State of California
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS FOR RULEMAKING

PUBLIC HEARING TO CONSIDER AMENDMENTS TO THE CALIFORNIA OFF-ROAD EMISSIONS REGULATION FOR COMPRESSION-IGNITION ENGINES AND EQUIPMENT

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

In January 2000, the Air Resources Board (ARB of Board) adopted amendments to the off-road emissions regulation for 2000 and later compression-ignition (diesel) engines and equipment. Those amendments established more stringent exhaust standards for particulate matter (PM), oxides of nitrogen (NOx), and non-methane hydrocarbon (NMHC) than were previously required. Furthermore, the amendments harmonized California's off-road diesel requirements with those of the United States Environmental Protection Agency (U.S. EPA). The 2000 standards, termed Tier 2 and Tier 3, are ongoing, and staff estimates that the statewide emissions inventory[1] will be reduced by 8 tons-per-day PM, 83 tons-per-day NOx, and 18 tons-per-day NMHC in 2010 because of them. The Board also adopted in-use durability requirements and an autonomous recall/warranty program in 2000 that invested California with full enforcement authority to ensure the regulatory compliance of off-road diesel engines throughout their entire useful lives.

Despite the significant improvements to air quality resulting from the Tier 2 and Tier 3 standards, many Californians are still plagued with unhealthful air. ARB estimates that over 50 percent of the State's air basins will be in violation of the federal eight hour ambient air quality standard beyond attainment due-dates if additional control measures are not undertaken to address the need for more reductions. Staff has recognized since the 2000 off-road diesel rulemaking that additional emission reductions were possible from the off-road sector with the incorporation of advanced emission control technologies.

Off-road diesel engines are similar to on-road diesel engines in design, but off-road emission control capability typically lags behind on-road capability. This is because of the added complexity in designing systems that will function reliably for the many different applications of off-road diesel engines. However, with cleaner standards now required for heavy-duty on-road diesel engines beginning in 2007 (ARB 2001), staff believes the time is appropriate to set similar standards for California's off-road diesel engines.

This report presents staff's proposal to amend existing regulations to harmonize with the requirements published by U.S. EPA in the Federal Register on June 29, 2004, to achieve a greater degree of emission reductions from non-preempt off-road diesel engines. The federal Clean Air Act preempts California from setting emission standards for new off-road engines rated less than 130 kilowatts (kW) used in farm or construction equipment ("preempt engines"). Because of this, staff worked diligently with U.S. EPA to develop a fourth tier (Tier 4) of emissions standards that would ensure the most stringent, technologically feasible standards for all of California's off-road diesel engines. The resulting federal Tier 4 standards are based on the use of advanced aftertreatment technologies, which will reduce PM and NOx emissions from new engines by up to 95 percent compared to previous emission requirements. This represents a significant

[1] Estimated 2010 benefits are based on July, 2004, off-road emissions inventory data, and may differ from earlier calculations.

reduction in emissions for California's preempt engines, which will constitute 71 percent of the entire off-road diesel population in 2020.

Staff's proposal to harmonize with the federal Tier 4 requirements would provide equally stringent standards for the remaining non-preempt engines in California. This would also preserve California's authority to ensure timely compliance and to enforce the regulation as necessary for these engines. Furthermore, harmonization serves the interest of the off-road industry in that resources would not have to be invested to comply with separate State and federal requirements.

In addition to the emissions standards, this proposal also mirrors other aspects of the adopted federal rule including requirements for not-to-exceed (NTE) limits, incentives to engine and equipment manufacturers for the early introduction of engines with advanced aftertreatment, new test procedures and test cycles, enhanced in-use compliance provisions, and transitional compliance assistance for engine and equipment manufacturers. As a package, these requirements would help assure that the air quality benefits of the proposed standards are achieved and that engines remain cleaner in-use longer. The harmonization of compliance programs such as averaging, banking, and trading, and equipment manufacturer flexibility should help to ease any administrative burdens and allow industry to maintain focus on the technical aspects of emission reductions.

Staff's proposal also supplements the federal rule in a few small, but important ways intended to provide additional safeguards for a more identifiable and enforceable deployment of flexibility allowances in California. To minimize the potential for abuse, staff proposes more descriptive labeling content requirements for flexibility engines to facilitate their identification by ARB inspectors and to provide a clear reference to original certification standards in the cases of rebuilding or repair. Staff also proposes to keep its autonomous in-use warranty/recall program to better address violations of the requirements from a California perspective. Neither of these changes is expected to encumber compliance nor incur additional implementation costs.

In 2020, the combined statewide benefits of staff's proposal and the federal rule would be approximately 6.9 tons per day PM, 72.8 tons per day NOx, and 3.0 tons per day NMHC, based on ARB's current off-road emissions inventory modeling. The estimated California cost-effectiveness associated with adoption of staff's proposal would be approximately $0.58 per pound of combined NMHC and NOx reduced, and $7.55 per pound of PM reduced. These estimates are based on the federal calculation of cost-effectiveness, appropriately adjusted to reflect what California's costs would be without harmonization. In actuality, however, there are no costs to the State associated with staff's proposal since U.S. EPA's estimates already include California's expenses. Based on these conclusions, staff recommends that the Board adopt this proposal.

1. INTRODUCTION

Compression-Ignition engines (hereafter "diesel engines") are used in a variety of off-road applications, and are often the preferred choice where durability and fuel economy are primary considerations. Some familiar examples include tractors, excavators, portable generators, transport refrigeration units (TRUs), irrigation pumps, welders, compressors, scrubber/sweepers, and a wide array of other agricultural, construction, and general industrial equipment. Although diesel engines are used extensively to propel other off-road equipment such as locomotives and commercial marine vessels, engines in those applications are not considered under this proposal.

The Air Resources Board (ARB or Board) and the United States Environmental Protection Agency (U.S. EPA) have made significant strides in controlling air pollution from off-road sources in recent years. Together, the two agencies have adopted three tiers of increasingly stringent emissions standards for off-road diesel engines (referred to as "nonroad diesel engines" in U.S. EPA publications). The first tier began in California in 1995 and the third tier will be phased-in across all applicable power categories by 2008. Despite these efforts, many regions of the State still suffer from unhealthy levels of air pollution.

To further improve California's air quality, and as agreed upon according to the settlement agreement amendments to the 1994 Ozone State Implementation Plan (SIP) (see subsection 3.3), staff is proposing that the Board adopt a fourth tier (Tier 4) of exhaust emission standards for off-road diesel engines in California. This is a crucial next step for improving air quality, where further reductions of particulate matter (PM) and ozone precursors are required to protect public health and to comply with federal and State air quality standards for ozone.

However, the federal Clean Air Act (CAA) Amendments of 1990 preempt California from regulating exhaust emissions from new farm and construction equipment under 130 kilowatts (kW), and ARB must rely on U.S. EPA to establish effective regulations for these preempt engines, which are a significant source of emissions in California. In 2020, approximately 71 percent of the roughly 560,000 land-based diesel engines in California will be under the exclusive regulatory authority of the federal government. This would be equivalent[2] to the ozone precursor emissions from 3.6 million passenger cars and the particulate emissions from 8.7 million passenger cars in 2020.

On May 11, 2004, the U.S. EPA Administrator, Michael Leavitt, signed the Clean Air Nonroad Diesel Rule into law, which promulgates Tier 4 standards for new nonroad diesel engines that can reduce emissions by up to 95 percent compared to previous standards

[2] The comparisons utilize data from the off-road diesel emissions inventory database (May 2004) and the EMFAC2002 V2.2 04-03-2003 on-road model

(69 Fed. Reg. 38958 (2004)). These new standards are based on the same advanced exhaust aftertreatment technologies that are likely to be utilized by heavy-duty on-road diesel engines beginning in 2007 (U.S. EPA 2001). U.S. EPA also adopted improved certification provisions including a transient test cycle, which will allow emission evaluations to be made under more appropriate engine operating conditions, and Not-To-Exceed (NTE) limits to verify emissions performance in-use. Staff's proposal harmonizes with the federal Tier 4 program, while maintaining ARB's enforcement authority to ensure timely compliance and emission reductions. Adoption of this proposal by the Board would provide equally stringent emission standards for California's non-preempt portion of engines.

This report has twelve sections. The Introduction and Background provide an overview and brief historical account of previous and existing emission control measures affecting the off-road diesel sector in California. Following those discussions is the Need for Control section, which explains why the proposed requirements are necessary. This is followed by a Summary of staff's proposal and a description of the Differences between the California and federal programs. Next is a discussion on Technology and Feasibility. The Environmental Impacts and Cost-Effectiveness of the proposal are discussed in the section after that, followed by the proposal's Economic Impacts and the Regulatory Alternatives considered. This is again followed by a discussion of Remaining Issues that arose during the development of the proposal. Staff's Conclusions and Recommendations are then summarized, followed by a list of the References used in this report.

2. BACKGROUND

This section provides a description of California's authority, existing off-road diesel regulations, emissions inventory, U.S. EPA programs, and the steps taken to inform the public about staff's proposal to amend the regulations.

2.1. Authority

California is the only State allowed to adopt emission requirements that are different from those of the federal government. This is appropriate since California has the worst air quality in the nation[3], and as such, has special emission control needs that may not be necessary for the rest of the country. The following subsection provides reference to the applicable legal citations that give California this authority.

Section 209(e)(2)(A) of the federal CAA authorizes California to adopt and enforce emission standards, and other requirements, for off-road engines and equipment, not

[3] The South Coast and San Joaquin Valley Air Basins, for example, are the only areas in the nation designated by U.S. EPA as "severe-17" and "extreme" zones for ozone non-attainment, respectively. This is based on 8-hour assessments in 40 CFR 81.305, http://www.epa.gov/ozonedesignations/part81r8c.pdf, dated June 15, 2004.

subject to federal preemption, so long as the California standards "will be, in the aggregate, at least as protective of public health and welfare as applicable Federal standards." California must apply for, and receive authorization from the U.S. EPA before federal requirements are waived and ARB may enforce its regulations.

In 1988, the State Legislature enacted the California Clean Air Act (CCAA), which declared that attainment of State ambient air quality standards is necessary to promote and protect public health, particularly the health of children, the elderly, and those with respiratory illness. The Legislature also directed that these standards be attained by the earliest practicable date.

Health and Safety Code (HSC) sections 43013 and 43018 authorize and direct ARB to achieve the maximum feasible and cost effective emission reductions from all mobile source categories, including off-road diesel engines and equipment.

2.2. Preemption

Along with authorizing California to set emissions standards for off-road engines and equipment, the federal CAA also prohibits the states, including California, from regulating certain types of engines and equipment. Section 209(e)(1)(A) of the federal CAA explicitly preempts California from regulating emissions from new farm and construction engines and equipment under 130 kW ("preempt engines").

Because only the U.S. EPA has authority to establish emission standards for preempt engines, ARB staff took an active role in working with U.S. EPA to develop a national emissions program that would cover those off-road diesel engines in California that ARB cannot regulate. Staff's proposal covers the remaining non-preempt engines, and harmonizes with the federal rule, to the extent feasible, to minimize any confusion and expenses that could result from significantly different State and federal requirements. A list of equipment types that are subject to federal preemption is included at the end of this report in Appendix A ("List of Preempted Off-Road Applications").

As required under CAA section 209(e)(2)(A), ARB will request U.S. EPA authorization for the adoption and enforcement of standards and other requirements relating to the control of emissions from non-preempt engines. Because ARB's proposed regulations closely mirror the federal requirements for these engines, staff believes they would be, in the aggregate, at least as protective of public health and welfare as the applicable federal Tier 4 standards. Further, because the emission reductions from these proposed regulations are necessary to meet the State's air quality commitments, staff's proposal would not be considered arbitrary or capricious.

2.3. Existing Regulations

Federal requirements notwithstanding, there are currently three tiers of increasingly stringent emission standards required for off-road diesel engines. Particulate matter (PM), oxides of nitrogen (NOx), non-methane hydrocarbons (NMHC), and carbon monoxide (CO) are the pollutants regulated by these requirements, though not always collectively. Off-road standards are unique in that they vary according to an engine's power rating, and have been implemented in stages rather than all at once in a single year. NMHC and NOx are usually combined into a single standard due to the inverse reciprocal relationship of those pollutants in untreated exhaust. However, separate NMHC and NOx standards will be necessary to support the advent of aftertreatment on off-road engines. The history and effects of the existing off-road diesel standards are briefly discussed in the following subsection.

2.3.1. Tier 1 Standards

The very first emission standards for new off-road diesel engines were adopted for engines less than 19 kW as part of the California requirements for 1995 and later small off-road engines (ARB 1994). Subsequently, in 1992, the Board approved standards for off-road diesel engines 130 kW and greater. These standards, which were implemented beginning in 1996, targeted NOx emission reductions without an increase in NMHC or PM emissions. The 130 kW boundary was chosen to avoid preemption issues in the implementation of the regulation rather than for technical or cost-effectiveness reasons.

The goal of initial off-road diesel control was to reduce emissions using the most feasible control technologies that would not require a need to change the packaging (shape) of the engine (ARB 1991). The majority of engine modifications that have been made to comply with the Tier 1 standards are fuel injector and fuel injection timing changes, combustion chamber enhancements, and the incorporation of engine after-coolers. Tier 1 has resulted in approximately a 50 percent drop in NOx emissions compared to previously uncontrolled off-road diesel engines of similar power. Following ARB's adoption of initial standards, U.S. EPA promulgated a substantially similar program for engines 37 kW and greater (<u>see</u> 40 CFR 89).

2.3.2. Tier 2 Standards

In 1992, the Board also adopted a second phase of more stringent emission standards for engines 130 = kW = 560 to begin in 2000. However, in 1998, U.S. EPA promulgated a slightly different version of California's 2000 standards plus a third, more stringent phase of emission standards to be implemented starting in 2006 (U.S. EPA 1998). To honor the Statement of Principles (SOP)[4] agreement, ARB went back to the Board in 2000 to fully align California's standards and implementation schedules with U.S. EPA's requirements (ARB 1999). Engines greater than 560 kW became applicable under the harmonized

[4] An agreement signed in 1995 by ARB, U.S. EPA, and engine manufacturers that called for the creation of multiple tiers of more stringent emissions standards in exchange for harmonized California and federal regulations, as feasible.

regulation in 2000, and the more stringent standards served to address ARB's 1994 State Implementation Plan (SIP) commitments.

Current Tier 2 requirements, as they have come to be referred, are scheduled to be completely phased-in by 2006, and encompass the entire power spectrum of diesel off-road engine applications including those above 560 kW and those under 19 kW. Tier 2 standards were originally intended to be equivalent in stringency to the 1991 on-road heavy-duty diesel engine standards, and are based on the emission control technologies used by those engines. The harmonized Tier 1 and Tier 2 standards included durability provisions[5] to ensure that the standards would continue to be met throughout the useful life of the engine. Fuel injection timing and combustion refinements, turbo/super charging, and air-to-air after-cooling have been the primary engine changes needed by most manufacturers to comply with the Tier 2 standards. This has resulted in tailpipe reductions of 21 to 39 percent for NMHC+NOx with respect to the previous Tier 1 standards, and 41 to 61 percent for PM for power categories that were previously uncontrolled.

2.3.3. Tier 3 Standards

Tier 3 off-road diesel standards are scheduled to begin in 2006 and are applicable to engines 37 = kW = 560. They will reduce NMHC+NOx emissions for most power categories by an additional 40 percent compared to existing Tier 2 standards. However, Tier 3 will not reduce PM emission levels beyond existing Tier 2 levels.

Some off-road diesel engines will comply with Tier 3 requirements in 2005, one year earlier than required by regulation. It was discovered that certain engine manufacturers were designing on-road diesel engines in the latter 1990s that intentionally circumvented emission requirements when operated outside the region of a certification test cycle, or off-cycle. Emissions were low when tested, but calibrations changed during off-cycle operation to favor better fuel economy at the expense of higher emissions. To avoid recalling engines with these "defeat devices", the engine manufacturers reached a settlement agreement with ARB and U.S. EPA in which they committed to a number of projects to advance the causes of improved air quality. One of the projects agreed upon in the consent decree/settlement agreement is for certain engine manufacturers to advance the introduction of Tier 3 compliant engines. To satisfy this commitment, those diesel engine manufacturers are obligated to implement the Tier 3 standards on engines rated between 225 and 560 kW, inclusive, in 2005 instead of 2006.

The control technologies that engine manufacturers are likely to use to comply with Tier 3 requirements will be enhanced combustion techniques including variable-timing overhead valve configurations, higher pressure fuel injection, exhaust gas recirculation (EGR), lean burn catalysts, and electronic engine management systems. More advanced

[5] Durability provisions were not retroactively applied to Tier 1 engines, only to those rated less than 37 kW after the 2000 model year.

aftertreatment technologies are not expected to be used to comply with the Tier 3 requirements because most of these technologies are sensitive to sulfur, and diesel fuel with less than 15 parts-per-million sulfur by weight (ppmw) for the off-road sector will not be available nationally until 2010 (USEPA 2004), although it will be available in California in 2006. Tables 2.1 - 2.3 below show the current California off-road diesel standards.

Table 2.1
Off-Road Diesel Exhaust Standards < 37kW
SORE, Tier 1, and Tier 2

POWER CATEGORY	DURABILITY PERIOD	STANDARD [1]	MODEL YEAR	NMHC+NOx	NMHC	NOx	CO	PM
				grams per kilowatt-hour [grams per brake horsepower-hour]				
kW < 8 [hp < 11]	NONE	SORE	1995	16/13.4 [2] [12/10]	—	—	402 [300]	1.2 [0.90]
			1996 - 1999		—	—	469 [350]	
	3000 HOURS OR 5 YEARS	Tier 1	2000 - 2004	10.5 [7.8]	—	—	8.0 [6.0]	1.0 [0.75]
		Tier 2	2005 - 2007	7.5 [5.6]	—	—		0.80 [0.60]
8 = kW < 19 [11 = hp < 25]	NONE	SORE	1995	16/13.4 [2] [12/10]	—	—	402 [300]	1.2 [0.90]
			1996 - 1999		—	—	469 [350]	
	3000 HOURS OR 5 YEARS	Tier 1	2000 - 2004	9.5 [7.1]	—	—	6.6 [4.9]	0.80 [0.60]
		Tier 2	2005 - 2007	7.5 [5.6]	—	—		
19 = kW < 37 [25 = hp < 50]	5000 HOURS OR 7 YEARS [3]	Tier 1	2000 [4] - 2003	9.5 [7.1]	—	—	5.5 [4.1]	0.80 [0.60]
		Tier 2	2004 - 2007	7.5 [5.6]	—	—		0.60 [0.45]

Notes:
1 Standards that first become applicable in 2000 or later do not apply to engines less than 50 cubic centimeters in displacement
2 Small off-road engine standards are subdivided by engine displacement - Class I (65 = cc < 225) and Class II (cc = 225), respectively
3 The durability period for constant speed engines rated = 3,000 rpm is 3,000 hours or 5 years, whichever occurs first
4 The federal Tier 1 standards for this power category began in 1999

Table 2.2
Off-Road Diesel Exhaust Standards 37 = kW < 225
Tier 1, Tier 2, and Tier 3

POWER CATEGORY	DURABILITY PERIOD	STANDARD	MODEL YEAR	NMHC+NOx	NMHC	NOx	CO	PM
				grams per kilowatt-hour [grams per brake horsepower-hour]				
37 = kW < 56 [50 = hp < 75]	8000 Hours or 10 Years	Tier 1	2000 [5] - 2003	—	—	9.2 [6.9]	—	—
		Tier 2	2004 - 2007	7.5 [5.6]	—	—	5.0 [3.7]	0.40 [0.30]
		Tier 3 [6]	2008 - 2011	4.7 [3.5]	—	—		
56 = kW < 75 [75 = hp < 100]	8000 Hours or 10 Years	Tier 1	2000 [5] - 2003	—	—	9.2 [6.9]	—	—
		Tier 2	2004 - 2007	7.5 [5.6]	—	—	5.0 [3.7]	0.40 [0.30]
		Tier 3	2008 - 2011	4.7 [3.5]	—	—		
75 = kW < 130 [100 = hp < 175]	8000 Hours or 10 Years	Tier 1	2000 [7] - 2002	—	—	9.2 [6.9]	—	—
		Tier 2	2003 - 2006	6.6 [4.9]	—	—	5.0 [3.7]	0.30 [0.22]
		Tier 3	2007 - 2011	4.0 [3.0]	—	—		
130 = kW < 225 [175 = hp < 300]	8000 Hours or 10 Years	Tier 1	1996 - 2002	—	1.3 [1.0]	9.2 [6.9]	11.4 [8.5]	0.54 [0.40]
		Tier 2	2003 - 2005	6.6 [4.9]	—	—	3.5 [2.6]	0.20 [0.15]
		Tier 3	2006 - 2010	4.0 [3.0]	—	—		

Notes:
5 The federal Tier 1 standards for this power category began in 1998
6 Manufacturers may optionally certify engine families to the interim Tier 4 standards for this power category through 2012
7 The federal Tier 1 standards for this power category began in 1997

Table 2.3
Off-Road Diesel Exhaust Standards = 225 kW
Tier 1, Tier 2, and Tier 3

POWER CATEGORY	DURABILITY PERIOD	STANDARD	MODEL YEAR	NMHC+NOx	NMHC	NOx	CO	PM
				grams per kilowatt-hour [grams per brake horsepower-hour]				
225 = kW < 450 [300 = hp < 600]	8000 Hours or 10 Years	Tier 1	1996 - 2000	—	1.3 [1.0]	9.2 [6.9]	11.4 [8.5]	0.54 [0.40]
		Tier 2	2001 - 2004	6.4 [4.8]	—	—	3.5 [2.6]	0.20 [0.15]
		Tier 3	2006[8] - 2010	4.0 [3.0]	—	—		
450 = kW = 560 [600 = hp = 750]	8000 Hours or 10 Years	Tier 1	1996 - 2001	—	1.3 [1.0]	9.2 [6.9]	11.4 [8.5]	0.54 [0.40]
		Tier 2	2002 - 2004	6.4 [4.8]	—	—	3.5 [2.6]	0.20 [0.15]
		Tier 3	2006[8] - 2010	4.0 [3.0]	—	—		
kW > 560 [hp > 750]	8000 Hours or 10 Years	Tier 1	2000 - 2005	—	1.3 [1.0]	9.2 [6.9]	11.4 [8.5]	0.54 [0.40]
		Tier 2	2006 - 2010	6.4 [4.8]	—	—	3.5 [2.6]	0.20 [0.15]

Notes:
8 Certain manufacturers are required to comply with these standards beginning in 2005 per the consent decree settlement agreement

2.4. Emissions Inventory

The emissions data referenced in this subsection were obtained from the publicly available 2004 California Almanac of Emissions and Air Quality[6] and the off-road emissions inventory database. Brake dust and tire wear, although significant sources of PM, are not included in the following analyses since the focus of this report is on exhaust emissions. The reactive organic gas (ROG[7]) component of hydrocarbon emissions from evaporative losses is also not included in the comparisons for the same reason. The analyses do not reflect the inclusion of federal or ARB proposed Tier 4 standards. Tier 4 emission benefits will be identified during the discussion on environmental impacts in subsection 7.1.1 of this

[6] Almanac data can de downloaded at http://www.arb.ca.gov/aqd/almanac/almanac04/almanac04.htm.
[7] The terms "ROG" and "NMHC" are used synonymously in this report to represent the component of hydrocarbon most likely to form ozone. The pie chart comparisons are expressed in units of ROG to reflect inventory modeling parameters, and standards are expressed in units of NMHC.

report. All emission estimates are statewide and annual averages. Figures 2.1, 2.2, and 2.3, below, show the relative contributions of the three categories of mobile emission sources.

