURRENT WARRANTY (miles)	PROPOSED WARRANTY (miles)
Heavy Heavy-Duty Engine	100,000 / 5 years / 3,000 hours	350,000 / 5 years
Medium Heavy-Duty Engine	100,000 / 5 years / 3,000 hours	150,000 / 5 years
Light Heavy-Duty Engine	100,000 / 5 years / 3,000 hours	110,000 / 5 years

Staff initially considered lengthening the warranty periods to coincide with the actual operational periods of modern heavy-duty trucks, which can approach one million miles. However, staff is now proposing that the Board approve for adoption the lengthened warranty periods set forth in Table III-1. Staff may subsequently propose, as part of CARB's comprehensive Low NOx rulemaking scheduled for Board consideration in late 2019, extending both useful life periods and warranty periods for heavy-duty vehicles with heavy heavy-duty engines. (See Chapter III, section B, for further discussion of this proposed approach).

As was explained in Chapter I, section B.2, although heavy-duty engine and heavy-duty vehicle combinations are usually consistent, there are instances when they are not, such as when a medium heavy-duty engine is installed into a Class 8 heavy heavy-duty vehicle. Under the current warranty regulations, there is no need to differentiate between heavy-duty engine service classes because the warranty period is the same across all engine classes. However, continuing to base the warranty period on the GVWR weight classification of a heavy-duty vehicle is problematic when the engine class does not match vehicle the vehicle class (e.g., if a medium heavy-duty engine with a useful life of 185,000 miles is installed in a Class 8 vehicle with a proposed warranty of 350,000 miles). To ensure that engines are not required to be warranted past their regulatory useful life, staff proposes that the period of warranty coverage would now be determined according to the primary intended service class of the engine family installed in the heavy-duty vehicle regardless of the GVWR of the vehicle in which it is installed, along with designating distinct warranty periods for each of the three heavy-

duty engine service classes (i.e., light heavy-duty, medium heavy-duty, and heavy heavy-duty). The scope of warranty coverage, however, would remain applicable to the vehicle.

1.2 Why Longer Warranties are Needed

As discussed further below, the proposed lengthened warranty periods for heavy-duty vehicles and engines are needed to reduce emissions by: (1) better representing their longer modern service lives and ensuring that the emission control systems remain sufficiently durable throughout a greater portion of a vehicle's service life, (2) reducing incidences of tampering and mal-maintenance, and (3) encouraging manufacturers to make parts more durable. As an added benefit, the lengthened warranty periods would protect heavy-duty vehicle owners from paying to replace emissions-related components that are supposed to remain durable throughout the useful life of the engine.

Better Represent Longer Modern Service Lives

As described above in Chapter II, section A.6, and illustrated previously in Figure II-5, manufacturer-provided "B10 life" and "B50 life" statistics indicate that heavy-duty engines are currently used much longer than 100,000 miles before being rebuilt or replaced. Therefore, because modern heavy-duty engines have longer service lives (up to 1.2 million miles), their warranty periods must also be increased to provide warranty coverage for a greater portion of that increased time in operation. The current warranty period of 100,000 miles covers less than a fourth of the useful life for heavy heavy-duty engines (i.e., 435,000 miles), which is the period over which the engine is required to emit no more than the applicable emissions standards for criteria pollutants.

The proposed amendments to the warranty periods are depicted in Figure III-1, along with the current applicable warranties based on vehicle classes 4-8. Figure III-1 also shows for each vehicle class the mileage estimate over a five-year timeframe.[39] The vehicle mileage highlights the need for the lengthened warranty coverage.

[39] Based on EMFAC 2017 populations for first five years.

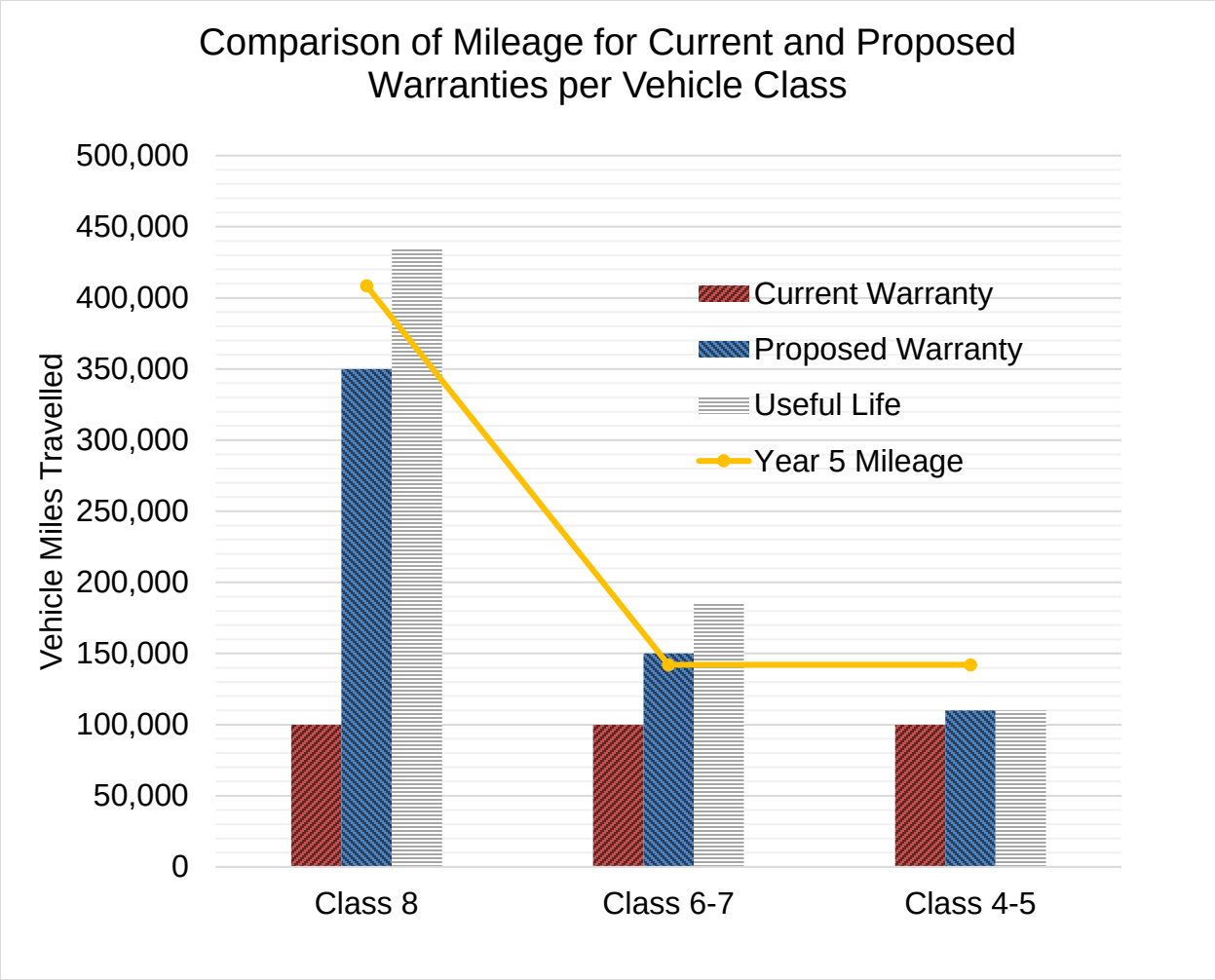

Figure III-1. Vehicle Miles Travelled over a Five-Year Period compared to the Current Heavy-Duty Warranties and Proposed Warranties

Reduce Incidences of Tampering and Mal-maintenance

Lengthened warranty periods may also reduce incidences of tampering and mal-maintenance. For example, there would be little incentive for a vehicle owner to tamper with the vehicle's emission control system, such as coring out or removing a DPF, or bypassing a catalyst, when the manufacturer is obligated to pay for any defect-related repairs. Further, vehicle owners would also have more of an incentive to perform scheduled maintenance on time so as not to void their lengthened warranty.

Staff estimates that only 30 percent of heavy-duty vehicle owners repair emissions-related problems that do not significantly affect a vehicle's fuel economy or performance outside of the warranty period (CARB, 2015b). One of the main observations of CARB's ongoing recent HD I/M Research Contract with UC Riverside: Center for Environmental Research and Technology confirms this estimate; researchers noted that

many heavy-duty vehicle owners decline emissions-related repairs if they are not crucial for keeping the vehicle operating (Durbin et al., 2017). Lengthening the warranty period might help to incentivize the approximately 70 percent of owners who do not currently repair emissions-related part malfunctions outside of the warranty period to now seek such repairs in a timely manner.

Encourage Development of More Durable Parts

Lastly, the proposed increased warranty periods may encourage manufacturers to develop more durable parts should the cost of frequent part replacements outweigh the cost to redesign and produce more durable parts.

Additional Benefit to Vehicle Owners

Lengthening warranty periods would also protect heavy-duty vehicle owners from paying-out-of-pocket expenses to replace emissions-related components that are supposed to remain durable throughout the useful life of the engine. In particular, lengthened warranty periods are needed in the near-term to protect heavy-duty vehicle owners from having to pay for future repair costs that are identified by CARB's planned amendments to the Periodic Smoke Inspection Program (PSIP) and Heavy-Duty Vehicle Inspection Program (HDVIP) and any potential future California heavy-duty vehicle inspection and maintenance (HD I/M) program. Amendments to PSIP and HDVIP are scheduled for Board consideration in May 2018, and may include much stricter opacity limits, which could result in more vehicle owners seeking to make timely engine repairs and replace DPFs, beginning in 2019 (CARB, 2018g). In addition, adoption of a potential HD I/M program is being contemplated for the 2020 time frame. Legislation sponsored by Senator Connie Leyva directing CARB to develop a HD I/M program is currently being considered by the California legislature (CARB, 2017i).

Without a lengthened warranty period requirement, even vehicle and engine owners who perform required maintenance as scheduled would be required to pay for any repairs due to defective emissions-related parts that cause a failure under the PSIP or HDVIP or a future HD I/M program after only 100,000 miles.

1.3 Why Longer Warranties are Feasible

Based on information obtained from the Sacramento ISR survey and other industry sources, which is detailed further in Chapter III, section C, of this report, staff determined that many heavy-duty vehicles already have warranty periods beyond the regulatory required 100,000 miles. For example, as summarized in Table III-2, staff estimates that only 15 percent of vehicles greater than 33,000 pounds GVWR (Class 8 vehicles) rely on the 100,000 mile warranty period, with the remainder having an extended warranty to 250,000 miles (45 percent) or to 500,000 miles (40 percent). In addition, only 60 percent of heavy-duty vehicle classes 4-5 and 6-7 are estimated to rely on the 100,000 mile warranty period, with the remaining 40 percent having an extended warranty.

Table III-2. Current Warranty Mileage Periods by Vehicle Service Classes

Class 8 HDV		Class 6-7 HDV		Class 4-5 HDV	
Miles Warranted	Percent Vehicle Population	Miles Warranted	Percent Vehicle Population	Miles Warranted	Percent Vehicle Population
500,000	40%				
250,000	45%	185,000	40%	110,000	40%
100,000	15%	100,000	60%	100,000	60%

In addition to reviewing "B10 life" and "B50 life" statistics for longer warranty period feasibility, staff consulted with heavy-duty vehicle and engine manufacturers, emission control system manufacturers, U.S. EPA, independent third-party warranty providers, and the Sacramento ISR in determining both the practicality and feasibility of lengthening the warranty period for heavy-duty vehicles.

Staff found that vehicle manufacturers universally already offer extended warranties longer than the minimum 100,000 mile length, usually at additional cost to the vehicle purchaser. Published manufacturers' basic mechanical warranties and extended warranties demonstrate that engines and components are capable of controlling emissions for significantly more miles than the current required emission warranty period of only 100,000 miles. In particular, the notable conclusions resulting from staff's information gathering include:

- Currently, heavy-duty engine and vehicle manufacturers offer basic mechanical warranties[40] of 2 years or 250,000 miles, and up to 3 years or unlimited miles based on the vehicle type (Cummins, 2017a). In addition, some manufacturers include aftertreatment devices in their basic mechanical warranties.
- Manufacturers also have a common practice of offering extended warranties, often at an additional cost to the purchaser of the vehicle. The coverage provided by these warranties varies by manufacturer. Some range up to 7 years or 700,000 miles (Cummins, 2017b), although a 500,000 mile warranty is most common.
- Extended warranties are also provided by independent third-party businesses. Third-party warranties are already offered as high as 1,000,000 miles (Truck Master Plus, 2018).

[40] Basic mechanical warranties cover defects of the "basic" or "major" engine components (e.g. cylinder block, cylinder head, camshafts, rocker arms, manifolds, etc.) but not necessarily any the emission control system components.

- A large majority of new heavy-duty vehicles are sold with at least 250,000 mile warranties (CARB, 2018h).
- Between 40 and 50 percent of all new heavy-duty vehicles are warranted to 500,000 miles (ISR, 2017).
- DPFs and SCR systems are typically designed for 1,000,000 miles of operation.

Further details and discussion of the survey is provided in subsection 1.4, below, and in Appendix H.

1.4 Scope of Staff's Proposal and Applicability of Lengthened Warranties

Staff is not proposing to amend the useful life for heavy-duty diesel engines at this time, as useful life is an intrinsic part of the new engine standards (as contained in 13 CCR 1956.8), which staff is also not proposing to modify at this time. However, as discussed further in Section B below, staff is planning to propose amendments to the on-road heavy-duty engine standards for the Board's consideration in 2019. Those future amendments may include extended useful life periods.

