State of California
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS

PUBLIC HEARING TO CONSIDER AMENDMENTS TO OFF-ROAD COMPRESSION-IGNITION ENGINE REGULATIONS: 2000 AND LATER EMISSION STANDARDS, COMPLIANCE REQUIREMENTS AND TEST PROCEDURES

Date of Release: December 10, 1999
Scheduled for Consideration: January 27, 2000
Agenda Item No.: 2000- -

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EXECUTIVE SUMMARY

In November 1994, the Air Resources Board (ARB) approved a State Implementation Plan (SIP) for ozone. The SIP contains measures M9 and M10, which call for new state and national emission standards for new off-road diesel engines beginning in 2005. In August 1996, ARB, the United States Environmental Protection Agency (U.S. EPA), and the manufacturers of off-road diesel engines signed a Statement of Principles (SOP) which established a progressive set of emission standards and called for harmonization of ARB and U.S. EPA off-road diesel engine regulations (62 Federal Register 200, January 2, 1997). In October 1998, U.S. EPA adopted the SOP emission standards, along with changes to the existing federal averaging, banking, and trading program (ABT), for off-road diesel engines sold in the other 49 states. This report presents the staff's proposal to amend the existing California exhaust emission standards for off-road diesel engines to harmonize with the recently adopted federal requirements, as per the SOP.

The heart of the proposal is a set of emission standards for new off-road diesel-cycle engines, which would be implemented beginning in 2000. The standards would limit emissions of oxides of nitrogen (NOx), non-methane hydrocarbons (NMHC) and particulate matter (PM). Rather than a single standard for all engine sizes, the proposal consists of different standards partitioned by the power produced by the engine. All standards are identical to those adopted by the U.S. EPA.

In addition to the emissions standards, this proposal mirrors adopted federal requirements for durability, maintenance intervals, recordkeeping, warranty periods, certification test fuel, and engine useful life periods. As a package, these requirements would help assure the air quality benefits of the proposed standards are achieved, and help ensure that the engines remain cleaner longer. Harmonization of certification and compliance procedures will facilitate the implementation of future controls, by minimizing administrative issues and ensuring a focus on the technical issues of emissions reductions.

As noted above, SIP measure M9 calls for new emission standards beginning in 2005. This proposal does not reach the 2.5 grams per brake-horsepower-hour (3.4 grams per kilowatt-hour) NOx level called for in the SIP, but the proposed emissions standards are implemented earlier, allowing greater fleet turnover by the SIP deadlines. The proposal achieves virtually the same emissions benefit as the SIP measure would in 2010, and provides benefits beyond the SIP measure in earlier years. However, the updated emissions inventory (also scheduled to be presented to the Board in January 2000) indicates that further emissions reductions from these sources will be necessary.

The staff estimates that in 2010, the statewide benefits of the proposal would be approximately 91 tons per day of NOx and 19 tons per day of NMHC, based on the proposed off-road emissions inventory. The estimated California cost-effectiveness associated with adoption of the staff's proposal would be approximately $ 0.32 per pound of NOx plus NMHC reduced. This cost-effectiveness is at the low end (i.e., not as expensive) of the range of cost-effectiveness for other adopted motor vehicle control measure costs. The staff recommends that the Board adopt the staff proposal.

I. INTRODUCTION

Despite significant improvements in California's air quality over the last forty years, more must be done to improve air quality and protect the health of those living in California. California currently has six major areas that are not in attainment with the one-hour federal ambient ozone standard. These areas are: the South Coast Air Basin, the Sacramento Metropolitan area, the San Diego Air Basin, the San Joaquin Valley Air Basin, the Southeast Desert Air Basin, and Ventura County.

Mobile source controls are vital to attainment of air quality standards, as mobile sources account for about 60 percent of ozone precursors, statewide. The California Clean Air Act (CCAA), as codified in the Health and Safety Code Sections 43013 and 43018, granted ARB the authority to control off-road mobile sources. California's plan for attaining the federal ozone ambient air quality standard, the 1994 Ozone State Implementation Plan (SIP), calls for more stringent exhaust emission standards for new off-road diesel engines.

The term "diesel" can be ambiguous, as it can refer to any engine that uses the diesel (compression-ignition) combustion cycle, or it can refer to a subset of those engines that are fueled by diesel oil. Typically, compression-ignition engines do burn diesel oil, but other fuels are sometimes used. To prevent confusion, the staff will refer to compression-ignition engines throughout this report.

Compression-ignition engines are in widespread use in off-road applications. Examples include tractors, excavators, backhoes, portable generators, irrigation pumps, welders, air compressors, scrubber/sweepers, airport service vehicles, and a wide array of other agricultural, construction and general industrial equipment. Although compression-ignition engines are also used extensively to propel locomotives and commercial marine vessels, engines in those applications are not included in this proposal. Those sources are or will be regulated in separate rulemakings by the U.S. EPA.

In summer 1996, the ARB, the U.S. EPA, and off-road compression-ignition engine manufacturers agreed that the U.S. EPA should adopt nationwide emission standards for those engines. The agreement was codified as a Statement of Principles (SOP) and signed by representatives of ARB, U.S. EPA, and various engine manufacturers (62 Federal Register 200, January 2, 1997). The text of the SOP and the signatories thereto, are included in Appendix C. Harmonization of the emissions standards and other requirements across the nation will benefit the engine manufacturers by allowing them to spread the cost of engine development and certification over a larger fleet.

In October 1998, the U.S. EPA promulgated the SOP standards for nonroad[1] compression-ignition engines (63 Fed. Reg. 56,968 (Oct. 23, 1998)). With this report, ARB staff is proposing to adopt the Tier 2 and Tier 3 national standards, as per the SOP (California has had Tier 1 emission standards in effect since 1996 for engines not preempted from state control and U.S. EPA has had substantially similar Tier 1 requirements in place since the same time). In addition to the proposed emission standards, this proposal mirrors the adopted federal requirements for equipment manufacturer flexibilities, durability period, maintenance intervals, recordkeeping, warranty period, and engine useful life period. As a package, the requirements would protect the air quality benefits of the proposed emission standards and help ensure that the engines remain cleaner for a longer period.

This proposal is designed to harmonize as closely as possible with the federal program, while maintaining the emission reduction benefits of the California program. There are some areas where staff believes it is not necessary or practical to replicate the federal requirements – specifically, with regards to the enforcement provisions. Furthermore, staff believes that further emissions controls are both necessary and technologically feasible, even though it is not proposing emissions standards that are more stringent than the federal standards at this time.

Sections I and II of this report contain the introduction and background, respectively. Section III contains a discussion on the need for the proposed emission standards. Section IV is a summary of the proposed requirements, while Section V describes the areas where the proposal differs from the federal program. The technological feasibility of the proposed program is addressed in Section VI. Section VII discusses remaining issues that arose during development of the requirements, and how they are addressed in this proposal. Section VIII describes the regulatory alternatives that were considered, and Section IX discusses the economic impacts. The environmental impacts and cost-effectiveness of the proposal then follow in Section X., as well as the cost-effectiveness analysis pertaining to the proposed requirements. Finally, Section XI summarizes the staff's findings and recommendations, followed by a list of references in Section XII.

II. BACKGROUND

This Section provides an overview of the exhaust emissions from compression-ignition engines, the current regulations for off-road compression-ignition engines, and the SIP commitments for off-road compression-ignition engines.

[1] The federal statutes and regulations refer to these engines and vehicles as "nonroad" but in this staff report the term "off-road" is most often used. This is because "off-road" is the term used in California statutes and regulations, except when referring specifically to federal sources.

A. COMPRESSION-IGNITION ENGINE EMISSIONS

In compression-ignition engines, liquid fuel is injected in the form of a mist of fine droplets that mix in the combustion chamber with air that has been heated by compression. The power output is controlled by regulating the amount of fuel injected into the combustion chamber, unlike spark-ignition engines, which regulate the amount of fuel and air entering the engine. The heat of the compressed air evaporates the fuel, which mixes with oxygen in the air. At several sites where the fuel mixes with the oxygen, the fuel autoignites due to the prevailing high temperature and pressure.

The primary pollutants of concern from compression-ignition engines are oxides of nitrogen (NOx) and particulate matter (PM). The high temperatures and excess air cause the nitrogen in the air to combine with available oxygen to form NOx. Because of the presence of excess air (and thus oxygen), hydrocarbons (HC) evaporating in the combustion chamber tend to be mostly burned, and HC and carbon monoxide (CO) are not emitted at high levels. Evaporative emissions from diesel engines are insignificant due to the low evaporation rate of diesel fuel. However, PM emissions result from the fuel that has not completely combusted. Lubrication oil that enters the cylinder also contributes to PM emissions.

B. EMISSIONS INVENTORY

Since the adoption of the 1994 SIP, the emissions inventory for compression-ignition engines has been updated. The updated inventory will also be presented to the Board for adoption in January 2000. In general, the attrition rate for older engines and the uncontrolled emissions rates have been revised to reflect improved sources of that data. The emissions information in this report is based on the updated proposed emissions inventory, unless noted otherwise.

As shown in Figures 1 and 2 below, off-road engines in 1990 emitted roughly 21 percent of the mobile source HC+NOx emissions and 46 percent of the mobile source PM10 exhaust emissions. The percentages are expected to increase with time, reaching 33 percent and 59 percent, respectively, in 2010. This increase is due to growth of off-road engine usage and the increased control of other sources. Mobile sources account for 61 percent of total HC+NOx and 4 percent of total PM10 emissions (including natural sources) in 2010.

Figure 1

Statewide Mobile Source Emissions (Tons/Day: 1990)

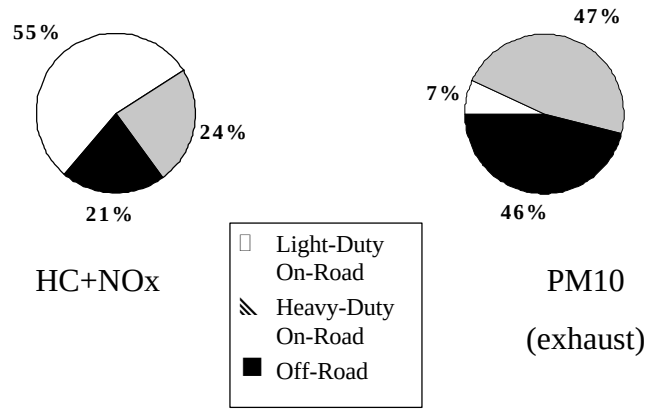
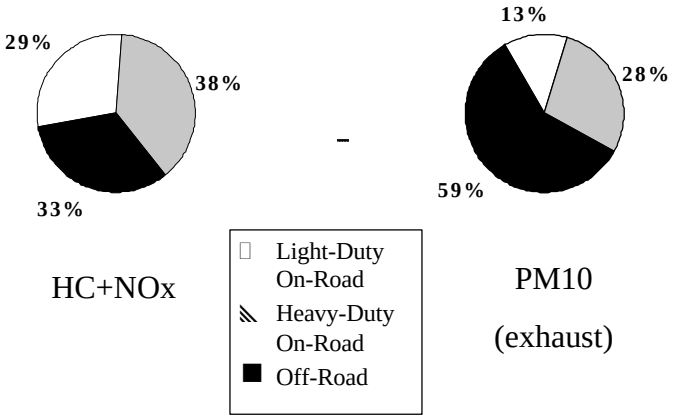


Figure 2

Statewide Mobile Source Emissions (Tons/Day: 2010)



C. CLEAN AIR ACT – PREEMPTION OF CONSTRUCTION AND FARM EQUIPMENT AND U.S. EPA AUTHORIZATION

The federal Clean Air Act Amendments of 1990 (CAA) preempt California's authority to control emissions from new farm and construction equipment under 175 horsepower (CAA Section 209(e)(1)(A)) and require California to receive authorization from U.S. EPA for controls over other off-road sources (CAA section 209 (e)(2)(A)). Because of the preemption, significant emissions from this engine category are beyond ARB's authority to regulate. Thus, since only the U.S. EPA has authority to establish emission standards for these preempt engines, the ARB staff has worked closely with U.S. EPA toward the development of a nationwide federal rule to cover all new engines in this category. This federal rule would then serve to regulate emissions from new farm and construction equipment in California in the absence of ARB's authority to do so. The federal rule and California's regulations, if adopted, will be harmonized as much as possible to minimize any confusion and expenses that could result from significantly different state and federal requirements for non-preempt engines in the near-term. Preemption, however, does not apply to existing farm and construction engines that are already in service. A list of those new engine applications considered to be subject to the federal preemption is included in Appendix B.

As with other off-road regulations, the ARB will request for these regulations U.S. EPA authorization under CAA section 209 (e) (2) (A), regarding adoption and enforcement of standards and other requirements relating to the control of emissions from the covered engines. Because the proposed regulations closely mirror the federal regulations for these engines but allow California to conduct its own enforcement programs, the California regulations will be, in the aggregate, at least as protective of public health and welfare as the applicable federal standards. In addition, the emission reductions from these proposed regulations are necessary to meet requirements under the State Implementation Plan.

D. EXISTING EMISSION STANDARDS

California is the only state that has the authority to establish off-road mobile source emission standards for new engines different from federal standards (CAA Section 209(e)(2)(A)), although Section 209(e)(2)(B) of the CAA does allow other states to adopt standards identical to California's (40 Code of Federal Regulations (CFR) 85.1601-1606). California standards must be, in the aggregate, at least as protective of public health and welfare are applicable federal standards. In 1992, the ARB approved regulations to control emissions from compression-ignition engines 175 horsepower and greater. The 175 horsepower boundary was chosen to avoid preemption issues in the implementation of the regulation, not for technical or cost-effectiveness reasons. Following the ARB's action, the U.S. EPA adopted a substantially similar program for engines 50 horsepower and greater.

Until the federal action in October 1998, which adopted the SOP emission standards, California's

emission standards for off-road compression-ignition engines 175 horsepower and greater and the federal emissions standards for those engines were aligned. However, the ARB also had adopted regulations for compression-ignition engines less than 25 horsepower, whereas the U.S. EPA had not. When the ARB last examined the small off-road engine regulations in March 1998, the emissions standards for the smaller compression-ignition engines were modified to reflect the SOP, and thus, they are already consistent with the October 1998 federal action.

Table 1, below, lists the current California emission standards for off-road compression-ignition engines. Table 2 lists the proposed future California standards that are the same as the recently-adopted U.S. EPA standards. All proposed future standards are noted in terms of grams per kilowatt-hour, rather than grams per brake horsepower-hour, to maintain consistency with the U.S. EPA[2].

Table 1
Current California Emission Standards
for Off-Road Compression-Ignition Engines
(grams per brake-horsepower hour)

Engine Power Category	Year	Emission Standard in g/bhp-hr				
		THC[a]	CO	NOx	PM	NMHC +NOx[b]
hp[c]<11	2000-2004		6.0		0.75	7.8
	2005		6.0		0.6	7.1
11≤hp[c]<25	2000-2004		4.9		0.6	5.6
	2005		4.9		0.6	5.6
175≤hp≤750	1996-2000	1.0	8.5	6.9	0.4	
	2001+	1.0	8.5	5.8	0.16	
hp>750	2000+	1.0	8.5	6.9	0.4	

Notes:

a. Total hydrocarbons.
b. NMHC + NOx = nonmethane hydrocarbons plus oxides of nitrogen.
c. The California standards for compression-ignition engines less than 25 horsepower already reflect the SOP standards. Previously, compression-ignition engines less than 25 horsepower had been regulated virtually identically to spark-ignition engines. In March of 1998, ARB took the first steps to align the smaller diesel engine requirements with the federal program. However, because the federal program had not yet been finalized, the regulations now require further modification.

[2] Kilowatts can be converted to horsepower by multiplying by 1.34. Thus, grams per kilowatt-hour can be divided by 1.34 to determine the equivalent grams per brake horsepower-hour.