Figure 2.1 Mobile ROG

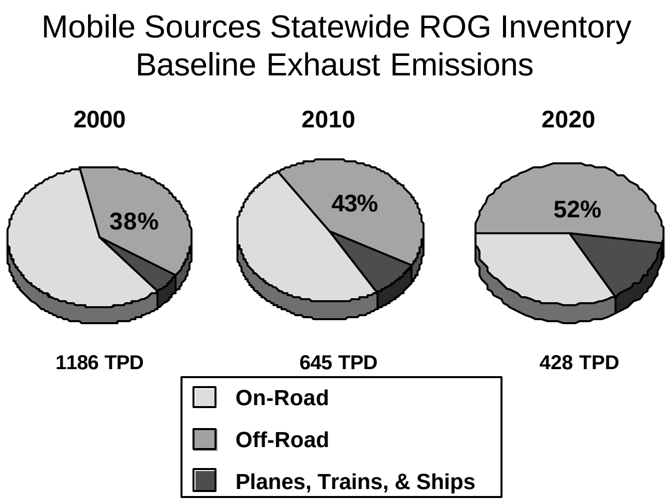


Figure 2.2 Mobile NOx

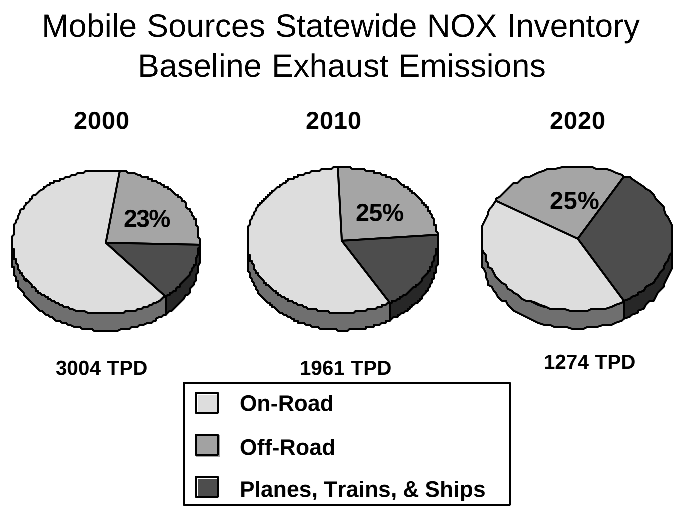
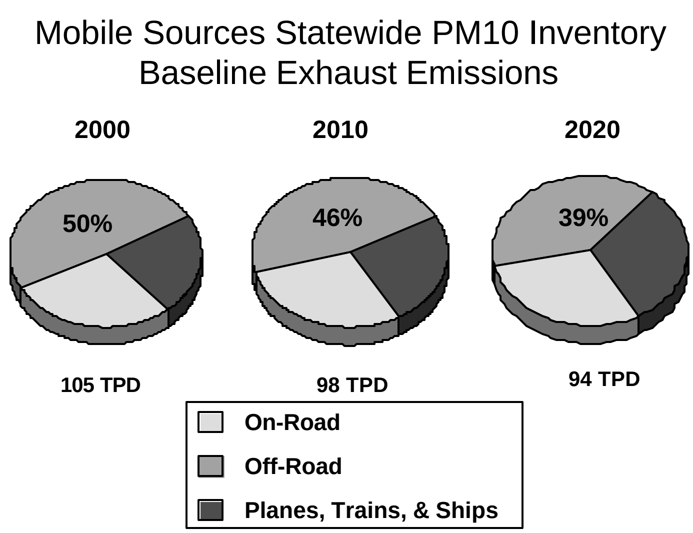


Figure 2.3 Mobile PM



Although the mobile source emissions inventory is decreasing overall as a result of State and federal regulations, the figures show that both ROG and NOx resulting from the use of land-based off-road engines (hereafter "off-road engines"[8]) generally become a greater

[8] The off-road estimates include recreational marine engines, but not trains, planes, or commercial ships.

portion of the remaining emissions through calendar year 2020. The PM[9] percentage decreases, but off-road engines remain a significant source of PM from all mobile sources at 39 percent in 2020. Increased off-road activity and more stringent control of on-road heavy-duty trucks are largely responsible for the trends in ROG and NOx. Flat sales of agricultural equipment and the lack of comparably stringent standards for planes, trains, and ships explain the trend for PM.

Though not shown[10] in the figures above, off-road diesel engines are projected to account for 20 percent (249 TPD) of the total mobile source inventory for NOx and 18 percent (17.3 TPD) of the total mobile source inventory for PM in 2020. They are also projected to make up 36 percent of the total statewide inventory of PM that occurs exclusively from diesel exhaust, or diesel PM, in 2020.

Table 2.4 compares the statewide baseline off-road diesel emission inventories for PM, NOx, and ROG in 2000, 2010, and 2020. These baseline estimates include the effects of State and federal requirements through Tier 3; however, they do not include emissions from locomotives, airplanes, or marine engines. The baseline data also reflect PM benefits resulting solely from the use of 15 ppmw sulfur diesel fuel in California after 2006. ARB estimates that direct diesel particulate matter emissions, due to the low-sulfur fuel alone, would be reduced by about four percent due to the lower engine-out formation of sulfates (ARB 2003). This would include virtually all off-road diesel engines currently produced and those expected to be produced without advanced particulate emission control technologies.

Table 2.4 also shows the contribution of emissions from off-road diesel engines categorized into groups that can and cannot be regulated by California. The number of non-preempt engines -- those that ARB can regulate -- varies slightly from year to year due to fluctuations in consumer demand, but on the whole it is roughly 29 percent of the total number of off-road diesel engines in California. However, emissions do not necessarily follow the population fraction. For example, non-preempt NOx emissions exceed the population fraction and account for approximately 40 percent of the NOx inventory attributed to all off-road diesel engines in the State. Furthermore, non-preempt engines are projected to be responsible for the majority of NOx and NMHC emission reductions. This is discussed in greater detail in subsection 7.1.1.

[9] PM and PM10 are virtually the same component in diesel exhaust; therefore, the terms are used synonymously in this report.
[10] The NOx and PM percentages were obtained by comparing the 2020 off-road diesel data in Table 2.4 with the 2020 total mobile sources inventory data in Figures 2.2 and 2.3. The total statewide inventory percentage contribution of PM from off-road diesel engines in 2020 was calculated using the off-road diesel data in Table 2.4 and an assessment of 47.4 tons per day total statewide diesel exhaust PM from the 2004 California Almanac of Emissions and Air Quality.

Table 2.4
Off-Road Diesel Baseline Emission Inventories
Statewide Annual Averages

Government Jurisdiction	Pollutant	Emissions Inventory (tons per day)		
		2000	2010	2020
California Authority Non-Preempt Engines	PM [1]	11.6	7.1	5.1
	NOx	236.1	157.2	101.0
	ROG	23.5	13.4	9.6
Federal Authority Preempt Engines	PM [1]	27.6	21.9	12.2
	NOx	352.4	251.3	148.0
	ROG	51.3	33.6	15.3
Total	PM [1]	39.2	29.0	17.3
	NOx	588.5	408.5	249.0
	ROG	74.8	47.0	24.9

Notes:
1 PM estimates have been adjusted to reflect 15 ppmw sulfur fuel reductions after 2006

2.5. Federal Rules

In addition to the diesel Tier 1, Tier 2, and Tier 3 regulations already mentioned, U.S. EPA promulgated Tier 4 emissions standards on June 29, 2004 (see "Control of Emissions from New and In-Use Nonroad Diesel Engines," (40 CFR 1039, Subpart U)). The new emission standards are based on the same advanced exhaust aftertreatment technologies likely to be employed by heavy-duty diesel on-road engines beginning in 2007. ARB is proposing to adopt the federal Tier 4 standards for non-preempt off-road diesel engines in California. The federal rule also contains a two step requirement to reduce the level of sulfur in nonroad diesel fuel, first to 500 ppmw in 2007 and then to 15 ppmw in 2010. California has already adopted a 15 ppmw sulfur diesel fuel program for California that starts in 2006.

U.S. EPA has also adopted a rule that sets emissions standards similar to nonroad diesel Tier 2 standards for recreational marine engines rated equal to and above 37 kW (see "Control of Air Pollution from Marine Diesel Engines," 40 CFR 94). Recreational marine diesel engines less than 37 kW have previously been controlled to the same standards as land-based diesel engines, and are commonly included in the emissions estimates for off-road land-based diesel engines. Additional standards for these engines may be considered in a separate rulemaking.

2.6. Public Process

On November 29, 2001, ARB solicited input from off-road engine manufacturers and other stakeholders regarding the development of advanced aftertreatment technologies for off-road diesel engines in ARB Mailout MSC 01-17. The purpose of this request was to learn how far the technologies had progressed and to understand industry's concerns regarding implementation, timing, and durability.

ARB held public discussions regarding future off-road diesel standards at the Clean Air Plan workshop and SIP Summit in Sacramento, CA, between February, 2002, and January, 2004.

The Executive Officer of the ARB, Catherine Witherspoon, testified at two U.S. EPA hearings on June 10, and June 17, 2003, regarding U.S. EPA's then proposed Tier 4 rulemaking and ARB's intention to align with its provisions.

On August 23, 2004, staff posted a letter to the ARB website[11] stating ARB's intent to adopt standards for California's off-road diesel engines at the December 9, 2004, Board Hearing that would harmonize with U.S. EPA's Tier 4 standards. An electronic announcement was sent to all subscribers of the Mobile Source List Serve that same day to inform all interested parties that the letter had been posted.

3. NEED FOR CONTROL

This section provides the rationale behind ARB's proposal for more stringent exhaust standards and test procedures.

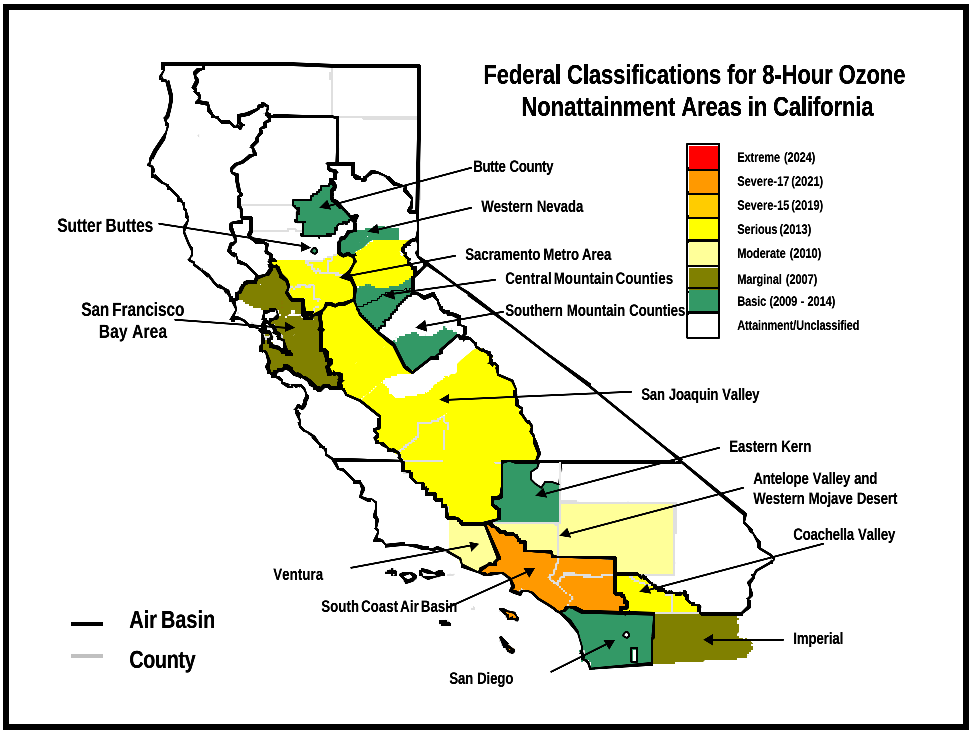
3.1. Overview

The emission standards being proposed would significantly reduce the human health and environmental impacts of PM and ground-level ozone. This section summarizes the air quality rationale for the proposed new standards.

Figure 3.1 below identifies air basins and counties that are in non-attainment with the recently adopted federal eight-hour standard for ozone.

[11] http://www.arb.ca.gov/msprog/offroad/orcomp/orcomp.htm/intentletter08232004.pdf

Figure 3.1
Eight Hour Ozone Non-Attainment Areas in California



Over 50 percent of California's air basins fall within this designation. Mobile sources presently[12] account for 68 percent of the total ozone precursors statewide (including evaporative emissions[13]), and the exhaust from off-road diesel engines is responsible for 20 percent of the NOx from all mobile sources, and 33 percent of the total NOx contribution from diesel mobile sources exclusively.

3.2. Diesel Exhaust

In order to start a diesel engine, finely misted fuel is injected, directly, or indirectly via a prechamber, into the engine's cylinder(s) with air that has been heated by piston compression. The power output of the engine is controlled by regulating the amount of fuel injected, unlike spark-ignition engines, which generally increase or decrease power by regulating the amount of air entering the engine. The heat of the compressed air in a diesel engine evaporates the fuel, which then ignites as it mixes with oxygen under high temperature and pressure inside the cylinder(s). Diesel fuel typically has a much higher sulfur content than gasoline, currently 140 ppmw on average in California (ARB 2003), and a lower evaporation rate making it suitable in diesel applications. Diesel engines operate best under lean air/fuel ratios (more air than fuel), which leaves behind excess oxygen.

[12] Estimates are for the 2003 calendar year.
[13] Evaporative emissions are included in this comparison because it includes all mobile and statewide sources, not just exhaust.

The pollutants of most concern in diesel exhaust are PM and NOx. NMHC and CO are also present, but are not emitted at comparably high levels due to their propensity to oxidize in the combustion chamber with abundant oxygen. The low evaporation rate of diesel fuel also helps in relegating evaporative emissions to insignificant levels.

3.2.1. Particulate Matter

Particulate matter from diesel exhaust is made primarily of four components:

- solid carbon soot,
- volatile and semi-volatile organic matter,
- inorganic solids (ash), and
- sulfate.

The formation of the solid carbon soot portion of PM is inherent in diesel engines due to the heterogeneous distribution of fuel and air in a diesel combustion system. Diesel combustion is designed to allow for lean combustion (excess oxygen) giving good efficiencies and low CO and NMHC emissions, with a small region of rich (excess fuel) combustion within the fuel injection plume. It is within this excess fuel region that PM is formed when high temperatures and a lack of oxygen cause the fuel to pyrolize[14], forming soot. Much of the soot formed in the engine is burned during the combustion process as the soot is mixed with oxygen in the cylinder at high temperatures. Any soot that is not fully burned before the exhaust valve is opened will be emitted from the engine as diesel PM.

The volatile and semi-volatile organic material in diesel PM is often referred to as the soluble organic fraction (SOF) in reference to a test method used to measure its level. SOF is primarily composed of engine oil that passes through the engine with no oxidation, or only partial oxidation, and condenses in the atmosphere to form PM. The SOF portion of diesel PM can be reduced through reductions in engine oil consumption and through oxidation of the SOF catalytically in the exhaust.

The inorganic solids (ash) in diesel PM come primarily from metals found in engine oil and, to a certain extent, from engine wear. Ash makes up a very small portion of total PM such that it is often not listed as a PM component and has no impact on compliance with PM emission standards. However, it does impact the maintenance of PM filter technologies because, in aggregate over a very long period of time, ash accumulation in the PM filter can reach a level such that it must be cleaned from the filter.

The sulfate portion of diesel PM is formed from sulfur present in diesel fuel and engine lubricating oil that oxidizes to form sulfuric acid, and then condenses in the atmosphere to

[14] Pyrolization is the process of using high temperature in an anaerobic environment to break down organic matter and release volatile organic products.

form sulfate PM. Approximately two percent of the sulfur that enters a diesel engine from the fuel is emitted directly from the engine as sulfate PM. The balance of the sulfur content is emitted from the engine as SO2 (RIA4 2004).

3.2.1.1. NOx Relationship

In addition to directly-emitted PM, secondary nitrate (a.k.a. indirect) PM accounts for a substantial fraction of the airborne particulate matter in some areas of California. This type of PM consists primarily of ammonium nitrate and represents about 25 percent of measured PM10 in the Los Angeles Basin (U.S. EPA 1997). Fine secondary nitrate particles are produced in the atmosphere from the NOx emitted by diesel engines and other sources. ARB believes that the control of secondary nitrate PM will be critical in meeting California's air quality attainment goals for the future.

3.2.1.2. Health Issues

The need for lower emission standards to protect public health, especially with respect to diesel PM, has prompted regulatory efforts throughout the world. Since virtually all particles in diesel particulate matter are 10 microns or less in diameter (PM10), with approximately 94 percent of them less than 2.5 microns in diameter (PM2.5), diesel particulate matter is readily respirable and can effectively reach the lowest airways of the lungs along with adsorbed compounds that are known as, or suspected of being, mutagens and carcinogens (SRP 1998). Accordingly, both ARB and U.S. EPA have identified diesel PM as a likely human carcinogen. Exposure to respirable diesel PM is associated with lung cancer, acute respiratory infection, exacerbation of asthma, increased hospital admissions, and an increase in mortality among the elderly and those with chronic heart and lung disease.

The estimated health risk from diesel PM is higher than the risk from all other toxic air contaminants combined. ARB estimates that 70 percent of the known statewide cancer risk from outdoor air toxics is attributable to diesel PM (Almanac 2004). Statewide, the estimated average lifetime potential cancer risk associated with diesel PM emissions is approximately 540 extra cases per million people[15], or 250 extra cases per year (Almanac 2004 and RRP 2000). In the South Coast Air Basin, the potential lifetime cancer risk associated with diesel PM emissions is estimated to be 720 extra cases per million people[16] (Almanac 2004), or approximately 150 extra cases per year (Almanac 2004 and Census 2000). Communities that adjoin busy roads and freeways, distribution centers, and other locations with large concentrations of diesel engines are particularly at risk.

Health impacts from exposure to the fine particulate matter component of diesel exhaust, PM2.5, have been calculated for California, using concentration-response equations from

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[15] These potential risk rates are based on 1.8 *u*g/m^3 average ambient PM concentration and are averaged over a 70 year lifespan.
[16] This estimate is for calendar year 2000 and distributes the risk over an average lifespan of 70 years.

several epidemiological studies (Lloyd & Cackette 2001). Both mortality and morbidity effects could be associated with exposure to either direct diesel PM2.5 or indirect diesel PM2.5, the latter of which arises from the conversion of diesel NOx emissions in the atmosphere to PM2.5 nitrates.

In California, the average population weighted exposure to directly emitted diesel PM2.5 is 1.8 micrograms per cubic meter (µg/m3). Long-term exposure to ambient concentrations of diesel PM2.5 at this level is estimated to have led to a range of about 2,000 to 2,500 premature deaths, statewide, for the year 2000. Indirect diesel PM2.5 (at 0.81 µg/m3 concentration level) is also estimated to contribute to an additional 900 premature deaths, although the mortality estimates may include some premature deaths due to cancer, because the epidemiological studies did not identify the cause of death.

Exposure to fine particulate matter, including diesel PM2.5, can also be linked to a number of heart and lung diseases. For example, it was estimated that statewide, on average, 2500 hospital admissions for chronic obstructive pulmonary disease, pneumonia, cardiovascular disease, and asthma were associated with exposure to direct diesel PM2.5. An additional 1,100 admissions were linked to exposure to indirect diesel PM2.5.

Staff's proposal, discussed in detail in subsection 4.2.1, will require PM reductions up to 95 percent more than currently required for new off-road diesel engines.

3.2.2. Ozone

Ground-level ozone is created by the photochemical reaction between NOx and ROG. Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, shortness of breath, and congestion. It can worsen bronchitis, emphysema, and asthma. Ozone can also reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.

The elderly, children, and people with compromised respiratory systems are among those persons who may be most affected by exposure to ozone. However, healthy people can also experience difficulty breathing when exposed to ozone pollution. Because ozone forms in hot weather, anyone who spends time outdoors in the summer may be affected, particularly children, outdoor workers and people exercising. Many Californians live in areas where the federal ozone health standards are exceeded.

Ground-level ozone also damages vegetation and ecosystems. It leads to reduced agricultural crop and commercial forest yields, reduced growth and survivability of tree seedlings, and increased susceptibility to diseases, pests, and other stresses such as harsh weather. Ground-level ozone also damages the foliage of trees and other plants, affecting the landscape of cities, parks and forests, and recreational areas. NOx also contributes to acid deposition and the overgrowth of algae in coastal estuaries.

3.3. State Implementation Plan (SIP)

Off-road diesel engine standards will be a part of California's post-2010 control strategy for attaining the eight-hour ozone and PM2.5 air quality standards. The emission benefits from these standards will be incorporated into future SIPs. A commitment for ARB to consider adoption of more stringent emission standards for off-road diesel engines is included in an agreement to settle a lawsuit filed over the 1994 SIP as discussed below.

In 1997, three environmental groups, namely Communities for a Better Environment, the Coalition for Clean Air, and the Natural Resources Defense Council, filed a complaint in the United States District Court for the Central District of California. The lawsuit was filed against ARB, the South Coast Air Quality Management District, and U.S. EPA related to California's progress in achieving the 1994 SIP commitments. ARB reached a settlement agreement with these groups in January 1999, which was amended most recently in July 2003, to include additional elements (SSA 2003). Although the 2003 SIP revision is intended to replace the State's original commitments under the 1994 SIP for the South Coast, the settlement agreement will remain in place until ARB fulfills its obligations as outlined.

The agreement contains a schedule under which ARB committed to achieving the remaining near-term emission reductions from the 1994 SIP. ARB also committed to submit to the Board, and propose for adoption, a number of specific measures including the adoption of more stringent emission standards for off-road diesel engines no later than December 31, 2004. The amendments to the off-road diesel regulation proposed in this report are intended to fulfill ARB's commitment with respect to the settlement agreement.

4. SUMMARY OF PROPOSED REGULATIONS

The staff recommends that the Board amend sections 2420, 2421, 2423, 2424, 2425, and 2327, Title 13, California Code of Regulations, as set forth in Attachment 1: "Proposed Amendments to the California Regulations for 2006 and Later Off-Road Compression-Ignition Engines and Equipment" and Attachment 2: "Proposed Amendments to the California Exhaust Emission Standards and Test Procedures for New 2008 and Later Tier 4 Off-Road Compression-Ignition Engines and Equipment, Part I-C" of this report. The proposed regulatory language is intended to harmonize California's exhaust emission requirements for new off-road diesel engines with those published by U.S. EPA on June 29, 2004 (69 FR 38958-39273), with minor differences as discussed in section 5 of this report. Although the California and federal programs for diesel engines will be similar upon adoption of this proposal, ARB will retain its authority to further regulate off-road mobile sources in the future and its ability to enforce the regulations in California.

In sum, the proposed amendments require new off-road diesel engines to meet more stringent exhaust emission standards for PM, NOx, NMHC, and CO than are currently required. Enhancements to test procedures and the certification process are proposed to ensure meaningful compliance with the new standards and to provide compliance flexibility without sacrificing air quality benefits. The following subsections discuss the major provisions of the staff proposal in further detail.

The amendments, which are discussed below, can be categorized as follows:

- Applicability
- Tier 4 Emission Standards and Implementation Schedules
- Enhanced Certification Requirements
- Enhanced Test Procedures, and
- Expanded Compliance Flexibility Provisions
- Miscellaneous

4.1. Applicability

The provisions in this proposal continue to apply to off-road diesel engines produced for sale in California with the exception of engines with a per cylinder displacement of less than 50 cubic centimeters, engines used to propel locomotives, underground mining equipment, marine vessels, aircraft, preempt engines and equipment, and off-road military tactical vehicles or equipment that have been exempted from regulations under the federal national security exemption.