The applicability of staff's warranty period proposal is limited to new 2022 and subsequent model year California-certified heavy-duty diesel vehicles and engines. Further, the proposed amendments would not amend the warranty periods specifically applicable to greenhouse gas components (CARB, 2017j) as required by California's Phase 2 greenhouse gas regulation (13 CCR 2036 (c)(4.1), (c)(4.2), and (c)(8.1). Such greenhouse gas components include tires, automatic tire inflation systems, vehicle speed limiters, idle shutdown systems, fairings, and hybrid system components, and devices added to the vehicle to improve aerodynamic performance, etc. Staff's proposal would apply to California-certified and registered (13 CCR 2035(b)) vehicles and engines only. Federally certified heavy-duty vehicles operating in California would not be subject to the new warranty period requirements.

The proposed warranty period requirements would only be applicable to new California-certified 2022 and subsequent model year heavy-duty vehicles greater than 14,000 pounds GVWR in which 2022 and subsequent model year heavy-duty diesel engines are installed. Staff is proposing that the initial date for the applicability of the amended warranty periods be based on the model year of the engine, and not on the vehicle because some new 2022 model year heavy-duty vehicles may still be equipped with 2021, or previous model year diesel engines at the time of sale.

In California, the majority of medium-duty vehicles (vehicle classes 2b and 3), with GVWR of 8,501 lbs. to 14,000 lbs, are certified under either the California's Low-Emission Vehicle (LEV) program regulations using chassis dynamometer-based test procedures (unlike heavy-duty vehicles whose engines are emission certified using engine dynamometer-based test procedures). Only three percent of the 2016 model

year medium-duty vehicles were powered by diesel engines that were certified using the engine dynamometer test procedures. Staff considered amending the warranty period for these engines which are used in medium-duty vehicles, but decided not to do so for the reasons enumerated below.

First, as explained previously, the main justification for proposing lengthening warranty periods, particularly for heavy-duty vehicles with engines certified as heavy heavy-duty engines, is because their lifetime vehicle miles travelled far exceeds their current warranty period. The same disproportionality is not as significant for vehicle classes 2b and 3 which have minimum warranties of 50,000 miles, which they travel in roughly 4 years.

Second, vehicle classes 2b and 3 are mainly in their own respective emissions "regulatory" group. Currently, engine dynamometer-based certifications are not required for Class 2b or 3 vehicles (i.e., engine dynamometer-based certification is optional for diesel-powered Class 3 vehicles). However, by 2020, all Class 2b diesel engine families will be required to certify to the LEV III standards using the chassis-based test procedures of 13 CCR 1961.2. So it seems that a natural regulatory division exists between heavy-duty vehicles with GVWR greater than 14,000 pounds and class 2b and 3 medium-duty vehicles with a GVWR of 14,000 pounds and less. Accordingly, Class 2b and 3 warranties would more naturally be considered along with warranties for other "lighter" vehicles covered under the LEV program and that are chassis-certified. Thus, it is reasonable to limit this warranty period proposal to only the heavy-duty vehicle group, and leave any necessary warranty period amendments for medium-duty vehicles in conjunction with future LEV amendments.

Staff also considered lengthening the warranty period for spark-ignition heavy-duty vehicles and engines in this proposal, but the number of such vehicles and engines in California is relatively small by comparison, and the emission benefits from lengthening warranty for them would also have been small.

This proposal is not including any warranty period amendments that affect heavy-duty vehicles powered by battery electric systems, fuel cells, hybrid-electric systems, or any other hybrid systems. These types of technologies are still developing, and their commercial integration in heavy-duty vehicles is still evolving. Warranty periods for heavy-duty vehicles and engines using other systems may be addressed in future rulemaking actions.

Lastly, staff is not proposing any exemptions from the proposed increases in minimum warranty mileage length for low-mileage vehicles (such as some refuse haulers). Although staff recognizes that some vehicles do not travel high mileages, and therefore their owners will see no benefit from the increased warranty mileage lengths, providing such an exemption would be impractical and would complicate both CARB's certification and enforcement activities for these vehicles because it is not always clear at time of sale whether any one vehicle will necessarily be a low-mileage vehicle. For low-mileage vehicles, the warranties would continue to be governed by the existing

minimum 5 year warranty periods and manufacturers would need to honor warranties out to that time.

2. Removal of the 3,000 Hour Engine Operating Warranty Limit

A key difference between current federal and California heavy-duty vehicle warranty requirements is that California regulations include a provision allowing warranty periods for heavy-duty diesel engines to be limited based on “hours of operation” in addition to “time in service” (i.e., years) or accumulated miles.

The original intent of limiting warranty periods on the basis of hours of operation was to prevent an unduly burdensome warranty obligation for vocational vehicles, such as refuse haulers, with engines that idle for many hours or that are driven very few miles at low speeds, and hence that do not accumulate mileage as quickly as other heavy-duty vehicles. Such vocational applications may only accumulate 15,000 miles per year, but may idle for many hours.

Given that operating conditions in California are no more severe than in other states, it is difficult to justify keeping the provision, especially considering that vocational manufacturers have still been able to successfully obtain federal certification for engines when the federal warranty regulations do not contain this 3,000 hour engine operating provision.

Therefore, staff proposes to now remove the 3,000 hour period limit no longer be applicable in California, just as it is not applicable nationally. This elimination should not present a burden to vocational vehicle manufacturers in that the amended yearly warranty period will not be extended beyond the current 5 year period already in effect. Just as they currently do federally, manufacturers would need to design engines to handle whatever hours of operation they could be expected to encounter during 5 years of operation.

3. Updated Maintenance Intervals

As discussed above in Chapter II, the existing minimum maintenance intervals have the potential to dilute the effectiveness of the proposed warranty periods and hence to cause emission increases. Accordingly, to prevent these emission increases, staff is proposing to amend the minimum maintenance intervals for light-, medium-, and heavy-heavy-duty engines, as shown in Tables III-3, III-4, and III-5, respectively, below. Staff is proposing to lengthen the maintenance intervals to the shortest (i.e., most frequent) repair/replacement maintenance interval currently needed by any manufacturer for each emissions-related parts. It is clear that the proposed lengthened minimum maintenance intervals are feasible because they represent the most frequent interval needed by any current heavy-duty engine for each component or system, and hence all current heavy-duty engines comply with them.

Table III-3. Light Heavy-Duty Diesel Engine (14,000 lb. < GVWR ≤ 19,500 lb.)

Component or System	Minimum Maintenance Interval from Survey of Owner's Manuals (miles/year)	California & Federal Minimum Maintenance Interval specified in 86.004-25 (miles/hr)	Proposed Minimum Repair or Replacement Interval (miles/year)
EGR Filters & Coolers only	None	A, CL, F, R 50k or 1,500 hr	Not Replaceable[1]
Crankcase Vent. Valve & Filter	R - 50k		50k
DEF Filter	R - 120k+		110k or 2 years
Fuel Injector tips	None	CL - 50k or 1,500 hr	110k
Fuel Injectors	None	A, CL, F, R 100k or 3,000 hr	110k
Turbocharger	I - 72k+		Not Replaceable[1]
ECU, Sensors, Actuators	A - 100k+		100k or 3,000 hr
DPF System (other than Filter)	A, I - 100k+ CL - 110k+		110k
EGR System other than Filter & Cooler	R - EGR Cooler hose 3 year		110k/3 years
Catalytic Converter (other than catalyst bed)	None		110k
DPF Filter only	CL - 100k+	A, CL - 100k or 3,000 hr	Not Replaceable[1]
Catalyst bed only	None		Not Replaceable[1]
Any other add-on or new technology emission-related component or system whose primary purpose is to reduce emissions or whose failure will significantly degrade emissions control	--	--	110,000 miles or 3,300 hr[2]

A – Adjust; I – Inspect; DEF - Diesel Exhaust Fluid; F – Repair; DPF - Diesel Particulate Filter; R – Replace; CL – Clean; k - 1,000 miles; hr – hours

[1] For components or systems designated in the table as "Not Replaceable," manufacturers shall not schedule any repair or replacement maintenance intervals throughout the applicable useful life of the heavy-duty diesel engine except as noted in 86.004-25 (b)(7)(i) of the "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles."

[2] Manufacturers may request more frequent repair / replacement maintenance intervals for add-on or new technology emission-related components provided that the manufacturer demonstrates to the Executive Officer's satisfaction that such intervals are technologically necessary and appropriate.

Table III-4. Medium Heavy-Duty Diesel Engine (19,500 lb. < GVWR ≤ 33,000 lb.)

Component or System	Minimum Maintenance Interval from Survey of Owner's Manuals (miles/year)	California & Federal Minimum Maintenance Interval specified in 86.004-25 (miles/hr)	Proposed Minimum Repair or Replacement Interval (miles/year)
EGR Filters & Coolers only	None	A, CL, F, R 50k or 1,500 hr	Not Replaceable[1]
Crankcase Vent. Valve & Filter	R - 50k		60k or 2,000 hr or 1 year
DEF Filter	R - 120k+		125k or 3,000 hr or 10 years
Fuel Injector tips	None	CL - 50k or 1,500 hr	185k
Fuel Injectors	None	A, CL, F, R 100k or 3,000 hr	185k
Turbocharger	I - 72k+		Not Replaceable[1]
ECU, Sensors, Actuators	A - 100k+		150k or 4,500 hr
DPF System (other than Filter)	A, I - 100k+ CL - 110k+		185k/3 years
EGR System other than Filter & Cooler	R - EGR Cooler hose 3 year		185k
Catalytic Converter (other than catalyst bed)	None		185k
DPF Filter only	CL - 100k+	A, CL - 100k or 3,000 hr	Not Replaceable[1]
Catalyst bed only	None		Not Replaceable[1]
Any other add-on or new technology emission-related component or system whose primary purpose is to reduce emissions or whose failure will significantly degrade emissions control	--	--	185,000 miles or 5,550 hr[2]

A – Adjust; I – Inspect; DEF - Diesel Exhaust Fluid; F – Repair; DPF - Diesel Particulate Filter; R – Replace; CL – Clean; k - 1,000 miles; hr – hours

[1] For components or systems designated in the table as "Not Replaceable," manufacturers shall not schedule any repair or replacement maintenance intervals throughout the applicable useful life of the heavy-duty diesel engine except as noted in 86.004-25 (b)(7)(i) of the "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles."

[2] Manufacturers may request more frequent repair / replacement maintenance intervals for add-on or new technology emission-related components provided that the manufacturer demonstrates to the Executive Officer's satisfaction that such intervals are technologically necessary and appropriate.

Table III-5. Heavy Heavy-Duty Diesel Engine (GVWR > 33,000 lb.)

Component or System	Minimum Maintenance Interval from Survey of Owner's Manuals (miles/year)	California & Federal Minimum Maintenance Interval specified in 86.004-25 (miles/hr)	Proposed Minimum Repair or Replacement Interval (miles/year)
EGR Filters & Coolers only	None	A, CL, F, R 50k or 1,500 hr	Not Replaceable[1]
Crankcase Vent. Valve & Filter	R - 50k		60k or 2,000 hr or 1 year
DEF Filter	R - 120k+		125k or 3,000 hr
Fuel Injector tips	None	CL - 50k or 1,500 hr	435k
Fuel Injectors	None	A, CL, F, R 100k or 3,000 hr	435k
Turbocharger	I - 72k+		Not Replaceable[1]
ECU, Sensors, Actuators	A - 100k+		150k or 4,500 hr or 5 years
DPF System (other than Filter)	A, I - 100k+ CL - 110k+		435k/3 years
EGR System other than Filter & Cooler	R - EGR Cooler hose 3 year		435k
Catalytic Converter (other than catalyst bed)	None		435k
DPF Filter only	CL - 100k+	A, CL - 100k or 3,000 hr	Not Replaceable[1]
Catalyst bed only	None		Not Replaceable[1]
Any other add-on or new technology emission-related component or system whose primary purpose is to reduce emissions or whose failure will significantly degrade emissions control	--	--	435,000 miles or 13,050 hr[2]

A – Adjust; I – Inspect; DEF - Diesel Exhaust Fluid; F – Repair; DPF - Diesel Particulate Filter; R – Replace; CL – Clean; k - 1,000 miles; hr – hours

[1] For components or systems designated in the table as "Not Replaceable," manufacturers shall not schedule any repair or replacement maintenance intervals throughout the applicable useful life of the heavy-duty diesel engine except as noted in 86.004-25 (b)(7)(i) of the "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles."

[2] Manufacturers may request more frequent repair / replacement maintenance intervals for add-on or new technology emission-related components provided that the manufacturer demonstrates to the Executive Officer's satisfaction that such intervals are technologically necessary and appropriate.

To determine what maintenance interval to propose, staff first determined what the current manufacturer-specified maintenance intervals were for critical emissions-related components by surveying owners manuals for all 2016 California-certified on-road heavy-duty diesel engines. Specifically, all of the owners manuals for these engine families were reviewed, and the shortest (i.e., most frequent) repair/replacement maintenance interval specified for emissions-related parts, by any manufacturer, was determined. For example, Table III-6 sets forth the repair/replacement intervals for an engine's crankcase filter specified by four different manufacturers.