Table 2
Proposed California Emission Standards
for Off-Road Compression-Ignition Engines [a]
(grams per kilowatt-hour)

Maximum Rated Power (kW)	Tier	Model Year	NOx	HC	NMHC+ NOx[e]	CO	PM
kW<8[b]	Tier 1	2000-2004	—	—	10.5	8.0	1.0
	Tier 2	2005 and later	—	—	7.5	8.0	0.80
8≤kW<19 [b]	Tier 1	2000-2004	—	—	9.5	6.6	0.80
	Tier 2	2005 and later	—	—	7.5	6.6	0.80
19≤kW<37	Tier 1	2000-2003	—	—	9.5	5.5	0.80
	Tier 2	2004 and later	—	—	7.5	5.5	0.60
37≤kW<75	Tier 1	2000-2003	9.2	—	—	—	—
	Tier 2	2004-2007	—	—	7.5	5.0	0.40
	Tier 3	2008 and later	—	—	4.7	5.0	—
75≤kW<130	Tier 1	2000-2002	9.2	—	—	—	—
	Tier 2	2003-2006	—	—	6.6	5.0	0.30
	Tier 3	2007 and later	—	—	4.0	5.0	—
130≤kW<225	Tier 1[c]	1996-2002	9.2	1.3	—	11.4	0.54
	Tier 2[d]	2003-2005	—	—	6.6	3.5	0.20
	Tier 3	2006 and later	—	—	4.0	3.5	—
225≤kW<450	Tier 1 [c]	1996-2000	9.2	1.3	—	11.4	0.54
	Tier 2[d]	2001-2005	—	—	6.4	3.5	0.20
	Tier 3	2006 and later	—	—	4.0	3.5	—
450≤kW≤560	Tier 1 [c]	1996-2001	9.2	1.3	—	11.4	0.54
	Tier 2 [d]	2002-2005	—	—	6.4	3.5	0.20
	Tier 3	2006 and later	—	—	4.0	3.5	—
kW>560	Tier 1 [d]	2000-2005	9.2	1.3	—	11.4	0.54
	Tier 2	2006 and later	—	—	6.4	3.5	0.20

Notes:

a. The proposed California standards for engines less than 130 kilowatts (175 horsepower) apply only to non-preempted equipment.
b. The Tier 1 and Tier 2 emission standards for less than 25 horsepower compression-ignition engines were already adopted in the small off-road engine rulemaking.
c. The Tier 1 emission standards were already adopted for 1996 and later engines. This proposal will modify the existing standards for 2000 and later engines, replacing them with the noted Tier 2 and Tier 3 standards.
d. The Tier 1 emission standards were already adopted for 2000 and later engines.
e. NMHC + NOx = nonmethane hydrocarbons plus oxides of nitrogen

E. STATE IMPLEMENTATION PLAN (SIP)

In November 1994, the ARB approved the State Implementation Plan (SIP) for ozone, which outlines the measures to be taken to bring the state's air quality into attainment with the federal ambient air quality standards for ozone. During the SIP's development, it became clear that reducing emissions of NOx and reactive organic gases (ROG)[3] from off-road engines and equipment operating within the state is imperative for cleaning California's air. The SIP identified several categories of off-road equipment where significant emission reduction opportunities exist, including compression-ignition engines used in off-road equipment.

SIP measures M9 and M10 call for ARB and U.S. EPA to adopt a 2.5 g/bhp-hr (3.4 g/kW-hr) NOx emission standard for new off-road compression-ignition engines beginning in 2005. The current proposal has been developed in response to M9, as the recent U.S. EPA final rulemaking for nonroad compression-ignition engines was developed in response to SIP measure M10. How the specifics of the federal action and this proposal compare to M9 and M10, and the implications regarding the SIP and attaining ozone compliance are discussed in detail in Section X.

III. NEED FOR CONTROL

The emission standards that staff is proposing to the Board for adoption, represent a major step in reducing the human health and environmental impacts of ground-level ozone and PM. This section summarizes the air quality rationale for the proposed new standards.

A. OZONE

There is a large body of evidence showing that ozone (which is created by the photochemical reaction of NOx and HC) causes harmful respiratory effects including chest pain, coughing, and shortness of breath. Among those who may be affected severely are people with compromised respiratory systems and children. In addition, NOx itself can directly harm human health. Beyond their human health effects, other negative environmental effects are also associated with

[3] Reactive Organic Gas (ROG): A reactive chemical gas, composed of hydrocarbons, that may contribute to the formation of smog . Also sometimes referred to as Non-Methane Organic Compounds (NMOCs). The ARB is primarily concerned with reducing ROG because it includes only those hydrocarbons that have the potential for reacting to form ozone.

ozone and NOx. Ozone has been shown to injure plants and materials; NOx contributes to the secondary formation of PM (nitrates), acid deposition, and the overgrowth of algae in coastal estuaries.

As described above, the 1994 Ozone SIP is California's plan for reaching statewide attainment with the ozone ambient air quality standards. The SIP calls for new measures to cut ozone precursor emissions from mobile sources to half of what the emissions would be under existing regulations. The current proposal, developed in response to SIP measures M9 and M10, would reduce both HC and NOx emissions, as well as directly-emitted PM emissions. Details are noted in Section X.

B. DIESEL EXHAUST AND PARTICULATE MATTER

In August 1998, the Board approved the identification of particulate matter from diesel exhaust as a toxic air contaminant (TAC). Section 39655 of the California Health and Safety Code defines a TAC 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." With the identification of diesel particulate as a TAC, the ARB is required by law to prepare a report, which assesses the need and appropriate degree of control of diesel particulate, in consultation with the local districts, affected industry, and the public. If reductions in exposure are needed, the ARB must design control measures that consider the issues and reduce emissions to the lowest level achievable through the application of best available control technology or a more effective control method. In the case of diesel particulate, there have been several regulations, including the emission standards for compression-ignition engines proposed in this document, that have resulted or will result in significant reductions in PM emissions from diesel engines.

Almost all of the particle mass in diesel exhaust is in the range of 10 microns or less in diameter (PM-10). PM-10, like ozone, has been linked to a range of serious respiratory health problems. These fine particles can be deposited deep in the lungs and result in health effects including premature death; increased hospital admissions and emergency room visits; increased respiratory symptoms and disease; decreased lung function, particularly in children and individuals with asthma; and alterations in lung tissue and in respiratory tract defense mechanisms. The proposal will require greater control of PM emissions from off-road compression-ignition engines than is currently required. Note that no PM emission standard is proposed at this time for Tier 3 engines. As part of a technology feasibility review in 2001, committed to as part of the SOP, the U.S. EPA and ARB will propose a Tier 3 PM standard. More stringent NMHC + NOx standards may also be considered at that time. More stringent standards will become more practicable, for instance, as the sulfur content of diesel fuel is reduced, since sulfur is one of the primary factors preventing aftertreatment devices such as catalysts and particulate traps from being applied to

these engines. The ARB will be involved in the feasibility review, which is described in further detail in Section IV. B.3. – Future Feasibility Review. The effects of fuel sulfur content are discussed in Section VI. B.6 – Aftertreatment.

In addition to the directly-emitted PM, secondary nitrate PM (consisting mostly of ammonium nitrate) accounts for a substantial fraction of the airborne particulate matter in some areas of California. For example, in the Los Angeles Basin, secondary nitrate PM levels represent about 25 percent of measured PM-10 (U.S. EPA 1997a). Fine secondary nitrate particles are produced in the atmosphere from the NOx emitted by compression-ignition engines and other sources. Because it is formed from a gaseous component that can spread more quickly than primary PM, secondary PM tends to be a regional, rather than a strictly local problem. Regional-scale NOx controls, like the proposed off-road compression-ignition engine emission standards, are very effective in reducing secondary PM over a significant area.

Although the proposal will reduce ozone precursor emissions as well as PM emissions, the proposal is not the last word regarding control of emissions from these engines. The use of compression-ignition equipment is widespread, covering virtually all populated areas in California. Combined with the serious health effects of the pollutants emitted from those engines, this ubiquity makes it clear that further control of emissions from compression-ignition engines will be required to safeguard the public health. The ARB staff has already begun evaluating additional controls as part of its response to the identification of diesel particulate as a toxic air contaminant, as mentioned above.

IV. SUMMARY OF PROPOSED REGULATIONS

The staff recommends that the Board amend sections 2111, 2112, 2137, 2139, 2140, 2141, 2400, 2401, 2403 (with referenced test procedures), 2420, 2421, and 2423-2427, Title 13, California Code of Regulations, as set forth in Attachments 1 and 2. The proposed regulatory language will essentially mirror the federal regulations adopted in 1998, except for some areas, which are discussed in detail in Section V. Although the California and federal programs for compression-ignition 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 August 1996, ARB signed the SOP that calls for harmonization of ARB and U.S. EPA regulations for off-road compression-ignition engines. This first step will result in lower-emission off-road vehicles and equipment being introduced nationwide. However, California's special air quality problems will continue to require ARB to seek additional

emission reductions in order to meet air quality goals. Future review of the feasibility of the proposed new emission standards will be needed. This review will likely result in a staff proposal for the adoption of appropriate Tier 3 standards for PM and Tier 4 standards for NOx and PM.

Today's proposal would require new off-road compression-ignition engines to meet stringent exhaust emission standards for NMHC + NOx, CO, and PM. Implementation of these standards would begin with the 2000 model year, but phased-in based on the engine power category. Staff proposes that the Board allow participation in the federal averaging, banking, and trading (ABT) program for compression-ignition engines and adopt new useful life extensions, maintenance intervals, emission warranty periods, rebuild provisions for compression-ignition engines, in-use compliance testing, and the Selective Enforcement Auditing program. Staff also proposes provisions for implementation flexibility for equipment and vehicle manufacturers and post-manufacture marinizers (i.e., those who produce marine engines by modifying engines purchased from other engine manufacturers). Staff further proposes optional reduced-emission standards and labeling requirements for compression-ignition engines ("Blue Sky Series"). The following sections discuss the major provisions of the staff proposal in further detail.

A. APPLICABILITY

At the core of this proposal are the emission standards that would apply to new off-road compression-ignition engines used in a variety of off-road vehicles and equipment. For this proposal, compression-ignition applies to those 2000 model year and later engines typically with operating characteristics significantly similar to the theoretical "diesel" combustion cycle, which includes any alternate-fueled compression-ignition engines. All the provisions in this proposal apply to off-road compression-ignition engines produced for sale in California, except for engines with a per cylinder displacement of less than 50 cubic centimeters, engines used to propel locomotives, underground mining equipment, marine vessels (propulsion engines rated at 37 kW and greater), aircraft, other preempt equipment, and off-road military tactical vehicles or equipment that have been exempted from regulations under the federal national security exemption.

Specific provisions of this proposal are:

- Emission standards for NMHC + NOx, CO, and PM would apply to new off-road compression-ignition engines beginning with the 2000 model year, being phased-in by power category.

- Emission standards aligned with the federal standards for small off-road compression-ignition engines less than 25 horsepower (19 kilowatts) have already been adopted. This proposal will not modify the existing standards. However, the small off-road engine regulations will be amended to exclude 2000 model year and later small off-road compression-ignition engines; procedural changes will be made to consolidate these

engines with all off-road compression-ignition engines subject to the provisions of this proposal.

- Amendment of closed crankcase requirements to begin with Tier 2 off-road compression-ignition engines, except turbocharged petroleum-fueled diesel cycle engines.

- Amendment to the smoke standards for new 2001 and later model-year heavy-duty off-road diesel cycle engines 175 to 750 horsepower (130 to 560 kilowatts) to align with federal smoke standards; adoption of smoke standards for all new off-road compression-ignition engines with the exception of single-cylinder, propulsion marine diesel, and constant-speed engines.

- New voluntary reduced-emission standards for compression-ignition engines ("Blue Sky Series") would be available beginning in 2000 through 2004. This proposal is the same as the federal program.

- New labeling requirements would apply to engines certified to optional standards and constant-speed engines; amendments to labeling requirements would apply to heavy-duty off-road diesel cycle engines and small off-road compression-ignition engines.

- Amendment to the test procedures to incorporate federal changes. Provisions requiring federal fuel to be used for off-road compression-ignition engine certification would apply beginning in 2000.

- New or revised useful life extensions, deterioration factors, maintenance intervals, emission warranties, in-use compliance testing/recall, and rebuild/replacement provisions would apply to new off-road compression-ignition engines.

- Incorporation of the federal Selective Enforcement Auditing program for new engine compliance, and incorporation of compression-ignition engines into the existing California in-use compliance and recall program beginning in 2000, in place of the existing new engine compliance and quality audit testing programs.

- Participation in the federal Averaging, Banking, and Trading (ABT) program (40 CFR 89.111) would be allowed for California-certified off-road compression-ignition engines upon adoption of this regulation.

- Implementation flexibilities for vehicle/equipment manufacturers and post-manufacture marinizers.

B. EMISSION STANDARDS

1. Proposed Mandatory Emission Standards

Staff proposes that the Board adopt NMHC + NOx, CO and PM emission standards for all off-road compression-ignition engines as outlined in Section IV. A. – Applicability. These standards would apply to model year 2000 and later, with the standards being phased-in by horsepower category. Current emission standards (Tier 1) for heavy-duty off-road diesel cycle engines 175 to 750 horsepower (130 to 560 kilowatts) would continue to apply until more stringent emission standards apply (Tier 2 and 3). Currently adopted emission standards for small off-road compression-ignition engines are the same as the recently promulgated federal regulations. Therefore, there will be no change to the current emission standards for this category. Tables 1 and 2 list the current California emission standards for off-road diesel engines and the proposed emission standards, respectively.

Staff proposes to amend the regulations to require closed crankcase requirements for Tier 2 and later off-road compression-ignition engines, except for petroleum-fueled engines using turbochargers, pumps, blowers, or superchargers for air induction. This provision will align closed crankcase control requirements with federal requirements.

Staff proposes to amend the smoke standards for new 2001 and later model-year heavy-duty off-road diesel cycle engines 175 to 750 horsepower (130 to 560 kilowatts) to align with federal smoke standards. With the adoption of this regulation smoke standards would apply to all new off-road compression-ignition engines subject to exhaust emission standards with the exception of single-cylinder engines, propulsion marine diesel engines, and constant-speed engines.

By 2020, the proposed standards reduce emissions for NOx and NMHC by more than 50 percent and PM by more than 40 percent, nationwide. Reductions in NOx will also reduce secondary nitrate PM. The resulting emission reductions will translate into needed improvements in air quality in California and assist in attaining applicable ambient air quality standards.

2. Proposed Voluntary Reduced-Emission Standards

To continue support of incentive programs that encourage the use of engines that go beyond mandatory emission standards, the staff proposes that the Board adopt the proposed voluntary reduced-emission standards through 2004, as shown in the following table.

Table 3 - Voluntary Emission Standards Through 2004
(grams per kilowatt–hour)

Maximum Rated Power (kW)	NMHC + NOx	PM
kW<8	4.5	0.5
8≤kW<19	4.5	0.5
19≤kW<37	4.5	0.36
37≤kW<75	4.7	0.24
75≤kW<130	4.0	0.17
130≤kW≤560	4.0	0.12
kW>560	3.8	0.12

Manufacturers may opt to certify engines to these voluntary standards earning the designation of a "Blue Sky Series" low-emitting engine. Tier 3 emission levels, where applicable, were chosen as the best level for defining Blue Sky Series engines. This represents a reduction of approximately 40 percent beyond the Tier 2 NMHC + NOx levels. For PM emissions and for engines with no Tier 3 standards, a calculated level corresponding to a 40 percent reduction beyond Tier 2 levels will be used to qualify as a Blue Sky Series engine. Engines certified to these voluntary standards would be eligible for marketable credit programs. The manufacturer must declare at the time of certification whether it is certifying an engine family to an optional reduced-emission standard (that could subsequently be used in a marketable credits program).

3. Future Feasibility Review

Staff also proposes that the Board allow for review of the new emission standards. Staff believes the proposed emission standards are technologically feasible, and achievable. However, as part of the SOP, U.S. EPA and ARB agreed to a future review of the proposed standards. U.S. EPA will conduct its review in 2001, and ARB staff will participate. ARB may elect to conduct its own review to reassess the appropriateness of the standards specific to California, and the technical and economic feasibility of the standards, based on information available in 2001.

With the recent identification of diesel PM as a TAC, the importance of further reducing the public's exposure to PM emissions has become more paramount. As previously indicated, staff expects that future review of the standards will likely result in a proposal for the adoption of appropriate Tier 3 standards for PM, Tier 4 standards for NOx and PM, and possibly standards for existing engines already in-use.

The Board's final review would take place after U.S. EPA completes its 2001 review, and would determine what changes, if any, would be required for California. If due to new information the proposed standards are determined not to be technologically feasible, staff would propose appropriate levels at a future date. The standards proposed herein, if adopted by the Board, would stay in effect until revised.