Recreational marine engines less than 37 kW are the significant omission with respect to the applicability of the Tier 4 proposal compared to previous off-road diesel regulations. U.S. EPA has chosen instead to regulate these engines under a future rulemaking that would consolidate all diesel marine engines less than 30 liters per cylinder. Comments on the need for, and the feasibility of, more stringent recreational marine diesel standards regarding this rulemaking are currently being solicited. In response, ARB intends to recommend that U.S. EPA promulgate a PM standard based on the reduction capacity of oxidation catalysts in the near-term, to be followed with advanced aftertreatment equivalent levels in the 2013 time frame. The precedent for aftertreatment-based standards on watercraft has already been established in California with ARB's adoption of catalyst-forcing standards for 2009 gasoline fueled inboard and sterndrive boats (ARB 2001b). Staff believes that the technology needed to adapt diesel exhaust aftertreatment to a marine environment would be nearly identical to the technology needed for gasoline marine engines. Until new standards are adopted, recreational marine engines will continue to meet the previous tiers of off-road standards, as appropriate.

4.2. Standards and Implementation Schedules

This section explains proposed exhaust standards, crankcase standards, not-to-exceed limits, and smoke test standards. Table 4.1 below identifies the model year when the new Tier 4 requirements are first applicable for each engine power category.

Table 4.1
Applicability by Model Year

Power Category	Model Year
kW < 19	2008 [1]
19 = kW < 56	2008 [2]
56 = kW < 130	2012
130 = kW = 560	2011
kW > 560	2011

Notes:
1 Hand-start, air cooled, direct injection engines below 8 kW are not be subject to the PM standard until the 2010 model year.
2 Engines 37 = kW < 56 may opt out of meeting interim standards by complying with final standards early in the 2012 model year.

4.2.1. Exhaust Emission Standards

Staff proposes that the Board adopt more stringent PM, NOx, and NMHC emission standards for new off-road diesel engines as outlined and scheduled in Table 4.2 below. The standards would be the same as those adopted federally in the U.S. EPA Tier 4 rulemaking. Staff is not proposing more stringent CO standards. Current emission standards for all pollutants would continue to apply until the more stringent proposed emission standards become effective.

Interim Tier 4 standards, targeting 50 percent tailpipe reductions in PM, would be introduced beginning with the 2008 model year for engines less than 56 kW, and ultra stringent PM and/or NOx standards based on advanced aftertreatment technologies would begin phasing-in on engines greater than and equal to 19 kW in 2011. The final Tier 4 standards would reduce tailpipe emissions upwards of 90 percent compared to previous off-road diesel standards. The proposed off-road aftertreatment based standards are modeled after the 2007 on-road heavy-duty diesel standards.

By 2020, the proposed Tier 4 off-road diesel standards would reduce the statewide PM emissions inventory by 40 percent, the NOx inventory by 29 percent, and the NMHC inventory by 12 percent. Reductions in NOx will also reduce secondary nitrate PM emissions. The resulting emission reductions will translate into needed improvements in air quality in California and assist in attaining applicable ambient air quality standards. The benefits of this proposal are discussed in detail in subsection 7.1 of this report.

Table 4.2
Proposed Tier 4 Off-Road Diesel Emission Standards

<table>
<tr><th rowspan="2">MAXIMUM ENGINE POWER</th><th rowspan="2">MODEL YEAR</th><th rowspan="2">TYPE</th><th>PM</th><th>NMHC+NOX</th><th>NMHC</th><th>NOX</th><th>CO</th></tr>
<tr><th colspan="5">grams per kilowatt-hour</th></tr>
<tr><td>kW < 19</td><td>2008 and later</td><td>FINAL</td><td>0.40 [1]</td><td>7.5</td><td>-</td><td>-</td><td>8.0/6.6 [2]</td></tr>
<tr><td rowspan="2">19 = kW < 37</td><td>2008 - 2012</td><td>INTERIM</td><td>0.30</td><td>7.5</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">5.5</td></tr>
<tr><td>2013 and later</td><td>FINAL</td><td>0.03</td><td>4.7</td></tr>
<tr><td rowspan="2">37 = kW < 56 [3]</td><td>2008 - 2012</td><td>INTERIM</td><td>0.30</td><td rowspan="2">4.7</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">5.0</td></tr>
<tr><td>2013 and later</td><td>FINAL</td><td>0.03</td></tr>
<tr><td rowspan="4">56 = kW < 75</td><td rowspan="3">2012 - 2014 [4]</td><td>PHASE-IN</td><td rowspan="4">0.02</td><td>-</td><td>0.19</td><td>0.40</td><td rowspan="4">5.0</td></tr>
<tr><td>PHASE-OUT</td><td>4.7</td><td>-</td><td>-</td></tr>
<tr><td>ALT NOx</td><td rowspan="2">-</td><td rowspan="2">0.19</td><td>3.4 [5]</td></tr>
<tr><td>2015 and later</td><td>FINAL</td><td>0.40</td></tr>
<tr><td rowspan="4">75 = kW < 130</td><td rowspan="3">2012 - 2014 [4]</td><td>PHASE-IN</td><td rowspan="4">0.02</td><td>-</td><td>0.19</td><td>0.40</td><td rowspan="4">5.0</td></tr>
<tr><td>PHASE-OUT</td><td>4.0</td><td>-</td><td>-</td></tr>
<tr><td>ALT NOx</td><td rowspan="2">-</td><td rowspan="2">0.19</td><td>3.4 [5]</td></tr>
<tr><td>2015 and later</td><td>FINAL</td><td>0.40</td></tr>
<tr><td rowspan="4">130 = kW = 560</td><td rowspan="3">2011 - 2013</td><td>PHASE-IN</td><td rowspan="4">0.02</td><td>-</td><td>0.19</td><td>0.40</td><td rowspan="4">3.5</td></tr>
<tr><td>PHASE-OUT</td><td>4.0</td><td>-</td><td>-</td></tr>
<tr><td>ALT NOx</td><td rowspan="2">-</td><td rowspan="2">0.19</td><td>2.0</td></tr>
<tr><td>2014 and later</td><td>FINAL</td><td>0.40</td></tr>
<tr><td rowspan="2">560 kW < GEN [6] = 900 kW</td><td>2011 - 2014</td><td>INTERIM</td><td>0.10</td><td rowspan="2">-</td><td>0.40</td><td>3.5</td><td rowspan="2">3.5</td></tr>
<tr><td>2015 and later</td><td>FINAL</td><td>0.03</td><td>0.19</td><td>0.67</td></tr>
<tr><td rowspan="2">GEN > 900 kW</td><td>2011 - 2014</td><td>INTERIM</td><td>0.10</td><td rowspan="2">-</td><td>0.40</td><td rowspan="2">0.67</td><td rowspan="2">3.5</td></tr>
<tr><td>2015 and later</td><td>FINAL</td><td>0.03</td><td>0.19</td></tr>
<tr><td rowspan="2">ELSE [7] > 560 kW</td><td>2011 - 2014</td><td>INTERIM</td><td>0.10</td><td rowspan="2">-</td><td>0.40</td><td rowspan="2">3.5</td><td rowspan="2">3.5</td></tr>
<tr><td>2015 and later</td><td>FINAL</td><td>0.04</td><td>0.19</td></tr>
</table>

Notes:

1 The Tier 4 PM standard for hand-start, air cooled, direct injection engines below 8 kW is 0.60 g/kW-hr, but is not required until 2010.

2 The CO standard is 8 g/kW-hr for engines below 8 kW and 6.6 g/kW-hr for engines 8 = kW < 19.

3 Engine families in this power category may alternately meet Tier 3 PM standards from 2008-2011 in exchange for introducing final PM standards in 2012.

4 Manufacturers have the option of complying with the Tier 4 standards over a two year period at 50% per year using banked Tier 2 credits or over a three year period at 25% per year without the use of credits. The three year phase-in period is shown as the more likely option. The 2014 model year cannot extend beyond December 30, 2014, when the 3 year phase-in option is used.

5 This Manufacturers may comply with the standards during the transitional implementation years using either a phase-in / phase-out approach or by using the Alternate NOx approach. The three year 25% alternate NOx standard is shown as it corresponds to the three year phase-in period shown in the table. The two year 50% phase-in NOx standard would be 2.3 g/kW-hr.

6 “GEN” refers to generator engines only.

7 “ELSE” refers to all mobile machinery excluding generator engines.

4.2.1.1. Power Category Reclassification

The new Tier 4 standards would be phased-in according to power category. Tier 4 power categories differ from previous power categories in that there are now only five distinct groupings, whereas nine existed before. The five Tier 4 power categories are shown in Table 4.2 above with alternating gray and white shading. Fewer categories reduce the burden on engine manufacturers at certification and allow more compliance options for equipment manufacturers without sacrificing long-term post 2014 air quality benefits. For example, more equipment flexibility allowances would be available within a power category that could potentially be used to address problematic applications over a longer period of time; however, the total number of flexibility allowances for all power categories would remain the same. Additionally, the previous power category defined by engines 37 = kW < 75 has been split into two separate categories defined by engines 37 = kW < 56 and engines 56 = kW < 75. This regrouping would more closely match the degree of challenge involved in transferring advanced emission control technology from highway engines to off-road engines by limiting advanced NOx aftertreatment requirements to engines greater than and equal to 56 kW. This would ease the burden of certifying engines between 37 = kW < 56 due to the less rigorous NOx standards.

4.2.1.2. Phase-in Allowances

A new feature for diesel off-road standards in staff’s Tier 4 proposal is the gradual phasing-in of aftertreatment NOx standards for some power categories. Manufacturers would be allowed to continue producing engines that meet previously certified levels of NMHC+NOx emissions for a portion of new sales (hereafter phase-out engines) during years for which the phase-in provisions are permitted. Generally speaking, up to 75 percent of the engines produced in the 56 = kW < 130 power category from 2012 through 2014 could be phase-out engines, and 50 percent would be permitted in the 130 = kW = 560 category from 2011 through 2013. Other compliance options exist for these categories as explained in the attached regulations and test procedures including the use of alternate NOx standards for all engines in lieu of phase-in/phase-out implementation. These are the same allowances adopted by U.S. EPA in the federal nonroad Tier 4 rule.

4.2.2. Not-To-Exceed (NTE) Limits

The NTE limits have been developed as a means to confirm the emissions performance of engines under all normal in-use operating conditions, not just those encountered during certification testing. In the past, some diesel manufacturers were designing their engines to perform differently depending on whether they were operated on a certification test cycle or off-cycle (see subsection 2.3.3). This had a negative impact on emissions despite the fact that the engines were meeting the certification limits. To ensure against a similar occurrence in the future, staff proposes that the Board adopt NTE limits and test procedures for new off-road diesel engines to align with federal Tier 4 NTE requirements beginning in 2011. These limits and test procedures are similar to those that U.S. EPA and ARB have adopted for 2007 and later heavy-duty on-road diesel engines. Table 4.3 below shows the NTE starting date that would correspond to each power category.

Table 4.3
NTE Implementation Schedule

Power Category	NTE Implementation Model Year [1,2]
kW < 19	2013
19 = kW < 56	2013 [3,4]
56 = kW < 130	2012 [4]
130 = kW = 560	2011 [4]
kW > 560	2011

Notes:
1 All engines in a given power category are required to meet the NTE limits.
2 NTE limits are not applicable for NOx and NMHC on phase-out engines that are certified to the same numeric limits or FELs as engines which were previously certified under the Tier 3 requirements.
3 NTE limits would apply in 2012 for engines in the 37 = kW < 56 power category that do not comply with 2008 interim Tier 4 standards.
4 NTE limits do not apply for engines certified to transient alternate FELs (ALT 20%) unless those engines are also certified to optional transient standards.

For off-road diesel engines subject to NTE limits, the engine manufacturer would be required to state in the application for certification that the engine is able to meet the NTE limits under all conditions that may reasonably be expected to occur in normal equipment operation and use. Manufacturers would be required to maintain a detailed description of all testing as specified in the test procedures, engineering analysis, and other information that forms the basis for this statement.

For a limited time, engine manufacturers would be permitted to certify an engine family with NTE deficiencies. The NTE deficiency provision would allow the Executive Officer to certify a nonroad diesel engine as compliant although some specific NTE limits may not be fully met. This provision provides a means of relief to address the occurrence of unanticipated technical problems, which are limited in nature but, cannot be resolved in time to meet production schedules. The number of NTE deficiencies that a manufacturer can apply for during the first three model years of the NTE requirement is unlimited. However, manufacturers would not be allowed to apply for more than three deficiencies per engine family for the fourth through seventh model years, and no deficiencies would be granted after the seventh model year.

Table 4.4 below shows the methodology that would be used to determine NTE thresholds for each applicable pollutant. The detailed NTE requirements, including how to perform an emissions test, can be found in the attached test procedures.

Table 4.4
Criteria for Determining NTE Limits [1]

Pollutant	Apply NTE Multiplier of 1.25 when ...	Apply NTE Multiplier of 1.50 when ...
NOx	NOx Standard or FEL = 2.5 g/kW-hr	NOx Standard [2] or FEL< 2.5 g/kW-hr
NMHC	NOx Standard or FEL = 2.5 g/kW-hr	NOx Standard [2] or FEL< 2.5 g/kW-hr
NMHC+NOx	NMHC+NOx Standard or FEL = 2.7 g/kW-hr	NMHC+NOx Standard [2] or FEL< 2.7 g/kW-hr
PM	PM Standard or FEL = 0.07 g/kW-hr	PM [2] Standard or FEL [3]< 0.07 g/kW-hr
CO	Always	Never

1 Other provisions as specified in the test procedures may affect the calculation of NTE limits.
2 Engines must be certified to these limits without the use of ABT credits.
3 For engines certified to a PM FEL less than or equal to 0.01 g/kW-hr, the PM NTE limit shall be 0.02 g/kW-hr.

4.2.3. Universal Closed Crankcase Requirement

Staff proposes to amend the regulations to require closed crankcase requirements for all off-road diesel engine engines including those previously exempted due to turbochargers, pumps, blowers, or superchargers used for air induction. These changes would become effective beginning in 2008 and phased-in by power category (see Table 4.1 above). Optionally, crankcase emissions may be vented to the atmosphere if these emissions are added to the total of exhaust emissions and so long as the deterioration of crankcase emissions is taken into account for the purposes of certification and in-use testing (see subsection 4.4.5). This provision would align crankcase requirements with 2007 federal heavy-duty highway and California heavy-duty on-road requirements.

4.2.4. Smoke Test Standards

Staff proposes to amend the smoke requirements for new off-road diesel engines to align with federal Tier 4 smoke standards. These changes would become effective beginning in 2008 and phased-in by power category (see Table 4.1 above). With this change, engines employing a particulate filter and certified to a Family Emission Limit (FEL) of 0.07 g/kW-hr or lower would be exempted from this requirement. Smoke levels would need to take into account the effects of deterioration for certification and in-use testing. The particulate filter should effectively eliminate all visible smoke from an engine so equipped. Single-cylinder engines, propulsion marine engines, and constant-speed engines would continue to be exempted from this requirement.

4.3. Early Introduction Incentives for Engine Manufacturers

To encourage the early introduction of Tier 4 off-road diesel engines in California, staff proposes to align with the provisions in U.S. EPA's final rule allowing engine manufacturers to benefit from producing engines certified to the Tier 4 standards prior to the 2011 model year. In exchange for the early introduction of these engines, engine manufacturers would be allowed to make fewer Tier 4 engines after 2011, a concept that U.S. EPA terms "engine offsets" to avoid confusion with Averaging, Banking, and Trading (AB&T) program credits. The number of offsets that could be generated would depend on the degree to which the engines are able to meet, or perform better than, the final Tier 4 standards.

Table 4.5 summarizes the requirements and available offsets for engine manufacturers in this program. As the purpose of the incentive is to encourage the introduction of clean technology engines earlier than required, actual emission standard levels would need to be met, and met early, by qualifying engines to earn the early introduction offsets. In other words, the standards must be met without the use of AB&T credits, and actual production of the engines must begin by September 1 of the year prior to the first model year when the standards would otherwise be applicable. Also, to avoid double-counting, the early incentive engines can earn either engine offsets or AB&T emissions credit, but not both. Note that this is different from the approach taken in the early Tier 4 incentive program for equipment manufacturers (see subsection 4.7.2.6) where incentives for both the engine manufacturer (AB&T credits) and the equipment manufacturer (flexibilities) are needed to ensure a successful early introduction of clean engines. Since 15 ppmw sulfur diesel fuel will be readily available in California by 2007, staff proposes to allow engine manufacturers to begin certifying engines to the very low emission levels required for eligibility in this incentive program, beginning with the 2007 model year.

An important aspect of the early incentive provision is that it must be done on an engine count basis. That is, a diesel engine meeting new standards early would count as one and one half diesel engines later. This contrasts with a provision done on an engine percentage basis which would count one percent of diesel engines early as one and one half percent of diesel engines later. Basing the incentive on an engine count basis removes the uncertainty regarding fluctuations in engine sales for different model years.

Another important aspect of this program is that it is limited to engines sold prior to the 2013 model year for engines 19 = kW < 56, prior to the 2012 model year for engines 56 = kW < 130, and prior to the 2011 model year for engines 130 = kW = 560. In other words, as in the heavy-duty on-road diesel program, nonroad diesel engines sold during the transitional “phase-in” model years would not be considered “early” introduction engines and would therefore not be eligible for generating early introduction offsets. However, such engines and vehicles would still be able to generate AB&T credits. Because engines over 560 kW have no phase-in provisions, staff proposes to allow offsets for early incentive engines in this power category for any model year prior to 2015. For the same reason, there is no PM-only offset for these engines. As with the phase-in itself, and for the same reasons, an early introduction engine could only be used to offset engines in the same engine power category as the offset-generating engine.

Table 4.5
Incentives for Engine Manufacturers

EARLY INTRODUCTION	POWER CATEGORY	QUALIFYING STANDARDS [1] g/kW-hr	PER-ENGINE INCENTIVE
Final Tier 4 PM-Only [2]	19 = kW < 56	0.03 PM	3 for 2 PM-Only
	56 = kW < 560	0.02 PM	
Final Tier 4 ALL	19 = kW < 56	0.03 PM / 4.7 NMHC+NOx	3 for 2
	56 = kW = 560	0.02 PM / 0.40 NOx / 0.19 NMHC	
	GEN > 560	0.03 PM / 0.67 NOx / 0.19 NMHC	
	ELSE > 560	0.04 PM / 3.5 NOx / 0.19 NMHC	
Ultra Low NOx	kW = 19	Final Tier 4 PM & NMHC / 0.20 NOx	2 for 1

Notes:

1 Engines must also meet the Tier 4 crankcase emissions requirements and must be certified for all other Tier 4 requirements such as transient testing and Not-To-Exceed testing as appropriate.

2 Offsets must be earned prior to the start of phase-in requirements in applicable engine groups (prior to 2013 for 19=kW<56 engines, prior to 2012 for 56=kW<130 engines, prior to 2011 for 130=kW=560 engines, prior to 2015 for >560 kW engines)

4.4. Certification

The amendments in this section are related to labeling, executive orders, test fuel, test procedures, deterioration factors, and definitions.

4.4.1. Labeling

This section proposes federal alignment with most aspects of the labeling requirements for off-road diesel engines and equipment as well as some California specific changes.

4.4.1.1. Flexibility Label Content

Staff generally proposes to align with federal labeling requirements for new off-road diesel engines, except that the label must state that the engine complies with California or both California and U.S. EPA regulations.

However, staff also proposes a modified version of the label content for engines that qualify under the transitional flexibility provisions for equipment manufacturers (flexibility engines). This proposal, including revised labeling content, is discussed in detail in subsection 5.1.1.

4.4.1.2. Rebuilt Labeling Prohibition

Staff also proposes to adopt language prohibiting the removal of the original label from off-road diesel engines that have been rebuilt or remanufactured. This proposal is discussed in detail in subsection 5.2.

4.4.2. Executive Orders

Staff proposes to amend the current regulations to clarify that engines certified under the transitional flexibility provisions for equipment manufacturers, discussed in subsection 4.7 of this report, must be covered by an Executive Order. The Executive Order need not be current for the year in which the engine is used as a flexibility allowance, but may have been issued previously so long as the engine was certified to the appropriate standards required by the flexibility provision. This requirement is discussed in detail in subsection 5.1.2.

4.4.3. Test Fuel

Staff proposes to align with the federal nonroad rule regarding the use of ultra low-sulfur diesel fuel (15 ppmw) as the certification test fuel for all engines in 2011 and as likewise permitted for new engines in previous years. Since ultra low-sulfur diesel fuel will be the only fuel available to the California off-road market by 2007, previously uncertified new engine families for that year may also use ultra low-sulfur fuel as their certification test fuel. Carry-over engine families that have previously been certified using higher sulfur content certification fuel must continue to certify using that fuel.

4.4.4. Test Procedures

The current off-road diesel test procedures “California Exhaust Emission Standards and Test Procedures for New 2000 and Later Off-Road Compression-Ignition Engines and Equipment, Part I-B” will continue to apply through 2007 and beyond as applicable to engines and equipment designed to comply with the Tier 1, Tier 2, or Tier 3 standards. New test procedures applicable beginning in 2008 for engines designed to meet the Tier 4 standards are proposed for adoption by the Board and are equivalent to the federal requirements in 40 CFR, Part 1039 and the documents incorporated by reference. A copy of the new test procedures is included at the end of this report in Attachment 2. Staff’s proposed amendments to the current test procedures to restrict applicability to pre-Tier 4 engines and equipment are included in Attachment 3: “Proposed Amendments to the California Exhaust Emission Standards and Test Procedures for New 2000 and Later Tier 1, Tier 2, and Tier 3 Off-Road Compression-Ignition Engines and Equipment, Part I-B.”

The Tier 4 emission standards proposed in subsection 4.2.1 are based on using the existing steady-state (modal) test cycle or alternative Ramped-Modal Cycle and a new transient test cycle specific to off-road engines. A new steady-state test cycle would also be specified as an alternative for transport refrigeration units (TRU)s. PM measurement techniques have also been modified. The following subsection briefly describes the most significant proposed amendments to the test procedure provisions.

4.4.4.1. Ramped-Modal Cycle (RMC) Alternative

The optional RMC steady-state test cycle is a modified version of the existing steady-state test cycle which allows continuous PM sampling through a single filter. The RMC permits more consistent and reliable emissions testing of diesel engines with add-on emission control components and eliminates the downtime between modes. It also permits the sampling of emissions to be done on a composite basis for the whole test as opposed to sampling emissions mode-by-mode. This continuous emission sampling approach allows regeneration events from devices such as particulate traps to be captured more reliably and with greater repeatability. Engine manufacturers would benefit from using this optional cycle by virtue of the reduced cost in going to a single filter. Further, their test runs will be subject to less test cell "tuning" and fewer test runs will be needed to "fit" the emission test cycle to the dynamometer in order to operate a particular engine (U.S. EPA 2004).

4.4.4.2. Off-Road Transient Test Cycle

The Nonroad Transient Composite (NRTC) test cycle, as the name implies, is the compilation of a number of cycles developed by U.S. EPA to reproduce realistic operating conditions for equipment such as backhoes, dozers, and other off-road equipment. It supplements the existing off-road steady-state test cycle such that the majority of off-road diesel engines subject to the proposed Tier 4 requirements would be required to certify using both test cycles. The NRTC captures transient emissions over much of the typical off-road engine operating range, and helps to ensure effective control of the regulated pollutants. This new transient requirement is expected to significantly reduce in-use exhaust emissions from off-road diesel engines by providing a more thorough and realistic evaluation of emission control system performance. Proper transient testing captures engine emissions from the broad range of engine speed and load combinations that the engine may encounter in-use, while steady-state testing captures emissions at the eight operating points that are typical for off-road diesel engines. Transient testing will also identify emissions that result from speed and load fluctuations due to turbocharger engagement, throttle lag, etc (U.S. EPA 2004).