Table III-6. Example Repair/Replacement Intervals for Crankcase Filter

Manufacturer	Indicated Repair/Replacement Intervals (miles)
A	**50k**
B	60k
C	70k
D	80k

In this example, the shortest maintenance interval specified (i.e., 50,000 miles by Manufacturer A, as shown in **bold** font) was the shortest repair/replacement maintenance interval specified by any manufacturer needed and hence would have been selected as the proposed new minimum repair/replacement interval. Further, if all manufacturers did not recommend any required maintenance for a component or system, then the minimum repair/replacement maintenance interval for that component or system is proposed as the useful life of the engine. Manufacturers are required to disclose any maintenance requirements that would prevent the engine from complying with emission standards throughout the useful life of the engine in their certification applications. If no manufacturer indicates maintenance is required within the useful life for a particular emissions-related component or system, then it is technologically feasible for the minimum maintenance interval to be set at useful life for that component or system.

The results from the owners manual survey were divided based on the intended service classes of the engine families surveyed. These lists of proposed minimum maintenance intervals for light-, medium-, and heavy-heavy-duty engines, are shown in Tables III-3, III-4, and III-5, respectively. In these tables, the first column identifies the component or the system for which regulatory-specified minimum maintenance intervals are applicable. The second column shows the minimum maintenance interval periods that were derived from the owners manual survey. The current regulatory minimum maintenance intervals are the same for both California and U.S. EPA, and are shown in third column, as specified in 40 CFR 86.004-25 (as updated by U.S. EPA, on Oct. 25, 2016). Lastly, the fourth column is the proposed minimum repair/replacement intervals for the specified components and systems based on the rationale previously discussed.

Further, as discussed in greater detail in section A.5, below, in consideration of the degree to which emissions can significantly increase if turbochargers and EGR systems malfunction, along with the high cost of such systems, staff proposes to treat turbochargers and EGR systems in the same manner as presently required for DPF elements and catalyst beds (see sections 86.004-25 (b)(4)(iii)(D), (F), and (i) of the "California On-Road Heavy-Duty Diesel Test Procedures") with respect to allowable maintenance. In other words, manufacturers would not be allowed to schedule repair or replacement maintenance for turbochargers or EGR systems throughout the engine's useful life unless CARB's Executive Officer approves to a manufacturer's request to schedule maintenance for such systems and the manufacturer pays for the repair or replacement.

4. OBD Link to Warranty

In order to ensure repairs of malfunctioning emissions-related parts and systems on heavy-duty engines are performed in a more timely manner during the proposed lengthened warranty periods and to prevent emission increases, staff proposes to formally clarify the link between HD OBD and heavy-duty warranty requirements by adding language to 13 CCR 2036 (b)(2) for heavy-duty vehicles that is similar to the language currently in 13 CCR 2037 (b)(2) for light-duty vehicles. Specifically, the proposed language added to 13 CCR 2036 (b)(2) would specify that, "any defects in materials or workmanship which cause the vehicle's on-board diagnostic malfunction indicator light to illuminate," would be considered a warrantable condition. HD OBD systems have been fully implemented on on-road heavy-duty vehicles since the 2013 model year.

Staff proposes to formally clarify the link between HD OBD and heavy duty warranty by specifying that failures that cause the vehicle's OBD MIL to illuminate would be considered a warrantable condition. Because the HD OBD system is required to monitor all emission-related components and systems for proper operation, HD OBD provides a perfect tool for alerting the vehicle operator to emission-related failures and malfunctions that should be repaired during the warranty period. HD OBD even stores fault codes that specifically identify the malfunction, which can aid in vehicle repairs. . Under staff's proposal, any failure that lights the MIL, including components that directly increase emissions as well as indirectly emission-related components such as coolant level sensors and vehicle speed sensors would be covered.

Manufacturers today often submit warranty reports with HD OBD based warranty claims that indicate potential emission related defects to CARB. Therefore, this proposed amendment merely clarifies the current relationship between emission-related parts that must be warranted and the same parts that must be monitored by HD OBD systems. However, expressly specifying this relationship is expected to alert vehicle owners to emission-related parts failures and to incentivize them to address the causes of MIL illumination more quickly, especially in cases where no loss of vehicle performance or fuel economy is apparent.

5. Special Consideration for EGR Systems and Turbochargers

To prevent significant emissions increases from turbocharger and EGR system malfunctions, staff proposes that manufacturers would not be allowed to schedule repair or replacement maintenance for turbochargers or EGR systems throughout the engine's useful life unless CARB's Executive Officer approves to a manufacturer's request to schedule maintenance for such systems and the manufacturer pays for the repair or replacement. As discussed further below, it is feasible to not allow scheduling such maintenance or replacement because no manufacturer requires repairs or replacements of either the EGR systems or the turbochargers throughout the useful life of the engine, i.e., these components are already deemed durable by manufacturers to last throughout the full useful life of the engine.

As discussed in Chapter III, section A.3, under sections 86.004-25 (b)(4)(iii)(D), (F), and (i), of the "California On-Road Heavy-Duty Diesel Test Procedures," the filter element of the particulate trap or trap oxidizer systems, as well as the beds in catalytic converters (including diesel oxidation catalysts, SCR systems, and NOx adsorbers), are not permitted to be scheduled by manufacturers for replacement during the useful life of the engine unless the manufacturer covers the cost of that replacement. This prohibition was adopted in 2001, and was based on the rationale that the newly implemented low-sulfur levels in diesel fuels would allow these technologies to remain durable, with little or no other scheduled maintenance other than cleaning (FR, 2001). Accordingly, manufacturers were required to use designs that were durable enough to last the full useful life of the engine. The existing provisions also allow a manufacturer to request to replace one or more of these components during the useful life period, subject to CARB's Executive Officer approval and if the manufacturer pays for the repair or replacement.

The filter element and catalyst beds, along with other emissions-related components, are listed in Table III-7 for engines used in heavy-duty diesel vehicles that have a GVWR greater than 33,000 lbs. Table III-7 also includes the corresponding repair costs and emissions increase under a condition that would illuminate the HD OBD system's MIL. The repair cost is the average cost of the component plus the labor cost associated with fixing the component. As shown in Table III-7, for the currently excluded components (i.e., DPF, DOC, and SCR), any malfunctions that cause the MIL to illuminate result in significant increases in NOx emissions that exceed 100 percent, meaning that these components emit NOx at over twice the baseline during malfunction. In addition, these components are relatively expensive to repair, costing from $2,600 to $5,371.

Table III-7. Repair Cost and Emissions Increase for Heavy Heavy-Duty Diesel Components

Component	Repair Cost	Emissions Increase	
	HHD	**NOx**	**PM**
DOC*	$3,800*	108%*	
DPF*	$2,600*	282%*	4,766%*
EGR System	*$3,100*	*102%*	
Electronic Controls (NOx Sensor)	$670	114%	
Fuel Injection	$1,900	99%	
SCR*	$5,371*	304%*	
Turbocharger	*$5,100*	*147%*	

* Component where requiring replacement at owner's cost during useful life is already prohibited.

Because malfunctioning EGR systems and turbochargers (shown in italics in the table above) also can cause significant NOx increases and also are expensive to repair ($3,100 to $5,100), staff believes they should be treated like those special components indicated with an asterisk in the table. Thus, staff proposes that they be excluded from existing allowable scheduled replacements, and be subject to the same provisions applicable to catalyst beds and diesel particulate filters.

For further discussion of how the turbocharger and EGR system operate and their typical failure modes which lead to emission increases, a more detailed description is contained in Appendix E.

Feasibility of Limiting Maintenance Intervals for EGR Systems and Turbochargers

Section 86.004-25, of the "California On-Road Heavy-Duty Diesel Test Procedures," specifies the minimum allowable service intervals for specific heavy-duty engine emissions-related components. These minimum maintenance intervals are shown in Table III-8 for the EGR cooler, EGR valve, and Turbocharger. Based on the staff's survey (described above in Chapter III, section A.3) of the current heavy-duty engine owners manuals, no manufacturer requires repairs or replacements of either the EGR systems or the turbochargers throughout the useful life of the engine. Table III-8 provides the staff survey results for these particular components. As shown, these components are already deemed durable by manufacturers to last throughout the full useful life of the engine, and it is reasonable that they too should be exempted from an allowance for replacement during useful life.

Table III-8. Maintenance Schedule for Select Components in the Provisions and from Vehicle Manuals from the Manufacturer

Component	Minimum Maintenance Interval Specified in CFR 86.004-25[a]			Minimum Maintenance Interval from Survey of Manufacturers' Vehicle Owners Manuals		
	LHD	MHD	HHD	LHD	MHD	HHD
EGR Cooler	A, CL, F, R 50k or 1,500 hr	A, CL, F, R 50k or 1,500 hr	A, CL, F, R 50k or 1,500 hr	None	None	None
EGR Valve	A, CL, F, R 100k or 3,000 hr	A, CL, F, R 150k or 4,500 hr	A, CL, F, R 150k or 4,500 hr	None	None	None
Turbocharger Systems	A, CL, F, R 100k or 3,000 hr	A, CL, F, R 150k or 4,500 hr	A, CL, F, R 150k or 4,500 hr	None	I, CL 180k+	I[41] 270k+

[a]LHD = Light Heavy-Duty Engines; MHD = Medium Heavy-Duty Engines; HHD = Heavy Heavy-Duty Engines; A = Adjust; CL = Clean; F = Repair; hr = hours; I = Inspect; k =1,000 miles; R =Replace

6. Prevent Current Maintenance Interval Provisions from Shortening Proposed Lengthened Warranty Periods

When staff reviewed California's current heavy-duty maintenance provisions, staff discovered existing provisions that could unintentionally supersede and shorten the proposed lengthened warranty periods.

13 CCR 2036 (d)(3) states that warranty coverage ends after the first scheduled replacement of any emissions-related component, Under the current 100,000 mile warranty period, section 2036 (d)(3) has little practical effect because the minimum allowable maintenance intervals for almost all emissions-related components are at least 100,000 miles, and manufacturers are therefore generally unable to require the replacement of an emissions-related component before the 100,000 miles occurs.

However, with staff's proposed lengthened warranty periods for heavy-duty diesel vehicles, any maintenance scheduled that requires replacement of an emission-related component at 100,000 miles would effectively shorten the lengthened warranty period back to the original 100,000 miles. Consequently, increasing the warranty period would provide no additional incentive to vehicle owners to affect more timely repairs because

[41] Inspection intervals should not dictate minimum levels for adjustment, cleaning, repair, or replacement.

they would still have to pay out-of-pocket after the first replacement interval for a given component, and this would also decrease the emission benefits of staff's proposal.

Staff is accordingly proposing to amend this provision to now require that any component replaced during the lengthened warranty period would continue to remain subject to the warranty requirements throughout the remainder of the proposed warranty period. The existing provision is not present in the federal warranty regulations, so staff's proposed amendment to section 2036 (d)(3) would align California warranty requirements with those of the U.S. EPA regarding the continuation of warranty period requirements.

The proposed amendment is set forth below:

> "Any such part repaired or replaced under warranty shall be warranted for the ~~remainder of the period prior to the first scheduled replacement point for the part~~ remaining warranty period defined in subsection (c)."

7. Clarifications of Definitions and Vehicle Owner Obligations

This subsection describes two other clarifications staff is proposing as part of the proposed amendments.

Definition of a Warranted Part

Staff proposes to clarify the definition of a warranted part in 13 CCR 2035 (c)(2)(A) to include "any part that can affect emissions," as is already the case for light-duty vehicles. The proposed clarification is consistent with the definition of an "emissions-related part" in 13 CCR 1900 (b)(3) which is currently applicable to heavy-duty vehicles and engines, and includes the language in question.

Vehicle Owner Obligations

Staff also proposes to clarify the language in 13 CCR 2040 to be consistent with the requirement in 13 CCR 2036 (d)(2), which clearly indicates that manufacturers must pay to replace defective components discovered during inspections. Section 2040 does not currently differentiate whether the liability falls on manufacturers or vehicle owners in this case.

B. Possible Future Rulemakings to Extend Useful Life and Warranty

Staff is planning to propose amendments to the on-road heavy-duty engine standards for the Board's consideration in late 2019. Those future amendments may include lower NOx standards, improved certification requirements to better reflect emission control under low load urban driving operations, an improved in-use compliance testing

program, among other elements, and extended useful life periods, as well as consideration of revised minimum warranty periods.

As mentioned previously, staff initially considered lengthened warranty periods to be nearer to the service lives of modern heavy-duty trucks, but is now proposing that the Board approve for adoption the lengthened warranty periods as specified in this rulemaking action. In addition, proposing such extended useful lives involves greater analysis, and is thus best addressed as part of CARB's comprehensive Low NOx rulemaking scheduled for Board consideration in late 2019. This allows for useful life to be considered in conjunction with expected changes to the emission standards and certification procedures.

The proposed revisions to the warranty regulations as set forth in this staff report are intended to reduce emissions and to incentivize manufacturers to develop more durable emission-related parts, not to predict what warranty periods may be appropriate for any revised standards adopted in the future. In particular, for on-road heavy-duty diesel vehicles, the revised warranty periods addressed in this staff report are aimed at helping ensure that engines built to meet the current 0.2 grams per brake-horsepower hour (g/bhp-hr) NOx and 0.01 g/bhp-hr PM exhaust emission standards actually comply with such standards in use.