C. CERTIFICATION

1. Definition of Compression-Ignition

The requirements of this rulemaking will apply to all compression-ignition engines subject to California regulations as outlined in Section IV. A. – Applicability. Most current compression-ignition engines burn diesel fuel and operate over the conventional diesel cycle, which generally allows interchangeable use of the terms "compression-ignition," "diesel-cycle," and "diesel." Some of these engines, however, can be modified to operate on other fuels such as natural gas or liquefied petroleum gas. This definition will serve to include all fuel types that fall under the compression-ignition engine category and will be applicable beginning with the 2000 model year.

2. Labeling

The proposed language for new and replacement off-road compression-ignition engine labels will align California with the federal requirements, except that the label must state that the engine complies with both California and U.S. EPA regulations. Also, new labeling requirements would apply to engines certified to optional standards and constant-speed engines. It is proposed that engines certified to the optional emission standards be labeled as "Blue Sky Series" and constant-speed engines labeled as "constant-speed only."

3. NMHC Test Method

Beginning with the 2000 model year, staff proposes two options for NMHC measurement procedures: 1) use of a measurement procedure selected by the manufacturer with prior approval of the Executive Officer; or 2) subtraction of two percent from the measured THC value to obtain a NMHC value. The methodology must be specified at the time of certification and will remain

the same for the engine family throughout the engines' useful life. These proposed amendments would align the NMHC test methods with the federal test methods recently adopted.

4. Certification Test Fuel

The regulations for 1996 and later model year heavy-duty off-road diesel cycle engines included a provision to allow manufacturers the option of certifying on California diesel fuel. Since California diesel fuel is cleaner burning than federal fuel, this option has been beneficial to engine manufacturers. This option was provided to help manufacturers meet the emission standards for a newly regulated mobile source category. After adoption of this rulemaking, emission standards for California-certified off-road compression-ignition engines will be the same as federal standards. It is proposed that the test procedures be amended to require that all off-road compression-ignition engines be certified on federal fuel beginning in 2000.

5. Test Procedures

Current test procedures will continue to apply through 1999. Amendments to the test procedures are proposed for 2000 and later model year compression-ignition engines that are equivalent to the International Organization for Standards[4] (ISO) test cycles (Attachment 5). The proposed emission standards are based on the use of existing steady-state (modal) test procedures. New steady-state test cycles are specified for constant-speed engines, marine propulsion engines, and engines rated less than 19 kilowatts. The following describes the proposed selection of various test cycles.

Compliance with emission standards is determined by measuring emissions while operating engines over a prescribed test cycle. The current regulations specify a cycle that is nominally the same as the ISO 8178 C1 test cycle as the principle test cycle for measuring emissions from engines 175 horsepower (130 kilowatts) and greater. It is proposed that the C1 test cycle be retained for most engines and that additional cycles be defined for specific engine types. Engines that are limited by design to constant-speed operation would be subject to testing using a test cycle equivalent to the ISO 8178 D2 cycle. This cycle, which omits idle and intermediate-speed modes from the C1 cycle, is representative of engines such as generators, which are designed never to run at these omitted speeds. Because of the more limited range of engine operation in the D2 cycle, manufacturers must ensure that engines certified with data generated with the D2 cycle are used exclusively in constant-speed applications. Accordingly, these engines would include labeling information indicating this limited emission certification.

[4] ISO is an international organization of engineers and scientists who work to develop appropriate and consistent standards and procedures.

For variable-speed engines rated less than 19 kilowatts, it is proposed that the regulations continue to specify a test cycle that is equivalent to the ISO 8178 G2 cycle. The G2 cycle includes the same modes as the D2 cycle and adds a mode for operation at idle. The G2 and D2 cycles also have different weighting factors for the various modes. The G2 cycle was developed to represent the operation of small compression-ignition engines used primarily at rated speed, such as in lawn and garden applications, generators, pumps, welders, and air compressors. Staff proposes to specify a test cycle equivalent to the ISO 8178 E3 cycle for testing propulsion marine engines rated less than 37 kilowatts. The E3 cycle, which consists of engine operation at four different engine speeds and four different loads, was developed by ISO to represent the operation of propulsion marine engines. Auxiliary marine engines subject to this rule (i.e., engines installed on a marine vessel, but not used for propulsion) would be tested using either the G2, C1, or D2 test cycles, consistent with the constraints described above for the counterpart land-based off-road engines.

Finally, staff recommends that manufacturers generally be allowed to use the C1 test cycle to generate certification data for engines otherwise required to use the D2 or G2 test cycle. Staff also proposes to allow manufacturers to use the C1 test cycle to generate certification data for propulsion marine engines where such engines are included in a land-based engine family. In each of these cases in which the manufacturer elects to use the C1 cycle, ARB would retain its ability to test using the respective G2, D2, or E3 test cycle, but would also be able to test using the C1 test cycle.

D. DURABILITY AND WARRANTY PROVISIONS

To achieve the full benefit of the emissions standards, programs are necessary to encourage manufacturers to design and build engines with durable emission controls and encourage proper maintenance and repair of engines throughout their lifetime. The goal is for engines to maintain good emission performance throughout their life in-use.

Currently, there are few requirements in the regulations that address deterioration concerns for off-road compression-ignition engines. As tighter standards are put into place, staff believes that it becomes necessary to adopt measures to address concerns about possible in-use emission performance degradation. The adoption of durability demonstration requirements and the revision of warranty provisions that parallel the U.S. EPA's provisions would help ensure adequate durability and proper maintenance of the engine and emission controls.

1. Useful Life Extension/Warranty Provisions/Recall Testing Periods

In order to align this proposal with the federal provisions, staff proposes the Board adopt a useful life period of 8,000 hours or ten years of use for all engines rated at 37 kilowatts and greater; 5,000 hours or seven years of use for engines rated at 19 kilowatts and greater, but less than 37 kilowatts; and 3,000 hours or five years of use for constant-speed engines rated less than 37 kilowatts with rated speeds greater than or equal to 3,000 rpm. The useful life period for engines rated less than 19 kilowatts will remain unchanged at 3,000 hours or five years of use.

For warranty, the Board has already adopted periods of two years for engines rated less than 19 kilowatts; and 3,000 hours or five years of use for engines 130 kilowatts and greater. Proposed changes to these provisions, in order to align with federal requirements, include: 1) the addition of a 1,500 hour warranty period for engines rated less than 19 kilowatts; 2) 1,500 hours or two years of use for constant-speed engines rated less than 37 kilowatts with rated speeds greater than or equal to 3,000 rpm; and 3) for all other engines 3,000 hours or five years of use. Current requirements for warranty language that manufacturers are to provide for consumers is proposed to be amended to align with federal warranty language.

Federal provisions for recall testing periods were based on the ratio of useful life and liability periods established for engines rated at or above 37 kilowatts. The purpose of having liability periods that are shorter than the useful lives is to ensure that engines used in recall testing are not statistical outliers with poor emissions durability. However, if a recall were ordered, all engines in that family would be subject to the recall regardless of their age. The following recall testing periods are proposed for adoption in order to align with federal requirements: 1) 2,250 hours or four years for engines rated less than 19 kilowatts and constant-speed engines rated less than 37 kilowatts with rated speeds greater than or equal to 3,000 rpm; 2) 3,750 hours or five years for all other engines rated at 19 kilowatts and greater, but less than 37 kilowatts; and 3) 6,000 hours or seven years for all engines rated at 37 kilowatts and greater.

2. Selective Enforcement Audit and In-Use Compliance/Recall Programs

The U.S. EPA has a Selective Enforcement Audit program to ensure that actual production engines meet the emission standards. California has its own new engine compliance program which is similar, but allows the ARB to independently ensure that new engines intended for sale in California are meeting the emission standards. In order to align with federal requirements, staff proposes to adopt the federal Selective Enforcement Audit program for 2000 model year and later off-road compression-ignition engines. However, small off-road compression-ignition engines (less than 19 kilowatts or 25 horsepower) will continue to comply with Section 2407, Title 13, California Code of Regulations, through 1999. ARB reserves the right to order a Selective Enforcement Audit of a new engine being sold in California. However, in any case, ARB would

limit the number of Selective Enforcement Audit test orders to the annual limit in the regulations. The annual limit is determined to be the larger of either 1) Production factor, determined by dividing the projected off-road engine sales in the United States for that model year by 16,000 (if the projected sales are less than 8,000, this factor is one); or 2) Family factor, determined by dividing the manufacturer's total number of certified engine families by five. When the annual limit has been met, ARB may issue additional test orders to test those families for which evidence exists indicating noncompliance. In addition, manufacturers shall supply upon request emission test results from U.S. EPA-directed audits for engines certified in California.

The U.S. EPA has in-use testing and recall procedures in place to ensure that certified engines meet the emission standards over the useful life of the engine. California adopted its own in-use compliance and recall program for on-road vehicles and certain off-road vehicles under Articles 2.1 – 2.3, Chapter 2, Title 13, California Code of Regulations. Staff has proposed that the California In-Use Compliance/Recall Program be extended to all 2000 and later model year off-road compression-ignition engines certified for use in California.

3. Emission Defect Reporting Requirements

Staff is proposing that the emission defect reporting requirements for 2000 and later model year California off-road compression-ignition engines be the same as the federal requirements. The specific federal sections that describe the reporting requirements are outlined in the California Exhaust Emission Standards and Test Procedures for New 2000 and Later Off-Road Compression-Ignition Engines, Part I-B (Attachment 4).

4. Deterioration Factors

California regulations do not currently require off-road diesel engines 175 horsepower (130 kilowatts) or greater to accumulate operating time on durability data engines or to generate deterioration factors for engine certification. This is because the focus was on reductions in NOx emissions, requiring emission control technologies that were not expected to deteriorate. The degree of emissions control stability can be attributed to the fact that diesel engine manufacturers have met emission standards through internal improvements to the engine and fuel systems, rather than relying on aftertreatment and other devices that would be more susceptible to in-use degradation.

As NOx, NMHC, and PM standards are made more stringent and off-road compression-ignition engine manufacturers introduce new technologies solely for emission control purposes, such as aftertreatment, sophisticated fuel delivery controls, and exhaust gas recirculation (EGR), long-term emissions performance becomes a greater concern. In addition, emission deterioration characteristics are not well known for aftertreatment, EGR, and other more sophisticated emission control strategies.

Staff proposes that the Board adopt provisions for deterioration to align with federal requirements. As proposed, the application of deterioration factors (DFs) would apply to all engines covered by this rulemaking. The DF is a factor applied to the certification emission test data to represent emissions at the end of the useful life of the engine. Separate DFs apply to each measured pollutant, except that a combined NMHC + NOx DF applies to engines that do not use aftertreatment devices. Decreasing emissions of one pollutant over time would not be allowed to offset increasing emissions of the other pollutant in this combined DF.

It is not the intent to force a great deal of data gathering on engines using established technology for which the manufacturers have the experience to develop appropriate DFs. New DF testing may not be needed where sufficient data already exist. The main interest is that technologies with unproven durability in off-road applications, such as EGR, are demonstrated to meet emission requirements throughout their useful lives. However, because this rule proposes to create a program that will introduce new standards and new technologies over many years, the DF requirement is being proposed for all engines so that ARB can be sure that reasonable methods are being used to ascertain the capability of engines to meet standards throughout their useful lives.

Similar to the provisions for on-road engines, staff proposes to allow the off-road engine manufacturers the flexibility of using durability emission data from a similar engine that has either been certified to the same standard or for which all of the data applicable for certification has been submitted. In addition, staff proposes to extend this flexibility to allow deterioration data from on-road engines to be used for similar off-road engine families.

Furthermore, staff proposes that, for engines using established technology for which the manufacturers have the experience to determine appropriate deterioration factors, good engineering analysis be allowed in place of actual service accumulation. For instance, in the case where no durability data exist for a certain engine but both smaller and larger engines using similar technology have been shown not to deteriorate for NOx in use, it would be possible to build a case showing no NOx deterioration for that engine. It is proposed that engines be considered as using established technologies if they do not meet the Tier 3 emission standards, unless they use EGR or aftertreatment devices. In addition, staff proposes that manufacturers of engines that do meet the Tier 3 standards but have technologies similar to those employed in Tier 2 designs may also rely on engineering analysis in lieu of actual service accumulation, with prior Executive Officer approval. This proposal is essentially the same as that adopted by U.S. EPA.

5. Emissions Related Maintenance

Staff proposes changes to the minimum allowable maintenance intervals for engines 130 kilowatts and greater and the addition of minimum allowable maintenance intervals for all off-road compression-ignition engines. These provisions would align California regulations with federal requirements. The following amended minimum intervals being proposed for adjustment, cleaning, repair, or replacement of various components are as follows:

At 1,500 hours, and 1,500-hour intervals thereafter:

1. EGR related filters and coolers
2. Positive crankcase ventilation valve
3. Fuel injector tips (cleaning only)

At 3,000 hours, and 3,000-hour intervals thereafter for engines rated less than 130 kilowatts or 4,500-hour intervals thereafter for engines rated 130 kilowatts and greater:

1. Fuel injectors
2. Turbocharger
3. Electronic engine control unit and its associated sensors and actuators
4. PM trap or trap-oxidizer system
5. EGR system (including all related control valves and tubing)
6. Catalytic converter
7. Any other add-on emissions-related component

Add-on emission-related components are those whose sole or primary purpose is to reduce emissions or whose failure will significantly degrade emission control, yet not significantly affect the performance of the engine.

In addition, the following components are defined as critical emission-related components:

1. Catalytic converter
2. Electronic engine control unit and its associated sensors and actuators
3. EGR system (including all related filters, coolers, control valves and tubing)
4. Positive crankcase ventilation valve
5. PM trap or trap-oxidizer system
6. Any other add-on emissions-related component

If maintenance is scheduled on critical emission-related components in-use, it will be required that the manufacturer show the reasonable likelihood that the maintenance will, in fact, be performed in use. The regulations list options for this demonstration, including showing that

performance would degrade without maintenance, providing survey data showing that the maintenance is performed, using a visible signal system, offering free maintenance, and other methods approved by the Executive Officer. These special provisions do not apply to critical emission-related components for which no maintenance is specified over the useful life of the engine.

6. Rebuild Provisions

A remanufactured engine must be rebuilt equivalently from an emissions standpoint, to the original certified engine. As a means of preventing tampering, staff proposes that the Board adopt rebuild requirements for all off-road compression-ignition engines subject to the Tier 2 or subsequent standards and regulations. The proposed rebuild requirements would be the same as those adopted in the federal regulations.

Staff believes that the proposed rebuild requirements are commonly accepted practices and would not add a significant additional burden on rebuilders. The staff's proposal would require that rebuilders have a reasonable technical basis for knowing that the rebuilt engine is equivalent from an emissions standpoint to a certified configuration. That is:

- the model year(s) of the engine configuration must be identified;
- replacement parts used when rebuilding an engine, whether the part is new, used, or rebuilt, must perform the same function with respect to emissions control as the original part; and
- parameter adjustments or design changes must be made only in accordance with the original engine manufacturer's instructions, without affecting in-use emissions.

Secondly, staff proposes that when an engine is being rebuilt and remains installed or is reinstalled in the same vehicle, it must be rebuilt to a configuration of the same or later model year as the original engine. In addition, when an engine is being replaced, the replacement engine must be an engine of (or rebuilt to) a configuration of the same or later model year as the original engine. Lastly, when conducting an in-frame rebuild or the installation of a rebuilt engine, all emissions-related components must be checked and cleaned, repaired, or replaced where necessary, following manufacturer recommended practices.

At the time of rebuild, emissions-related codes or signals from any on-board monitoring systems may not be erased or reset without diagnosing and responding appropriately to the diagnostic codes. Furthermore, such signals may not be rendered inoperative during the rebuilding process. All codes must be responded to and the problems corrected before the rebuilt engine is returned to service.

Different parties may perform different tasks during the engine rebuilding process. For example, one party may rebuild engine components, while another is responsible for full engine assembly and installation. Staff therefore proposes that individual parties have full responsibility for only the activities they are conducting and have control over. Furthermore, the party responsible for supplying a rebuilt engine would not be allowed to supply a replacement engine that is not rebuilt to a certified configuration of the same or later model year as the trade-in engine.

7. Rebuild Record Keeping Requirements

Staff proposes that the Board adopt requirements consistent with the federal record keeping requirements. These requirements are consistent with customary business practices, and will assist in assessing compliance with the new rebuild provisions. The records would be kept by persons involved in the process of off-road engine rebuilding or remanufacturing. Records would include the following:

- Mileage and/or hours at the time of rebuild;
- A list of the work performed on the engine;
- Any repair of emission control systems, including a list of replacement parts used, engine parameter adjustments, and design element changes;
- Emissions-related codes and equipment monitoring signals that are responded to and reset; and
- Responses to such signals and codes, and work performed as described in the rebuild provisions above.