Transient testing would be required according to the implementation schedule shown in Table 4.6 below. In general, the requirement is applicable to all engines at the time those engines are first equipped with advanced aftertreatment technologies for reducing emissions of PM or NOx. Testing would not be required for diesel engines rated above 560 kW or constant speed engines; nor would it be required for measuring NMHC, NOx, and CO on phase-out[17] or flexibility engines.

Table 4.6
Transient Test Cycle Implementation Schedule

Power Category [1]	Model Year Implementation [2]
kW < 19	2013
19 = kW < 56	2013
56 = kW < 130	2012
130 = kW = 560	2011

Notes:
1 Transient testing is not required for engines > 560 kW
2 Transient testing is not required for gaseous pollutants on phase-out engines or flex engines

4.4.4.3. Cold Start Transient Testing

To better approximate actual in-use emissions, the transient test procedure includes the effects of engine operation after an extended period of inactivity (cold soak). Since most advanced exhaust aftertreatment technologies work less efficiently when cold, it is critical to address cold-start emissions in the measurement test procedures. U.S. EPA has determined, based on test data provided by industry, that a five percent weighting factor is appropriate for categorizing the effects of cold-start emissions. This is based on the scenario of an off-road engine with an overnight soak and a total of seven hours of operation over the course of a workday. At this weighting, engine manufacturers would likely need to take cold-start emissions into consideration when designing emission control strategies.

4.4.4.4. Transport Refrigeration Unit (TRU) Test Cycle

Staff's proposal includes a provision for a four-mode steady-state test cycle designed specifically for engines used in TRU applications. This test cycle is more representative of TRU operation than the other steady-state cycles currently available and it may be used by engine manufacturers in lieu of normal steady-state testing to certify their TRU engines. Engine manufacturers opting to use the TRU test cycle will be able to test their engines under a broad range of intermediate test speeds at specified test cycle engine load points.

[17] This exemption applies only to phase-out engines that are certified to the same gaseous standards or FELs as previously certified Tier 3 engines.

4.4.4.5. PM Measurement Techniques

Staff's proposal includes changes to the test procedures to improve the precision of emission measurements. In general, the requirements would be nearly identical to the test procedures adopted for implementation on 2007 and later heavy-duty on-road diesel engines. Most noteworthy of the changes are those directed at improving the accuracy and precision of PM measurements. These include changes to the type of PM filters that are used and improvements in how PM filters are weighed before and after emission measurements, including requirements for more precise microbalances. A single filter methodology would replace the existing multiple filter methodology for engines with particulate filters. The single filter proposal would represent a cost savings to engine manufacturers.

4.4.5. Deterioration Factors

The purpose of this amendment is to ensure that technologies with undemonstrated durability in off-road applications, such as particulate filters and NOx adsorbers, demonstrate compliance with the proposed emission requirements throughout their useful lives. Further, manufacturers that choose to vent crankcase emissions to the exhaust or atmosphere in lieu of meeting a closed system requirement must consider deterioration of these emissions when certifying their engines.

Listed below are proposed amendments applicable to the use of deterioration factors:

(1) Additive deterioration factor for exhaust emissions. Except as specified in paragraph (2) below, an additive deterioration factor must be used for exhaust emissions. An additive deterioration factor for a pollutant is the difference between exhaust emissions at the end of the useful life and exhaust emissions at the low-hour test point. In these cases, the manufacturer would adjust the official emission results for each tested engine at the selected test point by adding the factor to the measured emissions. If the factor is less than zero, zero would be used. Additive deterioration factors would need to be specified to one more decimal place than the applicable standard.

(2) Multiplicative deterioration factor for exhaust emissions. The use of a multiplicative deterioration factor would be allowed if good engineering judgment calls for the deterioration factor for a pollutant to be the ratio of exhaust emissions at the end of the useful life to exhaust emissions at the low-hour test point. For example, if aftertreatment technology is used, it may be appropriate to use a multiplicative deterioration factor. The manufacturer could then adjust the official emission results for each tested engine at the selected test point by multiplying the measured emissions by the deterioration factor. If the factor is less than one, one would be used. A multiplicative deterioration factor may not be appropriate in cases where testing variability is significantly greater than engine-to-engine variability. Multiplicative deterioration factors would need to be specified to one more

significant figure than the applicable standard.

(3) Deterioration factor for smoke. Deterioration factors for smoke would always be additive, as described in paragraph (1) above.

(4) Deterioration factor for crankcase emissions. If an engine vents crankcase emissions to the exhaust or to the atmosphere, the manufacturer must account for crankcase emission deterioration, using good engineering judgment. Separate deterioration factors may be used for crankcase emissions of each pollutant (either multiplicative or additive). Alternatively, combined deterioration factors may be used that include exhaust and crankcase emissions together for each pollutant.

4.4.6. Definitions

This section provides background on two key terms that are defined in the U.S. EPA nonroad rule. Staff proposes alignment with the definitions of these terms.

4.4.6.1. Maximum Engine Power

In order to assign standards more objectively, staff proposes to align with the federal nonroad definition for "Maximum Engine Power." The proposed definition provides more standardized guidance than the previously utilized terms "rated power" and "power rating" for determining which power category an engine belongs to and the applicable standards it must meet. An engine's maximum power is the maximum brake power point on the nominal power curve for the engine configuration. The nominal power curve of an engine configuration is the relationship between maximum available engine brake power and engine speed for an engine, using the mapping procedures of 40 CFR, Part 1065, based on the manufacturer's design and production specifications for the engine. This information may also be expressed by a torque curve that relates maximum available engine torque with engine speed. The nominal power curve must be within the range of the actual power curves of production engines considering normal production variability.

4.4.6.2. Maximum Test Speed

Staff proposes alignment with the federal definition of "Maximum Test Speed" as found in 40 CFR, Part 1065.515. This definition of maximum test speed is the single point on an engine's normalized maximum power versus speed curve that lies farthest away from the zero-power, zero-speed point. This is intended to ensure that the maximum speed of the test is representative of actual engine operating characteristics and is not improperly used to influence the parameters under which their engines are certified. In such cases where the definition of maximum test speed results in an engine speed that is unrepresentative of in-use operation, the Executive Officer would have authority to specify a different maximum speed if the manufacturer can show that the alternative is more representative (see 40 CFR, Part 1065.10(c)).

4.5. Durability and Warranty Provisions

The U.S. EPA nonroad rule did not make significant changes to the useful life, warranty, recall testing periods, selective enforcement audit, or emissions related maintenance requirements. Staff therefore proposes to retain its already harmonized provisions for these requirements, with the addition of an updated list of emission related components to more thoroughly reflect the emergence of advanced aftertreatment technologies. However, other provisions have been modified or appended such as in-use testing, defect reporting, replacement engine provisions, separate aftertreatment shipments, and in-use compliance margins. These changes are addressed below. Except as noted, staff proposes to adopt these amended or appended provisions to align with the federal requirements.

4.5.1. In-Use Testing

U.S. EPA does not specify an in-use testing program for Tier 4 engines in its final rulemaking, although it does obligate manufacturers (at least on paper) to certify engines that will meet NTE limits during in-use operation. Both U.S. EPA and ARB are currently developing in-use NTE test programs for off-road diesel engines patterned after a program that is being developed for on-road heavy-duty diesel vehicles. These in-use NTE requirements are expected to provide superior verification of emission performance in the field and to eventually become the in-use testing program for those engines. Staff proposes to harmonize with U.S. EPA regarding NTE certification requirements now and with in-use NTE requirements in the future. However, for the time being at least, California proposes to retain its own in-use compliance and recall program for off-road diesel engines as previously adopted under Articles 2.1 - 2.3, Chapter 2, Title 13, California Code of Regulations. No changes to that program are proposed.

4.5.2. Defect Reporting Requirements

U.S. EPA has amended its defect reporting requirements for Tier 4 engines such that investigations and reports would be triggered by a number of incidences that are proportional to engine power and the number of engines in an engine family, rather than to a fixed percentage as was previously practiced. The new approach should result in fewer overall defect reports being submitted by manufacturers than would otherwise be required under the old defect-reporting requirements because the number of defects triggering the submission requirement rises with the engine family size.

As shown in Table 4.7, an investigation threshold of 10 percent of total production, or 50 engines, whichever is greater, for any single engine family in one model year shall apply to engines less than or equal to 560 kW. In addition, a defect-reporting threshold of two percent of total production or 20 engines will apply, whichever is greater. For engines greater than 560 kW, the same percentage thresholds apply, but the percentage values will be extended down to smaller engine families to reflect their disproportionate contribution to total emissions. For these engines, the absolute thresholds are 25 engines for investigations and 10 or 15 engines for defects.

Further, manufacturers are now obligated to track and report available warranty claims and any other available information from dealers, hotlines, diagnostic reports, or field-service personnel to identify possible defects. Staff proposes to align with U.S. EPA regarding defect reporting requirements, which are presented in more detail in Attachment 1 and Attachment 2.

Table 4.7
Investigation and Defect-Reporting Thresholds
for Varying Sizes of Engine Families

Engine Size	Investigation Threshold	Defect-reporting Threshold
= 560 kW	Less than 500: 50 500-50,000: 10% 50,000+: 5,000	Less than 1,000: 20 1,000-50,000: 2% 50,000+: 1,000
> 560 kW	Less than 250: 25 250+: 10%	Less than 150: 10 150-750: 15 750+: 2%

4.5.3. Replacement Engines

In California, manufacturers are currently required to submit a report on the number and types of replacement engines they sell at the end of a model year. U.S. EPA added regulatory language to its Tier 4 rule to address concerns that manufacturers could potentially use the replacement-engine provisions to produce large numbers of previous-tier engines. Specifically, U.S. EPA included a statement that manufacturers may not use the replacement-engine exemption to circumvent the regulations. In addition, U.S. EPA plans to use the data-collection provision to ask manufacturers to report the number of engines they sell under the replacement-engine exemption. Staff proposes to incorporate similar language for its replacement engine regulatory requirements. Staff also proposes to extend the reporting requirements to include 2006 and later model year replacement engines. Subsection 5.3 provides additional information regarding this proposal.

4.5.4. Separate Aftertreatment Shipment

U.S. EPA promulgated provisions that allow engine manufacturers to ship engines to equipment manufacturers without aftertreatment devices installed or otherwise included as part of the engine shipment. This allowance would temporarily exempt engines from final assembly in cases where it would be impractical to install aftertreatment devices on the engine before shipment or where shipping the engine with aftertreatment already installed would require it to be disassembled and reinstalled when the engine was placed in the equipment. To ensure that the aftertreatment device is properly installed and used with the engine that it was certified with, the federal rule requires the following:

- Engine manufacturers are required to include the aftertreatment devices in the price of the engine and provide detailed and clear instructions so that the equipment manufacturer can readily install the engine and its components in a configuration covered under the executive order held by the engine manufacturer.

- Engine manufacturers must have a contractual agreement obligating the equipment manufacturer to complete the final assembly into a certified configuration.

- Engine manufacturers must ship any aftertreatment devices directly to the equipment manufacturer or arrange for their shipment from an aftertreatment device supplier.

- Engine manufacturers must tag the engines and keep records.

- Engine manufacturers must obtain annual affidavits from each equipment manufacturer as to the parts and part numbers that the equipment manufacturer installed on each engine.

- Engine manufacturers must conduct a limited number of audits of equipment manufacturers' facilities, procedures, and production records to monitor adherence to the instructions it provided.

Ultimately, the engine manufacturer is responsible for the in-use compliance of the engine as installed. Staff proposes to adopt the federal language for the separate catalyst shipment allowance and associated requirements.

4.5.5. Other Issues

U.S. EPA also made some minor changes to the compliance program. These changes are summarized in Table 4.8 and referenced by section. Staff believes that these changes are straightforward and non-controversial. A detailed explanation can be found in staff's proposed regulations and test procedures for Tier 4 off-road diesel engines in Attachment 1 and Attachment 2 of this report, respectively.

Table 4.8
Regulatory Changes

Issue	Federal Regulatory Provision
Applicability to alcohol-fueled engines	§§1039.101, 1039.107
Prohibited controls	§1039.115
Emission-related maintenance instructions	§1039.125
Engine installation instructions	§1039.130
Engine labels	§§1039.20, 1039.135, 1068.320
Engine family definition	§1039.230
Test engine selection	§1039.235
Deterioration factors	§1039.240
Engines that use noncommercial fuels	§1039.615
Use of good engineering judgment	§1068.5
Separate shipment of aftertreatment	§1068.260
Exemptions	40 CFR 1068 Subpart C
Importing engines	40 CFR 1068 Subpart D
Hearings	40 CFR 1068 Subpart G

4.5.6. Temporary In-Use Compliance Margins

To reduce the risk of non-compliance in the early years of the Tier 4 regulation, staff proposes that in-use standards be “cushioned” by the addition of an error margin to the certification standards. This would align with federal requirements and would provide assurance to off-road engine manufacturers that they will not face recall if they exceed certification standards by a small amount during this transition to cleaner diesel technologies. Although off-road manufacturers are expected to benefit greatly from the experiences gained in the on-road sector, which must meet similar standards several years earlier, designing an engine to meet the diversity of applications in the off-road sector will still be challenging. The allowance would provide relief for a limited number of model years after the Tier 4 off-road standards take effect and would be similar to the provisions for 2007 and later on-road heavy-duty diesel engines.

Table 4.9 below shows the compliance margins being proposed and their applicability.

Table 4.9
Add-On Levels Used in Determining In-Use Standards

Engine Power	Model Years	NOx		PM
		Add-On Level [1] **(g/kW-hr)**	**For Operating Hours**	**Add-On Level** [2] **(g/kW-hr)**
19 = kW < 56	2013 - 2014	none		0.01
56 = kW < 130	2012 - 2016	0.16	= 2000	0.01
		0.25	2001 - 3400	
		0.34	> 3400	
130 = kW = 560	2011 - 2015	0.16	= 2000	0.01
		0.25	2001 - 3400	
		0.34	> 3400	
kW > 560	2011 - 2016	0.16	= 2000	0.01
		0.25	2001 - 3400	
		0.34	> 3400	

1 Applicable only to those engines certifying to standards or with FELs at or below 2.1 g/kW-hr NOx
2 Applicable only to those engines certifying to standards or with FELs at or below the Tier 4 PM standards (0.02 g/kW-hr for 56 = kW = 560 engines, 0.03 g/kW-hr for 19 = kW < 56 engines and for > 560 kW engines in generator sets, and 0.04 g/kW-hr for all other > 560 hp engines).

4.6. Averaging, Banking, and Trading Program

California's existing regulations for off-road diesel engines include an averaging, banking, and trading (AB&T) program that mirrors the administrative provisions of the federal program. Manufacturers are required to fulfill the same reporting and authorization requirements to ARB regarding engines certified in California as they are to U.S. EPA regarding engines certified nationally. However, the California program does not restrict the generation and use of AB&T credits within State borders, nor does it use a separate calculation for determining credits, but rather allows California credits to be accounted for under the federal program and used accordingly. The current AB&T program is applicable to NMHC, NOx, and PM emissions and the Tier 4 AB&T program would continue to be applicable to these same pollutants. In U.S. EPA's final rule, the basic structure of the existing AB&T program was retained, but a number of changes were made to accommodate the implementation of the new Tier 4 emission standards. These changes to the AB&T program are intended to enhance the ability of engine manufacturers to meet the more stringent Tier 4 standards while limiting the production of very high-emitting engines. The new AB&T program also aims to avoid any unnecessary delays in the transition to new exhaust emission control technologies.

Staff is proposing that the Board adopt the amended federal AB&T program provisions.

Since the proposed AB&T program for use in California would be identical in nature to the federal AB&T program, staff is not providing an exhaustive explanation of the specific requirements. Only the major provisions of the program are discussed below. The complete proposed AB&T program provisions can be found in Attachment 2 of this report.

4.6.1. Family Emission Limit (FEL) Caps

The existing AB&T program for off-road diesel engines includes FEL caps, or limits, on the maximum emission levels from credit-using engine families. No engine family may be certified above these FEL caps. These limits provide manufacturers with compliance flexibility while protecting against the introduction of unnecessarily high-emitting engines.

Table 4.10 contains the proposed FEL caps and the effective model year for the FEL caps (along with the associated proposed Tier 4 standards). As proposed, a new transient test will be required for most engines, as well as the current steady-state test. The FEL established by the engine manufacturer will be used as the enforceable limit for the purpose of compliance testing under both test cycles. In addition, under the NTE limits, the FEL times the appropriate multiplier will be used as the enforceable limit for the purpose of such compliance testing.

Table 4.10
FEL Caps for the Tier 4 Standards in the AB&T Program

Power Category	Model Year	NOx or (NMHC+NOx) Standard	NOx or (NMHC+NOx) FEL Cap	PM Standard	PM FEL Cap
		g/kW-hr			
kW < 19	2008 +	(7.5) [1]	(10.5) [1] for < 8 kW (9.5) [1] for = 8 kW	0.40 [2]	0.80
19 = kW < 37	2008 - 2012	(7.5) [1]	(9.5) [1]	0.30	0.60
	2013 +	(4.7) [3]	(7.5) [3]	0.03	0.05 [4]
37 = kW < 56	2008 - 2012 [5]	(4.7) [1]	(7.5) [1]	0.30	0.40
	2013 + [6]			0.03	0.05 [4]
56 = kW < 130	2012 +	0.40	0.80 [7,8,9]	0.02	0.04 [4]
130 = kW = 560	2011 +	0.40	0.80 [7,8,9]	0.02	0.04 [4]
kW > 560	2011 - 2014	3.5	6.2	0.10	0.20
		0.67 [9]			
Generator Sets kW > 560	2015 +	0.67	1.07 [7]	0.03	0.05 [4]
Else kW > 560	2015 +	3.5	6.2	0.04	0.07 [4]

Notes:
1 This is the previous tier combined (NMHC+NOx) standard or FEL cap. These levels are not being revised and are listed here solely for reference.
2 A manufacturer may delay implementation until 2010 and then comply with a PM standard of 0.60 g/kW-hr for air-cooled, hand-startable, direct-injection engines under 8 kW.
3 This is a combined (NMHC+NOx) standard or FEL cap.
4 As described in the following section, a small number of engines are allowed to exceed this FEL cap.
5 The FEL caps do not apply if the manufacturer opts out of the 2008 standards. In such cases, the existing Tier 3 standards and FEL caps continue to apply.
6 The FEL caps apply in model year 2012 if the manufacturer opts out of the 2008 standards.
7 For engines certified as phase-out engines, the NMHC+NOx FEL caps for the Tier 3 standards apply.
8 For engines certified to the alternative NOx standards during the phase-in, the NOx FEL caps shown in Tables 4.12 and 4.13 apply.
9 The 0.67 g/kW-hr NOx standard applies only to engines above 900 kW used in generator sets.

4.6.2. Limited Use of Higher FEL Caps

U.S. EPA is allowing a limited number of engines to have a higher FEL than the caps noted in Table 4.10 under certain circumstances. The FEL cap for such engines would be set based on the level of the standards that applied in the year prior to the new standards and will allow manufacturers to produce a limited number of engines certified to these earlier standards in the Tier 4 timeframe. The allowance to certify up to these higher FEL caps will apply to Tier 4 engines 19 = kW = 560 beginning as early as the 2011 model year, and will apply to engines above 560 kW starting with the 2015 model year. The provisions are intended to provide some limited flexibility for engine manufacturers as they make the transition to the aftertreatment-based Tier 4 standards while ensuring that the vast majority of the engines are converted to the low-emission technologies expected under the Tier 4 program.

Staff is proposing to adopt the same limited use provision for higher FEL caps. Under these provisions, a manufacturer would be allowed to certify up to 40 percent of its engines above the FEL caps shown in Table 4.10 over the first four years the aftertreatment-based Tier 4 standards take effect. This percentage would be calculated as a cumulative total of the percent of engines exceeding these FEL caps in each year over the four years. A maximum of 20 percent would be allowed in any give year. After the fourth year the Tier 4 standards apply, the allowance to certify engines using the higher FEL caps will still be available but for no more than five percent of the engines a manufacturer produces in each power category in a given year.

Table 4.11 presents the model years, percent of engines, and higher FEL caps that will apply under these allowances. Engines certified under these higher FEL caps during the first four years would not be required to perform transient testing or NTE testing, and air-charged engines 56 = kW = 560 would not be required to have closed crankcase controls. However, beginning in the fifth year, when the five percent allowance takes effect, these engines will be considered Tier 4 engines and all other requirements for Tier 4 engines will also apply, including the Tier 4 NMHC standard, transient testing, NTE testing, and closed crankcase controls.

Table 4.11
Allowance for Limited Use of FEL Caps Higher than Tier 4 FEL Caps

Power Category	Model Years	Engines Allowed to have Higher FELs	NOx FEL Cap (g/kW-hr)	PM FEL Cap (g/kW-hr)
19 ≤ kW < 56	2013-2016 [1]	40% [2]	Not applicable	0.30
	2017 + [1]	5%		
56 ≤ kW < 130	2012 - 2015	40% [2]	4.4 [3] for hp < 75 3.8 [3] for hp ≥ 75	0.40 [4] for hp < 75 0.30 [4] for hp ≥ 75
	2016 +	5%		
130 ≤ kW ≤ 560	2011 - 2014	40% [2]	3.8 [3]	0.20 [4]
	2015 +	5%		
> 560 kW	2015 - 2018	40% [2,5]	3.5	0.10
	2019 +	5%		

Notes:
1 For manufacturers choosing to opt out of the 2008 model year Tier 4 standards for engines 37 = kW < 56 and instead comply with the Tier 4 standards beginning in 2012, the 40% allowance would apply to model years 2012 through 2015, and the 5% allowance would apply to model year 2016 and thereafter.
2 Compliance with 40% limit is determined by adding the percent of engines that have FELs above the FEL caps shown in Table 4.10 in each of the four years. A manufacturer may not have more than 20% of its engines exceed the FEL caps shown in Table 4.10 in any model year in any power category.
3 The allowance to certify to the higher NOx FEL cap is not applicable during the phase-in period.
4 The higher PM FEL cap is applicable to phase-out engines only during the phase-in period.
5 The limits of 40% or 5% allowed to exceed the NOx FEL cap would apply to engines used in generator sets only. (Engines > 560 kW used in other machines are allowed to have a NOx FEL as high as 6.2 g/kW-hr.) The limits of 40% or 5% allowed to exceed the PM FEL cap would apply to all engines above 560 kW.

4.6.3. Restrictions

Under the Tier 4 program, manufacturers could simultaneously produce two different groups of 56 = kW = 560 engines during the NOx phase-in period. In one group ("phase-out engines"), engines would certify to the applicable Tier 3 NMHC+NOx standard and be subject to the NMHC+NOx AB&T restrictions and allowances previously established for Tier 3. In the other group ("phase-in engines"), engines would certify to the 0.40 g/kW-hr NOx standard, and be subject to the restrictions and allowances under Tier 4. Although engines in the two groups would be certified to different standards, manufacturers would be allowed to transfer credits across these two groups of engines with the following adjustment to the amount of credits generated.

Manufacturers will be able to use credits generated during the phase-out of engines certified to the Tier 3 NMHC+NOx standard to average with engines certified to the

0.40 g/kW-hr NOx standard, but these credits would be subject to a 20 percent devaluation to compensate for the contribution of NMHC in the Tier 3 standard. Thus, each gram of NMHC+NOx credits from the phase-out engines will be worth 0.8 grams of NOx credits in the new AB&T program. The ability to average credits between the two groups of engines will give manufacturers a greater opportunity to gain experience with the low-NOx technologies before they are required to meet the final Tier 4 standards across their full production. The 20 percent discount will also apply, for the same reason, to all NMHC+NOx credits used for averaging purposes with the NOx standards for engines equal to and greater than 56 kW.