The low NOx standards that staff anticipates proposing in the future (late 2019) will likely be based in part on the technology demonstrations currently underway at Southwest research Institute (SWRI) (SwRI, 2016; CARB, 2017d; SwRI, 2017). Under contract with CARB and other partners, the work at SWRI is focusing on assessing the feasibility of lower NOx standards and the development of a low load test cycle. Because the technologies and strategies being assessed include evolutionary rather than revolutionary changes, any work that engine, aftertreatment, and component manufacturers do to improve durability to meet the warranty amendments discussed in this staff report would very likely still be relevant and valuable to systems developed to meet any new standards/test cycle that staff expects to propose in 2019.

C. Warranty Survey

As mentioned above, CARB hired the Sacramento ISR in 2016 to conduct a survey of heavy-duty vehicle owners and operators. The purpose of the survey was to better understand the cost structure and administration of base, corporate, and extended warranties currently being offered for heavy-duty vehicles. The results of the survey helped inform the economic impact analysis regarding the costs and savings associated with staff's proposal.

A total of 539 heavy-duty vehicle owners and 92 dealer/repair facilities participated in the survey. A detailed discussion of survey methodology including sample pool creation, a list of questions, weighted responses, and the statistical relevance of the data collection process can be found in Appendix H.

Highlights of the survey finding include:

- When it comes to satisfaction with their heavy-duty vehicle warranties, 64 percent of the vehicle owners say that they are either dissatisfied or very dissatisfied with the mandatory 5 year / 100,000 mile warranty.

- A majority of heavy-duty vehicle owners said that a 500,000 mile warranty was the most appropriate warranty duration that should be offered by manufacturers. The possible choices included 100,000 miles, 200,000 miles, 300,000 miles, 400,000 miles, 500,000 miles, and "other").[42]

- Owner/operators indicated that the average cost of repairs per vehicle was $2,131 per vehicle, while the average current mileage was 508,000 miles. The repair cost is similar to that deduced from CARB's warranty data, as described further below in Chapter IX.

- Of those vehicle owners that have an extended warranty, more than half (55 percent) say their extended warranty package costs over $2,500.

- Most vehicle owner extended warranty packages cover both parts and labor (84 percent) and are provided by the dealer (70 percent).

- More than half of the vehicle owner respondents (54 percent) report having experienced downtime due to repairs, and 62 percent say those repairs were not covered under warranty.

- Figure III-2 provides a breakdown of the average number of days of downtime due to vehicles being out of commission (days of downtime per vehicle). As Figure III-2 shows, average downtime per vehicle is significant, with over 15 percent of 2007 to 2017 model vehicles experiencing over a month of downtime due to repairs. Figure III-3 provides a breakdown of revenue per vehicle that was lost because of vehicle downtime due to repairs.

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[42] ISR Warranty Survey, "CARB FINAL REPORT 15MSC009 DEC 19 2017.pdf," Figure 16, Pg. 11, "Suggested Future Warranty Coverage Requirement" - 100k (4%), 200k (14%), 300k (9%), 400k (4%), 500k (52%), and Other > 500k (18%)," 12-19-2017

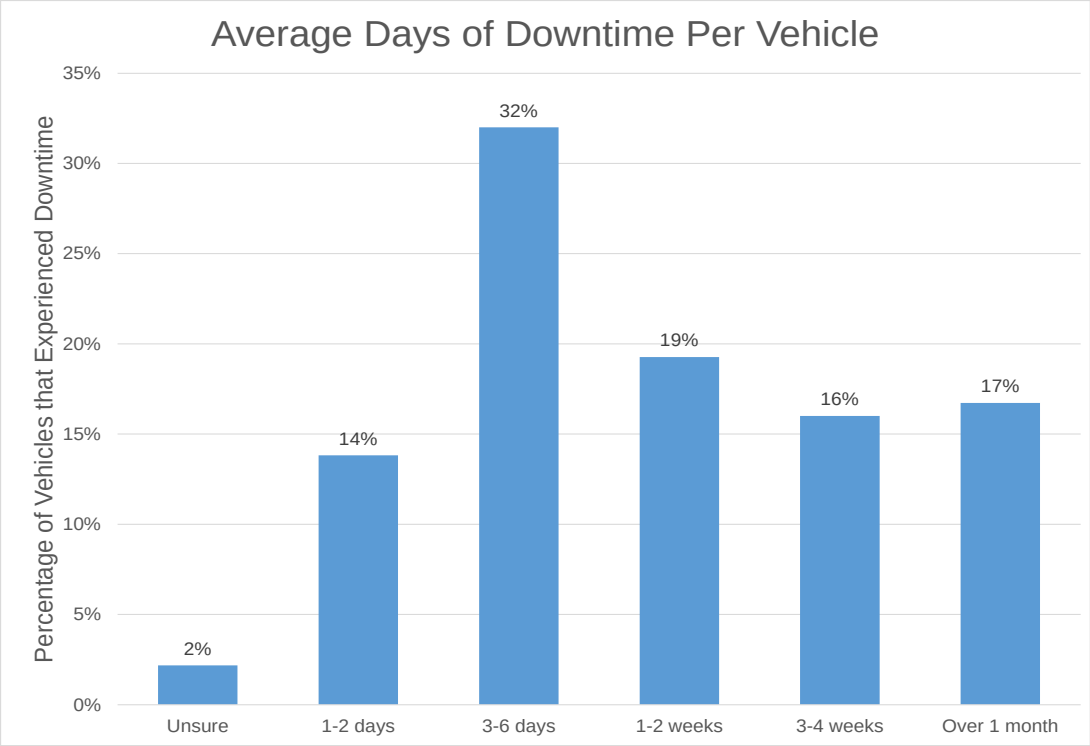

Figure III-2. Average Days of Downtime per Vehicle

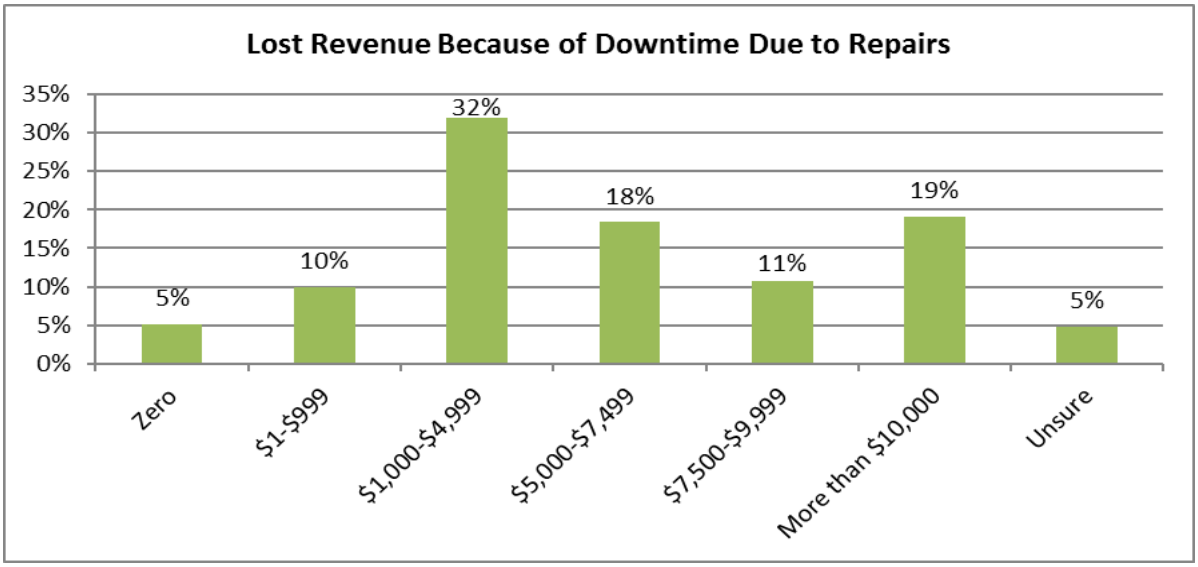

Figure III-3. Lost Revenue from Downtime Due to Repairs per Vehicle

IV. THE SPECIFIC PURPOSE AND RATIONALE FOR CARB'S DETERMINATION THAT EACH ADOPTION, AMENDMENT, OR REPEAL IS REASONABLY NECESSARY

California Government Code section 11346.2(b)(1) requires a description of the specific purpose for each proposed amendment, as well as a description of the rationale for determining that each proposed amendment is reasonably necessary to both carry out the purposes of staff's proposal and to address the problems described in Chapter II. Accordingly, Appendix I: Heavy-Duty Warranty Amendments Summary and Rationale presents the summary of each proposed amendment and describes its purpose and rationale.

V. BENEFITS ANTICIPATED FROM THE REGULATORY ACTION, INCLUDING THE BENEFITS OR GOALS PROVIDED IN THE AUTHORIZING STATUTE

Government Code section 11346.2(b)(1) requires enumeration of the anticipated benefits of regulatory actions. The air quality benefits of staff's proposal, including 0.75 tons per day of NOx reductions and 16 pounds per day reduction in PM2.5 emissions statewide in 2030, are further detailed in Chapter VI: Air Quality. This chapter discusses the anticipated health benefits of staff's proposal. Staff's proposal would result in statewide health-related benefits because it would improve air quality through the reduction of NOx and diesel PM emissions.

Lowering NOx emissions helps in lowering the levels of ozone, thereby reducing the premature aging of lungs and instances of chronic respiratory illnesses (CARB, 2017f). Further, lowering NOx emissions also results in lower PM2.5 levels, which helps to prevent cases of bronchitis, asthma, emergency room visits, respiratory symptoms, and restricted activity days, as well as premature deaths.

Reducing diesel PM emissions has been directly correlated with a reduction in the risk of premature deaths and hospital visits (especially for sensitive groups such as children, the elderly, and people with chronic heart or lung disease (CARB, 2016c)). While the short term (up to 24-hours duration) exposure to PM2.5 leads to acute and chronic bronchitis, asthma attacks, emergency room visits, respiratory symptoms, and restricted activity days, the long-term (months to years) exposure to PM2.5 has been linked to premature death, particularly in people who have people with chronic heart or lung disease, and reduced lung growth in children (CARB, 2017f).

CARB staff estimated health benefits resulting from staff's proposal using the health effects analysis model for the years 2022 to 2040 (CARB, 2010a). Table V-1 below summarizes the anticipated health benefits from the proposed warranty amendments. As noted in Table V-1, the reductions in diesel PM and NOx emissions on a statewide basis due to staff's proposed warranty amendments are projected to avoid 40 premature deaths. In addition, there are no benefits to worker safety anticipated as a result of this rulemaking. The methodology for estimating health benefits is described in Appendix G: Estimated Health Benefits Analysis.

Table V-1. Cumulative Statewide Avoided Health Impacts from 2022 to 2040 due to the Proposed Amendments

	Premature Mortalities Avoided	ER Visits Avoided	Hospitalizations Avoided
Statewide	40 (31 – 49)*	17 (11 – 23)*	6 (1 – 14)*

*Values in parentheses represent the 95 percent confidence interval.

VI. AIR QUALITY

This chapter provides a summary of the expected emission benefits associated with the proposed warranty amendments. The estimates were obtained using CARB's emissions inventory model version EMFAC2017 (CARB, 2018d). Staff calculated the NOx and PM2.5 emissions baseline and projected benefits for several selected calendar years starting in 2022, the first year when the proposed regulation would be implemented, through 2040. A more detailed discussion of how the emission benefits were calculated can be found in Appendix F: Heavy-Duty Vehicle Emissions Inventory and Estimated Emission Benefits for Proposed Heavy-Duty Engine Warranty Amendments.

As mentioned above, continued implementation of existing programs will provide significant emission reductions needed to bring many areas in California into attainment of the air quality standards for ozone and PM2.5. However, challenges still remain in meeting air quality standards in both the South Coast and San Joaquin Valley Air Basins, the only two areas in the nation classified as extreme nonattainment areas. For ozone attainment, CARB's air quality modeling indicates that total NOx emissions from all sources in the South Coast Air Basin will need to decrease to approximately 96 tons per day in 2031, representing an approximate 80 percent reduction from current levels (CARB, 2017k).

As discussed above, the proposed amendments would lengthen the emission warranties for Classes 4 and 5 heavy-duty vehicles to 110,000 miles, for Classes 6 and 7 heavy-duty vehicles to 150,000 miles, and for Class 8 heavy-duty vehicles to 350,000 miles. As also discussed above, lengthening the warranty period for heavy-duty vehicles would lead to reductions in emissions by helping ensure emission-related repairs are made in a timely manner and improving emission control system durability by encouraging manufacturers to produce more durable products. The effect of the proposed action would be to lower the tampering, mal-maintenance, and malfunctioning (TM&M) frequencies in EMFAC2017, which in turn would lead to a reduction in emissions from heavy-duty vehicles over the vehicles' useful lives and beyond. As shown in Table VI-1, in 2030, the proposed amendments would provide emission reductions of approximately 0.75 tons per day of NOx and 0.008 tons per day of PM2.5 (16 pounds per day) statewide.

Table VI-1. NOx and PM Statewide Emission Benefits (tons per day) From Proposed Amendments Implemented In 2022

Calendar Year	NOx		PM2.5	
	Baseline Emissions	Benefits	Baseline Emissions	Benefits
2023	157.3	0.06	1.39	0.001
2030	163.2	0.75	1.47	0.008
2031	163.9	0.84	1.47	0.009
2040	173.9	1.49	1.57	0.016

Figures VI-1 and VI-2 show a plot of the NOx and PM2.5 emission benefits, respectively, as they would increase with time as older vehicles are turned over and replaced with new vehicles with longer warranty periods.