Staff proposes that records be kept for two years after the engine is rebuilt. The records may be kept in a format or system of the rebuilder's choice. Parties are not required to keep information that they do not have access to as part of normal business practices.

For rebuilders, if it is customary practice to keep records for engine families rather than specific engines, such record keeping practices would satisfy these requirements. Rebuilders can use records that they keep for the engine families being rebuilt, rather than for individual engines, provided each engine is rebuilt in the same way to those specifications. Records could include build lists, parts lists, engineering parameters, etc.

In addition, rebuilders are only required to keep information on individual emissions-related diagnostic codes if the codes are addressed through a set of procedures that are not considered to be uniform. For example, if an engine is equipped with a sensor that monitors the EGR flow rate,

the rebuilder may keep on record the specifications and procedures used to rebuild the EGR system in all instances. It is a general practice that engine remanufacturers keep these types of records in order to control the quality of their products.

E. AVERAGING, BANKING, AND TRADING PROGRAM

Federal regulations provide for an ABT program in the other 49 states. The federal ABT program was modified as part of the October 1998 federal rulemaking for compression-ignition engines to provide manufacturers additional flexibility in meeting lower federal NMHC + NOx, and PM standards. The federal ABT program applies to all off-road compression-ignition engines subject to the regulations, and contains a family emission limit (FEL) approach, discussed in the following section, for determining ABT credits generated for averaging, banking, and/or trading.

California does not currently allow participation in the federal ABT program. However, in order to more closely align with federal regulations, staff proposes the Board adopt regulations to allow California participation in the recently revised federal ABT program. Participation in ABT would apply to all off-road compression-ignition engines subject to California regulations as outlined in Section IV. A. – Applicability; manufacturers participating in the ABT program would be allowed to trade ABT credits throughout California and the other 49 states.

The ABT program is designed to provide engine manufacturers flexibility in meeting applicable emission standards. It would also encourage the early introduction of cleaner engines, thus securing earlier emissions benefits. Under the ABT program, manufacturers would average emissions across engine families to determine compliance with the applicable standard. If average engine family emissions are below the applicable standards, a manufacturer could generate ABT credits, and unused or excess ABT credits could be banked for future use. Excess ABT credits could also be traded or sold to other engine manufacturers participating in the ABT program. If average emissions are above the applicable standard, manufacturers could use their own, or purchase ABT credits to meet the applicable emission standards. Manufacturers choosing to certify engines to the Blue Sky Series standards, however, would not be allowed to include those engines in the ABT program.

1. General ABT Provisions for Compression-Ignition Engines

Staff is proposing that the Board adopt the federal ABT program provisions to allow California participation. Since the proposed ABT program for use in California is identical in nature to the federal program, staff is not providing an exhaustive explanation of the specific requirements for each power category of compression-ignition engines. The proposed ABT program provisions can be found in the "California Exhaust Emission Standards and Test Procedures for New 2000 and Later Off-Road Compression-Ignition Engines, Part I-B" which references the federal program.

2. Generating ABT Credits Using the Family Emission Limit (FEL)

The FEL is an emission limit that the engine manufacturer selects for each engine family in its fleet. Generally, the FEL is based on an emission level that the manufacturer is confident a particular engine family could test to and meet over the useful life of the engine. Staff proposes that ABT credits be calculated based on an FEL declared by the engine manufacturer for each engine family.

Separate FEL declarations would be required for each engine family. To be eligible to generate credits in the ABT program, FELs would be declared below the adopted emission standard. The FEL must be based on an emission level calculated for the useful life of the engine family. Engine manufacturers with FELs established below the adopted emission standards would have ABT credits available to average, bank, trade or combination thereof. Manufacturers declaring FELs above the applicable standard would use or obtain ABT credits to address the excess emissions. The proposed upper limits to the FEL values that may be declared are shown in the following table.

Table 4 – Upper Limit for Family Emission Limits (FEL)
(grams per kilowatt–hour)

Maximum Rated Power (kW)	Tier	Model Year	NOx	NMHC + NOx	PM FEL
kW<8	Tier 1	2000-2004	—	16.0	1.2
	Tier 2	2005 and later	—	10.5	1.0
8≤kW<19	Tier 1	2000-2004	—	16.0	1.2
	Tier 2	2005 and later	—	9.5	0.80
19≤kW<37	Tier 1	2000-2003	—	16.0	1.2
	Tier 2	2004 and later	—	9.5	0.80
37≤kW<75	Tier 1	2000-2003	14.6	—	—
	Tier 2	2004-2007	—	11.5	1.2
	Tier 3	2008 and later	—	7.5	
75≤kW<130	Tier 1	2000-2002	14.6	—	—
	Tier 2	2003-2006	—	11.5	1.2
	Tier 3	2007 and later	—	6.6	
130≤kW<225	Tier 1	1996-2002	14.6	—	—
	Tier 2	2003-2005	—	10.5	0.54
	Tier 3	2006 and later	—	6.6	
225≤kW<450	Tier 1	1996-2000	14.6	—	—
	Tier 2	2001-2005	—	10.5	0.54
	Tier 3	2006 and later	—	6.4	
450≤kW≤560	Tier 1	1996-2001	14.6	—	—
	Tier 2	2002-2005	—	10.5	0.54
	Tier 3	2006 and later	—	6.4	
kW>560	Tier 1	2000-2005	14.6	—	—
	Tier 2	2006 and later	—	10.5	0.54

F. FLEXIBILITY PROVISIONS

In implementing the new standards, staff's intention is to avoid unnecessary hardship for equipment manufacturers (sometimes referred to as original equipment manufacturers or OEMs), who install diesel engines in their products. Engine suppliers may not always provide adequate lead time for the equipment redesigns needed to accommodate engine design changes such as mounting locations and heat rejection loads. For some OEMs, even timely information on the new engine designs may not be sufficient because of the sheer volume of redesign work needed to change diverse product offerings with limited engineering staffs.

In response to these concerns, staff proposes that the Board adopt an OEM transition program, which would be the same as the federal program, to provide equipment manufacturers with some flexibility in transitioning to the new standards. It is recognized that new emission standards may create challenges for engine and equipment manufacturers beyond simply developing low-emission technologies. As specified and agreed to in the SOP, some form of implementation flexibility was needed in order to gain the desired air quality benefits as early as possible while still addressing manufacturers' concerns. The OEM transition program consists of four major elements, each directed at a specific need. Although they involve certain planning and recordkeeping responsibilities if taken advantage of, all of these elements are voluntary. The elements of the proposed program, which are identical to the federal program, are 1) a percent-of-production allowance, 2) a small-volume allowance, 3) continuance of the Tier 1 allowance to use up existing inventories of engines, and 4) availability of hardship relief. Each of these is discussed in detail below.

1. Percent-of-Production Allowance

Each equipment manufacturer would be able to install engines not certified to the proposed new emission standards in a limited percentage of equipment produced for the U.S. market. This percentage applies separately to each power category and is expressed as a cumulative percentage of 80 percent over the 7 years beginning when the Tier 2 standard first applies in the category (Tier 1 for power categories less than 37 kW). No exemptions are allowed after the seventh year. For example, an OEM may exempt 40 percent of its 2003 production of equipment that use engines rated between 130 and 225 kilowatts, 30 percent of its 2004 production, and 10 percent of its 2005 production. If the same OEM were to produce equipment using engines rated between 8 and 19 kilowatts, a separate cumulative percentage allowance of 80 percent would apply to these equipment during the seven years beginning in 2000. Staff proposes to allow equipment manufacturers to participate in this program, but must comply with the Enforcement and Recordkeeping Requirements outlined in Section F. 5. below.

It is recognized that the 80 percent exemption allowance, were it to be used to its maximum extent by all OEMs, would bring about the introduction of cleaner engines later than would have occurred if the new standards were to be fully implemented on their effective dates. Although there is no way of knowing at this time how many exempted engines will be produced, staff believes it will be substantially less than the allowance. Many engine designs being planned for the new standards will fit the equipment with little change. Also, the desire of engine manufacturers to avoid producing two engine designs that, from an applications perspective, are redundant, will prompt them to change over to the new designs as quickly as they can accommodate their customers' needs.

Equipment that uses engines built before the standard goes into effect needs not be included in the exemption count. Engines that produce emissions at higher levels than the standards, but for which the engine manufacturer uses ABT program credits to demonstrate compliance, count as complying engines. In power categories rated at 37 kilowatts and greater, the exempted engines must comply with Tier 1 standards. In power categories rated below 37 kilowatts, the exempted engines may be uncontrolled. This is consistent with U.S. EPA requirements.

In addition, ARB is requiring the engine manufacturers to have, available upon request, a list of equipment manufacturers that plan to and have received engines under this and the other flexibility provisions. The list should include the manufacturer name, engine models, and production volumes. When needed, this recordkeeping requirement will provide ARB with information to track these flexibility programs.

2. Small Volume Allowance

The percent-of-production approach described above may provide little benefit to small businesses[5] focused on a small number of equipment models. Therefore, staff proposes that equipment manufacturers be allowed to participate in a small volume allowance program, but must comply with the Enforcement and Recordkeeping Requirements outlined in Section F. 5. below. Equipment manufacturers would be allowed to exceed the percent-of-production allowances described above during the same years affected by the allowance program for general applications, provided they limit the number of nationally exempted engines used in each power category to 700 total over the 7 years, and to 200 in any one year. In addition, manufacturers making use of this provision must limit exempted engines to a single engine family (or to a single manufacturer for engines rated less than 37 kW) in each power category. These restrictions are considered necessary to maintain the intent of this provision--helping small businesses with limited product offerings--rather than giving bigger exemption allowances for larger OEMs who can effectively use the percent-of-production provisions. These provisions are the same as the federal program.

[5] Small business for manufacturing companies is defined by the Small Business Administration as those companies with 500 or fewer employees.

3. Existing Inventory Allowance and Replacement Engines

With regard to replacement engines, current California regulations require that by the year 2000, all replacement engines for pre-1996 equipment must comply with the 1996 emission regulations. However, in their final rule, the U.S. EPA requires that replacement engines only need to be identical in configuration in all material respects to the original engine being replaced. In order to harmonize with federal requirements, staff proposes to amend current California regulations to allow replacement engines for pre-1996 engines similar to the U.S. EPA's final rule (U.S. EPA 1998a). However, manufacturers are required to use complying engines whenever feasible. If newer, cleaner engines do not "fit" into older equipment, the engine manufacturer may offer noncomplying engines provided 1) the engine manufacturer has ascertained that no certified engine is available, 2) the replacement engine is properly labeled as such, and 3) the actual number of replacement engines produced for California is reported annually for 4 years, beginning with 2000.

4. Hardship Relief Provision

Staff is also proposing a safety-valve provision whereby an OEM 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 the OEM transition program provisions outlined above. Such a situation might occur if an engine supplier without a major business interest in the OEM 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 OEM (such as a supply contract broken by the engine supplier), 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 OEM, for recovering the lost environmental benefit.

5. Enforcement and Recordkeeping Requirements

Engine manufacturers would be allowed to continue to build and sell the engines needed to meet the market demand created by the OEM transition program, provided they receive written assurance from the engine purchasers 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 OEMs requesting such engines.

OEMs 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) include in such records 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 it such as by adding specialized attachments or relabel 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 OEM 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 vehicle or 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 OEM.

Staff recognizes that the OEM transition program may involve a certain amount of complexity and administrative burden that was not present for OEMs under the Tier 1 rule, which limited the compliance options for OEMs. However, this program is entirely voluntary and manufacturers wishing to implement the new standards in the same manner as for the Tier 1 regulations are free to do so.

G. FLEXIBILITY FOR POST-MANUFACTURE MARINIZERS

Post-manufacture marinizers produce marine engines by modifying engines purchased from other manufacturers. They are therefore subject to both the engine manufacturer's concern about certifying engines to the standards and the OEM's concern about timely delivery of redesigned engines from their engine suppliers.

U.S. EPA recognized that the potential unavailability of certified base engines may make it difficult for post-manufacture marinizers to comply with the adopted emission control program, since they may not be able to obtain base engines in time to adjust their marinization process,

especially considering that most of the marine engines under the federal rule are subject to standards beginning in 1999 (U.S. EPA 1998a). Based on these concerns, U.S. EPA determined that the recently adopted emission standards would not be feasible for post-manufacture marinizers who produce marine engines less than 37 kW without some flexibility provisions beyond those available in the ABT program. As a result U.S. EPA adopted two additional flexibility provisions for post-manufacture marinizers. Staff is proposing that these two additional flexibilities also be adopted for California as outlined below.

First, the OEM flexibility provisions discussed above are proposed to be extended to post-manufacture marinizers. Second, provided they informed the Executive Officer in writing before the date Tier 1 standards would take effect, post-manufacture marinizers could elect to delay the effective dates applicable to marine engines less than 37 kW for one year, instead of using the OEM flexibility provisions. Post-manufacture marinizers would not be able to take advantage of both the delayed effective date provision and the OEM flexibility provisions.

Although it provides a substantial boost in certainty to post-manufacture marinizers, the optional 1-year delay provision would have a very small environmental impact. This is because: (1) the marine engines less than 37 kW produced by post-manufacture marinizers are a very small part of the total off-road diesel engine production; (2) these engines produce relatively low emissions due to their small size and low usage characteristics; and (3) the total number of engines potentially exempted under this flexibility provision would not be much greater than that possible under the exemption allowance provisions.

V. DIFFERENCES BETWEEN FEDERAL AND CALIFORNIA REGULATIONS

Staff has endeavored to harmonize as closely as possible with U.S. EPA's final rule for off-road compression-ignition engines. However, the proposed California off-road compression-ignition program differs from the federal program in some aspects. Aligning California's program completely with the federal program would require policy changes to several California programs. Those policy changes would relax current California standards to the extent that attaining ambient air quality standards and meeting California's SIP commitments would be jeopardized. Therefore, staff's proposal differs from the federal program in ways that staff believes are needed to protect the air quality benefits of ARB's mobile source program, as discussed below.

A. CURRENT CALIFORNIA PM TESTING

In 1992, the Board adopted emission standards and test procedures for new 1996 and later heavy-duty off-road diesel cycle engines. The test procedures that were adopted were based on the International Standards Organization (ISO) 8178 test procedure for steady state emission testing. U.S. EPA chose not to amend their test procedures for PM testing during their recent rulemaking, but ongoing efforts to examine the ISO test procedures will likely result in future amendments during their 2001 feasibility review. Although there are updated versions of the ISO test procedures for PM testing available, additional changes to the ISO test procedures are currently underway. Rather than adopt an ISO test procedure that may soon be outdated, ARB intends to work with U.S. EPA during the 2001 feasibility review that may incorporate the latest ISO test procedures at that time.

At the time the regulations were adopted, staff had incorporated the ISO test method for measuring emissions with some changes, which included the requirement of using a multiple filter method of measuring PM emissions instead of a single filter method. The multiple filter method requires one set of particulate filters[6] to be used for each mode of the certification test. U.S. EPA allows the use of one set of filters for an entire test. Staff had originally proposed the multiple filter method to minimize any problems or errors associated with the adjustment of the exhaust gas flow rate to match the modal weighting factors (i.e., the single filter method measures PM emissions by timing of the modes rather than mathematically after the test procedure has been completed).

In addition, since using the multiple filter method provides PM emissions data on a mode-by-mode level, the emissions data can be compared with other ISO test cycles. This benefits those manufacturers who wish to certify their engines for other applications in countries that also subscribe to the ISO test methods. Therefore, staff is proposing no change to the current requirement for PM emissions testing with regard to the multiple filter method.

B. IN-USE COMPLIANCE/RECALL PROGRAM

The 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 adopted its own in-use compliance and recall program for on-road vehicles and certain off-road vehicles under Articles 2.1 –2.3, Chapter 2, Title 13, California Code of Regulations. Staff has proposed that the California In-Use Compliance/Recall Program be extended to all 2000 and later model year off-road compression-ignition engines certified for use in California.

[6] The filters are used to gather particulate matter in the exhaust stream during emissions testing. The filters are weighed and the mass of the particulate emissions is measured and converted to grams per kilowatt-hour for compliance determination.

This California program for in-use compliance/recall should not cause manufacturers any significant burden. These program procedures would only be performed periodically 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.