Another restriction will be that manufacturers may only use credits generated from other Tier 4 engines or from engines certified to the previously applicable tier of standards, except for engines in the power category 37 = kW < 56. Manufacturers would be allowed to use previously generated Tier 2 credits to demonstrate compliance with the interim Tier 4 standards in 2008 for this power category. Manufacturers that choose instead to comply with the Tier 3 standards in 2008 and only the final Tier 4 standards in 2012 would not be allowed to use Tier 2 credits on Tier 4 engines. Only Tier 3 credits could be used under the standard provisions.

An additional restriction concerns the use of AB&T credits above the 560 kW threshold. Because the standards for Tier 4 engines greater than 560 kW will not be based on the use of PM aftertreatment technology in 2011, or NOx aftertreatment for all engines except generators in 2015, manufacturers will not be allowed to use credits from these engines to demonstrate compliance with engines equal to and below 560 kW.

4.6.4. NOx FEL Caps for Engines Certified to the Alternative NOx Standards

As proposed, a set of alternative NOx standards will be allowed for those manufacturers that need to certify “split” engine families during the phase-in years. These engines will be allowed to participate in the AB&T program. Table 4.12 presents the FEL caps that will apply to engines certified to the alternative NOx standards during the phase-in years.

Table 4.12
NOx FEL Caps for Engines Certified to the Alternative NOx Standards

Power Category	Alternative NOx Standard (g/kW-hr)	NOx FEL Cap (g/kW-hr)
56 = kW < 130 50/50/100 phase-in option	2.3	3.0
56 = kW < 130 25/25/25/100 phase-in option	3.4	4.4 (for 56 = kW < 75) 3.8 (for 75 = kW < 130)
130 = kW = 560	2.0	2.7

Since manufacturers will be allowed to use AB&T for demonstrating compliance with the alternative standards for engines 56 = kW = 560, manufacturers will also be allowed to exceed the FEL caps noted in Table 4.12. These would be included in the 40 percent of engines allowed to exceed the FEL caps over the first four years in which the Tier 4 standards are in effect. Table 4.13 presents the NOx FEL caps that would apply to engines certified under the alternative standards limited by the 40 percent cap over the first four years. For manufacturers certifying under the reduced phase-in option (25/25/25/100 percent), engines may not exceed the FEL cap during the years the alternative standard applies.

Table 4.13
Limited Use NOx FEL Caps Under the Alternative NOx Standards

Power Category	Model Years	NOx FEL Cap (g/kW-hr)
56 = kW < 130 50/50/100 phase-in option	2012-1013	4.4 for kW < 75 3.8 for kW = 75
130 = kW = 560	2011-2013	3.8

All AB&T program provisions are described in greater detail in the proposed regulatory amendments, standards and test procedures in Attachment 1 and Attachment 2 of this report, respectively.

4.7. Equipment Manufacturer Transitional Flexibility Provisions

The sections that follow describe the main components of the U.S. EPA Tier 4 flexibility program, which is similar to the proposed California provisions with the exception of labeling requirements for flexibility engines. California's proposed modifications to the label content are discussed in subsection 4.7.2.9.

4.7.1. Original Flexibility Program

California incorporated U.S. EPA's transitional flexibility program for equipment manufacturers as part of the Tier 2 and Tier 3 amendments to the off-road diesel regulation. This original program is still in the early stages of implementation, but to date the program appears to be working as intended with most equipment manufacturers having used up only a portion of their allowances according to U.S. EPA data.

Engines that do not meet current model year emissions standards, but which have been previously certified, and can be used by equipment manufacturers in their existing product offerings without significant modification, are eligible to be sold new under the provisions of the transitional flexibility program for equipment manufacturers. The flexibility program is intended to provide relief in the event that an engine supplier does not provide enough lead time for an equipment manufacturer to modify the chassis of a particular piece of equipment to accommodate a new engine that may be packaged significantly differently than the previous model. Each equipment manufacturer is permitted to install previously certified engines in equipment adding up to 80 percent of one year's national production spread out over a period of seven years. There are additional allowances for small volume manufacturers and for hardship situations that can extend the percent of production allowances. The provisions of this original program were not intended to be used beyond the 2014 model year.

Equipment manufacturers do not need to apply for permission to use these provisions; however, engine manufacturers must annually submit a list of equipment manufacturers requesting flexibility engines, including engine models and quantities, as part of their certification applications. The program is administered on a national level by U.S. EPA, and California is a special participant entitled to the same reporting, notification, and approval authority as U.S. EPA for engines sold within the State. There are no limits on the number of flexibility engines that can be sold in a particular state so long as the total from all states does not exceed 80 percent of the national sales for one year.

Under this original program, flexibility engines were not specifically required to posses emission labels indicating their participation in the program. Some manufacturers have voluntarily attached labels to their flex engines, but in most cases the information they provide serves little purpose in helping to identify the specifications of the engine.

4.7.2. Tier 4 Flexibility Program

In its Tier 4 rulemaking, U.S. EPA adopted a new round of flexibility provisions for equipment manufacturers to help ease the transition to Tier 4 requirements. Although modeled after the original program, this new provision includes several new and enhanced features to protect against possible abuses and to provide better understanding of the extent to which the flexibility provisions are being used and distributed. No longer allowed is the provision for using uncertified engines in applications below 37 kW. The Tier 4 program also identifies new opportunities for flexibility not provided for in the original proposal. The following subsections summarize the main components of the program, including a supplement to the federal program proposed by staff to ensure a more identifiable and enforceable deployment of flexibility provisions in California through more descriptive engine labels.

4.7.2.1. Percent-of-Production Allowances

The percent of production allowances under the Tier 4 flexibility program remain the same as under the original program. Each equipment manufacturer is allowed to produce flexibility engines over a seven year period in cumulative quantities that sum up to 80 percent of a single year's national production at the end of the seven year period. The allowances would apply separately to each of the five Tier 4 power categories, as defined in subsection 4.2.1.1, with eligibility beginning the year Tier 4 standards first apply to that category. With fewer Tier 4 power categories than under the previous program, more engine families will populate each category resulting in proportionately more flexibility allowances that could potentially be used to extend the lead time for bringing an especially challenging engine family into compliance with the Tier 4 standards. Table 4.14 shows the applicable usage periods for each power category.

Table 4.14
Flexibility Usage Periods

Power Category	Flexibility Program	Flexibility Period Options (Model Years)	Flexibility Standards
< 19 kW	Tier 2/3	2000 - 2006	Pre-controlled
	Tier 4	2008 - 2014	Tier 2 Standards
19 = kW < 37	Tier 2/3	1999 - 2005	Pre-controlled
	Tier 4	2008 - 2014	Tier 2 Standards
	Tier 4 Delayed	2012 -2018	Model Year 2008 Tier 4 Standards
37 = kW < 56	Tier 2/3	2004 - 2010	Tier 1 Standards
	Tier 4	2008 - 2014[1]	Tier 3 Standards
	Tier 4 Delayed	2012 - 2018	Model Year 2008 Tier 4 Standards
56 = kW < 75	Tier 2/3	2004 - 2010	Tier 1 Standards
	Tier 4	2012 - 2018	Tier 3 Standards
	Tier 4 Delayed	2014 - 2020	Model Year 2012 Tier 4 Standards
75 = kW < 130	Tier 2/3	2003 - 2009	Tier 1 Standards
	Tier 4	2011 - 2017	Tier 3 Standards
	Tier 4 Delayed	2014 - 2020	Model Year 2011 Tier 4 Standards
130 = kW = 560	Tier 2/3	2003 - 2009[2]	Tier 1 Standards
		2001 - 2007[3]	
		2002 - 2008[4]	
	Tier 4	2011 - 2017	Tier 3 Standards
	Tier 4 Delayed	2014 - 2020	Model Year 2011 Tier 4 Standards
> 560 kW	Tier 2/3	2006 - 2012	Tier 1 Standards
	Tier 4	2011 - 2017	Tier 2 Standards
	Tier 4 Delayed	2015 - 2021	Model Year 2011 Tier 4 Standards

Notes:
1 This usage period is only available if interim Tier 4 standards have been met starting in 2008.
2 Applies to the power range 130 = kW < 225.
3 Applies to the power range 225 = kW < 450.
4 Applies to the power range 450 = kW = 560.

Staff estimates that the entire 80 percent flexibility allowance, if used to its maximum extent by all equipment manufacturers, would result in a one percent increase in NOx emissions (2.1 TPD) and about a six percent increase in PM emissions (0.6 TPD), statewide, in 2020. However, the equipment manufacturer flexibility program is a key factor in assuring sufficient lead time to implement the Tier 4 standards as scheduled.

Regarding flexibility allowances, the following engines would not have to be included in the equipment manufacturer's percent of production calculations: 1) diesel off-road equipment using engines built before the effective date of the Tier 4 standards, 2) equipment using engines certified to the previous Tier of standards under any small business provision, 3) all engines certified to the Tier 4 standards, including those engines that produce emissions at higher levels than the standards, but for which an engine manufacturer uses AB&T credits to demonstrate compliance (they would count as Tier 4 complying engines), and 4) engines that meet the Tier 4 PM standards, but are allowed to meet the Tier 3 NMHC+NOx standards during the phase-in period (they would also count as Tier 4 complying engines).

4.7.2.2. Delayed Implementation Option

A provision of the Tier 4 flexibility program allows equipment manufacturers to choose when to begin using flexibility allowances. As shown in Table 4.14 above, the start of the seven year period may generally be delayed to coincide with the commencement of final Tier 4 standards rather than the start of interim standards. Allocations for engines less than 19 kW must be used starting in 2008 since no interim standards are specified for this range of engines.

Although this provision has the potential to delay the promulgation of final Tier 4 standards from a fleet-wide perspective, there would be no loss in long-term emission benefits according to U.S. EPA since the flexibility engines under the delay schedule will have to meet more stringent standards than under the non-delay schedule. Furthermore, more engines with particulate filters will be introduced during the interim standards period to make up for the unused flexibility engines resulting in greater short-term PM benefits than under the non-delay schedule.

4.7.2.3. Small Volume Allowances

The Tier 4 flexibility program provides a choice between the same relief for small volume manufacturers as under the original flexibility program, or an optional provision that would allow fewer allowances per power category, but which could be spread out over multiple engine families.

Under the original proposal, a manufacturer would be allowed to exceed the 80 percent of production total for its flexibility allowances and produce a total of 700 flexibility engines per power category to be used over seven years in no more than 200 engine increments per year per power category. Further, this allowance applies to only one engine family per power category for the duration of the seven years. Since some small volume manufacturers produce several engine families in a year, this relief may not go far enough.

The alternate small volume allowance addresses this situation by permitting a total of 525 flex engines to be produced per power category over a seven year period for use in applications less than 130 kW with no more than 150 flex engines to be used per year per power category. For applications requiring engines greater than or equal to 130 kW, a manufacturer may produce a total of 350 flex engines per power category to be used over seven years in 100 engine increments per year per power category. There is no limit on the number of engine families for which these alternate allowances apply.

4.7.2.4. Technical Hardship Allowances

Staff recommends adoption of a new provision for the Tier 4 flexibility program that would allow equipment manufacturers to petition additional relief on the basis of technical or engineering hardships. Allowances of up to 70 percent in addition to the 80 percent of production allowance (150 percent total) could be granted should the manufacturer be able to justify the need. This new provision would be available to all equipment manufacturers, but would only be applicable when the equipment manufacturer is different from the engine manufacturer. In other words, a vertically integrated manufacturer, i.e., a manufacturer who produces both engines and equipment, could petition additional flexibility allowances, but only if that manufacturer was installing an engine from another manufacturer into one of its own chassis, or vice versa. This provision is most likely to benefit non-integrated equipment manufacturers who may be at a technical disadvantage with respect to manufacturers who produce both engines and equipment, and who can rely on other programs such as AB&T to ease the burden of compliance, if necessary.

This additional flexibility allowance would only be available for the Tier 4 power categories 19 = kW = 560 since engines less than 19 kW will not require advanced aftertreatment, and nearly all of the equipment above 560 kW is produced by manufacturers qualifying for small volume allowances described in subsection 4.7.2.3.

Appeals for relief under this provision would need to be made in writing to the Chief of the Mobile Source Operations Division and would be decided on a case-by-case basis. The equipment manufacturer would have the burden of demonstrating the existence of extreme technical or engineering hardship conditions that are beyond its control. It must also demonstrate that it has exercised reasonable precautions to avoid the situation. The exemption could only be granted upon written application setting forth essentially why the previously successful relationship between engine and equipment manufacturer has not provided adequate lead time to address a particular equipment model.

An application for technical hardship exemption would not be granted unless the equipment manufacturer demonstrates that the full 80 percent allowed under the percent of production allowance is reasonably expected to be used up in the first two years of the seven-year flexibility period. Furthermore, any technical hardship allowance would have to be used up within two years after the Tier 4 percent of production allowances start for any power category.

4.7.2.5. Retroactive Use of Flexibilities

The Tier 4 flexibility program allows equipment manufacturers to start using a limited number of their Tier 4 flexibility allowances, including small volume allowances, once the seven-year period of the original flexibility program expires. In this way, a manufacturer could continue exempting a troublesome Tier 3 application, if necessary, beyond the allotted time of the original flexibility program. Equipment manufacturers may use no more than 10 percent of their Tier 4 percent of production allowances, or up to 100 of their Tier 4 small volume allowances, prior to the commencement of the Tier 4 standards for each power category. Flexibility allowances provided under the technical hardship provision cannot be used retroactively.

Using Tier 4 allowances early will reduce the number of allowances available for transitioning to the Tier 4 standards. The amount of equipment utilized early will be subtracted from the total Tier 4 allowances, leaving the remainder to be applied in the normal timeframes. The short-term emissions impact associated with the early use of flexibility allowances in California would likely be negligible.

4.7.2.6. Early Introduction Incentives for Equipment Manufacturers

In addition to the flexibility provisions already mentioned, equipment manufacturers may earn unlimited additional allowances for the early introduction of Tier 4 compliant engines. This incentive provision is generally applicable to engines 19 = kW = 560, and conditionally applicable to engines above 560 kW.

The purpose of this provision is to allow equipment manufacturers an opportunity to share in the benefits for the early introduction of cleaner engines. Previously, only the engine manufacturer was the beneficiary of early introduction credits, but this provision transfers the incentive to the equipment manufacturer so long as that manufacturer meets certain criteria. If the equipment manufacturer fails to meet the requisite conditions, or declines the flexibility allowance, the early introduction benefits fall back to the engine manufacturer (see subsection 4.3 for details).

Equipment manufacturers installing engines complying with the final Tier 4 standards would earn one flexibility allowance for each early Tier 4 compliant engine used in its equipment. Equipment manufacturers installing engines 56 = kW = 560 that comply with the final Tier 4 PM standard and the alternative NOx standard would earn one-half of a flexibility allowance for each early Tier 4 engine used in its equipment. Table 4.15 below illustrates some of the criteria for determining an early Tier 4 engine and the earned flexibility benefits.

Table 4.15
Offset Generating Incentives for Equipment Manufacturers

POWER CATEGORY	QUALIFYING STANDARDS (g/kW-hr)	INSTALLATION DEADLINE	FLEXIBILITY ALLOWANCE
19 = kW < 56	0.03 PM / 4.7 NMHC+NOx	December 31, 2012 [1]	1 for 1
56 = kW = 130	0.02 PM / 0.40 NOx / 0.19 NMHC	December 31, 2011	1 for 1
	0.02 PM / 3.4 NOx / 0.19 NMHC [2]		1 for 2
130 = kW = 560	0.02 PM / 0.40 NOx / 0.19 NMHC	December 31, 2010	1 for 1
	0.02 PM / 2.0 NOx / 0.19 NMHC [2]		1 for 2
GEN > 560	0.03 PM / 0.67 NOx / 0.19 NMHC	December 31, 2014	1 for 1
ELSE > 560	0.04 PM / 3.5 NOx / 0.19 NMHC		

Notes:
1 The installation date for 37 = kW < 56 engines purchased from manufacturers choosing to opt out of the 2008 model year Tier 4 standards and instead comply with the Tier 4 standards beginning in 2012 would be December 31, 2011
2 To be eligible, engines must meet the 0.02 g/kW-hr PM standard and the alternative NOx standards

Benefits would be generated and used on an engine power basis across any of the power categories within the 56 = kW = 560 power range. For example, an early introduction of seventy-five 500 kW engines could be used to offset three-hundred and seventy-five 100 kW engines (75*500 kW = 375*100 kW = 37,500 kW). Other restrictions apply regarding the generation and use of early introduction allowances pertaining to engines greater than 560 kW.

To provide assurance that early Tier 4 compliant engines will be placed into equipment within a reasonable time frame, engine manufacturers are required to certify candidate engines before September 1 of the year before the Tier 4 standards take effect in order for them to be eligible to earn offset generating credits. Similarly, equipment manufacturers must install offset generating engines in equipment before January 1 of the year before the Tier 4 standards take effect to claim credits. Compliance with transient testing requirements, as applicable, NTE limits, and closed crankcase requirements are also required for the early introduction allowances.

4.7.2.7. Economic Hardship Allowance

The Tier 4 flexibility program also contain a safety-valve provision whereby an equipment manufacturer that does not make its own engines could obtain limited additional relief by providing evidence that, despite its best efforts, it cannot meet the implementation dates, even with all the flexibility provisions outlined above. Such a situation might occur if an engine supplier, without a major business interest in the equipment manufacturer, were to change or drop an engine model very late in the implementation process.

Appeals for hardship relief must be made in writing to the Chief of the Mobile Source Operations Division, must be submitted before the earliest date of noncompliance, must include evidence that failure to comply was not the fault of the equipment manufacturer (such as a broken contract), and must include evidence that serious economic hardship to the company would result if relief is not granted. Staff intends to work with the applicant to ensure that all other remedies available under the flexibility provisions are exhausted before granting additional relief, and would limit the period of relief to no more than one year. Manufacturers should be able to complete their strategy on how they will meet a new emission standard within the first year of implementation. Therefore, applications for hardship relief would only be accepted during the first year after the effective date of an applicable new emission standard.

Staff would like to make clear that it expects this provision to be rarely used. Each granting of relief would be treated as a separate agreement with no prior guarantee of success, and with the inclusion of measures, agreed to in writing by the equipment manufacturer, for recovering the lost environmental benefit.

4.7.2.8. Existing Inventory Allowance and Replacement Engines

Staff proposes to extend provisions for equipment manufacturers to continue using engines built prior to the effective date of the Tier 4 standards to further ease the transition to the Tier 4 standards. Federal anti-stockpiling language will be appended to the provision to harmonize with U.S. EPA.

4.7.2.9. Flexibility Engine Labeling Requirements

Staff proposes to adopt more descriptive labeling requirements for engines produced under the equipment manufacturer flexibility provisions described above than those adopted by U.S. EPA in its final Tier 4 rule. This proposal, including the revised label content, is discussed at length in subsection 5.1.1.

4.7.2.10. Import Restrictions

The original flexibility program treats foreign importers as individual equipment manufacturers with respect to the allocation of flexibilities. As a group, these importers could potentially combine for more flexibility allowances than 80 percent of the foreign equipment manufacturer’s production for the United States market by each claiming to qualify under the small volume flexibility provision.

To address this potential for abuse, staff proposes to align with federal requirements specifying that only those off-road equipment manufacturers that install engines and have primary responsibility for designing and manufacturing equipment will qualify for the allowances, or other relief, provided under the Tier 4 flexibility provisions. Foreign equipment manufacturers who comply with the provisions discussed in the proposed regulations and test procedures, found in Attachment 1 and Attachment 2 of this report, respectively, will receive the same allowances and other transitional provisions as domestic manufacturers. Importers with little involvement in the manufacturing and assembling of equipment will not receive any allowances or other transitional relief directly, but may import flexibility equipment if it is covered by an allowance or transitional provision associated with a foreign equipment manufacturer. These provisions allow transitional allowances and other provisions to be used by foreign equipment manufacturers in the same way as domestic equipment manufacturers, while limiting the potential for abuse.

Additionally, foreign equipment manufacturers that participate in the flexibility program will be required to post a monetary bond for engines imported into the United States. The bond requirement is necessary for ensuring that foreign equipment manufacturers are subject to the same level of enforcement as domestic equipment manufacturers, and for collecting any judgments assessed against a foreign equipment manufacturer for violations of flexibility provisions.

4.7.2.11. Enforcement and Recordkeeping Requirements

Staff proposes to extend the enforcement and recordkeeping requirements from the original flexibility program such that engine manufacturers would be allowed to continue to build and sell engines to meet the market demand created by the flexibility program, provided they receive written assurance from the equipment manufacturers that such engines are being procured for this purpose. Engine manufacturers who participate in this program would be required to annually provide copies of letters from equipment manufacturers requesting such engines to the Chief of the Mobile Source Operations Division.

Equipment manufacturers choosing to take advantage of the allowances must:

(1) keep records of the production of all pieces of equipment produced for sale (on a national basis) exempted under the allowance provisions for at least two full years after the final year in which allowances are available for each power category;

(2) record the serial and model numbers and dates of production of equipment and installed engines, rated power of each engine, and the calculations used to verify that the allowances have not been exceeded in each power category; and

(3) make these records available to the Executive Officer upon request.

Secondary manufacturers who purchase new equipment, modify or re-label it (i.e., privately branded equipment), and resell it as new equipment would be subject to the regulations in the same way as independent dealers and distributors. The equipment manufacturer flexibility provisions would only apply to the manufacturer who originally installs the engine into the equipment.

All companies/manufacturers that are under the control of a common entity, and that meet the definition of an off-road equipment manufacturer, must be considered together for the purposes of applying exemption allowances. This would provide certain benefits for the purpose of pooling exemptions but would also preclude the abuse of the small volume allowances that would exist if companies could treat each operating unit as a separate equipment manufacturer.

Staff recognizes that the Tier 4 flexibility program may involve a certain amount of complexity and administrative burden; however, this program is entirely voluntary and manufacturers not wishing to participate do not have to do so.

4.7.2.12. Notification and Reporting Requirements

As in the federal rule, staff proposes that equipment manufacturers wishing to participate in the Tier 4 flexibility program be required to notify the Chief of the Mobile Source Operations Division prior to using Tier 4 allowances. No such requirement exists in the original flexibility program. Equipment manufacturers would be required to submit their written notification before the first calendar year in which they intend to use the transitional provisions. Adoption of this notification requirement would help to ensure that flexibility allowances are used appropriately in California.

The specific information to be provided to the Chief of the Mobile Source Operations Division would be:

(1) the equipment manufacturer's name, address, and contact person's name, phone number;

(2) the allowance program that the equipment manufacturer intends to use by power category;

(3) the calendar years in which the equipment manufacturer intends to use the exception;

(4) an estimation of the number of engines to be exempted under the flexibility provisions by power category;

(5) the name and address of the engine manufacturer from whom the equipment manufacturer intends to obtain exempted engines; and

(6) identification of the equipment manufacturer's prior use of Tier 2 and Tier 3 flexibility

provisions.

Staff also proposes to adopt new reporting requirements such that equipment manufacturers participating in the flexibility program would be required to submit an annual accounting to the Chief of the Mobile Source Operations Division showing their calculated number of maximum flexibility allowances by power category based on sales from the previous year. Equipment manufacturers would also have to report the number of flexibilities used and the percent of production these allowances represent for the current year. Each report would include a cumulative calculation (both total number and, if appropriate, the percent of production) for all years the equipment manufacturer is using the flexibility provisions for each of the Tier 4 power categories. This proposal is consistent with the reporting requirements of the federal Tier 4 flexibility program.