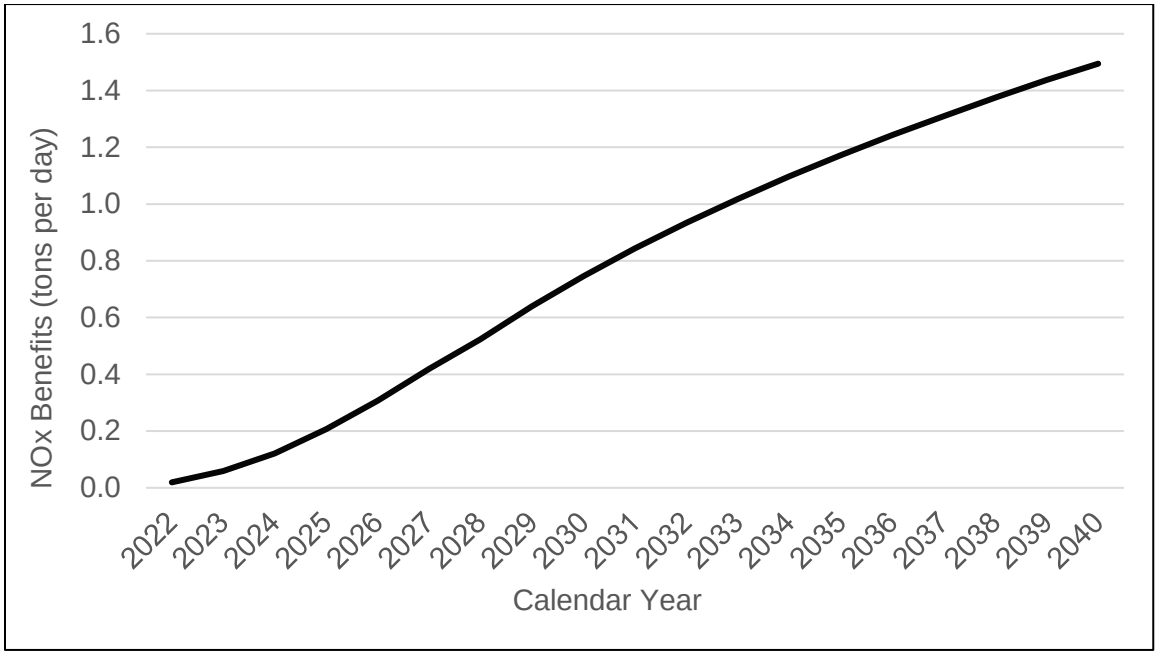

Figure VI-1. Statewide NOx Emission Benefits of Proposal

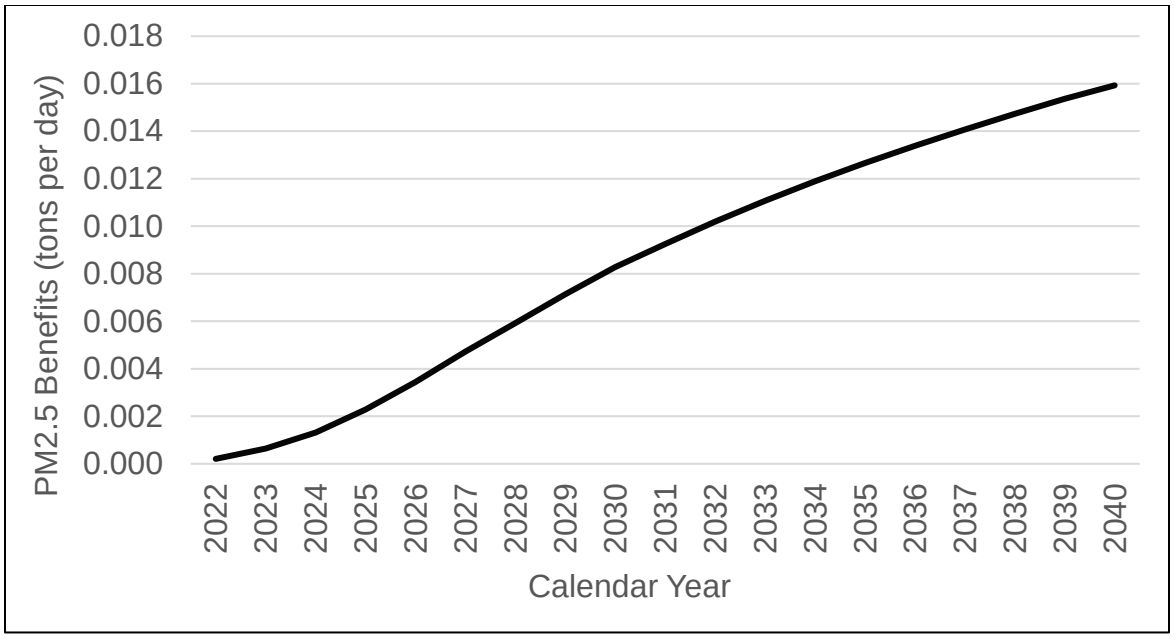

Figure VI-2. Statewide PM2.5 Emission Benefits of Proposal

VII. ENVIRONMENTAL ANALYSIS [CEQA ANALYSIS]

A. Introduction

This section provides the basis for staff's determination that the proposed amendments to the Warranty Regulations for On-Road Heavy-Duty Vehicles and Engines are exempt from the requirements of California Environmental Quality Act (CEQA). An analysis of this determination is provided in section B below. CARB's regulatory program, which involves the adoption, approval, amendment, or repeal of standards, rules, regulations, or plans for the protection and enhancement of the State's ambient air quality, has been certified by the California Secretary for Natural Resources under Public Resources Code section 21080.5 of CEQA (14 CCR 15251(d)). Public agencies with certified regulatory programs are exempt from certain CEQA requirements, including but not limited to, preparing environmental impact reports, negative declarations, and initial studies. CARB, as a lead agency, prepares an equivalent environmental document (referred to as an "Environmental Analysis" or "EA") as part of the Staff Report to comply with CEQA (17 CCR 60000-60008). If the proposed regulatory amendments are finalized, a Notice of Exemption will be filed with the Office of the Secretary for the Natural Resources Agency and the State Clearinghouse for public inspection.

B. Analysis

In compliance with the requirements of CEQA, staff has concluded that the proposed regulatory amendments qualify as exempt under CEQA because the action is both an action taken by a regulatory agency for protection of the environment (as described in CEQA Guidelines 15308 for "class 8" exemptions); and because it can be seen with certainty that there is no possibility that the proposed amendments may have a significant effect on the environment (as described in CEQA Guidelines 15061(b)(3) for "common sense" exemptions).

The proposed amendments to the Warranty Regulations for On-Road Heavy-Duty Vehicles and Engines would lengthen the required warranty periods and make other amendments to strengthen warranty-related requirements as described above in Chapter III. As described further above in Chapter I, since the 2010 model year, new heavy-duty vehicles have been subject to strict PM and NOx emission standards, which manufacturers have met by equipping new vehicle engines with DPFs for control of PM and SCR systems for control of NOx. If these systems fail, an individual vehicle's emissions can increase dramatically. Thus, it is critical that these after treatment systems work throughout a vehicle's life to ensure emissions remain low. Manufacturer warranties guarantee repairs and replacement of defective parts as needed, within a specified period of time, and provides assurance to the vehicle owner that the engine and its associated emission control system perform as required. Increasing the emission warranty periods would encourage manufacturers to improve the durability of their engines and emission control systems through the development and use of higher quality parts and materials. In addition, a lengthened warranty period would result in

fewer incidences of tampering and improper maintenance because the cost of repairs would be covered longer by the manufacturer, which in turn would result in reduced emissions deterioration rate and thus reduced emissions over the heavy-duty vehicles' service lives. Thus, amending the existing warranty period to require longer warranty periods would better protect air quality and the environment by encouraging vehicle owners to perform better maintenance and encouraging engine manufacturers to improve engine durability. Further, the amendments would incentivize vehicle owners who currently do not repair emission-related malfunctions after 100,000 miles to make repairs all the way up to the proposed warranty period. Further explanation of DPFs and SCR systems is provided below.

DPFs use catalysts that belong to the platinum group metals (PGM). The newer engines contain lower PGM content as these engines are designed to operate at higher temperatures and emit less PM. Used DPFs are recycled and stripped of their precious metals before being disposed. During periodic maintenance, the filters are regenerated wherein the accumulated PM is oxidized to inert gases such as carbon dioxide. The components of diesel PM that cannot be oxidized (ash) are physically removed. Ash cleaning is not required frequently, occurring approximately every 100,000 miles, and is conducted at a designated repair shop or dealer. Once the ash and the PGM group metal is removed, the DPF usually needs to be disposed of as hazardous waste. Federal and California laws require that hazardous waste is properly managed and disposed. Existing hazardous waste facilities, including landfills permitted for hazardous waste disposal, are expected to fully accommodate this disposal.

SCR is an emissions control technology system that injects a liquid-reductant agent through a special catalyst into the exhaust stream of a diesel engine. The reductant source is usually automotive-grade urea (i.e., containing ammonia), otherwise known as Diesel Exhaust Fluid or DEF. Using ammonia, NOx is reduced to nitrogen, water and carbon dioxide. This is one of the most cost-effective and fuel-efficient technologies available to help reduce NOx emissions. DEF is a non-toxic, non-polluting, and non-flammable substance that is safe to handle and store and poses no serious risk to humans, animals, equipment or the environment when handled properly. It is stored in a separate tank, and never comes in contact with the diesel fuel. The DEF has to be replenished periodically. SCR has been used for decades to reduce stationary source emissions from various industrial operations. In addition, marine vessels worldwide have been equipped with SCR technology, including cargo vessels, ferries and tugboats. SCR systems are typically coated with copper zeolite as opposed to PGM, so they do not have a recycle value. Once the core is removed, the ceramic material, which serves as a carrier for the active catalyst, is often donated to local artists or to producers of concreate or aggregate materials. Overall, maintenance and disposal of SCR systems poses no potential for an impact on the environment.

Under staff's proposed amendments, there would be an increase in the hazardous waste produced due to repairs and maintenance of heavy-duty vehicles. While routine maintenance should be taking place anyway, as noted above, the warranty amendments would provide vehicle owners an additional incentive to ensure that the

maintenance occurs regularly and properly and to promptly repair parts that fail. Any hazardous waste generated following heavy-duty vehicle repair must be managed, transported and disposed in accordance with State and federal law regulating hazardous waste management. In addition, staff's proposal is expected to result in emission benefits as summarized above in Chapter VI. Overall, CARB's action to amend the warranty regulations for engine and emission control systems of heavy-duty vehicles would have no potential to adversely affect air quality or any other environmental resource area.

Based on the information above, the proposed regulatory amendments would not result in a significant adverse impact on the physical environment. Further, the proposed action is designed to protect the environment, and staff found no substantial evidence indicating the proposal could adversely affect air quality or any other environmental resource area, or that any of the exceptions to the CEQA exemptions apply (14 CCR 15300.2). Therefore, staff has concluded that it is appropriate to rely on the class 8 and common sense exemptions to satisfy the requirements of CEQA for the proposed amendments.

VIII. ENVIRONMENTAL JUSTICE

State law defines environmental justice as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (Gov. Code 65040.12(c)). CARB is committed to making environmental justice an integral part of its activities. The Board approved its Environmental Justice Policies and Actions (Policies) on December 13, 2001, to establish a framework for incorporating environmental justice into CARB's programs consistent with the directives of State law (CARB, 2001). These policies apply to all communities in California, but recognize that environmental justice issues have been raised more in the context of low-income and minority communities.

The proposed amendments to the heavy-duty vehicle warranty regulations described in this staff report are consistent with CARB's environmental justice policy of reducing exposure to air pollutants and reducing adverse health impacts from toxic air contaminants in all communities. The proposed amendments would lengthen the minimum warranty periods, as well as strengthen warranty provisions in other ways, as detailed above in Chapter III. This would have the benefit of promoting timelier repairs of malfunctioning emission-related vehicle components, and support better overall maintenance and less tampering of the engines, and result in emission reductions of NOx as well as diesel PM. The emissions reductions resulting from adopting staff's proposal would contribute to the overall lowering of public exposure to criteria air pollutants from heavy-duty vehicles operating throughout the State. Emission reductions and health benefits due to reduction of diesel PM are expected to be the greatest where the majority of trucks operate, i.e., near major trucking and freight corridors and major ports and rail yards. Such areas tend to be in environmental justice regions. As a result, the amendments are expected to benefit residents of such regions.

IX. ECONOMIC IMPACTS ANALYSIS/ASSESSMENT

This chapter provides a summary of the estimated costs that would be incurred by industry and local and state agencies to comply with staff's proposal. For the purposes of this analysis, staff assumes that the direct costs incurred by engine and vehicle manufacturers due to the proposed amendments would be passed on to the ultimate purchasers of California-certified heavy-duty vehicles in the form of an increase in the purchase price of the vehicle. Currently, warranty costs are either included in the original purchase price of the vehicle or by providing extended warranties at an additional cost at the time of purchase. While there would be additional costs to heavy-duty vehicle purchasers, there would also be repair cost savings that would offset those initial capital costs.