VI. TECHNOLOGICAL FEASIBILITY

A. EPA'S REVIEW

The technological feasibility of the proposed standards has already been thoroughly evaluated by the U.S. EPA as part of their Regulatory Impact Analysis (RIA). As noted in the preamble for the U.S. EPA regulations (U. S. EPA 1998a, pages 56985-56986):

> The emission standards finalized in this document apply to a broad range of diesel engines used in a wide variety of nonroad applications. Section 213 (a)(3) of the Clean Air Act calls for EPA to establish standards that provide for the "greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the engines or vehicles to which such standards apply, giving appropriate consideration to the cost of applying such technology within the period of time available to manufacturers and to noise, energy, and safety factors associated with the application of such technology" (63 Fed. Reg. 56968, 56984, October 23, 1998). EPA has concluded, as described in the Final RIA, that the new standards will have no significant negative effect on noise, energy, or safety.
>
> Because the emission standards for nonroad diesel engines are based largely on the standards for highway engines and rely on the evaluation of technologies for complying with the standards for highway engines, the discussion of technological feasibility in the highway engine rulemaking is central to supporting the feasibility of the new standards for nonroad engines. This analysis of diesel engine technologies is contained in Chapter 4 of the Final RIA for the highway rulemaking ["Final Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines,'' U.S. EPA, September 16, 1997 (Docket A-95-27)]. This analysis is considered and applied to nonroad engines in Chapter 3 of the Final RIA for this rulemaking.

And:

> Emission control technology for diesel engines is in a period of rapid development in response to the range of emission standards anticipated for the years ahead. This effort will need to continue to meet the requirements of this final rule. However, the emission targets are set in the framework of a long lead time with various flexibility provisions,

which provide manufacturers the time they will need to apply emission control technology developments to nonroad engines. Also, the experience gained in response to EPA's emission standards for highway engines will be invaluable in meeting the comparable requirements for nonroad engines. Because the technology development for highway engines will to a large extent constitute basic research of diesel engine combustion, this effort will also benefit manufacturers that produce no highway engines.

On the basis of information currently available, EPA believes that it is feasible for nonroad diesel engine manufacturers to meet the standards finalized in this document within the specified time frame, using combinations of the technological approaches discussed in the Final RIA. In addition, EPA believes that the flexibilities incorporated into this final rule will permit nonroad vehicle and equipment manufacturers to respond to engine changes in an orderly way. For both industries, EPA expects that meeting these requirements will pose a significant challenge. As described above, EPA plans to assess, as part of the 2001 feasibility review, the appropriateness of the Tier 3 standards, and the Tier 2 standards for engines rated under 37 kW.

The thoroughness of the U.S. EPA analysis and the 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 the U.S. EPA's Regulatory Impact Analysis.

B. SUMMARY OF TECHNOLOGY

In general, manufacturers of off-road compression-ignition engines are expected to use emission controls similar to those already in use by the manufacturers of on-road compression-ignition engines, even though the effectiveness could vary because of the different operating environment experienced by off-road engines. Although on-road and off-road engines alike experience frequent load and speed changes, the operating speed of an off-road engine is less likely to change speeds often compared to an on-road engine. Another important consideration is that the same off-road engine may be used in a variety of applications; this can complicate the application of some strategies due to different packaging constraints. However, as noted in the U.S. EPA Regulatory Impact Analysis, "[n]onroad engine manufacturers are . . . currently in the process of introducing models that have been certified to the Tier 1 standards and are successfully demonstrating their ability to meet the first level of emission standards. Based on a review of current emissions research, EPA believes that emission control improvements from engine design changes have not yet leveled off and that further emission reductions are possible" (U.S. EPA 1998b, page 20).

1. Turbocharging and Aftercooling

Turbocharging is used for both on-road and off-road applications to generate increased power from a given displacement engine. A turbocharger uses the waste energy in the exhaust gas to drive a turbine, which then boosts the pressure of the incoming air charge. By forcing more air into the combustion chamber, more fuel can also be added, resulting in higher power while still inhibiting particulate formation.

Aftercooling was initially developed to improve the specific power output of an engine by increasing the density of air entering the combustion chamber, but it also reduces NOx emissions, since it works by reducing the temperature of the charge air after it has been heated during compression. There are two kinds of aftercooling strategies: air-to-water, which releases the absorbed heat to the engine coolant system; and air-to-air, which releases the heat to a separate heat exchanger. Air-to-air aftercoolers are more effective, but are less commonly used for off-road engines. This is in large measure due to concerns about the dust encountered during off-road use and space constraints. However, according to the U.S. EPA, "[g]round-level dust is becoming less of an issue because recent developments have improved dust resistance, primarily through greater fin spacing on the heat exchanger. Over time, equipment manufacturers are expected to modify their designs to make space for air-to-air aftercooling technology. While introducing air-to-air aftercooling requires a greater degree of engine and equipment modification, the benefits for improved fuel efficiency, greater engine durability, and better control of NOx emissions make a compelling case for their widespread use in the long term" (U.S. EPA 1998b, page 25).

2. Timing retard

Retarding the fuel injection timing is the strategy most likely to be used by manufacturers of smaller engines (i.e., those less than 37 kilowatts) to meet the new standards. Retarding the timing reduces NOx emissions by shortening the time available for combustion and lowering cylinder temperature and pressure. Conversely, timing retard increases HC, CO, PM, and fuel consumption, for the same reasons. In most cases, timing retard will be used in conjunction with other strategies to counteract those increases.

3. Combustion chamber design

While manufacturers already use combustion chamber design to reduce emissions, further improvements are likely for the off-road engines. Specifically, modifications to: (1) the shape of the chamber and the location of injection to induce swirl[7]; (2) crevice volumes; and (3) compression ratio; it has been thoroughly explored for on-road engines, and thus off-road engine design can benefit from that experience.

4. Advanced Fuel Injection Controls

Improved fuel injection is a major part of virtually any approach to reduce emissions from compression-ignition engines. High injection pressures offer better fuel atomization and mixing of the fuel and air, achieving more complete combustion. Timing retard can be used in conjunction with this strategy to inhibit NOx formation, resulting in overall reductions in NOx, HC, and PM simultaneously. Rate shaping is another technique that helps reduce NOx. In a rate shaping system, the fuel is injected in several different injection events. Especially with electronic controls, this results in more carefully-controlled combustion. Thus, rapid increases in temperature and pressure can be minimized, reducing NOx formation. Some manufacturers already use electronically-controlled fuel injection, and staff expects the number to increase.

5. Exhaust Gas Recirculation

Exhaust gas recirculation (EGR) reduces peak combustion chamber temperatures by feeding exhaust gas back into the cylinder. This slows reaction rates and absorbs some of the heat, resulting in lower NOx emissions. PM increases can be minimized by reducing the amount of EGR during high-load operation. Another concern is that soot from the exhaust is added to the intake air, which could increase engine wear, damage a turbocharger or reduce the efficiency of an aftercooler. Researchers are evaluating ways to reduce the soot fed back into the engine.

6. Aftertreatment

Aftertreatment strategies are not expected to be needed to achieve the emission standards being proposed. However, aftertreatment remains a likely option for the future. Further reductions in emissions from diesel exhaust sources will be needed, particularly since diesel PM was recently

[7] "Swirl" refers to the turbulence of the intake air entering the combustion chamber. A high degree of turbulence in the combustion chamber better mixes air and fuel. This reduces the amount of unburned and unevaporated fuel, and thus reduces HC, PM and smoke emissions.

identified as a TAC. When ARB conducts its feasibility review of the proposed standards in 2001, it is expected that Tier 3 PM and Tier 4 NOx and PM emission standards will be proposed, and aftertreatment devices will be seriously considered as feasible technology.

The primary use of diesel aftertreatment in today's off-road equipment is in underground mining applications, where oxidation catalysts and particulate traps are used to maintain acceptable conditions for workers in the enclosed spaces. Some of these retrofit devices may be feasible to reduce emissions from other categories of diesel engines that are already in service.

There are a number of aftertreatment technologies being researched for use on diesel-fueled vehicles and equipment where demonstrations have shown a potential to control greater than 75 percent of engine-out NOx emissions. Some of these include DeNOx or "Lean-NOx" catalysts, NOx Adsorbers or NOx "Traps," Selective Catalytic Reduction (SCR) Technology, and Non-Thermal Plasma. For advanced particulate emissions control, a NOx Oxidation Catalyst/Continuously Regenerating Diesel Particulate Filter has been applied commercially in Europe and may provide reductions in excess of 85 percent for PM, HC, and CO emissions. These technologies are strong candidates for both new engine and retrofit applications.

All catalyst-based technologies are sensitive, to some extent, to the sulfur content in fuels. Sulfur impacts the emissions reduction capability of the aftertreatment device by attaching to the chemical sites that are needed for the catalytic reaction that reduces the emissions. Therefore, it is desirable to use the lowest sulfur diesel fuel available. Currently, California limits the sulfur level of diesel fuel used in on-road and most off-road engines to 500 ppm (parts per million). Actual sulfur levels are about 120 ppm, well below the maximum limit. The U.S. EPA also limits sulfur levels of diesel fuel for on-road vehicles to 500 ppm; in-use levels average 350 ppm. The U.S. EPA does not currently regulate diesel fuel used in off-road vehicles and equipment; and sulfur levels average about 3,500 ppm. In order for manufacturers to take advantage of the emissions reduction potential of these advanced aftertreatment technologies, adoption of a nationwide sulfur limit of 30 ppm or less for all on- and off-road diesel fuel will be necessary. This is particularly true for PM reductions, as a high sulfur content directly leads to high levels of sulfate-based PM, rendering low PM levels infeasible with high-sulfur fuel.

VII. REMAINING ISSUES

Staff presented the concepts for the proposed regulations in a document made available October 8, 1999. Draft versions of the regulations and test procedures were made available to interested stakeholders for comment in October 1999. Following receipt of comments from interested stakeholders, the staff then modified portions of the regulations and this report accordingly to address those industry concerns which could be addressed without impeding the goals of the regulations.

VIII. REGULATORY ALTERNATIVES

The staff evaluated various alternatives to the current proposal, including some alternatives suggested by interested stakeholders. A brief description of the alternatives and the staff's reasoning for rejecting them follows.

A. DO NOT AMEND CURRENT CALIFORNIA REGULATIONS

One alternative to this proposal would be to continue the use of the off-road diesel engine emission standards that have already been set in place for 2001 and subsequent years. The existing California regulations for off-road diesel engines were adopted by the Board in 1992. With the passage of U.S. EPA's nonroad compression-ignition rule in 1998, 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)). Furthermore, under the SOP, ARB committed to harmonize with U.S. EPA's emissions standards and other provisions, provided such action would not compromise California's obligations to comply with state and federal law including the SIP. Therefore, staff rejected this alternative.

B. REPEAL CALIFORNIA REGULATIONS ENTIRELY

In the early stages of developing this regulation, staff was asked to consider repealing the separate California regulatory program in its entirety, and allow all control of these sources to fall to the U.S. EPA. This would result in the least possible burden for engine manufacturers. However, the staff has serious reservations about abdicating its ability to independently enforce the regulations. There is also the possibility for modifications to the federal program that would place California in jeopardy of not complying with the national ambient air quality standards. Repeal would place implementation of measures M9 and M10 fully with U.S. EPA, where ARB would be just one of many interested parties involved in establishing the effectiveness and timing of the federal regulations. Furthermore, this alternative would hinder California's ability to pursue further control of these sources. Since California has long been recognized by the federal government as having special air quality problems, and needing special authority to address those problems, this alternative was rejected.

C. ADOPT MORE STRINGENT EMISSIONS STANDARDS

The staff recognizes that more stringent control of emissions from these sources will be necessary both to attain the federal ambient air quality standard for ozone and to reduce public exposure to diesel particulate, a toxic air contaminant. The details of the benefits of the proposal and the impact on the SIP are discussed in Section X. At this time, in compliance with the SOP, the staff is not recommending more stringent standards. Harmonization of the certification requirements with the federal program will reduce the administrative burden on industry, allowing a greater focus on the technical issues of emissions control. Future strategies that will be examined include the revision of diesel fuel standards to require lower sulfur levels, the wider application of aftertreatment technologies, and perhaps alternate fuels. The need for quick action on the provisions of the SOP did not provide enough time for the development of proposed requirements reflecting those technologies. Therefore, staff rejected this alternative at this time, but anticipates setting more stringent standards in 2001.

IX. ECONOMIC IMPACTS

The proposed regulatory amendments harmonize, with federal regulations, California emission standards, useful life, warranty, deterioration factors, maintenance intervals, rebuild/replacement provisions, test procedures and test fuel requirements, labeling requirements, and provide for participation in an ABT program. 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.

A. 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.

B. AFFECTED BUSINESSES

Any business that is involved in manufacturing and/or rebuilding of off-road CI engines and equipment manufacturers that utilize these engines in their equipment can potentially be affected by the federal standards and the proposed state standards. U. S. EPA had identified 30 major engine manufacturers and 581 original equipment manufacturers nationwide. Also affected are businesses that operate or service CI engines. An estimated 790,000 off-road CI engines will be utilized in equipment and vehicles operating in California in 2000.

C. ESTIMATED COSTS TO ENGINE MANUFACTURERS

The costs of the proposed requirements to engine manufacturers have been estimated and are based on U.S. EPA's analysis for the national emission standards. Engine manufacturers will likely use multiple technologies to meet the 2000 and later standards and the maintenance and durability requirements. To estimate the incremental impact of the federal standards on engine costs, U.S. EPA determined a plausible combination of technologies taking into account the observed value of performance improvements in the field. Some of the technologies expected to be used include modifications to basic engine design features, electronic controls, advanced fuel injection, and cooled exhaust gas recirculation. To take into account the non-emission benefits of those technologies in the way of engine performance, fuel consumption, and life of the engine, a discounting method based on equal weighting of emission and non-emission benefits was used. Assuming that engine manufacturers pass on the entire costs of the new standards to end users, the incremental increase in per-engine purchase price and overall life-cycle operating costs have been estimated. These cost estimates are presented in the following table.

Table 5
Projected Unit Costs – Engines

Cost Category	Year of Production	Power (kW)					
		0-37	37-75	75-130	130-450	450-560	560+
Tier 1							
Incremental purchase price	1	$34	—	—	—	—	—
Life-cycle Operating Costs (npv[8])	all	$44	—	—	—	—	—
Tier 2							
Incremental purchase price	1	$72	$124	$425	$464	$1355	$683
Life-cycle Operating Costs (npv)	all	$44	$59	-$147	-$262	-$1347	$0
Tier 3							
Incremental purchase price	1	—	$240	$511	$758	$1858	—
	6	—	$120	$297	$435	$535	—
Life-cycle Operating Costs (npv)	all	—	$97	-$652	-$826	-$1212	—

Source: U.S. EPA's Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, August 1998. Costs are in 1995 dollars.

The estimated costs are separated into incremental purchase price and total life-cycle operating costs. The incremental purchase price for new engines and equipment includes 1) variable costs for hardware and assembly time, and 2) fixed costs for research and development, retooling, and certification. Total operating costs include any expected increases in maintenance or fuel consumption. Since U.S. EPA relied extensively on the contracted study of the cost of highway

[8] Net Present Value

engine technologies conducted by ICF, Incorporated[9] and Arcadis Geraghty & Miller[10], all costs are presented in 1995 dollars. Life-cycle costs have been discounted to the year of sale using a discount rate of 7 percent.

Overall, the incremental costs of the new federal standards are expected to decline over time. For example, the incremental purchase price of a new Tier 3 engine greater than 450 kilowatts in its first year of production is estimated to be $1858. The estimated incremental cost of a new engine purchased in its sixth year of production is $535, reflecting the benefits of a "learning-curve." Standards were called for in ARB's 1994 SIP, and further defined in the SOP in August 1996, giving manufacturers extensive lead time. This lead time allows substantial technology development before reaching production. U.S. EPA's analysis predicts that extended research will allow manufacturers to use simpler packages of emission control technologies, that innovations will lower the cost of production, and that manufacturers will have time to focus research efforts on eliminating problems such as increased fuel consumption or maintenance costs. As an example, manufacturers expect that upgrading from air-to-water aftercoolers to air-to-air aftercoolers at Tier 1 emission levels would provide a fuel economy improvement of 6 to 8 percent. That benefit would decrease as NOx emission levels declined. Therefore, U.S. EPA estimated the fuel economy improvement would be 3 percent for upgraded aftercooling systems and 6 percent for those engines that currently have no aftercooling. As such, there is an expected positive effect on operating costs over the lifetime of the engine/equipment. U.S. EPA's analysis shows that the operating costs are likely to offset much, if not all, of the increased engine and equipment costs for engines above 75 kilowatts due to expected improvements in fuel economy for engines meeting the new standards.