4.8. Miscellaneous

Staff proposes to amend the preemption reference in Title 13 CCR, 2420(a)(1) to clarify that new locomotive engines are not subject to California's off-road diesel regulation. Title 13 CCR, 2420(a)(1) currently references Section 209(e)(1)(A) of the Federal Clean Air Act (42 U.S.C. 7543(e)(1)(A)) when identifying preempt engines and equipment that are outside the scope of applicability of the regulation. However, the preemption for new locomotive engines is found in Section 209(e)(1)(B) of the Federal Clean Air Act; therefore, the current preemption reference could be interpreted not to include new locomotive engines, which is not the intent. Staff proposes to change the reference to "Section 209(e)(1) of the Federal Clean Air Act (42 U.S.C. 7543(e)(1))," which would then encompass all preemption engines as being outside the scope of the regulation.

Staff also proposes to extend the voluntary provisions for designating Blue Sky Series engines for Tier 1, Tier 2, and Tier 3 engines. Current requirements do not extend beyond the 2004 model year. This change would harmonize with current U.S. EPA requirements.

5. DIFFERENCES BETWEEN CALIFORNIA AND FEDERAL REGULATIONS

Staff has endeavored to harmonize California's off-road diesel proposal with the provisions of U.S. EPA's Clean Air Nonroad Diesel Final Rule (40 CFR, Part 1039 and incorporated Parts). To this end, ARB staff recommends that the Board adopt the majority of provisions outlined in the federal rule, including all emission standards and implementation schedules for California's non-preempt diesel engines. However, staff's proposal differs from the federal program in some relatively minor, but important ways that are necessary to protect the air quality benefits of the Mobile Source program. These differences are primarily documentary in nature and do not present any technical obstacles for the off-road industry to overcome. Staff is also proposing to retain its autonomous In-Use Compliance and Recall Program previously adopted by the Board in 2000 as part of the regulatory amendments for 2000 and later compression-ignition engines.

5.1. Flexibility Program for Equipment Manufacturers

Although staff is in conceptual agreement with the provisions of the federal Tier 4 flexibility program for equipment manufacturers, additional safeguards are needed to ensure a more identifiable and enforceable deployment of flexibility provisions in California.

5.1.1. Flexibility Engine Labeling

U.S. EPA recognized the need for labeling flexibility engines in its Tier 4 rule, and now requires both the engine and equipment manufacturer to affix labels indicating that these engines are to be used only according to flexibility provisions under penalty of law. Labeling was not specifically required under the original flexibility program adopted as part of the Tier 2/3 regulation. Although U.S. EPA's new labeling requirement is a step in the right direction, it does not go far enough in describing emissions performance to provide verification of whether or not the flexibility engine has been correctly placed in service. The table below is provided to show an example of why the U.S. EPA labeling requirement, without an engine family designation, is inadequate. The table lists the certification level that flexibility engines must meet depending on when the manufacturer first begins using flexibility allowances. According to the table, Tier 3 engines could be used as flexibility allowances in the 19 = kW < 56 power category from 2008-2014, but interim Tier 4 engines must be used if the allowances are delayed until 2012-2018. Consequently, there is a three year overlap from 2012-2014 during which the certification level of the flexibility engine could not be directly ascertained from the U.S. EPA emissions label. The other power categories are subject to the same or similar type of confusion.

Table 5.1
Tier 4 Flexibility Usage Periods

Power Category	Flexibility Period Options (Model Years)	Flexibility Standards
< 19 kW	2008 – 2014	Tier 2 Standards
19 = kW < 56	2008 - 2014 [1]	Tier 3 Standards [2]
	2012 – 2018	Model Year 2008 Tier 4 Standards
56 = kW < 130	2012 – 2018	Tier 3 Standards
	2014 – 2020	Model Year 2012 Tier 4 Standards
130 = kW = 560	2011 – 2017	Tier 3 Standards
	2014 – 2020	Model Year 2011 Tier 4 Standards
> 560 kW	2011 – 2017	Tier 2 Standards
	2015 – 2021	Model Year 2011 Tier 4 Standards

Notes:
1 This usage period is available for allowances greater than or equal to 37kW only if interim Tier 4 standards have been met starting in 2008.
2 Flexibility allowances under 37kW may contain engines certified to the Tier 2 standards.

In practical terms, this means that ARB field investigators would not be able to determine the appropriateness of these flexibility engines upon inspection. Although it may be possible to verify the emissions performance of the engines post inspection by contacting the engine manufacturer directly, this diverts resources and hinders the field inspector's ability to identify violations and enforce the regulation in a timely manner. Furthermore, should the flexibility engine ever need to be rebuilt or repaired, U.S. EPA's label would not be able to provide an adequate reference for determining that the engine had been rebuilt to at-least the original emissions specifications as required, or that correct replacement parts had been used to repair an emissions related malfunction.

Staff is aware that some manufacturers are voluntarily labeling their flexibility engines, and other manufacturers have been requested by staff to begin labeling or to provide more descriptive labeling content. However, a strictly voluntary program does not provide the assurance of compliance and may not result in a standardized application of the remedy. Therefore, staff proposes to amend existing regulations such that the label to be attached by the engine manufacturer must include the engine family name to which the flexibility engine was originally certified. In this way, ARB field investigators would be able to immediately identify a flexibility engine and know the standards to which it was certified. This knowledge would aid the investigator in determining that all required emission control equipment was present on the engine, and that it had not been tampered with. The label would also be used to identify whether or not the engine is a candidate for a future retrofit or re-power control measure in California. Although this amendment applies to the engine manufacturer only, both engine and equipment manufacturers would be held responsible for ensuring that the flexibility engine possesses the correct label at the time of sale.

Staff also proposes that this amendment take effect earlier than required under the federal rule, and apply to Tier 2/3 engines used as flexibility allowances beginning in 2006. Under this proposal, one of two labels with modified statements of compliance would be affixed to the engine to differentiate between participation in the original Tier 2/3 flexibility program or the new Tier 4 flexibility program. The proposed statement of compliance for these labels would read as follows:

Engines Allowed Under the New Tier 4 Flexibility Program
"THIS ENGINE BELONGS TO FAMILY _____._____ AND MEETS ARB EMISSION STANDARDS UNDER 13 CCR 2423(d). SELLING OR INSTALLING THIS ENGINE FOR ANY PURPOSE OTHER THAN FOR THE EQUIPMENT FLEXIBILITY PROVISIONS CITED MAY BE A VIOLATION OF STATE LAWS SUBJECT TO CIVIL PENALTY."

Uncertified Engines Less Than 37 kW Allowed Under the Tier 2/3 Flexibility Program
"THIS ENGINE QUALIFIES FOR USE IN EQUIPMENT RATED BELOW 37 KW AND IS EXEMPT FROM CURRENT MODEL YEAR EMISSION STANDARDS UNDER THE ARB EQUIPMENT FLEXIBILITY PROVISIONS IN 13 CCR 2423(d). SELLING OR INSTALLING THIS ENGINE FOR ANY PURPOSE OTHER THAN FOR THE EQUIPMENT FLEXIBILITY PROVISIONS CITED MAY BE A VIOLATION OF STATE LAW SUBJECT TO CIVIL PENALTY."

The revised statement of compliance does not preclude the referencing of similar federal requirements that would be satisfied simultaneously by meeting the provisions of Section 2423(d). Furthermore, the Executive Officer may, upon request, approve alternate labeling specifications provided that they meet the intent of this requirement.

5.1.2. Executive Order Clarification

Staff proposes to amend the existing regulations to more clearly indicate that non-preempt engines certified under the flexibility provisions for equipment manufacturers must be covered by an Executive Order. The Executive Order need not be current for the year in which the engine is used as a flexibility allowance, but may have been issued previously so long as the engine was certified to the appropriate standards required by the flexibility provision.

Title 13 CCR, 2420(a)(3) defines the scope of applicability for needing an Executive Order as "Every new off-road compression-ignition engine that is manufactured for sale, sold, offered for sale, ... into California ... subject to any of the standards prescribed in this article [Article 4] ..."

ARB interprets this language to include engines sold under the transitional flexibility provisions for equipment manufacturers. In its amendment, staff intends to clarify that Executive Orders are required for all engines, including flexibility engines. Title 13, CCR 2423(d)(1)(A) currently reads as follows:

> "Equipment rated at or above 37kW. For off-road equipment and vehicles with engines rated at or above 37kW, a manufacturer may take any of the actions identified in the 2000 and Later Test Procedures (Section 89.1003(a)(1)) for a portion of its California-directed production volume of such equipment and vehicles during the seven years immediately following the date on which Tier 2 engine standards first apply to engines used in such equipment and vehicles, provided that the seven-year sum of the U.S.-directed portions in each year, as expressed as a percentage for each year, does not exceed 80, and provided that all such equipment and vehicles or equipment contain only Tier 1 engines;"

The reference to 40 CFR, Part 89.1003(a)(1) provides a list of otherwise prohibited actions that may be applied to flexibility engines. It reads:

> "The following acts and the causing thereof are prohibited:

(i) In the case of a manufacturer of new nonroad engines, vehicles, or equipment for distribution in commerce, the sale, or the offering for sale, or the introduction, or delivery for introduction, into commerce, of any new nonroad engine manufactured after the applicable effective date under this part, or any nonroad vehicle or equipment containing such engine, unless such engine is covered by a certificate of conformity issued (and in effect) under regulations found in this part.

(ii) In the case of any person, except as provided in subpart G of this part, the importation into the United States of any new nonroad engine manufactured after the applicable effective date under this part, or any nonroad vehicle or equipment containing such engine, unless such engine is covered by a certificate of conformity issued (and in effect) under regulations found in this part."

At first glance, this may appear to exempt flexibility engines from requiring an Executive Order[18]; however, this would be inconsistent with language in the same section that requires "… all [flexibility] equipment and vehicles or equipment [to] contain only Tier 1 engines;" In order to qualify as a Tier 1 engine, the engine must have been previously certified to the Tier 1 standard and thereby covered by an Executive Order. The purpose, therefore, of 40 CFR, Part 89.1003(a)(1) is not to exempt flexibility engines from needing an Executive Order, but to exempt them from needing an Executive Order current to the year in which the flexibility engines are used.

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[18] A "certificate of conformity" is synonymous to an Executive Order for the purpose of this reference (Section 89.2, California Exhaust Emission Standards and Test Procedures for New 2000 and Later Off-Road Compression-Ignition Engines, December 28, 2000).

U.S. EPA has attempted to clarify this provision in its final rule by referencing a new section, 40 CFR, Part 1068.101(a)(1), which essentially rewords the prohibited actions language in 40 CFR, Part 89.1003(a)(1) by adding the qualifying statement that "… engines must have a valid certificate of conformity for its model year …" It therefore follows that flexibility engines would be exempt from this otherwise prohibited action, which means that flexibility engines do not have to be covered by a certificate of conformity/executive order for "... its model year …" or in other words, for the model year in which it is sold. The full text of 40 CFR, Part 1068.101(a)(1) is copied below:

> "You may not sell, offer for sale, or introduce or deliver into commerce in the United States or import into the United States any new engine or equipment after emission standards take effect for that engine or equipment, unless it has a valid certificate of conformity for its model year and the required label or tag. You also may not take any of the actions listed in the previous sentence with respect to any equipment containing an engine subject to this part's provisions, unless the engine has a valid certificate of conformity for its model year and the required engine label or tag. This requirement also covers new engines you produce to replace an older engine in a piece of equipment, unless the engine qualifies for the replacement-engine exemption in Sec. 1068.240. We may assess a civil penalty up to $31,500 for each engine in violation."

Staff believes this is an awkward means of clarifying the requirement that flexibility engines must have been previously certified and covered by a Certificate of Conformity, or an Executive Order, and might still be subject to misinterpretation. Therefore, staff instead proposes to remove all references to 40 CFR, Part 89.1003(a)(1) in the California regulations pertaining to flexibility allowances and to create a subsection stating plainly that:

> "Engines used in accordance with the transitional flexibility provisions for equipment manufacturers described in section 2423(d) must be covered by an Executive Order. The Executive Order need not be current for the year in which the engine is claimed as a flexibility allowance, but may have been issued previously so long as the engine was certified to the appropriate standards required by the flexibility provision."

An Executive Order is needed in addition to, or in lieu of, a federal Certificate of Conformity so that ARB has the authority to enforce non-preempt engines found to be in violation of the off-road diesel regulations. Engines used as flexibility allowances prior to the adoption of this amendment would not be subject to enforcement actions retroactively.

5.2. Rebuild Labeling Prohibition and Supplemental Label Requirement

Staff proposes to adopt language prohibiting the removal or defacing of the original emissions label from non-preempt off-road diesel engines that have been rebuilt or remanufactured. The rebuilder or remanufacturer must take care to protect the original label from the effects of sandblasting, acid dipping, or any other restorative process. A supplemental label must be affixed to the rebuilt or remanufactured engine indicating the date of renovation and other pertinent information, but must not obscure in any way the visibility of the original label or imply that the rebuilt or remanufactured engine is “new” or that it belongs to an engine family other than the one to which it was originally certified. Retaining the original label offers proof, and a means to verify, that the engine was “rebuilt to a certified configuration of the same or later model year as the original engine” as required by 40 CFR, Part 89.130(c) and 40 CFR, Part 1068.120(f). Furthermore, the original label will be used to identify whether or not the rebuilt or remanufactured engine can be used in a future retrofit or re-power control measure. ARB investigators have discovered that the replacement of engine labels is a common practice among some engine re-builders.

Notwithstanding, the original label on any engine that is remanufactured to “like-new” condition and which is recertified to current-year emission requirements including all durability and warranty provisions, must be removed by the remanufacturer and replaced with one identifying the engine as belonging to a family meeting current-year emission requirements. A supplemental label may be affixed by the remanufacturer, if desired, but must adhere to the requirements for supplemental labels described in the paragraph above.

5.3. Extension of Replacement Engine Reporting Requirements

When replacing a California certified off-road diesel engine, equipment manufacturers are required to use the cleanest engines whenever feasible. However, if newer, cleaner engines do not “fit” into older equipment, the engine manufacturer may continue to produce replacement engines that are identical in configuration in all material respects to the original engine being replaced provided that 1) the engine manufacturer has ascertained that no certified lower-emitting engine is available, 2) the replacement engine is properly labeled as a replacement engine, and 3) the actual number of replacement engines produced for California is reported annually.

Currently, manufacturers are only required to satisfy the replacement engine reporting requirements, including an inventory of engines sold and proof that every effort was made to find a cleaner replacement, through the 2004 model year. Staff proposes to extend the reporting requirements for replacement engines to 2005 and subsequent model years.

5.4. In-Use Compliance/Recall Program

U.S. EPA has recall procedures in place to ensure that certified engines meet the emission standards over the useful life of the engine. California incorporated off-road language into its own in-use compliance and recall program under Articles 2.1 - 2.3, Chapter 2, Title 13, California Code of Regulations in 2000. Staff is proposing no changes to its In-Use Compliance/Recall Program. The program will continue to be applicable to all non-preempt off-road diesel engines in California, including those meeting the Tier 4 standards and those used as flexibility allowances. California reserves the right to investigate and recall engines found to be in violation of the regulations apart from U.S. EPA, if necessary.

The California program for in-use compliance/recall should not cause manufacturers any significant burden. The program procedures would only be performed when needed (i.e., when information might indicate a problem with meeting the emission standards). This proposal will allow the ARB to continue to ensure that engines are meeting the emission standards, regardless of any subsequent changes to the federal programs.

6. TECHNOLOGY AND FEASIBILITY

This section discusses the most likely technologies to be employed in meeting the Tier 4 standards, and the feasibility of implementing them in the timeframes proposed.

6.1. Federal Feasibility Review

The technological feasibility of the proposed standards has already been thoroughly evaluated by U.S. EPA as part of their Regulatory Impact Analysis. Staff concurs with U.S. EPA's conclusion that given the timing of the emissions standards proposed in the federal final rule, and this report, and the availability and continuing development of emission control technologies, off-road diesel engines can be designed to meet the proposed Tier 4 standards in the lead time provided.

The thoroughness of the U.S. EPA analysis, and staff's concurrence with that analysis, render redundant any exhaustive discussion of technological feasibility in this report. This Section will, therefore, briefly discuss some of the likely control strategies. Much of the information contained herein is derived from Chapter 4 of U.S. EPA's Regulatory Impact Analysis: Technologies and Test Procedures for Low-Emission Engines.

6.2. Summary of Technologies

In general, manufacturers of off-road diesel engines are expected to use emission controls similar to those already in use by the manufacturers of on-road diesel engines, although effectiveness could vary due to the different operating conditions experienced by off-road engines and the wide variety of applications.

Arguably the most challenging consideration in transferring advanced emission control technologies to the off-road will be exhaust temperature. Exhaust temperature is critical for the regeneration of catalyzed exhaust emission control devices. The following abridgment will focus primarily on PM and NOx aftertreatment, which staff believes to be the most likely means of achieving final Tier 4 standards. However, some of the technologies for meeting interim standards will also be discussed. For the most part, staff is summarizing the feasibility studies already performed by U.S. EPA and documented in its Regulatory Impact Analysis pertaining to the final nonroad diesel regulation. To complement this, staff also provides the results of an ARB / U.S. EPA funded test program by Southwest Research Institute that evaluated the performance of particulate filters and ultra low-sulfur diesel fuel on three diesel engines.

6.2.1. Exhaust Temperature Management

The primary concern for catalyst-based emission control technologies is exhaust temperature. In general, exhaust temperature increases with engine power and can vary dramatically as engine power demands vary. For catalyzed diesel particulate filters (CDPFs), exhaust temperature determines the rate of filter regeneration, and if too low, causes a need for supplemental means to ensure proper filter regeneration. A CDPF controls PM emissions under all conditions and can function properly even when exhaust temperatures are low for an extended time and the regeneration rate is lower than the soot accumulation rate, provided that occasionally exhaust temperatures, and the soot regeneration rate, are increased enough to regenerate the CDPF. Similarly, there is a minimum temperature (e.g., 200° Celsius) for NOx adsorbers below which regeneration is not readily feasible and a maximum temperature (e.g., 500° Celsius) above which NOx adsorbers are unable to effectively store NOx. Therefore, there is a need to match diesel exhaust temperatures to conditions for effective catalyst operation under the various operating conditions of off-road engines.

U.S. EPA has conducted an analysis of various operating cycles and various engine power density levels to better understand the matching of off-road engine exhaust temperatures, catalyst installation locations, and catalyst technologies. This study, documented in U.S. EPA's Regulatory Impact Analysis, shows that for many engine power density levels and equipment operating cycles, exhaust temperatures are quite well matched to catalyst temperature window characteristics. In particular, the nonroad transient composite test cycle was shown to be well matched to the NOx adsorber characteristics with estimated performance in excess of 90 percent for a turbocharged diesel engine tested under a range of power density levels. The analysis also indicated that the exhaust temperatures experienced over the nonroad transient test cycle are better matched to the NOx adsorber catalyst temperature window than the temperatures that would be expected over the highway Federal Test Procedure (FTP) test cycle.

Still, some off-road engines may experience in-use conditions requiring the use of temperature management strategies (e.g., active regeneration) to effectively use the NOx adsorber and CDPF systems. Accordingly, the cost analysis estimates for meeting Tier 4 standards assumes that all off-road engines complying with a PM standard of 0.04 g/kW-hr or lower will have an active means to control temperature, although some applications likely may not need one. Based on U.S. EPA's analyses, staff does not believe that there are any off-road engine applications above 19 kW for which active temperature management will not work.

6.2.2. PM Control Technologies

The following is a summary of technologies expected to be used to meet the Tier 4 PM standards.

6.2.2.1. In-Cylinder Control

The soot portion of PM emissions can be reduced by increasing the availability of oxygen within the cylinder for soot oxidation during combustion. Oxygen can be made more available by either increasing the oxygen content in-cylinder or by improving the mixing of the fuel and oxygen in-cylinder. Several current technologies can influence oxygen content and in-cylinder mixing, including improved fuel-injection systems, air management systems, and combustion system designs. In addition to enabling compliance with required emission standards, the application of better combustion system technologies across the broad range of off-road applications offers an opportunity for significant reductions in engine-out PM emissions and possibly for reductions in fuel consumption.

6.2.2.2. Diesel Oxidation Catalysts

Diesel oxidation catalysts (DOCs) are the most common form of diesel aftertreatment technology today and have been used for compliance with the PM standards for some on-road diesel engines since the early 1990s. DOCs reduce diesel PM by oxidizing a small fraction of the soot emissions and a significant portion of the SOF emissions. In general, the DOC's effectiveness to reduce PM emissions is normally limited to approximately 30 percent because the SOF portion of diesel PM for modern diesel engines is typically less than 30 percent, and because the DOC typically increases sulfate emissions, reducing the overall effectiveness of the catalyst. Limiting fuel sulfur levels to 15 ppmw allows DOCs to be designed for maximum effectiveness (nearly 100% control of SOF with highly active catalyst technologies) since their control effectiveness is not reduced by sulfate formation. The sulfate formation rate is still high, but because the sulfur level in the fuel is low, the resulting PM emissions are well controlled.

DOC effectiveness to control NMHC and CO emissions are directly related to the "activity" of the catalyst material used in the DOC washcoat. Highly active DOCs can reduce NMHC emissions by 97 percent while low activity catalysts realize approximately 50 percent NMHC control. Today, highly active DOC formulations cannot be used for NMHC and CO control because the sulfur in current diesel fuel leads to unacceptable sulfate PM emissions. However, with the low-sulfur diesel fuel that will be available under this program, DOCs will be able to provide substantial control of these pollutants. The use of DOCs is likely to factor in heavily as part of an overall compliance strategy for engines meeting the interim PM standards in 2008. For those engines, DOCs would also provide significant reductions in CO and NMHC. Oxidation catalyst technologies (i.e., DOCs and

CDPFs) generally will also be an effective tool for ensuring compliance with the NTE provisions of the Tier 4 program. In addition, test data show that toxics such as polycyclic aromatic hydrocarbons (PAHs) can be reduced by more than 80 percent with a DOC (RIA4 2004).

6.2.2.3. Diesel Particulate Filters

CDPFs have been shown to be very effective at reducing PM mass by dramatically reducing the soot and SOF portions of diesel PM. In addition, recent data show that they are also very effective at reducing the overall *number* of emitted particles when operated on ultra low-sulfur fuel (RIA4 2004). CDPFs have been shown to reduced particle count by over 95 percent, including some of the smallest measurable particles (< 50 nanometers). The combination of CDPFs with ultra low-sulfur fuel is expected to result in very large reductions in both PM mass (> 90 percent) and the number of ultra-fine particles. CDPFs are also capable of decreasing NMHC in excess of 90 percent.

Engine operating conditions have little impact on the particulate trapping efficiency of CDPFs, so 90 percent and greater efficiencies for elemental carbon particulate matter will apply to engine operation within the NTE zone and over the regulated transient cycles. These efficiencies will also be realized over steady-state test conditions such as the International Standards Organization C1 schedule. However, CDPF performance is dependent on the filter's ability to regenerate accumulated particulates and on sulfate formation. Sulfate formation will reduce the measured removal rate of particulates at some NTE operating conditions and some steady-state modes, even when using 15 ppmw sulfur diesel fuel. Additionally, a minimum operating temperature must be achieved for CDPF regeneration to occur. Exhaust temperature can vary significantly depending on operation and duty-cycle, and may not be sufficient to initiate regeneration for some off-road applications using a passive system. For these applications, an active diesel particulate filter system (i.e., one that requires external heat) may be necessary to ensure that temperature remains high enough, long enough to allow regeneration to occur. Although not typically an issue with new engines, excessive oil consumption can also reduce the efficiency of passive CDPFs due to the high content of sulfur in the lubricating oil. Active particulate filters may be needed to ensure regeneration for these engines.