Section A below discusses the estimated costs, while Section B discusses the estimated repair cost savings (i.e., benefits). Section C discusses the cost-effectiveness. Sections D through G discuss the economic impacts on California jobs and businesses. Sections H through I discuss the fiscal impact to State and local government agencies. Finally, Section J discusses why the proposed amendments to the minimum maintenance intervals do not impact costs. For more detail regarding how the costs and economic impacts were determined, refer to Appendix C: Economic Impact Analysis / Assessment.

A. Warranty Costs

1. Warranty Purchasing Business Practices

Staff used a survey by the Sacramento ISR of vehicle owners and dealers, and discussions with manufacturers and third-party warranty providers to establish the current business practices for purchasing heavy-duty vehicles with CARB-required emission control system warranties, manufacturer-provided warranties, and customer-purchased extended warranties. Staff also used this information to extrapolate the projected warranty purchasing practices under the proposed amendments. More detailed information on staff's assumptions can be found in Appendix C. The current and projected warranty purchasing business practices for heavy-duty vehicles greater than 14,000 pounds GVWR are shown in Tables IX-1 and IX-2.

Table IX-1. Current Warranty Purchasing Business Practices for Heavy-Duty Vehicles[43,44]

HHDV		MHDV		LHDV	
Miles Warranted	% of Vehicle Population	Miles Warranted	% of Vehicle Population	Miles Warranted	% of Vehicle Population
500,000	40%				
250,000	45%	185,000	40%	110,000	40%
100,000	15%	100,000	60%	100,000	60%

Table IX-2. Projected Warranty Purchasing Business Practices Due to the Proposed Amendments

HHDV		MHDV		LHDV	
Miles Warranted	% of Vehicle Population	Miles Warranted	% of Vehicle Population	Miles Warranted	% of Vehicle Population
500,000	40%	185,000	40%	110,000	100%
350,000	60%	150,000	60%		

2. Mileage Covered Under Warranty

Elimination of the 3,000 hour limit is unlikely to add measurable cost to the regulatory costs of the proposed warranty amendments for the reasons described below. The current warranty expires when a vehicle exceeds the mileage threshold, year threshold, or hour limit, whichever comes first. The majority of vehicles exhaust their warranties by exceeding either the mileage threshold or the year threshold, rather than the current 3,000 hour limit. Only vehicles with extensive idling practices or worksite vehicles which tend to use power take-off applications as their main function and which represent about 5 percent of total vehicles (Calstart, 2013), have the potential to exhaust their warranties due to the current 3,000 hour limit. Since some of these vehicles have extended warranties without an hours of operation provision, the actual percentage of vehicles that exceed their warranties due to the 3,000 hour limit is likely significantly less. Because so few vehicles exhaust their warranty due to the 3,000 hour limit, staff concluded elimination of the 3,000 hour limit is likely to add only negligible cost to the regulatory costs of the proposed warranty amendments.[45]

[43] Throughout this document, medium heavy-duty vehicle (MHDV) means a vehicle with an engine with medium heavy-duty certified primary intended service class. Heavy heavy-duty vehicle (HHDV) means a vehicle with an engine with heavy heavy-duty certified primary intended service class.

[44] Warranties are assumed to expire in 5 years or once the mileage threshold has been reached, whichever comes first.

[45] As discussed further in section A.3., staff provides a range of potential costs to stakeholders. Staff anticipates that any additional costs associated with vehicles currently affected by the 3,000 hour limit would be smaller than the range of costs provided.

The warranty year threshold is currently 5 years, so staff used the EMFAC[46] on-road vehicle model to examine the mileage accumulated during the first 5 years by vehicle application to estimate which vehicle types sold in California typically exhaust their warranties due to the mileage threshold and which do so due to the year threshold. This information was used to establish the average miles traveled under warranty for both the current warranty period and the proposed lengthened warranty period, as shown in Tables IX-3 and IX-4.

Table IX-3. Current Average Miles Traveled Under Warranty for Each Vehicle Category

Vehicle Category	Avg. Miles Traveled Under Warranty
HHDV	316,000
MHDV	116,600
LHDV	99,000

Table IX-4. Projected Average Miles Traveled Under the Proposed Warranty Amendments for Each Vehicle Category

Vehicle Category	Avg. Miles Traveled Under Warranty
HHDV	348,100
MHDV	140,600
LHDV	103,800

3. Cost of Repairs Under Warranty

Manufacturers are required to submit warranty claims data to CARB under 13 CCR 2141 through 2146 when their "unscreened" warranty claim rate for a specific part in an engine family is greater than or equal to one percent of sales, or 25 total parts[47] (13 CCR 2141-2146). Staff used the warranty claims data[48] for each engine component and the number of vehicles sold in each vehicle class to establish the rate of repair under warranty. Staff estimated repair costs for individual engine and aftertreatment components by analyzing repair shop data and through discussions with manufacturers and service providers (CARB, 2018b; Personal communication, 2017). Staff then applied these repair costs to the rate of repairs for each engine component to estimate the average repair costs that a typical heavy-duty vehicle experiences while still under

[46] CARB's Mobile Source Emissions Inventory Model for assessing the population, activity, and emissions from mobile sources. https://www.arb.ca.gov/emfac/

[47] The "25 total parts" threshold would generally be used for those engine families that had less than 2,500 sales.

[48] Staff used "unscreened" warranty claims data to estimate the repair rate which thus provides a conservative estimate of repair costs under warranty. If staff used "screened" warranty claims data, the repair costs would potentially be underestimated. Further explanation of the methodology for calculating repair costs is contained in Appendix C.

warranty. Staff estimates that average HHDVs experience about $2,289 worth of repairs, MHDVs experience about $2,100 worth of repairs, and LHDVs experience about $2,556 worth of repairs while under the current warranty periods. By assuming a linear relationship between the vehicle odometer mileage and the warranty claims rate, staff extrapolated these values to determine the average cost of repairs under the proposed lengthened warranty periods. The difference between the current warranty repair costs and the projected warranty repair costs equals the additional repair costs covered due to the proposed lengthened warranty period amendments. A comparison of the estimated repair costs under the current versus proposed warranties is shown in Table IX-5.

Table IX-5. Estimated Repair Costs Associated with the Proposed Lengthened Warranty Period Amendments (2017$)

Vehicle Category	Current Warranty		Proposed Warranty		Additional Repair Costs Covered
	Avg. Miles	Repair Cost	Projected Avg. Miles	Projected Repair Costs	
HHDV	316,000	$2,289	348,100	$2,522	$233
MHDV	116,600	$2,100	140,600	$2,534	$434
LHDV	99,000	$2,556	103,800	$2,680	$124

As stated above, staff is proposing to require warranty coverage for every component that causes the HD OBD MIL to illuminate. Further, as discussed in Chapter III, "indirectly emission-related" components that illuminate the MIL, but are not currently warranted by manufacturers, would now be warranted under staff's proposal. Thus, these components would be warranted in addition to the repaired parts that are estimated to be covered between the baseline scenario and the proposed warranty scenario.

Table IX-6 breaks down, for each vehicle category, the estimated repair costs associated with the proposed lengthened warranty period amendments and the additional repair costs covered due to linking HD OBD to heavy-duty warranty. Additional total repair costs due to the proposed amendments range from $149 to $437.

Table IX-6. Total Estimated Repair Costs Associated with the Proposed Warranty Amendments (2017$)

Vehicle Category	Additional Repair Costs Covered Due to Lengthened Warranty	Additional Repair Costs Covered Due to Linking HD OBD	Total Additional Repair Costs Covered Due to Proposed Amendments
HHDV	$233	$7	$240
MHDV	$434	$3	$437
LHDV	$124	$25	$149

4. Cost of Warranties

To estimate the cost of current warranties, staff used the projected average repair costs in Table IX-5 plus the additional repair costs covered due to linking HD OBD to heavy-duty warranty as the cost that the manufacturers must consider when providing warranties for heavy-duty vehicles. Manufacturers and third-party warranty providers offer warranty packages at different prices depending on the relationship they have with a customer. For example, a manufacturer may charge a lower price for an extended warranty to secure a large purchase order for many vehicles. Warranties are sometimes included with the vehicle purchase order at no charge for high-volume customers, whereas warranty packages can be marked up higher for other customers. Current practices make it difficult to project a specific cost to purchase an extended warranty package. Therefore, staff is providing a range of costs to cover the variability in potential costs. Overall, staff assumes that manufacturers and third-party warranty providers do pass on the costs of repairs to their customers (i.e., by either including the cost in the original purchase price of the vehicle, or by providing extended warranties at an additional cost at the time of purchase). Staff expects that warranty packages could also be marked up to include a profit. Staff estimates that the average warranty package may be marked up beyond the cost of repairs by as much as 45 percent (Fullbay, 2018). Table IX-7 provides a range of costs for the estimated current warranty packages for each vehicle category compared to the proposed warranty packages that include the additional costs to cover repairs due to the lengthened warranty periods and the additional costs for warranted parts due to linking HD OBD to heavy-duty warranty.

Table IX-7. Cost of Warranty Packages (2017$)

Vehicle Category	Cost of Current Warranty Package	Cost of Proposed Warranty Package
HHDV	$2,289-$3,319	$2,529-$3,667
MHDV	$2,100-$3,045	$2,537-$3,678
LHDV	$2,556-$3,706	$2,705-$3,923

5. Costs to the Vehicle Purchaser

The cost of the proposed warranty package compared to the cost of the current warranty package is the projected increase in costs passed to the vehicle purchaser through an increase in the vehicle purchase price. Table IX-8 lists the projected increase in costs to vehicle purchasers as a result of the proposed warranty amendments.

Table IX-8. Projected Increase in Costs Passed to Vehicle Purchasers Due to Proposed Amendments on a Per-Vehicle Basis (2017$)

Vehicle Category	Minimum Cost Increase	Maximum Cost Increase
HHDV	$240	$348
MHDV	$437	$633
LHDV	$149	$217

Staff assumes that vehicle purchasers will finance their purchases through a 5-year loan with a 6 percent interest rate (WF, 2018a and WF, 2018b). Therefore, the increase in "capital" costs to the vehicle purchaser is slightly higher than the costs passed through by the manufacturer because of loan interest costs. Table IX-9 projects the increase in total capital costs to the vehicle purchaser as a result of the proposed warranty amendments. Because vehicle purchasers would receive repair cost savings from the lengthened warranties, described in Section B, staff also estimated the total net cost, capital cost increase (Table IX-9) minus repair cost savings (Table IX-6), as shown in Table IX-10.

Table IX-9. Total Capital Cost Increase to the Vehicle Purchaser Due to the Proposed Amendments on a Per-Vehicle Basis (2017$)

Vehicle Category	Minimum Total Capital Costs	Maximum Total Capital Costs
HHDV	$285	$413
MHDV	$519	$752
LHDV	$177	$257

Table IX-10. Estimated Net Cost on a Per-Vehicle Basis for Vehicle Purchasers (2017$)

Vehicle Category	Minimum Net Increase in Costs	Maximum Net Increase in Costs
HHDV	$45	$173
MHDV	$82	$315
LHDV	$28	$108

6. Total Statewide Costs

Staff used the total capital costs on a per vehicle basis and the EMFAC future vehicle purchase projections to estimate annual statewide costs. As capital costs are assumed to be purchased on a 5-year loan, the increased capital costs incurred by the vehicle purchaser is spread evenly through the first 5 years after purchase. The estimated minimum and maximum total statewide capital costs are shown in Table IX-11. Because vehicle purchasers would receive repair cost savings from the lengthened warranties, described in Section B, staff also estimated the total net cost (capital cost increase minus repair cost savings), as shown in Table IX-11, and the total net regulatory costs are shown in Table IX-12.

Table IX-11. Total Statewide Capital Costs from 2022 through 2040 Due to the Proposed Amendments (2017$)

Minimum Costs	Maximum Costs
$127,956,000	$185,417,000

Table IX-12. Total Net Regulatory Costs Due to the Proposed Amendments (2017$)

Minimum Net Regulatory Costs	Maximum Net Regulatory Costs
$34,615,000	$92,076,000

B. Benefits

As previously stated, it is assumed that the manufacturers will pass on the costs from staff's proposal through the increased purchase price of heavy-duty vehicles. Currently, heavy-duty vehicle owners have to pay out-of-pocket for any emission-related repair once their current emissions control warranty coverage (paid for either with the original purchase price of the vehicle or with a purchased extended warranty) expires. Under the proposed amendments, the warranty periods would be lengthened so the warranty would cover emission-related repairs for longer periods, and therefore provide a cost savings to heavy-duty vehicle owners. These are average cost savings recognizing that some owners that purchase heavy-duty vehicles with the lengthened warranties will benefit more than others if many repairs are needed, and some may not benefit at all if repairs are not needed during the lengthened warranty periods. The additional average repair cost savings to the end user is estimated to be $240 for a HHDV, $437 for MHDVs, and $149 for LHDVs. The additional statewide repair cost savings from the proposed amendments for heavy-duty vehicles purchased from 2022 to 2040 is estimated to be $93,341,000.

Other benefits of the regulation to the health and welfare of California residents and the state's environment can be found in Chapters V, VI, and Appendices F and G of the ISOR. As stated in Chapter V, there are no benefits to worker safety anticipated as a result of this rulemaking.