D. POTENTIAL COSTS TO EQUIPMENT MANUFACTURERS

In addition to the costs directly associated with the manufacture of complying engines, costs may also result from the need to redesign the off-road equipment in which these engines are used. The main concern for equipment manufacturers in accommodating complying engines has been the late delivery of such engines by engine manufacturers, which cuts into the lead time that equipment manufacturers need to properly redesign their equipment. The flexibility provisions that were adopted by the U.S. EPA and are proposed by staff attempt to avoid any business disruptions resulting from the changes associated with the new emission standards.

[9] "Benefits of Reducing Mobile Source NOx Emissions," prepared by ICF Incorporated for Office of Mobile Sources, U.S. EPA, Draft Final, September 30, 1996.

[10] "Estimated Economic Impact of New Emission Standards for Heavy-Duty On-Highway Engines," Acurex Environmental Corporation Final Report (FR 97-103), March 31, 1997. The Acurex Environmental Corporation has since changed its name to Arcadis Geraghty & Miller.

With adequate lead time, an equipment manufacturer can invest enough engineering time to design around the new engine, usually with minimal increase in hardware costs. The main issue anticipated for equipment redesign is in changing the engine compartments to accommodate the physical changes to engines; i.e., making space for the larger engine system and to integrate the engine into the overall functioning of the equipment. The projected unit costs are shown in the following table.

Table 6a
Projected Unit Costs

Tier		Power (kW)					
		0-37	37-75	75-130	130-450	450-560	560+
Tier 1	Equipment	$24	—	—	—	—	—
	Total Engine & Equipment	$59	—	—	—	—	—
Tier 2	Equipment	$8	$125	$441	$340	$1315	$404
	Total Engine & Equipment	$80	$250	$867	$804	$2670	$1087
Tier 3 short-term	Equipment	—	$42	$147	$113	$439	—
	Total Engine & Equipment	—	$282	$658	$872	$2296	—
Tier 3 long-term	Equipment	—	$3	$4	$5	$7	—
	Total Engine & Equipment	—	$122	$301	$440	$543	—

Source: U.S. EPA's Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, August 1998. Costs are in 1995 dollars.

E. 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 detailed analysis of these costs is provided in the U.S. EPA regulatory impact analysis of the new federal standards. The incremental costs of the new standards can be viewed in the context of their fraction of the total purchase price of equipment. For example, U.S. EPA collected quoted list prices on different types of equipment with high sales volume to represent low and high end prices for several engine ratings. Using a range of these prices (discounted by 20 percent from list prices to obtain estimated actual sales prices), U.S. EPA determined a best estimate of actual prices for off-road compression-ignition equipment (see Table 6b). The table includes both portable and motive (self-propelled) equipment, as both types of equipment are powered by engines subject to this proposal. Comparing the estimated unit costs for engines and equipment with the current purchase prices show cost increases are almost all under 2 percent of purchase price, while most are well below 1 percent.

Table 6b
Federal Estimated Prices for New Nonroad Diesel Equipment

Power Range	Portable Equipment Estimated Sale Price	Motive Equipment Estimated Sale Price
0-37 kW (0-50 hp)	$1,600-12,000	$16,000-20,000
185-335 kW (250-450 hp)	$24,000-40,000	$130,000

Source: U.S. EPA's Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, August 1998. Costs are in 1995 dollars.

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, which often face production inefficiencies when they have to comply with different standards.

F. 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 compression-ignition engines. Thus, California operators of off-road compression-ignition 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.

G. 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.

H. 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 compression-ignition equipment or vehicle operators in California are expected. The implementation flexibilities proposed would help alleviate the potential impact on businesses including small businesses.

I. POTENTIAL COSTS TO LOCAL AND STATE AGENCIES

As discussed in the Section on regulatory alternatives, 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. ARB staff believes the proposed standards are the only feasible and cost-effective means of achieving emission reductions of the same magnitude as the standards by 2010. ARB staff 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. However, there may be a small increase in enforcement/certification resources to ensure the standards are being met over the useful life of these off-road compression-ignition engines.

X. ENVIRONMENTAL IMPACTS AND COST-EFFECTIVENESS

This Section presents the air quality benefits and the cost-effectiveness of the proposed standards. Staff's analysis is based on U.S. EPA's national analysis, adjusted to reflect California costs and emission reductions. Control of these sources was committed to in the 1994 Ozone State Implementation Plan as part of SIP measures M9 and M10; this Section also includes an analysis of how the proposed standards fulfill the SIP commitments for the South Coast Air Basin, the only area of the state that relied on measures M9 and M10 reductions for attainment. Because the proposed regulations would apply statewide, they would provide significant cost-effective emission reductions throughout California.

A. AIR QUALITY BENEFITS

1. Statewide Benefits

By 2010, it is estimated that the emission standards proposed and those adopted by the U.S. EPA would result in 75 tons per day of NOx reductions, almost 16 tons per day of NMHC reductions, and 2.7 tons per day of PM reductions in California, using the updated proposed emissions inventory. Table 7 shows the statewide emissions benefit of the staff's proposal and from equivalent federal control in 2010 as compared to the baseline emissions inventory; the baseline includes the effect of the Tier 1 ARB and U.S. EPA rules that were implemented beginning in 1996. Table 8 shows the emission reduction benefits in the South Coast Air Basin in 2010. The data in these tables reflect the latest information on engines in the category affected by the staff proposal and their emissions.

Table 7

2010 Statewide Benefit of the Proposal
Updated Proposed Inventory (in tons per day)
(Note that discrepancies may occur due to rounding of the numbers)

Measure	Pollutant	Emissions Inventory		Reductions
		Baseline	Controlled	
Staff Proposal (Non-Preempt Engines)	NMHC	15.9	13.1	2.8
	NOx	187.5	155.5	32.0
	PM	7.7	6.8	0.9
Federal Action (Preempt Engines)	NMHC	49.6	33.2	16.4
	NOx	307.2	247.8	59.4
	PM	29.6	22.0	7.6
TOTAL	**NMHC**	**65.5**	**46.3**	**19.2**
	NOx	**494.7**	**403.3**	**91.4**
	PM	**37.3**	**28.8**	**8.5**

Table 8

Emissions from Compression-Ignition Engines
In the South Coast Air Basin
Updated Proposed Inventory (in tons per day in 2010)

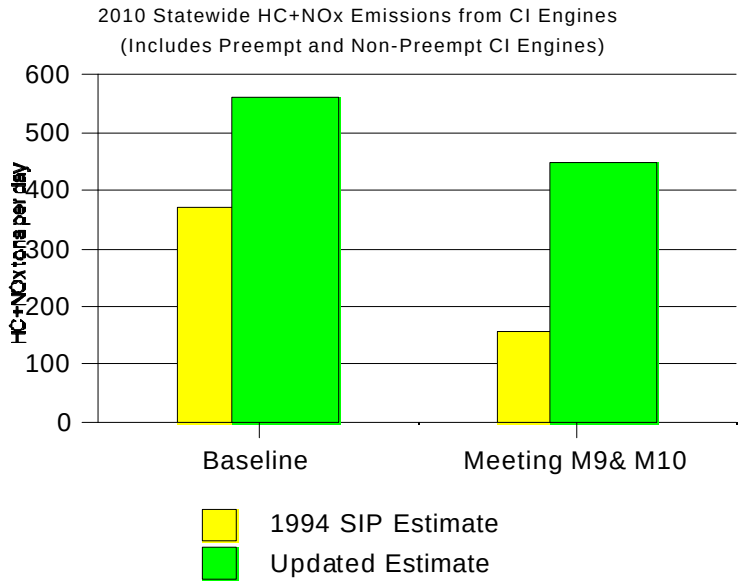
Category	Emissions Inventory				Reductions due to Staff Proposal	
	Baseline		Controlled			
	ROG	NOx	ROG	NOx	ROG	NOx
M9 (Non-Preempted)	4.5	49.7	3.8	41.1	0.7	8.6
M10 (Preempted)	14.4	89.0	9.3	70.3	5.1	18.7
Total	18.9	138.7	13.1	111.4	5.8	27.3

2. Inventory Updates

Substantial improvements have been made to the emissions inventory for off-road compression-ignition engines. Updated data on activity, growth, population, turnover (useful life), emission rates (including emissions deterioration), and which engine applications are exclusively under the jurisdiction of U.S. EPA, have been incorporated into the revised inventory.

The inventory revisions show that the projected hydrocarbon and NOx emissions in 2010 from both uncontrolled and controlled engines are much higher than anticipated in 1994. Much of these increases result from inclusion of a wider range of equipment types, and an increase in base population estimates. Figure 3 illustrates the impact of the revised estimates on compression-ignition engine emissions. The 1994 SIP estimate shows the baseline and controlled emissions assumed in the SIP. In the 1994 SIP, it was believed that more than half of the emissions from off-road diesel engines were in the South Coast Air Basin (SCAB). The current estimate shows that the SCAB portion of the off-road inventory is now only roughly one quarter of the statewide total. The reason for this change is that the statewide emission inventory for agricultural equipment has increased significantly. As a result, emissions from off-road compression-ignition engines are now much higher than previously assumed in the San Joaquin Valley and other farming regions.

Figure 3



The emissions reductions associated with measures M9 and M10 for the updated proposed inventory are less than estimated in SIP currency due to the differences in the turnover rate and deterioration rate. The 1994 SIP assumed a higher turnover rate than the updated proposed inventory. This meant that the SIP calculations assumed replacement of older, more-polluting engines with newer, cleaner engines would happen earlier, providing greater benefits in the 2010 timeframe. Additionally, the updated proposed inventory includes deterioration, which causes a further increase in emissions, while the SIP currency estimate assumed no deterioration.

3. Impacts on the 1994 Ozone State Implementation Plan

The 1994 Ozone SIP is California's master plan for achieving the federal ozone standard in all areas of the state by the federally required date. The 1994 Ozone SIP includes state measures to control motor vehicles and pesticides, local measures for stationary and area sources, and federal measures for sources under exclusive or practical federal control. The U.S. EPA approved the 1994 Ozone SIP in September 1996 (62 Federal Register 1150, January 8, 1997).

a. Review of SIP Measure M9 – SIP Measures M9 and M10 were developed in 1994 with the belief that manufacturers would be able to use proven on-road technologies – such as improved engine design, EGR, and aftertreatment – to reduce NOx emissions from off-road compression-ignition engines by approximately 60 percent while also reducing hydrocarbon emissions by 50 percent on a per engine basis. U.S. EPA's action and the staff's proposal have established that the technological underpinnings of measures M9 and M10 are sound, although the specifics of the staff's proposal have changed somewhat to address the significant changes to the emissions inventory.

b. Comparison of Staff Proposal to SIP Measure M9 – The NOx and reactive organic gas (ROG) emission reductions anticipated from SIP measures M9 and M10 in the South Coast Air Basin are listed in Table 9[11]. Also shown are the effects of the staff proposal in "1994 SIP currency"(using ARB's off-road mobile source emission inventory model that was used during the development of the 1994 SIP). While 1994 SIP currency must be used as the official guide to provide consistency with the legal obligations of the SIP, staff recognizes that the SIP currency does not reflect updated information and that further control of emissions from these engines may be necessary in the future. The staff proposal would provide more ROG reductions than the SIP measures M9 and M10, while falling short of the NOx reductions anticipated in the SIP. Taken as a whole, the combined ROG and NOx reductions from the proposal are essentially equal to the combined ROG and NOx reductions called for in the SIP.

Table 9

Emissions from Compression-Ignition Engines
Compared to the SIP Target
In "1994 SIP Currency"
(Tons per day in South Coast Air Basin in 2010)

Category	1994 SIP Emission Reductions		Emission Reductions from Staff Proposal		Change in Emission Reductions	
	ROG	NOx	ROG	NOx	ROG	NOx
M9 (ARB)	2.7	33.5	5.4	29.4	+ 2.7	- 4.1
M10 (Federal)	5.3	44.2	9.7	41.7	+ 4.4	- 2.5
Total	**8.0**	**77.7**	**15.1**	**71.1**	**+ 7.1**	**- 6.6**

c. Benefits of Staff's Proposal in 2005 – Although other nonattainment areas did not rely on emissions reductions from Measures M9 and M10 in the SIP, the earlier implementation of the staff proposal will provide some emissions benefits for those areas by 2005. Table 10 describes the emissions reductions expected in these areas from the proposed regulations using 1994 SIP currency.

[11] For purposes of this analysis, ROG and NMHC emissions are considered to be equivalent.

Table 10

Expected Emission Reductions for SIP Measures M9 and M10 and the Staff Proposal
(1994 SIP Currency in tons per day)

SIP Area	Year	1994 SIP Emission Reductions		Emission Reductions from Staff Proposal	
		ROG	NOx	ROG	NOx
Ventura	2005	0	0	0.1	0.4
Sacramento	2005	0	0	0.2	0.9
South Coast	2005	1	9	6	18
South Coast	2010	8	78	15	71

d. Summary of 1994 SIP Analysis – Using 1994 SIP currency, the staff's proposal meets the 1994 SIP commitment to achieve 86 tons per day of ROG and NOx reductions from off-road compression-ignition engines. Additionally, the staff's proposal provides some emissions benefits in SIP areas with 2005 attainment dates (Sacramento and Ventura Air Basins). This measure will also provide emission reductions in the San Joaquin Valley Air Basin in 2005 – the San Joaquin Valley will not meet their attainment date of 1999 and must submit a new plan demonstrating attainment by 2005.

It should be noted that because the updated inventory is higher than previously estimated, the remaining emissions from off-road compression-ignition engines are higher than envisioned in the 1994 SIP. As air quality plans are updated in the future, the larger contribution of emissions from off-road compression-ignited engines will be closely scrutinized.

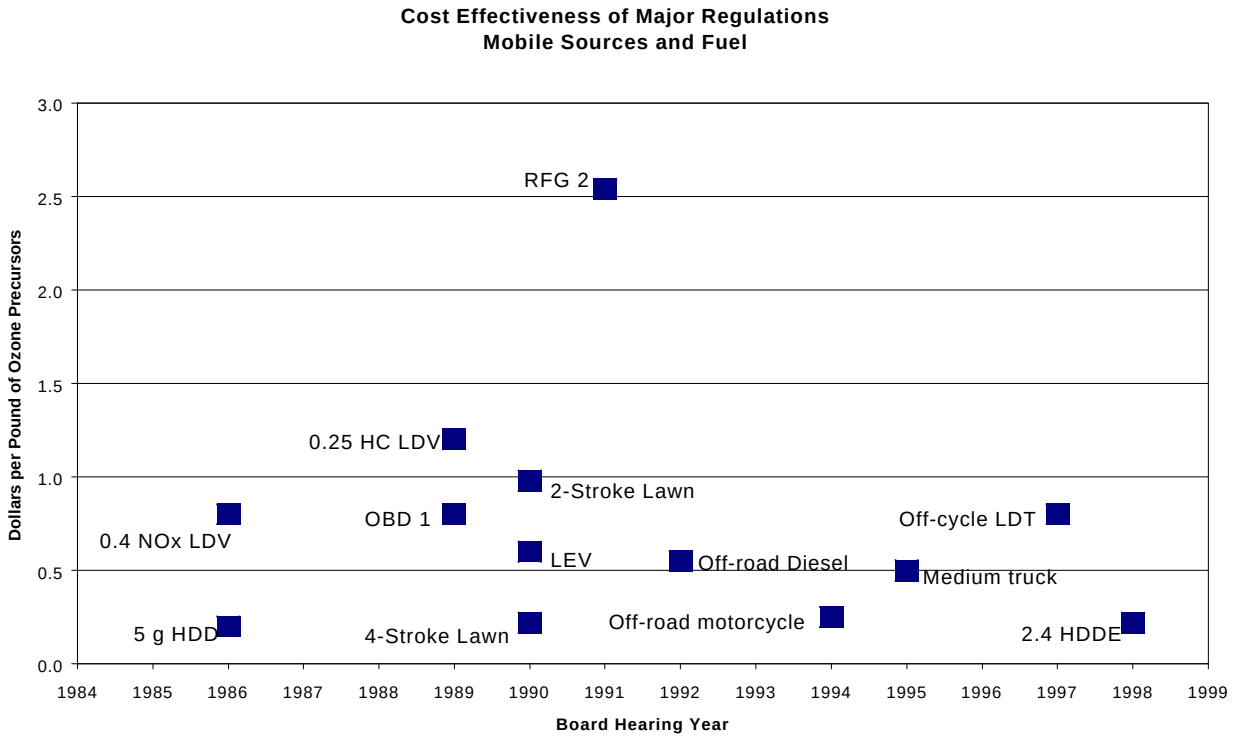
e. Future Planning Efforts – ARB is scheduled to revise its statewide control strategy for ozone in 2000. In future years, ARB will also develop plans for meeting fine particulate matter ambient air quality standards and to meet regional haze requirements. Due to increases in both the on- and off-road emission inventories, staff will be evaluating all feasible cost effective emission reductions, including re-examining the regulations currently in place for a broad range of mobile sources and consumer products under the jurisdiction of the ARB. Due to the large upward revision of the off-road compression-ignition engine emission inventory, particularly in areas outside of the South Coast Air Basin, ARB will be closely examining the progress made toward reducing emissions from these engines and evaluating the feasibility of further reductions.