Recent testing by the Southwest Research Institute (SwRI), in San Antonio, Texas, under joint contract with ARB and U.S. EPA, clearly demonstrated that the proposed Tier 4 PM standards are achievable on off-road diesel engines using passive particulate filters and ultra low-sulfur diesel fuel. The engines evaluated were a 1999 Caterpillar 3408 rated at 358 kW, a 1999 Cummins QSL9 rated at 242 kW, and a prototype development engine based on a 1995 Deere 4045T rated at 81 kW. All three engines were tested on a number of transient and steady-state test cycles, including the nonroad transient composite test cycle, with and without particulate filters. Emissions performance with passive filters was typically well below the 0.02 g/kW-hr proposed PM standard. Table 6.1, below, shows the PM results for each engine as evaluated on the nonroad transient composite and the C1 steady-state test cycles. Particulate filters were supplied by DCL, Inc., and Engine Control Systems, Inc., with substrates from Corning and Delphi (SwRI 2004). Based on the results of this study, staff believes that engine manufacturers should have great success in employing CDPF technology as proposed.

Table 6.1
Catalyzed Diesel Particulate Filter Testing at SwRI
Transient and Steady-State PM Results
Caterpillar, Deere Development Engine, and Cummins

Engine	Test Cycle [1]	PM (g/kW-hr)		Reduction [2]
		Engine Out	w/ Filter	
CAT 3408	Transient	0.343	0.012	96 %
	Steady-State	0.170	0.015	91 %
DDE 4045P	Transient	0.192	0.017	91 %
	Steady-State	0.173	0.013	92 %
CUM QSL9	Transient	0.208	0.007	97 %
	Steady-State	0.159	0.011	93 %

Note:
1 Transient testing was performed on the U.S. EPA nonroad transient composite test cycle and steady-state testing was performed on the 8-mode C1 test cycle.
2 The sulfur content of the fuel used in these evaluations was measured by SwRI to be 12 parts per million by weight

6.2.3. NOx Control Technologies

The rate of NOx formation in the combustion chamber is exponentially related to peak cylinder temperatures and is also strongly related to nitrogen and oxygen content. NOx control technologies for diesel engines have traditionally focused on reducing emissions by lowering the peak cylinder temperatures and by decreasing the oxygen content of the intake air.

6.2.3.1. In-Cylinder NOx Control

Fuel injection timing retard, fuel-injection rate control, charge air cooling, exhaust gas recirculation (EGR) and cooled EGR are some forms of in-cylinder NOx control. The use of these technologies can result in significant reductions in NOx emissions, but are limited due to practical and physical constraints of heterogeneous diesel combustion.

U.S. EPA's Highway Diesel Progress Review Report investigated the extent to which in-cylinder NOx control technologies had advanced. The report noted that a number of diesel engine manufacturers introduced cooled EGR systems on their heavy-duty diesel engines in 2002 that met the 2004 emission standards for NMHC+NOx (3.4 g/kW-hr). Engine manufacturers have demonstrated that these systems can be further refined to allow NOx emissions compliant with the 2007 NOx averaging level of approximately 1.6 g/kW-hr. To reduce NOx emissions below 1.6 g/kW-hr, engine manufacturers will likely need to increase EGR flow rates. Although there are challenges to applying similar technologies to off-road diesel engines (most notably the lack of ram-air for cooling), fundamental NOx control technologies are applicable to all diesel engines. The continuing development of heavy-duty on-road diesel technologies for in-cylinder NOx control, such as cooled EGR and Caterpillar's Advanced Combustion and Emission Reduction Technology (ACERT), is a good indication that off-road diesel engines 19 = kW = 560, and non-generator off-road engines greater than 560 kW, will be able to comply with their respective Tier 4 standards.

A new form of diesel engine combustion, commonly referred to as homogenous diesel combustion, or premixed diesel combustion, can give very low NOx emissions over a limited range of diesel engine operation. In the regions of diesel engine operation over which this combustion technology is feasible (light-load conditions), NOx emissions can be reduced enough to comply with the 0.4 g/kW-hr NOx emission standard. Some engine manufacturers are already producing engines that utilize this technology over a narrow range of engine operation. Unfortunately, it is not currently feasible to apply this technology over the full range of diesel engine operation.

6.2.3.2. Lean-NOx Catalyst

Passive and active lean-NOx catalyst systems have been under development for some time. However, neither system typically yields more than a 30 percent reduction in NOx. The active lean-NOx catalyst injects a reductant[19] that serves to reduce NOx to nitrogen and oxygen (diesel fuel is typically used as the reductant). The reductant is introduced upstream of the catalyst and reduces oxygen locally allowing NOx emissions to be reduced by the catalyst.

The lean-NOx catalyst washcoat incorporates a zeolite[20] technology that acts to adsorb hydrocarbons from the exhaust stream. Once adsorbed on the zeolite, the hydrocarbons will oxidize and create an oxygen-poor region that is more conducive to reducing NOx. To promote hydrocarbon oxidation at lower temperatures, the washcoat can incorporate platinum or other precious metals. The platinum also helps to eliminate the emission of unburned hydrocarbons that can occur if too much reductant is injected, referred to as "hydrocarbon slip." With platinum, the NOx conversion can take place at the low exhaust temperatures that are typical of diesel engines. However, the presence of the precious metals can lead to production of sulfate PM.

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[19] A substance capable of bringing about the chemical reduction of another substance as it itself is oxidized.
[20] Zeolites are three-dimensional, micro-porous, crystalline solids with well-defined structures used to adsorb a variety of materials including volatile organic chemicals, isomers, and gases.

Although active lean-NOx catalysts have been shown to provide up to 30 percent NOx reduction under limited steady-state conditions, this NOx control is achieved with a fuel economy penalty upwards of seven percent due to the need to inject fuel into the exhaust stream. NOx reductions over the transient on-road FTP cycle are on the order of twelve percent due to excursions outside the optimum NOx reduction efficiency temperature range for these devices. Consequently, the active lean-NOx catalyst does not appear to be capable of enabling the significantly lower NOx emissions required by the Tier 4 NOx standards.

Passive lean-NOx catalysts use no reductant injection. The passive lean-NOx catalyst is therefore even more limited in its ability to reduce NOx because the exhaust gases normally contain very few hydrocarbons. For that reason, current passive lean-NOx catalysts are only capable of ten percent steady-state NOx reductions. Neither of the lean-NOx catalyst technologies described can provide the significant NOx reductions necessary to meet the Tier 4 standards.

6.2.3.3. NOx Adsorber

The NOx adsorber is an extension of the three-way catalyst technology developed for gasoline powered vehicles more than twenty years ago. It enhances the three-way catalyst function through the addition of storage materials on the catalyst surface that can adsorb NOx under oxygen-rich conditions. NOx adsorbers work to control NOx emissions by storing NOx on the surface of the catalyst during the lean engine operation typical of diesel engines. The adsorber then undergoes subsequent brief rich regeneration events through the injection of a reductant (typically fuel) where the NOx is released and reduced across precious-metal catalysts. The NOx storage period can be as short as 15 seconds, or as along as 10 minutes, depending on engine-out NOx emission rates and exhaust temperature. This method for NOx control has been shown to be highly effective when applied to diesel engines, but has some technical challenges associated with it. Primary among these is sulfur poisoning of the catalyst.

NOx adsorber performance can be enhanced by incorporating a CDPF into the system. Partial oxidation of the secondary fuel reductant injected into the exhaust during regeneration could lead to soot formation. Using a CDPF upstream of the NOx adsorber, but downstream of the secondary fuel injection, allows partial oxidation of the fuel hydrocarbons to occur on the surface of the CDPF. The CDPF efficiently captures any soot formed during partial oxidation of the injected fuel, preventing an increase in soot emissions. The partial oxidation reaction over the CDPF is exothermic and can be used to increase the rate of temperature rise for the NOx adsorber, similar to the use of light-off catalysts with cascade three-way catalyst systems in gasoline vehicles. The fuel economy penalty from injecting the reductant varies depending on NOx adsorber control strategy, but a typical value is about three percent.

The ability of a diesel engine equipped with a NOx adsorber to control NOx emissions consistently in excess of 90 percent is dependent on the management of temperature. When the engine and NOx adsorber-based emission control system are well matched and integrated, NOx reductions can be far in excess of 90 percent. Conversely, if exhaust temperatures are well in excess of 500° Celsius, or well below 200° Celsius, for significant periods of engine operation, NOx control efficiency may be reduced. Researchers are developing and testing new formulations designed to increase the high temperature stability of the NOx adsorber and to widen the window of operation.

A NOx/Oxygen (O_2) sensor is needed for NOx adsorber regeneration control and is a component originally designed and developed for gasoline powered vehicles. Oxygen sensors have proven to be extremely reliable and long lived in passenger car applications, which see significantly higher temperature ranges than are normally encountered on a diesel engine. There is no reason why the application of a NOx/O_2 sensor on a diesel engine should prove more difficult. While diesel exhaust can cause fouling of the NOx/O_2 sensor damaging its performance, this situation can be addressed through the application of a CDPF in front of the sensor. The CDPF then protects the sensor from PM, but does not hinder its operation.

As previously mentioned, one of the technical challenges associated with NOx adsorbers relates to sulfate poisoning. While NOx adsorbers are known to be extremely efficient at storing NOx on the surface of the catalyzing surface during lean operation, they are, unfortunately, also efficient at storing oxides of sulfur (SOx). In fact, SOx has significantly more affinity for the adsorber than NOx does and is typically not released during regeneration. Thus, sulfate compounds quickly occupy the NOx storage sites on the catalyst rendering the catalyst ineffective (poisoned) for further NOx reduction.

The stored sulfur compounds are removed by exposing the catalyst to hot and rich air-fuel ratio conditions for a brief period. Under these conditions, the stored sulfate is released and reduced in the catalyst. This sulfur removal process, called desulfation, can restore the performance of the NOx adsorber to near new operation. NOx adsorber desulfation appears to be closely related to the temperature of the exhaust gases, air-fuel ratio, and the NOx adsorber catalyst formulation. Lower air-fuel ratios work to promote the release of sulfur from the surface, promoting faster and more effective desulfation. Both U.S. EPA and ARB staff believe that the NOx adsorber will be the dominant method of meeting the final Tier 4 NOx standards.

6.2.3.4. Selective Catalytic Reduction

Selective Catalytic Reduction (SCR) is another catalyst based method for reducing NOx. It requires an ammonia reductant to be injected in the exhaust to initiate catalysis. Most SCR systems, however, are based on an ammonia variant called urea, which tends to be less toxic and easier to handle and store than other forms of ammonia. With the appropriate control system to meter urea in proportion to engine-out NOx emissions, urea

SCR catalysts can reduce NOx exhaust emissions by more than 90 percent making the technology a viable candidate for meeting the Tier 4 NOx standards. SCR systems are also much less sensitive to sulfur poisoning than the other catalyst based methods of NOx control already discussed. They have been used effectively in stationary generator sets for over five years, and more recently in mobile source applications such as trucks, locomotives, and marine engines (MECA 2003).

There are some potential drawbacks with SCR technology, however, as it requires periodic user intervention to replenish urea storages in order to continue functioning properly. Since the urea consumption rate can be on the order of five percent of the engine fuel consumption rate, urea would likely need to be replenished at almost the same intervals that the engine is refueled, unless the urea storage tank is quite large (U.S. EPA 2004). Further, the infrastructure for dispensing automotive-grade urea to diesel fueling stations does not yet exist in sufficient quantity to satisfy the demand that would be created to meet the Tier 4 NOx standards should this technology be employed exclusively by engine manufacturers. Still, these issues could be overcome with the proper incentives and through innovative thinking. An on-board diagnostics requirement to monitor urea levels, for example, could be one way to verify that urea tanks were being replenished as needed to maintain emission system performance. Other methods may be possible as well.

Although SCR is not precluded as a means to meeting the Tier 4 NOx standards, it must be stipulated that a manufacturer intending to certify using this technology would need to satisfactorily demonstrate that its engine will use urea at all times in-use before an Executive Order would be issued.

7. ENVIRONMENTAL IMPACTS AND COST-EFFECTIVENESS

This Section presents the air quality benefits and the cost-effectiveness of the proposed standards. Staff's analyses of air quality benefits are based on ARB's off-road emissions inventory database, and cost-effectiveness is based on U.S. EPA's national analysis, adjusted to reflect California expenses and emission reductions.

7.1. Air Quality Benefits

The following summarizes the air quality impacts and benefits of staff's proposal.

7.1.1. Emissions Inventory Reductions

The intent of the proposed regulation is to reduce emissions from off-road diesel engines and equipment in the most technologically feasible and cost-effective manner possible. As shown in Table 7.1, it is estimated that by 2020 California's proposed emissions standards, and those already adopted by the U.S. EPA, would result in statewide emission reductions of 6.9 tons per day PM, 72.8 tons per day NOx, and 3.0 tons per day NMHC. These PM and NOx reductions would be equivalent[21] to taking 7.7 million passenger cars off California's highways in 2020. The baseline inventory includes all ARB and U.S. EPA's regulations currently in effect, except for the federal Tier 4 program. The federal Tier 4 program is excluded to facilitate the comparison between preempt and non-preempt emission benefits. Both the baseline and the control estimates assume the use of manufacturer flexibility provisions amounting to 80 percent over a four year period (a seven year period is allowed, but staff believes a four year period is more likely to be used) in increments of 40 percent the first year, 20 percent the next year, and 10 percent for years three and four. The data in these tables reflect the latest emissions information contained in California's off-road diesel emissions inventory database.

Table 7.1
2020 Projected Emission Benefits of the Tier 4 Proposal
Statewide Annual Averages

Government Jurisdiction	Pollutant	Emissions Inventory [1,2]		Reduction (tons per day)
		Baseline (tons per day)	Controlled (tons per day)	
California Proposal Non-Preempt Engines	PM	5.1	2.6	2.5
	NOx	101.0	62.2	38.8
	NMHC	9.6	7.8	1.8
Federal Authority Preempt Engines	PM	12.2	7.8	4.4
	NOx	148.0	114.0	34.0
	NMHC	15.3	14.1	1.2
Total	PM	17.3	10.4	6.9
	NOx	249.0	176.2	72.8
	NMHC	24.9	21.9	3.0

Notes:
1 PM estimates have been adjusted to reflect 15 ppmw sulfur fuel reductions after 2006
2 Emissions from recreational marine engines are not included in these estimates

Table 7.2 shows the estimated total population of engines by power category in 2020 as well as a projection of those engines expected to meet the Tier 4 standards at that time.

[21] The comparison was made for ozone precursor emissions only using data from the off-road diesel emissions inventory database (May 2004) and the EMFAC2002 V2.2 04-03-2003 on-road model. An equivalent particulate emissions comparison would correlate to the removal of 13.6 million passenger cars in 2020.

These projections are based on meeting the interim Tier 4 standards, at a minimum, and take into account the same flexibility usage rates described earlier in subsection 7.1.1. As expected, the majority of engines less than 19 kW would be Tier 4 compliant in 2020 since the standards for that category, as proposed, begin in 2008. The 19 = kW < 56 category is also heavily dominated by Tier 4 engines, but engines in this power range do not turn-over as quickly as engines rated less than 19 kW; therefore, the percent of the fleet meeting Tier 4 standards is less than that for the previous power category despite the same implementation starting date. The 56 = kW < 130 category begins meeting Tier 4 standards later than the rest of the power categories, in 2012, and this is evidenced by a relatively low percentage of engines meeting the Tier 4 standards. The standards for the 130 = kW = 560 and the over 560 kW categories begin one year earlier, in 2011, and have a higher rate of Tier 4 compliant engines.

Table 7.2
2020 Engine Populations by Power Category

Power Category	Total Engines [1]	Tier 4 Engines [1,2]	
kW < 19	117,978	112,216	95 %
19 = kW < 56	190,941	149,117	78 %
56 = kW < 130	191,687	106,778	56 %
130 = kW = 560	59,634	38,261	64 %
kW > 560	1,185	826	70 %
TOTAL	561,425	407,198	73 %

Notes:
1 All representations are for combined preempt and non-preempt engines
2 Estimates are based on 40/20/10/10 flexibility usage rates

Table 7.3 shows the benefits of the combined staff proposal and federal Tier 4 rule for two of the largest air basins in California, namely the South Coast Air Basin and the San Joaquin Valley Air Basin. Together these two air basins are home to almost half of all the off-road diesel engines in California and their associated emissions.

Table 7.3
2020 Benefits of the Tier 4 Proposal for Select Air Basins

Air Basin	Pollutant	Emissions Inventory [1,2,3]		Reduction (tons per day)
		Baseline (tons per day)	Controlled (tons per day)	
South Coast (157,059 Engines)	PM	5.2	3.1	2.1
	NOx	69.7	49.3	20.4
	NMHC	7.1	6.3	0.8
San Joaquin Valley (111,401 Engines)	PM	2.9	1.7	1.2
	NOx	43.8	31.0	12.8
	NMHC	4.4	3.8	0.6

Notes:
1 All calculations are annual average estimates expressed as statewide preempt plus non-preempt ratios
2 PM estimates have been adjusted on pre-Tier 4 equipment to reflect 15 ppmw sulfur fuel reductions
3 Emissions from recreational marine engines are not included in these estimates

7.1.2. Toxic Air Contaminants

Diesel exhaust is a mixture of many gases and fine particulate coated with organic substances. Over 40 chemicals in diesel exhaust have been identified by the State of California as toxic air contaminants (see Table 7.4 below). Many of the components in diesel exhaust, such as PM2.5, benzene, arsenic, dioxins, and formaldehyde, are also known carcinogens in California. Other components, such as toluene and dioxins, are known reproductive toxicants. Since the proposal will reduce PM and NMHC emissions, an added benefit will be a reduction in public exposure to the toxic compounds related to those pollutants.

Table 7.4
Toxic Air Contaminants in Diesel Exhaust

acetaldehyde	inorganic lead
acrolem	manganese compounds
aniline	mercury compounds
antimony compounds	methanol
arsenic	methyl ethyl ketone
benzene	naphthalene
beryllium compounds	nickel
biphenyl	4-nitrobiphenyl
bis{2-ethylhexyl]phthalate	phenol
1,3-butakiene	phosphorus
cadmium	polycyclic organic matter, including
chlorine	polycyclic aromatic hydrocarbons (PAHs)
chlorobenzene	propionaldehyde
chromium compounds	selenium compounds
cobalt compounds	styrene
creosol isomers	toluene
cyanide compounds	xylene isomers and mixtures
dibutylphthalate	o-xylenes
dioxins and dibenzofurans	m-xylenes
ethyl benzene	p-xylenes
formaldehyde	

Note:
California Health and Safety Code, section 39655, defines, in part, a "toxic air contaminant" as "an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health."

7.1.3. 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 (Senate Bill 115, Solis; Stats 1999, Ch. 690; Government Code § 65040.12(c)). The Board has established a framework for incorporating environmental justice into ARB's programs consistent with the directives of State law. The policies subsequently developed apply to all communities in California, but they recognize that environmental justice issues have been raised more in the context of low income and minority communities, which sometimes experience higher exposures to some pollutants as a result of the cumulative impacts of air pollution from multiple mobile, commercial, industrial, areawide, and other sources.

Over the past twenty years, ARB, local air districts, and federal air pollution control programs have made substantial progress towards improving the air quality in California. However, some communities continue to experience higher exposures than others as a result of the cumulative impacts of air pollution from multiple mobile and stationary sources and thus may suffer a disproportionate level of adverse health effects. Because the same ambient air quality standards apply to all regions of the State, all communities, including environmental justice communities, will benefit from the air quality benefits associated with the proposal. Alternatives to the proposed recommendations, such as maintaining the current exhaust emission standards without further reducing air pollution, would adversely affect all communities. As additional relevant scientific evidence becomes available, the off-road diesel engine standards will be reviewed again to make certain that the health of the public is protected with an adequate margin of safety.

To ensure that everyone has had an opportunity to stay informed and participate fully in the development of off-road diesel engine standards, staff has distributed information as described in subsection 2.6 of this report.

7.1.4. Health Impacts

Full implementation of staff's proposal and the federal rule would prevent approximately 900 premature deaths per year in California and account for a savings of $6.3 billion in health-related costs per year by calendar year 2030 based on the U.S. EPA scaling process for PM-related health benefits (RIA9 2004).

Additionally, 400 cases of chronic bronchitis would be prevented annually in 2030, as well as 20,000 cases of asthma exacerbations for children and 400,000 cases of restricted activity days for adults (RIA9 2004).

7.2. Cost-Effectiveness

The cost of complying with the proposed emission standards and regulations in California is not expected to be different than the cost of complying with the federal regulations. Therefore, no additional cost is anticipated from the adoption of staff's proposal. The estimated cost of complying with the standards will vary depending on the power category and model year under consideration.

The cost-effectiveness for aligning with the federal requirements in California is expected to be similar to the national cost-effectiveness (RIA9 2004) with the exception of the PM benefits attributed solely to the use of ultra low-sulfur diesel fuel. The highest federal fleet-wide cost-effectiveness of the NMHC+NOx standards is about $0.51 to $0.58 per pound of ozone precursors reduced. This compares favorably with other adopted emission control measures in California. The range of cost-effectiveness for the PM standards is expected to be $6.70 to $7.55 per pound of PM reduced after adjusting for the federal inclusion of benefits solely from the ultra low-sulfur diesel fuel, for which California has taken credit in a previous rule. The federal cost-effectiveness for PM including the benefits of ultra low-sulfur diesel fuel is $5.60 to $5.90 per pound. A more detailed summary of these estimates is provided in Appendix B: "Federal Cost-Effectiveness of the Off-Road

Compression-Ignition Emission Standards."

8. ECONOMIC IMPACTS

The proposed regulatory amendments harmonize with the federal regulations finalized on May 11, 2004. The California adoption of the standards would not impose additional costs above the costs to comply with the federal standards. The adoption is actually expected to benefit engine manufacturers, who may face production inefficiencies when they have to comply with different standards. The harmonization of the standards would reduce production inefficiencies, thereby lowering compliance costs. Therefore, staff believes that the proposed amendments would have no noticeable impact on business competitiveness, California employment, or on business creation, elimination, and expansion. This section discusses, in greater detail, the potential cost and economic impacts of the proposed amendments based on U.S. EPA findings.

8.1. Legal Requirement

Sections 11346.3 and 11346.5 of the Government Code require State agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include a consideration of the impact of the proposed regulation on California jobs, business expansion, elimination, or creation, and the ability of California business to compete.

State agencies are required to estimate the cost or savings to any state or local agency, and school districts. The estimate is to include any nondiscretionary cost or savings to local agencies and the cost or savings in federal funding to the state.

8.2. Affected Businesses

Any business that is involved in manufacturing and/or rebuilding off-road diesel engines, and equipment manufacturers that utilize these engines in their equipment, may potentially be affected by the federal standards and the proposed State standards. U.S. EPA has identified approximately 600 off-road equipment manufacturers using diesel engines in several thousand different equipment models. There are also more than 50 engine manufacturers producing diesel engines for these applications nationwide. Also affected are businesses that operate or service diesel engines. An estimated 553,800 off-road diesel engines will be utilized in equipment and vehicles operating in California in 2010 with that number increasing to over 560,000 by 2020.

8.2.1. Estimated Costs to Engine and Equipment Manufacturers

The costs of the proposed new requirements to engine manufacturers have been estimated and are based on U.S. EPA's Regulatory Impact Analysis for the national emission standards. Engine manufacturers will likely evaluate multiple technologies to meet the new emission standards. However, to estimate the incremental impact of the federal standards on engine costs, U.S. EPA assumed a single combination of technologies. Note that the costs presented here do not include potential savings associated with an engine averaging, trading, and banking program or the transition program (flexibilities) for equipment manufacturers. In addition, U.S. EPA assumed that engine companies who are eligible for the small business engine manufacturer specific provisions do not take advantage of the unique flexibilities the regulation provides for them, which includes the opportunity to delay compliance with the Tier 4 emission standards for a full three model years. While it is expected that manufacturers will use these flexibilities to reduce compliance costs, they are not factored into the cost analysis because they are voluntary programs. Given these assumptions, it is likely that the costs provided here are overestimated since they only relate to regulatory requirements and do not consider the voluntary flexibilities that offer the opportunity for significant cost reductions. Unless noted otherwise, all costs are in 2002 dollars.