C. Cost-Effectiveness

The cost-effectiveness of the proposed amendments is estimated to range from $2.97 to $7.91 per pound of NOx reduced and $18.35 to $48.81 per pound of PM reduced. This cost-effectiveness range is well within the cost-effectiveness range of previous regulatory measures. For example, CARB's public fleets rule (CARB, 2005a) resulted in a cost-effectiveness of $11.47 per pound of NOx and $159 per pound of PM, and CARB's Drayage Truck Regulation (CARB, 2007) resulted in a cost-effectiveness of $6 to $8 per pound of NOx and $57 to $77 per pound of PM.

D. Affected Businesses

Staff's proposal would have direct cost impacts on heavy-duty engine and vehicle manufacturers. Staff estimated that 61 manufacturers would be impacted by the rule, based on U.S. EPA and National Highway Traffic Safety Administration (NHTSA) published reports (U.S. EPA, 2016a and U.S. EPA, 2016b). Because staff assumed the increased cost impacts on these manufacturers would be passed on to heavy-duty vehicle fleets who purchase the California certified and registered heavy-duty vehicles with the lengthened warranties, the proposed amendments would have indirect cost impacts on those heavy-duty vehicle fleets. Staff estimated the number of impacted California heavy-duty vehicle fleets to be approximately 146,000, based on California DMV 2015 registration data and EMFAC. Additional indirect cost impacts may affect new heavy-duty vehicle dealerships and heavy-duty vehicle repair shops from the proposed amendments but is expected to be minimal.

E. Potential Impacts on Jobs and Business Creation, Elimination or Expansion

Minimal impacts on the creation or elimination of businesses within California are expected. For California heavy-duty vehicle fleets, the incremental costs are small when the savings resulting from additional repair costs being covered through the lengthened warranties are included. Staff anticipates that any additional costs can be absorbed without changing the number of employees or forcing any heavy-duty vehicle fleets to cease operations. For example, trucking companies who purchase heavy-duty vehicles with the proposed lengthened warranties will have to pay an increased cost for the longer warranties through the higher purchase price of heavy-duty vehicles. However, the benefits from reduced emission-related repair costs will mostly offset the increased capital cost.

Because of the longevity of a heavy-duty diesel vehicle's service life, the vehicle may have multiple owners. A report prepared for the International Council on Clean Transportation (ICCT) concluded that different sized fleets have different purchasing patterns for heavy-duty vehicles (ICCT, 2009). Larger fleets (more than 50 trucks) tend to buy new vehicles, keeping them for a relatively short period of time. Smaller fleets (less than 10 trucks) tend to purchase more used trucks and keep them for a longer period of time. In this case, the smallest businesses and owner-operators most

sensitive to increased costs would experience a smaller impact due to the proposed amendments if they tend to purchase used heavy-duty vehicles because they would likely only pay for the residual value of the remaining warranty on the vehicle, if any.

Heavy-duty vehicle new truck dealerships may see increased costs passed on from engine and vehicle manufacturers due to the proposed amendments, but these costs would be further passed on to the vehicle purchaser, so the dealerships would experience negligible impacts.

Finally, heavy-duty vehicle repair facilities may see increased emission-related repair business from vehicle owners who otherwise would not bring their vehicle in for repair without the lengthened warranty. There would also be some increase in business due to heavy-duty vehicle fleets shifting some of their in-house repairs to dealership and independent repair facilities that would now be covered under a lengthened warranty. Also, there may be a slight shift in income from independent to dealership-owned repair facilities for those repairs that would now be covered under the longer warranty periods. However, this shift could be offset by any repair work that manufacturers choose to contract-out to independent repair facilities to cover the additional demand for warranty-covered repairs.

F. Potential Impact on Business Competitiveness

The proposed warranty amendments would not affect the ability of California businesses to compete with businesses in other states, as explained further below:

- Heavy-duty vehicles used for local and regional business operations (which typically are Class 4-7 vehicles) typically compete only with other California businesses or out-of-state businesses who purchase vehicles within California because their operations are limited to within the State. All California businesses would be subject to the proposed amendments, and so there would be no impact on competitiveness.

- Heavy-duty vehicles used for interstate commerce (which typically are Class 8 vehicles) typically travel many miles and are likely to already be purchased with extended warranties regardless of whether the vehicle is California certified or federally certified. Thus, the cost would be the same for a Class 8 truck purchased in California (which would have a longer warranty, as required by our amendments, paid for as part of the vehicle purchase price) or outside California (which would have an extended warranty paid for as an add-on cost).

Even in the rare instance where a California business is competing with an out-of-state business with a truck purchased outside California with a shorter warranty, any impact on competitiveness would likely be insignificant because the overall cost of the proposed amendments is small when the repair savings are taken into account. Further mitigating any potential impacts on competitiveness with out-of-state fleets, the longer warranty required by the amendments would help California fleets comply with

upcoming stricter smoke inspection and potential heavy-duty inspection and maintenance requirements, both of which would apply to all vehicles operating in California.

G. Potential Impact on Small Business

Staff estimated about 33 percent of the impacted manufacturers are small businesses and 87 percent of the impacted heavy-duty vehicle fleets are small businesses. [49,50,51] Staff assumed the increased cost on regulated manufacturers due to the proposed warranty amendments would be passed on to California heavy-duty vehicle fleets who purchase California-certified heavy-duty vehicles with the lengthened warranties. Thus, costs per impacted business were estimated based on costs per California heavy-duty vehicle fleet.

As stated above, smaller fleets may have a tendency to purchase used heavy-duty vehicles compared to larger fleets. The initial and annual ongoing costs due to the proposed amendments would be minimal for fleets that buy used vehicles still under warranty for a short period (i.e., with residual value of the remaining warranty), and would be zero for used vehicles whose warranties have already ended.

For fleets that buy new heavy-duty vehicles, the average annual costs for an impacted small business range from $71 to $102 over an average loan period of 5 years at 6 percent interest. In addition, for those small businesses that do purchase new heavy-duty vehicles with lengthened warranties, there would be repair cost savings that can offset most of the costs of a lengthened warranty.

H. Fiscal Impact to State and Local Agencies

1. Local Government

The cost to local government in the current (2018/2019) fiscal year and two subsequent fiscal years is zero because the proposed amendments will not be implemented until year 2022. However, there would be costs and cost savings to local agencies who purchase heavy-duty vehicles greater than 14,000 pounds GVWR in future years. Local government agencies would be expected to pay a higher purchase price for new heavy-duty vehicles with engines covered by the proposed lengthened warranties and would also obtain the benefit of repair cost savings. Staff estimates the local government heavy-duty vehicle population to be about 8.1 percent of the State total, per CARB's EMFAC model, thus local government would bear 8.1 percent of the net cost of the proposed amendments. The cumulative net regulatory cost to local government is

[49] Staff estimated the number of impacted manufacturers using U.S. EPA and National Highway Traffic Safety Administration estimates, and the number of impacted California heavy-duty diesel vehicle fleets using California DMV registration data and CARB's EMFAC inventory model.
[50] "Small business" is defined in 40 CFR 1068.30 – Definitions.
[51] A vehicle fleet consisting of 3 vehicles or less is defined as a small business.

estimated to be between $2,804,000 to $7,458,000 over 2022 through 2040, or approximately $148,000 to $393,000 per year on average.

2. State Government

a. State Government Fleets

The cost to State government fleets in the current (2018/2019) fiscal year and two subsequent fiscal years is zero because the proposed amendments would not be implemented until year 2022. However, there would be costs and cost-savings to State agencies who purchase heavy-duty vehicles greater than 14,000 pounds GVWR in future years. State government agencies would be expected to pay a higher purchase price for new heavy-duty vehicles with engines covered by the proposed lengthened warranties, and would also obtain the benefit of repair cost-savings. Staff estimates the State government heavy-duty vehicle population to be about 3.1 percent of the total, per CARB's EMFAC model, thus State government would bear 3.1 percent of the net cost of the proposed amendments. The cumulative net regulatory cost to State government fleets is estimated to be between $1,073,000 to $2,854,000 over 2022 through 2040, or approximately $56,000 to $150,000 per year on average.

b. CARB

There would be some additional state costs to implement and enforce the proposed heavy-duty vehicle warranty amendments. The longer warranty periods would require additional CARB resources for reviewing warranty reports and approving corrective action plans. Staff estimates that an additional two CARB positions would be needed for the proposed amendments to be implemented and enforced.

I. Major Regulations

For a major regulation, a standardized regulatory impact analysis (SRIA) is required. A major regulation is one that has "an estimated economic impact to business enterprises and individuals located in or doing business in California exceeding $50 million in any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through 12 months after the major regulation is estimated to be fully implemented." The annual economic impact of staff's proposal does not exceed $50 million in 2023 which is 12 months after full implementation of the warranty amendments, and hence this proposal is not a major regulation as defined by title 1 CCR section 2000(g), and thus a SRIA is not required.

J. Why the Proposed Amendments to the Minimum Maintenance Intervals Do Not Impact Costs

As discussed in Chapter III, section A.3 (Updated Maintenance Intervals), staff's proposal includes amendments to the minimum maintenance interval provisions. These

particular amendments are not expected to result in any cost impacts on manufacturers for the following reasons:

- No change is proposed to the stringency of the existing emission standards or test procedures.

- Staff's proposal does not require manufacturers to change any aspect of their current engine designs.

- Staff's proposal does not require manufacturers to schedule maintenance any less frequently than they already do, although staff's proposed maintenance interval amendments would prevent a manufacturer from using emission-related parts that were less durable than the parts that had been used previously to comply with the same standards using the same test procedures (i.e., prevent "backsliding").

- The proposed minimum scheduled maintenance intervals represent the least-stringent frequency intervals currently utilized by all of industry.

- Under staff proposal, manufacturers still have the option to request the Executive Officer to approve more frequent maintenance intervals if these intervals are shown to be necessary and appropriate.

- Under staff's proposal, there is no need to conduct separate federal and California certification testing because the current certification testing would already satisfy the proposed maintenance interval amendments (i.e., there is nothing new that needs to be demonstrated).

- Manufacturers are already required to design engines that maintain emissions performance at, or below, current emission standards through useful life. All of the maintenance intervals in staff's proposal are equal to, or less than, useful life.

The only situation in which additional compliance costs could result from the proposed revised maintenance intervals is if staff assumed in the absence of the proposed revised intervals that a manufacturer would "backslide" by using less durable parts than they use today. Because backsliding is unlikely, staff estimates no cost impact due to the proposed revised maintenance intervals. Staff believes backsliding to be unlikely because it would require a manufacturer to invest resources in research, development, retooling, and testing, to develop less-durable and/or less-reliable components rather than continuing to build existing components which are more durable and reliable. Further, a manufacturer would have to be willing to risk their reputation, goodwill, and profit by introducing products that are less reliable and durable than that of both its own previous models and those of its competitors.

X. EVALUATION OF REGULATORY ALTERNATIVES

California Government Code section 11346.2, subdivision (b)(4) requires CARB to consider and evaluate reasonable alternatives to the proposed regulatory action and provide reasons for rejecting those alternatives. This section discusses alternatives evaluated and provides reasons why these alternatives were not included in the proposal. As explained below, no alternative proposed was found to be less burdensome and equally effective in achieving the purposes of the regulation in a manner that ensures full compliance with the authorizing law. The Board has not identified any reasonable alternatives that would lessen any adverse impact on small businesses.

Staff considered two alternatives to the current proposal. A brief description of the alternatives and staff's rationale for finding them unsuitable follows. Both alternatives would retain the 5 year warranty period and eliminate the 3,000 hour warranty period, consistent with the proposed amendments; thus the only differences among the proposal and Alternative 1 and 2 are the lengths of the warranty for the various vehicle classes.

A. Require only Diesel HHDVs to Comply with a Lengthened Warranty Period of 350,000 Miles and LHDVs and MHDVs to Continue to Comply with Their Current Warranty Period Requirements of 100,000 Miles.

Alternative 1 would require diesel HHDVs to comply with a lengthened warranty period of 350,000 miles, but retains the current warranty period for diesel LHDVs and MHDVs. Alternative 1 was considered because it targets the class of vehicles with owners that stand to benefit the most from staff's proposal and where there is the greatest disconnect between mileage driven and warranties required. Given that diesel HHDVs have the highest rates of mileage accumulation, the current warranty period of 100,000 miles is not enough to ensure that emission-related repairs are being performed as they should. While Alternative 1 would provide 7.78 tpd of NOx and 0.11 tpd of PM emission reductions from HHDVs, staff realized that 7.18 tpd of NOx and 0.05 tpd of PM emission benefits would be lost by not including lengthened warranties for MHDVs and LHDVs. Therefore, staff rejected Alternative 1 because it is less effective than the proposed amendments.

B. Require all Diesel LHDVs and MHDVs to Comply with Lengthened Warranty Periods Equal to their Respective Useful Life Mileage Periods and Diesel HHDVs to a Warranty Period of 250,000 Miles

Alternative 2 would require HHDVs to comply with a shorter warranty period of 250,000 miles compared to the proposed amendments and warranty periods equal to the useful life periods for LHDVs and MHDVs. The 250,000 mile warranty for HHDVs was

proposed by the Truck and Engine Manufacturers Association at the July 12, 2017 public workshop. As shown in Table 38, this alternative would provide about 11 tons per day of NOx and 0.08 tons per day of PM emission benefits, cumulative from 2022 through 2040, which is 27 percent and 50 percent less benefit, respectively, than the proposed amendments. As shown in Table 42, the cost-effectiveness of this alternative ranges from $3.18 to $8.51 per pound of NOx and $30.54 to $81.73 per pound of PM, which is about 8 percent and 67 percent less cost-effective, respectively, than the proposed amendments. Staff rejected this alternative because it would yield very little emission benefit for HHDVs as most of these vehicles already have a warranty of 250,000 miles or more, and thus provides lower emission benefits and is also less cost-effective than the proposed amendments.