B. COST-EFFECTIVENESS

The cost of complying with the proposed emission standards and regulations in California is not expected to be different from complying with the federal regulations. Therefore, no additional cost is anticipated from the adoption of the proposed off-road compression-ignition regulations for California. For informational purposes, the estimated fleet-wide cost-effectiveness of the federal requirements is given in Appendix A. The estimated cost of complying with the standards will vary depending on the power category and model year under consideration. Operating costs are actually expected to lower overall costs in the way of reduced fuel consumption.

The cost-effectiveness for aligning with the federal requirements in California is expected to be similar to the national cost-effectiveness. The highest federal fleet-wide cost-effectiveness of the NMHC + NOx standards is expected to be $650 dollars per ton reduced. In dollars per pound, the cost-effectiveness of this measure would be about $0.32 per pound of ozone precursors reduced. As shown in Figure 4, this compares favorably with the cost-effectiveness of California mobile source and motor vehicle fuels regulations adopted over the past decade. Those adopted measures had cost-effectiveness values from $0.17 to $2.55 per pound of ozone precursors reduced. The highest cost-effectiveness of the PM standard is expected to be $1.16 per pound of PM reduced.

Figure 4



XI. SUMMARY AND STAFF RECOMMENDATION

The staff estimates that in 2010, the statewide benefits of the proposal would be 89 tons per day of NOx and 32 tons per day of NMHC. The estimated California cost-effectiveness with adoption of the staff's proposal would be approximately $ 0.32 per pound of NMHC + NOx reduced. This cost-effectiveness is well within the range of other motor vehicle control measure costs.

Furthermore, harmonization of certification and compliance procedures with the U.S. EPA will facilitate the implementation of Tier 4 and later controls, by minimizing administrative issues and allowing a greater focus on the technical issues of emissions control. Future strategies that will be examined include the revision of diesel fuel standards to require lower sulfur levels, and the wider application of aftertreatment technologies to new and in-use engines.

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 or less burdensome to affected private persons than the proposed regulation. Therefore, the staff recommends that the Board adopt the staff proposal.

XII. REFERENCES

ARB, 1995. Public Hearing to Consider Amendments to Regulations Regarding California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel-engines and Vehicles, to Specify Mandatory Standards for 1998 and Subsequent Heavy-Duty Engines and Optional Standards for 1995 and Subsequent Heavy-Duty Engines, May 12, 1995 (Staff Report).

ARB, 1994. The California State Implementation Plan for Ozone, Volume II, November 15, 1994.

ARB, 1991. Public Hearing to Consider The Adoption of Regulations Regarding the California Exhaust Emission Standards and Test Procedures for New 1996 and Later Heavy-Duty Off-Road Diesel Cycle Engines and Equipment Engines, November 12, 1991 (Staff Report).

U.S. EPA, 1998a. Control of Emissions of Air Pollution From Nonroad Diesel Engines; Final Rule, 63 Federal Register 56967-57023, October 23, 1998.

U.S. EPA, 1998b. Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, August 1998, (Docket A-96-40).

U.S. EPA, 1997a. Control of Emissions of Air Pollution From Highway Heavy-Duty Engines; Final Rule, 62 Federal Register 54693-54730, October 21, 1997.

U.S. EPA, 1997b. Final Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines, September 16, 1997 (Docket A-95-27).

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

The following tables show the federal cost-effectiveness of the emission standards for compression-ignition engines. The estimated cost of complying with the standards varies depending on the model year under consideration. The Model Year Grouping refers to the different model years during which the costs are expected to change with respect to the implementation of the new emission standards.

Table 1
Discounted Fleet-wide Cost-effectiveness of the NMHC + NOx Standards
(Excluding operating costs)

Level of Standard	Model Year Grouping	Discounted Cost-effectiveness ($/ton)
Tier 2	1 to 2	$600
	3 to 5	$540
Tier 3	1 to 2	$650
	3 to 5	$550
	6 to 10	$410
	11+	$300

Table 2
Discounted Fleet-wide Cost-effectiveness of the NMHC + NOx Standards
(Including operating costs)

Level of Standard	Model Year Grouping	Discounted Cost-effectiveness ($/ton)
Tier 2	1 to 2	$540
	3 to 5	$480
Tier 3	1 to 2	$220
	3 to 5	$130
	6 to 10	$0
	11+	$0

Table 3
Discounted Fleet-wide Cost-effectiveness of the PM Standards

Level of Standard	Model Year Grouping	Discounted Cost-effectiveness ($/ton)
Tier 1 and Tier 2 combined	1 to 2	$2,320
	3 to 5	$2,100
	6 to 10	$1,680
	11+	$700

APPENDIX B: 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 C: NONROAD COMPRESSION-IGNITION ENGINE STATEMENT OF PRINCIPLES

NONROAD COMPRESSION-IGNITION ENGINE STATEMENT OF PRINCIPLES

Members of the nonroad compression-ignition (CI) engine and equipment industry, the U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (ARB) (collectively, the Signatories) recognize the importance of preserving the environment while maintaining a strong industry. This Statement of Principles (SOP) increases certainty and stability for the nonroad CI engine and equipment industry which is vital for their business planning. It also ensures cleaner air in a manner which is both realistic for industry and responds to environmental needs.

With this SOP the nonroad CI engine and equipment industry has stepped forward to become a leader in environmental protection, and industry and government will work as partners to bring about cleaner air.

EPA and ARB have recently established programs to control emissions from nonroad engines. EPA and ARB recognize these engines are sources of ozone-forming oxides of nitrogen (NOx) and hydrocarbons (HC), as well as of particulate matter (PM) and other pollutants, all of which raise concerns for public health and the environment. The current Tier 1 regulations for large CI nonroad engines are primarily focused on achieving significant NOx reductions as early as possible and are being phased in by horsepower level beginning in 1996. At the time of finalizing the Tier 1 regulations, EPA and ARB recognized that more stringent standards for these engines, and further evaluation of the test procedure by which compliance with the standards is measured, would likely be needed in the future to help meet air quality goals. These agencies also recognized the need to control emissions from spark-ignited (SI) and other CI nonroad engines as well.

Although recent progress in improving the nation's air quality has been encouraging, EPA and ARB believe there is strong evidence that currently adopted measures are insufficient to offset such factors as the growth in vehicle and equipment sales and usage. The states and others have strongly urged EPA to undertake new programs to achieve further cost-effective emission reductions in a time frame consistent with the Clean Air Act attainment goals. In response, among other initiatives, EPA and ARB have initiated a program to further reduce emissions from heavy-duty on-highway vehicles and nonroad engines.

The industries that produce these engines have also stepped forward, expressing a desire to develop and use cost-effective emission control technologies to help meet the nation's air quality goals. EPA and ARB have consulted with these

industries to help craft proposals that provide the needed air quality benefit. The effectiveness of this approach is evidenced by the issuance of a joint Statement of Principles (SOP) on July 11, 1995, outlining a proposal for stringent new nationwide standards for on-highway heavy-duty engines. EPA followed up that SOP with an Advanced Notice of Proposed Rulemaking (ANPRM) and a Notice of Proposed Rulemaking (NPRM). The 1995 SOP expressed an intent by the Signatories to pursue a similar SOP for heavy-duty nonroad engines.

After considerable discussion between EPA, ARB, and the nonroad engine and equipment industries, this SOP has been completed. The Signatories expect major reductions in emissions from the standards set forth in this SOP. For nonroad CI engines rated at 50 hp (37 kW) and higher, the Tier 2 and Tier 3 standards together will achieve about a 75 percent reduction in NOx from uncontrolled levels. The Tier 2 standards for PM represent about a 40 percent reduction from current levels. For nonroad CI engines rated at less than 50 hp, the Tier 2 standards are expected to result in NOx and PM reductions similar to those from the Tier 2 standards for engines rated at 50 hp and higher.

The Signatories agree that EPA should issue an ANPRM in 1996 and an NPRM in 1997 consistent with the points outlined in this document. A final rule would follow by February 1998. However, this SOP does not change the importance of EPA demonstrating the need for the standards described below and EPA's obligation to meet the criteria of the Clean Air Act in finalizing any rule, including complying with all applicable rulemaking procedures.

1. Scope

This SOP concerns CI nonroad engines as defined in 40 CFR 89.2, and the nonroad equipment powered by these engines, with the exception of engines used in aircraft, underground mining equipment, locomotives, and marine vessels. However, propulsion and auxiliary marine CI engines rated at less than 50 hp (37 kW) are included.[1/] EPA is addressing marine CI engines rated at 50 hp and higher separately from this SOP.

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1. Currently, EPA is required under a court order to take final action on proposed regulations for CI marine engines by December 18, 1996. EPA will seek appropriate changes to this order regarding final action on CI marine engines less than 50 hp (37 kW) to conform to this SOP.

Although EPA and ARB have made significant progress in SOP discussions with the manufacturers of nonroad SI engines rated at above 25 hp (19 kW) (as well as the manufacturers of equipment using these engines), these discussions have not yet reached a stage that would allow inclusion of these engines in this SOP. EPA and ARB will pursue the development of an SOP for nonroad SI engines above 25 hp by the end of 1996. Such an SOP would assist the nonroad engine and equipment manufacturers in their product planning. The Signatories recognize the possible competitive effects of regulating CI and SI engines separately, and EPA and ARB will take those effects into account in the development of an SI engine SOP.

2. National Standards for CI Nonroad Engines

This SOP seeks to establish a nationwide program that, in real-world operating experience, achieves the emission control levels indicated below. Recognizing that real-world control is closely linked to the test procedure by which conformance with standards is measured, the following discussion of standards should be read in the context of the test procedure discussion that follows it. The Signatories' goal is a combination of emission standards and test procedures that achieves real-world emission reductions corresponding to these standards, provided that such standards are technologically feasible and cost effective, taking into consideration both engine and equipment manufacturer costs.

a. NMHC, NOx, CO and PM Standards

EPA will propose combined standards for nonmethane hydrocarbons (NMHC) and NOx, and separate standards for carbon monoxide (CO) and PM. These standards would apply to any affected engine that is newly manufactured on or after January 1 of the year indicated in the following table, except as provided in Section 5, Implementation Flexibility, below. While this SOP does not specify PM standards in Tier 3, the Signatories acknowledge that there is, in general, an inverse relationship in controlling certain pollutants (e.g., NOx and PM). The Signatories recognize that the manufacturer signatories have agreed to the Tier 3 NMHC+NOx standards set forth below on the condition that there would be no further reduction in PM or CO from Tier 2 levels. If such reductions should be proposed, EPA will take the reductions into account in its review of the feasibility of the proposed Tier 3 NMHC+NOx standards (see Section 4, Feasibility Review, below). The Signatories recognize the role that direct injection engine technology plays in the less than 50 hp nonroad engine market and expect the standards set forth in this SOP to allow for the continued existence of that technology. As part of the feasibility review (see Section 4 below), EPA will assess the progress in meeting Tier 2 standards for those engines using direct injection technology.

b. Smoke

The Signatories support the completion and worldwide adoption of the new smoke test being developed by the International Standards Organization (ISO 8178-9). EPA intends to propose to replace its current smoke test with the ISO test procedure for the sake of harmonization and improved control of smoke, provided that it provides for a level of smoke control at least as adequate as the current test. EPA will also propose to extend the smoke standards that were adopted in the Tier 1 rule to the under 50 hp engine category, and will evaluate the appropriateness of any changes to the smoke standards for all engine size categories in formulating the proposal.

c. Crankcase Emissions

For several years, emission regulations for on-highway engines have required that crankcase emissions be eliminated, except in the case of turbocharged diesel engines, which present special difficulties in designing for closed crankcase. EPA will propose to extend this requirement to covered nonroad engines (including the provision for excepting turbocharged diesel engines).

NMHC+NOx / CO / PM in g/hp-hr (g/kW-hr)										
hp (kW)	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
	Tier 1						**Tier 2***			
<11 (8)		**7.8 (10.5) 6.0 (8.0) 0.74 (1.0)**					**5.6 (7.5) 6.0 (8.0) 0.60 (0.80)**			
≥11 (8) <25 (19)		**7.0 (9.5) 4.9 (6.6) 0.60 (0.80)**					**5.6 (7.5) 4.9 (6.6) 0.60 (0.80)**			
≥25 (19) <50 (37)	**7.0 (9.5) 4.1 (5.5) 0.60 (0.80)**					**5.6 (7.5) 4.1 (5.5) 0.44 (0.60)**				
			Tier 2					**Tier 3***		
≥50 (37) <100 (75)						**5.6 (7.5) 3.7 (5.0) 0.30 (0.40)**				**3.5 (4.7) 3.7 (5.0) ****
≥100 (75) <175 (130)					**4.9 (6.6) 3.7 (5.0) 0.22 (0.30)**				**3.0 (4.0) 3.7 (5.0) ****	
≥175 (130) <300 (225)					**4.9 (6.6) 2.6 (3.5) 0.15 (0.20)**			**3.0 (4.0) 2.6 (3.5) ****		
≥300 (225) <600 (450)			**4.8 (6.4) 2.6 (3.5) 0.15 (0.20)**					**3.0 (4.0) 2.6 (3.5) ****		
≥600 (450) <750 (560)				**4.8 (6.4) 2.6 (3.5) 0.15 (0.20)**				**3.0 (4.0) 2.6 (3.5) ****		
≥750 (560)								**4.8 (6.4) 2.6 (3.5) 0.15 (0.20)**		

* These standards are subject to a feasibility review as discussed in Section 4.

** See above discussion on PM standards.

3. Test Procedures

In adopting a steady-state test cycle for its Tier 1 final rule, EPA stated that further study will be required to better characterize the nature and level of transient operation experienced by nonroad engines in actual use. The Signatories recognize that additional data would be beneficial in assessing the adequacy of the steady-state test in achieving control of regulated emissions, especially PM, in use. Other test parameters, such as the composition of the test fuel, may also impact the program's success in controlling in-use emissions.

The Signatories further recognize: (1) the crucial role that the test procedure plays in ensuring real emissions control in use, (2) the critical importance of in-use emission reductions in improving air quality and in determining state implementation plan credits under the Clean Air Act, (3) the effect that changes to test procedures could have on industry's ability to design, test and produce engines that comply with the applicable standards in the time periods contemplated by the SOP, (4) the need for a well-planned and well-coordinated test program to settle the issue of test procedure adequacy, (5) the value of proceeding in concert with international standard setting organizations in adopting a harmonized test procedure, and (6) the potential for this to be a lengthy process.

In order to achieve major NOx reductions as early as possible, EPA will propose that the current steady-state test be retained in the adoption of this SOP's standards. In addition, the Signatories will initiate a comprehensive test program, coordinated by EPA and cooperatively executed, to evaluate the adequacy of the current test procedure for achieving in-use emissions control. The test program will be initiated within six months of signing this SOP and will be completed by December 1998. The Signatories will also engage interested parties in the European Union (EU) in this comprehensive test program with the goal of gaining their participation as partners, if possible. Should the results of the testing program indicate that the test procedure does not achieve adequate control of emissions in use, EPA will initiate action to revise the test procedure if another test procedure is expected to provide significantly better control.

It is recognized that the standards in the SOP are based on the current steady-state test procedure. Further, all Signatories recognize that any test cycle changes or additions would likely complicate and delay industry's ability to research, design, test, and produce engines that comply with the standards contained in the SOP. As a result, any proposal to revise the current test procedure would propose that the revision not be implemented before Tier 3. Any changes in the test procedure will be taken into consideration as part of the Tier 3 feasibility review outlined below.