The total costs include variable costs (for incremental hardware costs, assembly costs, and associated markups) and fixed costs (for tooling, research and development, and certification). For diesel engines, the projected compliance costs are largely due to using new technologies such as advanced emissions control technologies to meet the proposed Tier 4 emissions standards. Compliance costs for engines are broken out by horsepower category and impact year. The costs per unit change from year to year because engine standards are implemented differently in each power category. As shown in Table 8.1, the fixed cost per engine typically decreases after five years as these annualized costs are depreciated. The regulation's market impacts are primarily driven by the per-engine variable costs that remain relatively constant over time.

For off-road equipment, the majority of the projected compliance costs are due to the need to redesign the equipment. The variable cost consists of the cost of new or modified equipment hardware and of labor to install the new emission control devices. The fixed cost consists of the redesign cost to accommodate new emission control devices. The per unit compliance costs are weighted average costs within the appropriate horsepower range. The equipment compliance costs are broken out by horsepower category and impact year. As shown in Table 8.2, the majority of costs per piece of equipment are the fixed costs. The overall compliance costs per piece of equipment are less than half the overall costs associated with the same horsepower category engine (RIA10 2004).

Table 8.1
Compliance Costs per Engine

Power Range	Cost Types	2008	2009	2010	2011	2012	2013	2014	2015	2020	2030
0 = kW < 19	Variable	$129	$129	$123	$123	$123	$123	$123	$123	$123	$123
	Fixed	$33	$32	$31	$30	$30	$0	$0	$0	$0	$0
	Total	$162	$161	$154	$153	$153	$123	$123	$123	$123	$123
19 = kW < 37	Variable	$147	$147	$139	$139	$139	$849	$849	$645	$645	$645
	Fixed	$49	$48	$47	$46	$45	$74	$73	$71	$0	$0
	Total	$196	$195	$186	$185	$184	$923	$922	$716	$645	$645
37 = kW < 56	Variable	$167	$167	$158	$158	$158	$837	$837	$636	$636	$636
	Fixed	$50	$49	$49	$48	$47	$76	$75	$73	$0	$0
	Total	$217	$216	$207	$206	$205	$913	$912	$709	$636	$636
56 = kW < 75	Variable	$0	$0	$0	$0	$1,133	$1,133	$1,122	$1,122	$1,122	$1,122
	Fixed	$0	$0	$0	$0	$80	$78	$108	$106	$0	$0
	Total	$0	$0	$0	$0	$1,213	$1,211	$1,230	$1,228	$1,122	$1,122
75 = kW < 130	Variable	$0	$0	$0	$0	$1,375	$1,375	$1,351	$1,351	$1,351	$1,351
	Fixed	$0	$0	$0	$0	$78	$77	$106	$105	$0	$0
	Total	$0	$0	$0	$0	$1,453	$1,452	$1,457	$1,456	$1,351	$1,351
130 = kW < 450	Variable	$0	$0	$0	$2,191	$2,190	$1,697	$2,137	$2,136	$2,132	$2,126
	Fixed	$0	$0	$0	$326	$321	$316	$437	$430	$0	$0
	Total	$0	$0	$0	$2,517	$2,511	$2,013	$2,574	$2,566	$2,132	$2,126
kW = 450	Variable	$0	$0	$0	$2,911	$2,910	$2,246	$2,733	$6,153	$5,347	$5,347
	Fixed	$0	$0	$0	$861	$848	$835	$1,083	$1,526	$0	$0
	Total	$0	$0	$0	$3,772	$3,758	$3,081	$3,816	$7,679	$5,347	$5,347

Source: U.S. EPA's Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, May 2004.

Costs are in 2002 dollars.

Table 8.2
Costs per Piece of Equipment

Power Range	Cost Types	2008	2009	2010	2011	2012	2013	2014	2015	2020	2030
0 = kW < 19	Variable	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Fixed	$15	$15	$14	$14	$14	$13	$13	$13	$0	$0
	Total	$15	$15	$14	$14	$14	$13	$13	$13	$0	$0
19 = kW < 37	Variable	$0	$0	$0	$0	$0	$20	$20	$16	$16	$16
	Fixed	$8	$8	$8	$7	$7	$42	$41	$40	$31	$0
	Total	$8	$8	$8	$7	$7	$62	$61	$56	$47	$16
37 = kW < 56	Variable	$0	$0	$0	$0	$0	$21	$21	$17	$17	$17
	Fixed	$8	$8	$8	$8	$8	$44	$43	$42	$32	$0
	Total	$8	$8	$8	$8	$8	$65	$64	$59	$49	$17
56 = kW < 75	Variable	$0	$0	$0	$0	$45	$45	$48	$48	$48	$48
	Fixed	$0	$0	$0	$0	$109	$107	$132	$130	$120	$0
	Total	$0	$0	$0	$0	$154	$152	$180	$178	$168	$48
75 = kW < 130	Variable	$0	$0	$0	$0	$46	$46	$49	$49	$49	$49
	Fixed	$0	$0	$0	$0	$170	$168	$207	$204	$189	$0
	Total	$0	$0	$0	$0	$216	$214	$256	$253	$238	$49
130 = kW < 450	Variable	$0	$0	$0	$75	$75	$60	$80	$80	$79	$79
	Fixed	$0	$0	$0	$378	$372	$366	$453	$446	$415	$0
	Total	$0	$0	$0	$453	$447	$426	$533	$526	$494	$79
kW = 450	Variable	$0	$0	$0	$57	$57	$46	$61	$123	$111	$111
	Fixed	$0	$0	$0	$690	$680	$670	$806	$1,404	$1,310	$0
	Total	$0	$0	$0	$747	$737	$716	$867	$1,527	$1,421	$111

Source: U.S. EPA's Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, May 2004.

Costs are in 2002 dollars.

8.2.2. Potential Impacts on Business

The new federal standards are expected to impose additional costs on engine manufacturers, rebuilders, and equipment manufacturers that utilize these engines in their equipment. A more thorough analysis of these costs is provided in chapter 6 of U.S. EPA's Regulatory Impact Analysis. As shown in Table 8.3, U.S. EPA estimated the prices for seven engine categories using price data compiled from a variety of sources. These prices were sales weighted where appropriate.

Table 8.3
Baseline Engine Prices

Power Range	Estimated Price
kW < 19	$1,500
19 = kW < 37	$2,900
37 = kW < 56	$3,000
56 = kW < 75	$4,000
75 = kW < 130	$5,500
130 = kW < 450	$20,000
kW = 450	$80,500

Source: U.S. EPA Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, May 2004.

The incremental costs of the new standards can be viewed in the context of their fraction of the total purchase price of equipment. As illustrated in Table 8.4, the ratio of variable engine compliance costs to market price ranges from about 29 percent for engines 19 = kW < 37 to roughly three percent for engines equal to and above 450 kW. These different ratios lead to different relative shifts in the supply curves, and different impacts on the change in market price and quantity for each market. As stated earlier, the regulation's market impacts are driven primarily by the per-engine variable costs that remain relatively constant over time, which is why Table 8.4 does not compare total or fixed engine costs. Fixed costs are the unavoidable price of doing business and might give a false sense of the influence that the proposal would have on engine prices if included.

Table 8.4
Ratio of Variable Engine Compliance Costs to Engine Price

Power Range	Variable Engine Compliance Cost / Engine Price
kW < 19	8.2%
19 = kW < 37	29.3%
37 = kW < 56	27.9%
56 = kW < 75	28.3%
75 = kW < 130	25.0%
130 = kW < 450	8.5%
kW = 450	2.8%

Source: U.S. EPA Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, May 2004.

The California adoption of the new federal standards is not going to alter the above costs because these costs already include the cost to California. The harmonization of the standards would actually benefit most engine manufacturers, because they have would not have to comply with different standards for California.

8.2.3. Potential Impact on Business Competitiveness

The proposed amendments would have no significant impact on the ability of California businesses to compete with businesses in other states. The amendments would harmonize the California standards with the federal standards for off-road diesel engines. Thus, California operators of off-road diesel equipment and vehicles would not be disadvantaged relative to operators from other states. The harmonization of the standards should actually benefit engine manufacturers and equipment manufacturers. This is because these manufacturers would not have to deal with different requirements that can result in production inefficiencies.

8.2.4. Potential Impact on Employment

The proposed amendments are not expected to cause a noticeable change in California employment. The adoption of the federal standards in California is expected to benefit manufacturers, who might be faced with production inefficiencies if they had to comply with different California and federal standards. As mentioned above, the harmonization of the standards would reduce production inefficiencies, thereby lowering compliance costs. Since these costs are generally passed on to vehicle operators, they could benefit from lower compliance costs. This would, in turn, moderate any adverse impact the federal standards might have on employment.

8.2.5. Potential Impact on Business Creation, Elimination or Expansion

The proposed amendments would have no noticeable impact on the status of California businesses including small businesses. The proposed emission standards would be the same as the federal standards. Therefore, no additional costs for off-road diesel equipment or vehicle operators in California are expected. The implementation flexibilities proposed would help alleviate the potential impact on businesses including small businesses.

8.2.6. Potential Impact on Small Businesses

Small business entities comprise 68 percent of the off-road diesel private sector nationally based on estimates from the U.S. EPA. However, the sales from these small business entities are only about 11 percent of the total sales from the category. The ten largest engine manufacturers are responsible for 80 percent of the engines sold. The cost to small businesses should be considerable lower than for the rest of the off-road industry as a result of the many compliance facilitating provisions afforded to small business and small volume entities in the regulation.

8.3. Potential Costs to Local and State Agencies

As discussed in section 9 of this report, ARB must either adopt the requirements in this proposal, or other requirements that would result in equivalent or greater air quality benefits in order to comply with the federal Clean Air Act. Staff believes the proposed requirements are the only feasible and cost-effective means of achieving emission reductions of the same magnitude as the federal requirements by 2030. Staff also believes there would be no real incremental cost increase associated with adopting the federal standards as the California standards. Accordingly, the proposed requirements are not expected to result in an overall increase in costs for State and local agencies. The only costs to State government as a result of the proposed amendments would be for administratively implementing the new regulatory requirements. However, the implementation costs may be absorbed with existing ARB resources. ARB is already responsible for verifying the implementation of the existing regulations for off-road diesel engines. Thus, the proposed amendments would not increase the workload to the extent that hiring additional staff would be necessary.

8.4. Potential Costs to Non-Preempt Farm Equipment

As noted previously, the federal Clean Air Act preempts the ARB from regulating new farm equipment with engines rated at less than 175 horsepower (130 kW). This means that new farm equipment at or greater than 175 horsepower would be regulated under the staff's proposal. Under Health and Safety Code, section 43013(c), the ARB is required to hold a public hearing prior to adopting standards and regulations for farm equipment. In the hearing, the ARB shall find and determine that the standards and regulations are necessary, cost-effective, and technologically feasible. The ARB is also required to consider the technological effects of emission control standards on the cost, fuel consumption, and performance characteristics of mobile farm equipment.

8.4.1. Necessity of Proposal for Non-Preempt Farm Equipment

As discussed above in section 7.1 "Air Quality Impacts," it is clear that the Tier 4 standards are needed to achieve significant reductions in PM (particularly diesel PM), NOx, NMHC, and toxic air contaminants. Without these reductions, the public will continue to be exposed to high levels of these air pollutants. Therefore, the Tier 4 standards and this proposal to harmonize ARB's regulations with the U.S. EPA's Tier 4 regulation are necessary to achieve significant emission reductions and protect public health.

8.4.2. Cost-Effectiveness of Proposal for Non-Preempt Farm Equipment

As discussed above in section 7 "Environmental Impacts and Cost-Effectiveness" and Appendix B, the proposal clearly meets established criteria for cost-effectiveness for farm equipment. We are aware of no specific uniqueness to farm equipment that would make the cost analysis presented in this Staff Report inapplicable to new farm equipment.

The cost-effectiveness for aligning with the federal requirements in California is expected to be similar to the national cost-effectiveness (RIA9 2004), with the exception of the PM benefits attributed solely to the use of ultra low-sulfur diesel fuel. The highest federal fleet-wide cost-effectiveness of the NMHC+NOx standards is about $0.51 to $0.58 per pound of ozone precursors reduced. This compares favorably with other adopted emission control measures in California. The range of cost-effectiveness for the PM standards is expected to be $6.70 to $7.55 per pound of PM reduced after adjusting for the federal inclusion of benefits solely from the ultra low-sulfur diesel fuel, for which California has taken credit in a previous rule. The federal cost-effectiveness for PM including the benefits of ultra low-sulfur diesel fuel is $5.60 to $5.90 per pound.

Based on these reasons, we believe the proposal is cost-effective for new farm engines and equipment.

8.4.3. Technological Feasibility of Proposal for Non-Preempt Farm Equipment

The technological feasibility of the proposal is discussed in section 6 "Technological Feasibility." In summary, the U.S. EPA determined that the Tier 4 standards are technologically feasible for all of the regulated engine classes, including new farm engines and equipment at or above 130 kW. We agree with this determination. The various compliance methods and emission control technologies available to farm equipment manufacturers are discussed in section 6. We are aware of no technical reasons why new farm engines and equipment cannot meet the Tier 4 standards. Therefore, we have determined that the proposal is technologically feasible for new, non-preempt farm engines and equipment.

8.4.4. Technological Effects Of Emission Control Standards On The Cost, Fuel Consumption, And Performance Characteristics Of Mobile Farm Equipment

The effect of the emission control standards on the cost of mobile farm equipment was determined by the U.S. EPA and summarized in Tables 8.1 and 8.2. In summary, the compliance costs ranged from $0 to $2,574 (130 $\leq$ kW $\leq$ 450) and $0 to $7,679 (> 450 kW) per engine. This compares to base engine prices of $20,000 (130 $\leq$ kW $\leq$ 450) to $80,500 (> 450 kW) per engine. Because the U.S. EPA Tier 4 standards applies nationally, these costs should not adversely affect farming costs in California relative to farming outside of California.

The U.S. EPA's analysis of the standards on fuel consumption and performance characteristics is documented in their Regulatory Impacts Analysis, which is incorporated by reference herein. No significant adverse impacts on fuel consumption and performance characteristics were found as a result of the Tier 4 standards.

9. REGULATORY ALTERNATIVES

The staff evaluated various alternatives to the current proposal. A brief description of the alternatives and staff's rationale for finding them unsuitable follows below.

9.1. Maintain Current California Regulations

The first alternative to this proposal would be to simply maintain the current California off-road diesel engine emission standards. Prior to U.S. EPA's adoption of the Tier 4 standards for off-road diesel engines, current California and federal standards were the same. However, with its passage, current California regulations have become less stringent than the federal program. Pursuant to the federal Clean Air Act (CAA), in order for California to enforce its own emissions reduction program the Board must adopt regulations that are, in the aggregate, at least as protective of public health and welfare as applicable federal standards (CAA Section 209(e)(2)(A)). Therefore, staff rejected this alternative.

9.2. Adopt More Stringent Emission Standards

The degree of emissions control proposed by staff is already technology forcing for most of the engines being regulated, and should result in dramatic emission reductions over time. Staff recognizes that more stringent standards may be necessary in the future, especially for engines rated less than 19 kW. However, data are not yet available to suggest a more cost effective way to achieve greater emission benefits. Therefore, staff is not recommending the adoption of standards more stringent than those already proposed. Harmonization with the federal program will spare the industry unnecessary costs and administrative burdens, allowing a greater focus on the technical issues of emissions control. Staff rejects this alternative at this time.

9.3. Accelerate Implementation Schedule of Standards

The staff examined the possibility of accelerating the implementation schedule of standards to get cleaner engines into California earlier. While this alternative would provide emission benefits sooner, manufacturers would have less lead time to develop the necessary technologies since standards for many of the power groups would be changing simultaneously, and manufacturers would have fewer years over which to spread out and recoup the development expenses. This would also make the proposal far less cost-effective. Therefore, staff rejected this alternative.

10. REMAINING ISSUES

10.1. Technical Amendments

U.S. EPA intends to make additional improvements to their Tier 4 test procedures in a separate rulemaking titled "Test Procedures for Testing Highway and Nonroad Engines and Omnibus Technical Amendments," which was proposed on August 16, 2004. These changes will primarily be technical in nature, affecting the language in 40 CFR, Part 1065 mostly, and are intended to incorporate the latest measurement technologies. Staff has participated in varying degrees to the development of these technical amendments, and will likely propose that the Board consider incorporating them into California's off-road diesel program in a 15-day notice should U.S. EPA finalize them prior to the October 15, 2004 deadline and after staff has had sufficient opportunity to review them in finalized context.

10.2. Safety Concerns

Staff is unaware of any safety-related issues being raised by the off-road industry regarding this proposal or during the development of U.S. EPA's similar rule. However, with the likely incorporation of catalyzed materials in the exhaust stream to meet the proposed standards, there is the potential for increased heat dissipation. Although such technology could raise exhaust temperatures, staff does not believe it is likely to result in a fire hazard due to the out-of-reach location of the exhaust stack on most off-road diesel equipment and with the anticipated application of proper shielding by the equipment manufacturer. The majority of catalyzed aftertreatment devices are expected to replace mufflers, which should already necessitate sufficient heat resistant designs.

11. CONCLUSIONS AND RECOMMENDATIONS

Staff's objective in recommending the harmonization of ARB's off-road diesel Tier 4 program with federal requirements is to provide the citizens of California with the most effective approach for achieving major air quality improvements in a technologically feasible and cost effective manner. Staff estimates that in 2020, the statewide benefits of the California proposal and the federal rule would be 72.8 tons per day NOx, 6.9 tons per day PM, and 3.0 tons per day NMHC. The estimated California cost-effectiveness with adoption of the staff's proposal would be approximately $0.58 per pound of NMHC+NOx reduced. This cost-effectiveness is well within the range of other control measures adopted by the Board.

There are some differences, however, between the federal program and the California proposal for Tier 4 off-road engines. These are safeguards for ensuring California's continued ability to identify complying engines quickly, and to enforce the regulations. The proposed differences should not be overly burdensome or costly to the manufacturers, but will help to ensure that off-road engines remain in compliance with emissions standards throughout their useful lives.

No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed, or would be as effective as, or less burdensome, to affected private persons than the proposed regulation. Therefore, staff recommends that the Board adopt staff's proposal as contained in this report and noted in the attached proposed regulations and test procedures.

12. REFERENCES

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ATTACHMENT 1: PROPOSED AMENDMENTS TO THE CALIFORNIA REGULATIONS FOR OFF-ROAD COMPRESSION-IGNITION ENGINES AND EQUIPMENT

ATTACHMENT 2: PROPOSED AMENDMENTS TO THE CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR NEW 2008 AND LATER TIER 4 OFF-ROAD COMPRESSION-IGNITION ENGINES AND EQUIPMENT, PART I-C

ATTACHMENT 3: PROPOSED AMENDMENTS TO THE CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR NEW 2000 AND LATER TIER 1, TIER 2, AND TIER 3 OFF-ROAD COMPRESSION-IGNITION ENGINES AND EQUIPMENT, PART I-B

ATTACHMENT 4: PROPOSED AMENDMENTS TO THE CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR NEW 1996 AND LATER TIER 1, TIER 2, AND TIER 3 OFF-ROAD COMPRESSION-IGNITION ENGINES AND EQUIPMENT, PART II

APPENDIX A: LIST OF PREEMPTED OFF-ROAD APPLICATIONS

(a) Equipment types with engines less than 25 horsepower are presumed not to be construction or farm equipment, with the exception of the following equipment types, which have been determined to be construction or farm equipment:

Aerial devices: vehicle mounted
Asphalt recycler/reclaimer, sealer
Augers: earth
Back-hoe
Backpack Compressors
Baler
Boring machines: portable line
Breakers: pavement and/or rock
Brush cutters/Clearing saws 40 cc and above (blade capable only)
Burners: bituminous equipment
Cable layers
Chainsaws 45 cc and above
Chippers
Cleaners: high pressure, steam, sewer, barn
Compactor: roller/plate
Compressors
Concrete buggy, corer, screed, mixer, finishing equipment
Continuous Digger
Conveyors: portable
Crawler excavators
Crushers: stone
Cultivators: powered
Cutting machine
Debarker
Detassler
Drills
Dumper: small on-site
Dusters
Elevating work platforms
Farm loaders: front end
Feed conveyors
Fertilizer spreader
Forage box/Haulage and loading machine
Forklifts: diesel and/or rough terrain
Harvesters, crop
Jackhammer
Light towers
Mixers: mortar, plaster, grout
Mowing equipment: agricultural
Mud jack

Pavers: asphalt, curb and gutter
Pipe layer
Plows: vibratory
Post hole diggers
Power pack: hydraulic
Pruner: orchard
Pumps 40 cc and above
Rollers: trench
Sawmill: portable
Saws: concrete, masonry, cutoff
Screeners
Shredder/grinder
Signal boards: highway
Silo unloaders
Skidders
Skid-steer loaders
Specialized fruit/nut harvester
Sprayers: bituminous, concrete curing, crop, field
Stump cutters, grinders
Stumpbeater
Surfacing equipment
Swathers
Tampers and rammers
Tractor: compact utility
Trenchers
Troweling machines: concrete
Vibrators: concrete, finisher, roller
Welders
Well driller: portable
Wheel loaders

(b) Equipment types with engines 25 horsepower or greater are presumed to be construction or farm equipment, with the exception of the equipment types listed below, which have been determined not to be construction or farm equipment.

Aircraft Ground Power
Baggage Handling
Forklifts that are neither rough terrain nor powered by diesel engines
Generator Sets
Mining Equipment not otherwise primarily used in the construction industry
Off-Highway Recreational Vehicles
Other Industrial Equipment
Refrigeration Units less than 50 horsepower
Scrubbers/Sweepers

Tow/Push
Turf Care Equipment

APPENDIX B: FEDERAL COST-EFFECTIVENESS OF THE OFF-ROAD COMPRESSION-IGNITION EMISSION STANDARDS

The following tables show the federal cost-effectiveness of the emission standards for diesel engines. The estimated cost of complying with the standards varies depending on the model year under consideration. U.S. EPA calculated the cost per ton of the regulations based on the net present value of all costs incurred and all emission reductions generated over a 30-year time window following implementation of the program. This approach captures all the costs and emission reductions from the regulations, including costs incurred and emission reductions generated by both the new and the existing fleet.

Table B.1
Cost-Effectiveness Estimates ($2002)
30-Year Net Present Value at a 3% and 7% Discount Rate

Pollutant	3% discount rate	7% discount rate
	$/ton ($/lb)	
NMHC+NOx	$1,010 ($0.51)	$1,160 ($0.58)
PM w/Fuel	$11,200 ($5.60)	$11,800 ($5.90)
PM w/o Fuel	$13,400 ($6.70)	$15,100 ($7.55)

U.S. EPA also calculated the cost per ton of emissions reduced in the year 2030 using the annual costs and emission reductions in that year alone. This number, shown in Table B.2, approaches the long-term cost per ton of emissions reduced after all fixed costs of the program have been recovered by industry leaving only the variable costs of control (and maintenance costs), and after most of the pre-control fleet has been retired.

Table B.2
Long-Term Cost-Effectiveness ($2002)
Annual Values w/o Discounting

Pollutant	Long-Term Cost in 2030 $/ton ($/lb)
NMHC+NOx	$680 ($0.34)
PM	$9,300 ($4.65)