Table X-1 provides a comparison of the mileages applicable to the proposed amendments and Alternative 1 and Alternative 2. Table X-2 summarizes the costs and cost savings of the proposed amendments, Alternative 1 and Alternative 2.

Table X-1. Summary of Warranty Requirements in the Proposed Amendments and Alternatives

Heavy-Duty Category	Proposed Amendments (miles)	Alternative 1 (miles)	Alternative 2 (miles)
HHDV	350,000	350,000	250,000
MHDV	150,000	100,000	185,000
LHDV	110,000	100,000	110,000

Table X-2. Costs, Benefits, and Cost-Effectiveness Comparison of Proposal and Alternatives (2017$)

NOx					
Scenario	**Net Regulatory Costs**		**Emission Reductions by 2030 (tpd)**	**2022 through 2040 Cost-Effectiveness ($/lb.)**	
	Minimum	**Maximum**		**Minimum**	**Maximum**
Proposed Amendment	$32,458,155	$86,339,875	0.75	$2.97	$7.91
Alternative 1	$9,901,443	$26,305,864	0.38	$1.74	$4.63
Alternative 2	$25,502,678	$68,250,410	0.55	$3.18	$8.51
PM					
Scenario	**Net Regulatory Costs**		**Emission Reductions by 2030 (tpd)**	**2022 through 2040 Cost-Effectiveness ($/lb.)**	
	Minimum	**Maximum**		**Minimum**	**Maximum**
Proposed Amendment	$2,156,493	$5,736,349	0.008	$18.35	$48.81
Alternative 1	$657,844	$1,747,739	0.006	$8.05	$21.38
Alternative 2	$1,694,377	$4,534,500	0.004	$30.54	$81.73

Based on the analyses above, none of the alternatives considered by staff would be as effective, or less burdensome, in achieving the purposes of the regulation than the proposed amendments.

Small Business Alternative

Government Code Section 11346.2, subdivision (b)(4)(B), requires a description of reasonable alternatives to the regulations that would lessen any adverse impact on small business and the agency's reasons for rejecting those alternatives. Staff has not identified any alternatives that would lessen any adverse impact on small business. However, as described further in Chapter IX: Economic Impacts Analysis/Assessment above, staff projects that (1) many small businesses buy used vehicles and hence would be largely unaffected by the proposed amendments, and (2) repair savings for small businesses that purchase new California certified heavy-duty vehicles with lengthened warranties would largely offset the additional warranty cost.

Health and Safety Code section 57005 Major Regulation Alternatives

CARB estimates the proposed amendments will have an economic impact on the state's business enterprises of more than $10 million in one or more years of implementation. CARB will evaluate alternatives submitted to CARB and consider whether there is a less costly alternative or combination of alternatives that would be equally as effective in achieving increments of environmental protection in full compliance with statutory mandates within the same amount of time as the proposed regulatory requirements, as required by Health and Safety Code section 57005.

XI. JUSTIFICATION FOR ADOPTION OF REGULATIONS DIFFERENT FROM FEDERAL REGULATIONS CONTAINED IN THE CODE OF FEDERAL REGULATIONS

In 1982 and 1984, the U.S. EPA promulgated heavy-duty vehicle useful life and warranty requirements identical to those already mandated in California, except that U.S. EPA did not include a 3,000 hour warranty limit for heavy-duty diesel vehicles. Staff is now proposing to adopt lengthened warranty period requirements for Class 4 to 8 heavy-duty vehicles in California that would significantly differ from existing federal requirements.

National harmonization with U.S. EPA would offer several advantages. Specifically, manufacturers would have to comply with only one set of regulations for all nationwide production. However, the proposed amendments would extend the emissions warranty periods for California certified heavy-duty vehicles and engines beyond the comparable federal warranty periods, and consequently the amended California warranty provisions will be more protective, in the aggregate, than the comparable federal warranty provisions.

The disadvantage of waiting to lengthen heavy-duty vehicle warranty periods in concert with U.S. EPA is largely one of uncertainty regarding timing, with the likelihood of lost opportunity for emission benefits, making attainment with federal ozone standards in California more difficult. With the current U.S. EPA administration's emphasis on deregulation (Guardian, 2017), staff believes it is unlikely that U.S. EPA will lengthen the minimum warranty periods at the national level within the next couple of years. Staff intends to continue working with U.S. EPA to ensure consistency of requirements to the extent feasible. However, delaying action until U.S. EPA acts at a national level would forego emission benefits and unnecessarily burden California heavy-duty vehicle owners who would be required to comply with updated California smoke opacity requirements and HD I/M requirements in the next few years without the protection of longer warranties.

While harmonized requirements are usually preferable, additional stringency is justified in the case of heavy-duty vehicle warranty periods because of California's unique air quality concerns and the incidences of high in-use warranty claim rates for certain emission-related components during recent CARB monitoring and reporting studies. The differences between the proposed California requirements and existing federal requirements (see Table XI-1 below) are intended to help ensure that heavy-duty engines sold in California will remain compliant with existing emission standards throughout their useful lives, which currently is not happening. The cost of these regulations is justified by their benefit to human health and the environment. Finally, staff is hopeful that in the future U.S. EPA may choose to align with the warranty and maintenance provisions described in this staff report, thereby creating national harmonization.

Table XI-1. Existing Federal/California Warranty vs. California Proposed Warranty

VEHICLE/ENGINE CATEGORY	FEDERAL/CALIFORNIA CURRENT WARRANTY (miles)	CALIFORNIA PROPOSED WARRANTY (miles)
	DIESEL	DIESEL
Class 8 Heavy Heavy GVWR > 33,000 lbs.	100,000 5 years / 3,000 hours[1]	350,000 5 years
Class 6-7 Medium Heavy 19,500 lbs. < GVWR ≤ 33,000 lbs.	100,000 5 years / 3,000 hours[1]	150,000 5 years
Class 4-5 Light Heavy 14,000 lbs. < GVWR ≤ 19,500 lbs.	100,000 5 years / 3,000 hours[1]	110,000 5 years

[1] The current warranty period for heavy-duty diesel vehicles in California includes a 3,000 hour of operation limit in addition to mileage and yearly limits. U.S. EPA does not limit warranty on the basis of hours of operation. Staff is proposing to eliminate the 3,000 hour warranty limit as part of its proposed amended warranty requirements.

CARB is authorized to adopt different warranty requirements than those in effect at the federal level under the authority granted to it by the Health and Safety Code, and under the provisions of the federal Clean Air Act. Staff's proposed amendments would be more stringent in the aggregate than existing federal warranty requirements for heavy-duty vehicles, and would contribute to attainment with federal air quality standards throughout the State. Therefore, the proposed adoption of lengthened warranty periods for Class 4 to 8 heavy-duty vehicles is both reasonable and necessary, and is therefore justified for adoption, despite the differences from federal regulations.

XII. PUBLIC PROCESS

A. Public Process

Consistent with Government Code sections 11346, subdivision (b), and 11346.45, subdivision (a), and with the Board's long-standing practice, CARB staff held public workshops and had other meetings with interested persons during the development of the proposed regulation. These informal pre-rulemaking discussions provided staff with useful information that was considered during development of the regulation that is now being proposed for formal public comment.

Staff pursued many actions to inform, involve, and update the public and stakeholders during the development of its proposal, as required by Government Code, section 11346.45. As discussed in further detail below, staff conducted public workshops, formed a joint government/industry work group, and held individual stakeholder meetings to discuss issues and seek comments.

Throughout the rulemaking process, access to information including notices, presentations, and contact information, was made available on the internet on CARB's Heavy-Duty Low NOx webpage at https://www.arb.ca.gov/msprog/hdlownox/hdlownox.htm.

Staff considered all comments received in the workshops, work group meetings, and meetings with manufacturers and industry representatives. Staff received useful data and information from stakeholders to help understand the impacts of the proposed amendments. Staff made revisions to the proposal as a result of comments received, for example, staff is now proposing to link commencement of the warranty amendments based on the model year of the engine rather than the model year of the vehicle, as initially considered. As another example, based on feedback from truck and engine manufacturers, staff shortened the initially proposed warranty mileages and changed the proposal to base warranty length on the engine service class rather than the vehicle weight class.

B. Workshops

Staff conducted three public workshops to introduce and discuss the development of amended warranty period requirements for heavy-duty vehicles in California.

The first workshop took place on November 3, 2016, in Diamond Bar, California, and besides presenting an overview of possible low NOx technologies being evaluated for use in complying with California's future lower-NOx emission standards, staff described other rulemakings planned under California's "Lower In-Use Emission Performance Level" measure. These in-use strategies, of which

this staff report's proposal is one, seek to ensure that in-use heavy-duty vehicles continue to operate at their cleanest possible level (CARB, 2016b). The workshop was also webcast to extend outreach to those unable to attend in person. As part of the workshop's presentation, staff invited all stakeholders to join the warranty work group discussed further below. Staff also requested information from industry regarding the cost structure of commercial warranties already offered by manufacturers and third-party vendors, and regarding warranty claim rates and tampering statistics.

The second workshop took place on July 12, 2017, in Diamond Bar, California. Over 45 individuals, including representatives from industry and other stakeholders, participated in person, and approximately 154 participated remotely via a live view webcast (CARB, 2017g). The workshop included staff's presentation on amended warranty periods, emission benefits, and feasibility. After the presentation, the floor was opened to a discussion of staff's proposal, including dialogue on how best to ensure that turbochargers will remain functional throughout the useful life of a heavy-duty engine. A video recording (CARB, 2017b) of the workshop is provided as a reference document to this staff report and is available upon request from CARB's Regulations Coordinator Office, located at the CalEPA Headquarters Building, 23rd Floor, Office 14B, 1001 I Street, Sacramento, California 95812-2815.

The third workshop took place on January 12, 2018, in Diamond Bar, California. The workshop was physically attended by about 30 individuals participated in person. Approximately 253 additional individuals participated remotely via live view webcast (CARB, 2018e). Members of EMA, MECA, the Motor and Equipment Manufacturers Association (MEMA), U.S. EPA, and the American Trucking Association (ATA) were represented. The purpose of the workshop was to announce evolving elements of staff's proposal, including revised proposed warranty periods, and to introduce the inclusion of proposed updates to the minimum allowable maintenance intervals for heavy-duty engines. A representative from the Sacramento ISR participated via audio conferencing, and led a question and answer session regarding the trucker warranty survey that concluded in December 2017. A video recording (CARB, 2018a) of the workshop is provided as a reference document to this staff report and is available upon request from CARB's Regulations Coordinator Office, located at the CalEPA Headquarters Building, 23rd Floor, Office 14B, 1001 I Street, Sacramento, California 95812-2815.

C. Work Group Meetings

Staff also formed a warranty working group with over 50 stakeholder members to discuss staff's proposal, and to share information regarding the various types of warranty coverage offered by industry and the costs and terms for such warranties. Work group meetings were held via conference call on August 4, 2016, September 22, 2016, October 4, 2016, and June 15, 2017.

D. Stakeholder Meetings

Staff held numerous meetings and teleconferences with trade associations, individual manufacturers, and groups of industry representatives to gather information and receive input on staff's proposal. Among the trade associations represented were EMA, with whom staff met in person on June 5, 2017, July 12, 2017, September 1, 2017, and November 1, 2017, and via conference calls on June 15, 2017, and February 6, 2018. Staff met in person with members of MECA on June 27, 2017, and November 1, 2017, and via a conference call on November 29, 2017. Staff briefed U.S. EPA staff on its warranty proposal via conference call on November 27, 2017.

Staff also extended outreach to other stakeholders. The California Ombudsman's Office provided a list of independent repair facilities and service providers to whom staff extended outreach via listserv broadcasts. Staff directly contacted other associations including MEMA and the Automotive Aftermarket Supplier's Association (AASA) to ensure that as many members as possible of the interested public had the opportunity to participate in developing, or commenting on this rulemaking.

For additional information on staff's public process to amend the warranty period for heavy-duty vehicles, see Appendix D.

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XIV. APPENDICES

Appendix A: Proposed Regulation Order

Appendix A-1: Proposed Amendments to Section 1956.8, Title 13, California Code of Regulations

Appendix A-2: Proposed Amendments to Section 2035, Title13, California Code of Regulations

Appendix A-3: Proposed Amendments to Section 2036, Title13, California Code of Regulations

Appendix A-4: Proposed Amendments to Section 2040, Title13, California Code of Regulations

Appendix B: Proposed Amendments to California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles

Appendix C: Economic Impact Analysis / Assessment

Appendix D: Public Process for Development of the Proposed Action Environmental Analysis

Appendix E: Technical Details on the Failure Modes of Exhaust Gas Recirculation Systems and Turbochargers

Appendix F: Heavy-Duty Vehicle Emissions Inventory and Estimated Emission Benefits for Proposed Heavy-Duty Engine Warranty Amendments

Appendix G: Estimated Health Benefits Analysis

Appendix H: Heavy-Duty Vehicle Warranty Survey

Appendix I: Heavy-Duty Warranty Amendments Summary and Rationale

Appendix J: Sample Owners Manual Maintenance Schedule