Engines rated at under 50 hp are not subject to the current Tier 1 standards and test procedure. The Signatories recognize that the manufacturer signatories' agreement to the standards for these engines set forth in Section 2 of this SOP is based on the assumption that the following test cycles are adopted:

Land-based CI engines	
Variable- and constant-speed <25 hp (19 kW)	ISO 8178 G2
Variable-speed 25-50 hp (19-37 kW)	ISO 8178 C1
Constant-speed 25-50 hp (19-37 kW)	ISO 8178 D2
Auxiliary marine CI engines	
Variable- and constant-speed <25 hp (19 kW)	ISO 8178 G2
Variable-speed 25-50 hp (19-37) kW	ISO 8178 C1
Constant-speed 25-50 hp (19-37) kW	ISO 8178 D2
Propulsion marine CI engines <50 hp (37 kW)	ISO 8178 E3

In addition, the Signatories recognize that the manufacturer signatories' agreement to the application of the standards set forth in Section 2 of this SOP to land-based constant-speed engines rated at over 50 hp is based on the assumption that the ISO 8178 D2 test cycle is adopted for these engines as an optional alternative to the current steady-state test. EPA will assess the adequacy of the above cycles for the indicated engines and propose appropriate cycles in the NPRM. If EPA should propose different cycles, then EPA will reassess the feasibility of the standards in light of the proposed cycles.

4. Feasibility Review

In order to assess the progress of the industry in meeting the Tier 3 standards and effect dates for over 50 hp engines and Tier 2 standards and effect dates for under 50 hp engines (hereafter collectively, the "Later Standards"), and to ensure the lowest appropriate standard levels at the earliest appropriate time, EPA shall conduct a review of any rule adopting the Later Standards set forth in this SOP. This review will conclude in 2001 and will commence with a notice providing opportunity for public comment on whether or not the standards are technologically feasible and otherwise appropriate under the Clean Air Act. After the public comment period, EPA will take final action on the review under Section 307 of the Clean Air Act. Should the Agency conclude as a result of this review that these standards are not technologically feasible, or are otherwise not appropriate under the Clean Air Act, it shall revise the rule as appropriate. In any such revision, the NMHC+NOx standards are not expected to be raised more than 1.0 g/hp-hr (1.3 g/kW-hr), assuming no change in the PM and CO standards.

In reviewing the rulemaking as set forth above, EPA shall review the need for and feasibility and cost of the Later Standards, including, but not limited to: (1) the need to provide engine and equipment manufacturers an adequate period in which to recoup the capital investment required to achieve the previous standards; (2) the need to provide engine and equipment manufacturers no less than four full years of leadtime[1/] between the time the feasibility review is finalized and the Later Standards become effective (while maintaining the engine category phase-in set forth in Section 2 above); (3) the need to assess the suitability, effectiveness and cost of transferring on-highway engine technology to nonroad engines and equipment; and (4) the need to assess the costs associated with redesigning equipment to accommodate the Later Standards.

The Signatories acknowledge that the standards set forth in this SOP will require a substantial investment for nonroad engine and equipment manufacturers, and their customers, and that the affected nonroad industry ordinarily requires a substantial period of stability in which to recoup such an investment. The period of stability between the previous and Later Standards ordinarily would be too short a time in which to reasonably recoup the investment needed to comply with the previous standards before imposing additional costs to comply with the Later Standards. Thus, the Signatories agree that the Later Standards in this SOP are based on the premise that no significant equipment redesign beyond that required to accommodate engines meeting the previous standards will be required to accommodate engines meeting the Later Standards.

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2. In the case of engines rated at less than 50 hp, no less than two full years of leadtime.

As part of the review discussed in this Section, EPA will solicit information as to whether equipment redesign will be required as a result of changes to engines that will be required to meet the Later Standards. Should such equipment redesign be required, EPA will assess its significance, taking into account the cost and technical difficulty of such redesign, the need for a period of stability to reasonably recoup the investment in equipment redesign to meet the previous standards, the number of equipment models affected, and other relevant factors. If significant equipment redesign is required to accommodate engines meeting the Later Standards, EPA will propose appropriate measures to address the burden of such redesign. Such measures would include flexibilities similar to those set forth in Section 5 below, a minimum two-year[1/] adjustment of the time between the previous standards and Later Standards for all engine families in each affected power category, an adjustment to the Later Standards to address the need for the redesign, or some combination thereof. EPA also may propose additional measures as appropriate under the Clean Air Act. EPA and ARB acknowledge that this SOP will require the industry to make a commitment to meet the Later Standards that will require a substantial period of stability.

EPA's review and assessment of the feasibility and cost of the Later Standards will include a review of the costs associated with the Later Standards on a marginal cost basis, taking into consideration total equipment production and operating costs, not just engine costs. If this assessment shows that the nonroad equipment industry will experience significant adverse impacts from changes in standards that are too frequent, rapid, or costly, EPA further commits to propose relaxing the standards and/or delaying the effective date of the standards, consistent with relevant provisions of the Clean Air Act.

The Signatories shall meet periodically to provide updates on their efforts and progress in complying with this SOP.

5. Implementation Flexibility

The Signatories recognize that new emission standards may create challenges for engine and equipment manufacturers beyond simply developing low-emission technologies. The nonroad industry is characterized by a diversity in engine models and equipment applications, many of which have small markets, making it difficult to rapidly and frequently implement design changes across wide product lines. Even small changes in engine designs can create major difficulties for equipment makers with low volume models, diverse product lines, or inadequate leadtime to respond to the changes. If engine makers were to discontinue engine models made in small

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3. Minimum three years and one year for engines in the 175-300 hp and 300-600 hp categories, respectively.

volumes, this could cause market disruptions, especially for small manufacturers of equipment who buy these engines, and their customers.

Problems of this sort could be dealt with by phasing new standards in very gradually. However, in order to gain the desired air quality benefits as early as possible, this SOP instead aims to resolve the problem by broadening the flexibility granted to equipment manufacturers by providing them implementation options. Thus, EPA will propose programs whereby, on an annual basis, an equipment manufacturer would be allowed to install engines not meeting the otherwise applicable Tier 2 or 3 standards for engines 50 hp or higher in some of its equipment (Tier 1 standards for engines less than 50 hp). The following subsection describes two such programs that will be proposed, based on a percent-of-sales approach. The Signatories agree to work together in developing alternative flexibility proposals, with the understanding that these alternatives will not involve a projected loss in overall emission benefits over that entailed in the below-described program. One alternative approach under consideration would exempt equipment on an application-specific basis; EPA will, at a minimum, seek comment on such an approach in the NPRM.

a. Equipment Manufacturer Phase-in

Engines 50 hp or higher. For engines rated at 50 hp or higher, EPA will propose to allow each equipment manufacturer to install engines certified to the Tier 1 standards in a maximum of 15 percent of the equipment produced for sale in the United States during the first year that a new Tier 2 standard applies, and in a maximum of 5 percent during each of the six years thereafter. This allowance would continue for a total of seven years after Tier 2 standards become effective for each engine category. At the end of this allowance period, equipment manufacturers would be required to install Tier 3 engines (or Tier 2 engines in any engine categories without Tier 3 standards) in all new equipment using engines in the category. However, if the effective dates of Tier 3 standards in any engine category are delayed beyond those set forth in Section 2, the allowance period for that engine category would be extended by the same period of time. For manufacturers electing to take advantage of the special flexibility provision for farm and logging equipment described below, the above-described flexibility provision would apply to just the non-farm/logging equipment the manufacturer sells.

To avoid disadvantaging smaller companies with limited product offerings, manufacturers would be allowed to exceed the above percent of production allowances during the same years affected by the above allowance program, provided they limit the installation of Tier 1 engines to a single equipment model with an annual production level (for U.S. sales) of 100 pieces or less.

In addition to the above general flexibility allowances, EPA will propose that manufacturers of farming or logging equipment will be allowed to install Tier 1 engines in a maximum of 30 percent of this equipment (produced for sale in the United States) during the first year that a new Tier 2 standard applies, and in a maximum of 15 percent for each of the seven years thereafter. This allowance would continue for a total of eight years after Tier 2 standards become effective for each engine category. At the end of this allowance period, equipment manufacturers would be required to install Tier 3 engines (or Tier 2 engines in any engine categories without Tier 3 standards) in all new farm or logging equipment using engines in the category. However, if the effective dates of Tier 3 standards in any engine category are delayed beyond those set forth in Section 2, the allowance period for that engine category would be extended by the same period of time.

Nothing set forth above would change the rules established in the Tier 1 standards which allow equipment manufacturers to use up existing stocks of noncomplying engines at the time a new standard takes effect.

Engines less than 50 hp. EPA will propose flexibilities as described above for equipment manufacturers who install <50 hp engines into their equipment, except as follows:

(1) Equipment manufacturers will be allowed to install unregulated engines instead of Tier 1 engines.

(2) The flexibilities will expire after a total of four years. When they expire manufacturers must install certified engines in all equipment.

(3) A delay of the effective date for the <50 hp Tier 2 standards does not affect the expiration date of the flexibilities.

b. Engine Manufacturer ABT and Continued Sales of Previous-Standard Engines

EPA finalized an averaging, banking, and trading (ABT) program in its Tier 1 rule to help engine manufacturers meet the new standards. Consistent with the NPRM for heavy-duty on-highway engines, EPA will propose to modify the existing ABT program to eliminate any limit on credit life, to eliminate any discounts in the way credits are calculated, and to make ABT available for NMHC+NOx and PM. These provisions will apply to all of the standards set forth in Section 2 except as discussed below. In recognition of the role ABT plays in facilitating the introduction of new standards, EPA will reassess the appropriateness of these provisions as part of the feasibility review discussed in Section 4. The Signatories recognize that the manufacturers have agreed to the standards set forth in this SOP on the condition that the changes that EPA will propose in the ABT program are finalized and made a part of these standards.

EPA will also propose three special provisions for the ABT program for engines rated at less than 25 hp. First, no credits generated from the sale of these engines would be allowed to be used to demonstrate compliance for engines rated above 25 hp. Second, all credits generated from the sale of Tier 1 under 25 hp engines would expire at the end of 2007. Finally, credits from the sale of Tier 1 under 25 hp engines would only be generated by engine families with family emission limits of less than 5.6 g/hp-hr (7.5 g/kW-hr) for NMHC+NOx credits and 0.60 g/hp-hr (0.80 g/kW-hr) for PM credits, and these credits would be calculated against these baseline levels rather than against the actual Tier 1 standard levels.

In addition to these ABT provisions, EPA will propose that engine manufacturers be allowed to continue to build and sell the engines needed to meet the market demand created by the equipment manufacturer flexibility program set forth above. To avoid the creation of unfair business advantages, the engine manufacturer Signatories agree that, if they decide to continue the production of such engines, they will make them available for sale at reasonable prices to all interested buyers.

Finally, EPA also will propose to allow engine manufacturers to produce unregulated, Tier 1, or Tier 2 engines, as the case may be, to meet customer needs for replacement engines, so long as manufacturers comply with the replacement engine regulations that EPA is developing.

6. Harmonization

The participants in this SOP recognize the value that harmonizing standards within the United States would have on the cost of producing engines and equipment. EPA and the California Air Resources Board will pursue harmonized standards and test procedures for nonroad engines covered by this SOP such that an engine family tested and certified by EPA could be sold in California and, similarly, an engine family tested and certified in California could be sold in the rest of the country. California acknowledges that the emission standards set forth in this SOP meet its needs for emission reductions for the engines covered by this SOP. However, if these standards should not be implemented as proposed, California's obligations to comply with State and Federal law, including its State Implementation Plan, take precedence over this SOP.

Furthermore, the global nature of the nonroad equipment and engine markets argues for maximum harmonization between the U.S. standards and test procedures and those of other nations. In particular, the European Union has developed standards very similar to EPA's Tier 1 standards and has proposed its own Tier 2 standards. The Signatories support the goal of continued harmonization and intend to work with the EU, Japan, and other regulatory bodies in developing harmonized future standards, including provisions for implementation flexibility. Harmonized standards and test

procedures will be pursued in the program developed under this SOP to the maximum extent possible, provided that these measures do not compromise the other provisions of this SOP or the primary purpose of the program, which is to meet the air quality needs of the United States.

7. Fuels and Lower Emitting Alternatives

The standards set forth above contemplate the possibility of transferring on-highway technology to nonroad engines. The Signatories recognize that: (1) on-highway engines currently are operated on higher quality fuel than nonroad engines, (2) fuel composition has a significant impact on emission performance, (3) changes in the composition and improvements in the quality of nonroad fuels may be needed to make the Tier 3 standards technologically feasible and otherwise appropriate under the Act.

A number of states and other interested parties have expressed strong interest in programs to reduce emissions from nonroad engines beyond the levels established in this SOP. These parties believe that if a program were in place to certify low emitting engines (both diesel and alternative fuel engines), a market for these engines could be created through a variety of incentives including, but not limited to, marketable emission credits and the prominent labeling of low-polluting equipment as such. This certification program would be dependent on the establishment of a test procedure which reasonably evaluates the effectiveness of these engines in achieving real in-use emissions reductions.

Therefore, EPA shall propose an optional program for the certification of very low-emitting engines. This program would include, as needed, optional test procedures and standards that would encourage the sale of engines providing benefits beyond those corresponding to the program described elsewhere in this SOP. In addition, EPA will consider other programs to encourage the use of low-emitting engines and emission-reducing fuels.

8. Durability

All Signatories recognize that it is important that emissions control be maintained throughout the life of the engine. The Signatories will work together to develop appropriate measures which ensure that emission improvements are maintained in use.

9. Certification and Compliance

All Signatories recognize that it is important to minimize the costs associated with certification and they commit to working together to streamline and simplify the certification process. Further, the Signatories acknowledge that the standards set forth

in Section 2 of this SOP are based on the assumption that there will be no changes to the enforcement program adopted as part of the Tier 1 rule, except as specifically set forth in this SOP. Finally, the Signatories also recognize that engine manufacturers will be required to undertake significant engineering challenges in relatively short time frames in order to meet the Tier 2 and Tier 3 standards including the challenge of stabilizing initial production variability. Therefore, EPA will only impose selective enforcement audits (SEA's) during the first year in which a standard is in effect for those engine families where strong evidence exists that SEA failure would be likely.

10. Research Agreement

The Signatories recognize the benefits of a joint industry/government research program with the goal of developing engine technologies which can meet and exceed the standards for nonroad engines outlined in this SOP. The Signatories will undertake development of a separate research agreement with goals of reducing NOx emissions to 1.5 g/hp-hr (2.0 g/kW-hr) and PM emissions to 0.05 g/hp-hr (0.07 g/kW-hr), while maintaining attributes of current nonroad diesel engines such as performance, reliability, durability, safety, efficiency, and compatibility with nonroad equipment. These characteristics have allowed current nonroad diesel engines to serve as the pillar of the international nonroad equipment industry. This research agreement would include certain of the industry signatories below, EPA, ARB, and other organizations, such as the U.S. Department of Energy, as are approved by the participants.

ATTACHMENT 1 -- CALIFORNIA REGULATIONS FOR NEW 1996 AND LATER OFF-ROAD COMPRESSION-IGNITION ENGINES

ATTACHMENT 2 -- AMENDMENTS TO TITLE 13, CALIFORNIA CODE OF REGULATIONS, CHAPTER 2, ARTICLES 2.1, 2.3, and 2.4; PROCEDURES FOR IN-USE VEHICLE VOLUNTARY AND INFLUENCED RECALLS; IN-USE VEHICLE ENFORCEMENT TEST PROCEDURES; AND PROCEDURES FOR REPORTING FAILURES OF EMISSION-RELATED COMPONENTS.

ATTACHMENT 3 — CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR NEW 1996-1999 HEAVY-DUTY OFF-ROAD COMPRESSION-IGNITION ENGINES, PART I-A

ATTACHMENT 4 — CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR NEW 2000 AND LATER OFF-ROAD COMPRESSION-IGNITION ENGINES, PART I-B

ATTACHMENT 5 — CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR NEW 1996 AND LATER OFF-ROAD COMPRESSION-IGNITION ENGINES, PART II

ATTACHMENT 6 — CALIFORNIA SMOKE TEST PROCEDURES FOR NEW 1996-1999 OFF-ROAD COMPRESSION-IGNITION ENGINES, PART III

ATTACHMENT 7 — AMENDMENTS TO TITLE 13, CALIFORNIA CODE OF REGULATIONS, CHAPTER 9, DIVISION 3, ARTICLE 1; SMALL OFF-ROAD ENGINES

ATTACHMENT 8 — AMENDMENTS TO CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1995 AND LATER SMALL OFF-ROAD ENGINES